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Examining recent mortality trends: The impact of demographic change

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Examining recent mortality trends – the impact of demographic change

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Abstract

Between 2020 and 2022, OECD countries recorded an additional six million deaths compared to the years prior to the pandemic. The availability of near-complete data on the number of deaths by age and sex for almost all OECD countries makes it now possible to better examine overall trends and differences in mortality across the OECD over the three-year span of the pandemic.

Driven by a need to monitor the impact of the pandemic, the OECD exploited the improved availability and timeliness of national data to continually track COVID-19 and all-cause deaths across most OECD countries. In 2020, an analysis of the first waves of the pandemic using weekly measures of all-cause mortality were published as an OECD Health Working Paper (Morgan, 2020[1]) and subsequent estimates of the changes in overall mortality have been included in various OECD publications.

While a simple comparison of the raw number of deaths with reference to a historical base period has proved to be an important and straightforward indicator to assess the overall impact of the pandemic on populations, significant differences in methodological approach and the terminology used regarding 'excess mortality' has led to some issues concerning the interpretation of results. Notably, many OECD countries have undergone major changes in population size and structure in recent years as a result of population ageing and migration. These changes can have a significant bearing when comparing absolute mortality numbers. This OECD Health Working Paper reviews the methodology of calculating changes in mortality to take account of such demographic trends and, in producing a revised set of estimates of adjusted numbers of deaths, highlights some important variations in mortality across years, countries and age groups.

The calculation of age-standardised mortality rates (ASMR) further provides an indication of how the pandemic has impacted the observed trends in mortality across different countries, and for the OECD as a whole. The enlarged dataset covering the three-year period also provides an opportunity to re-examine the analysis of underlying health and health system factors contributing to the observed outcomes that forms part of the ongoing resilience work of the OECD Health Division.

Résumé

Entre 2020 et 2022, les pays de l'OCDE ont enregistré six millions de décès supplémentaires par rapport aux années précédant la pandémie. La disponibilité de données quasi complètes sur le nombre de décès par âge et par sexe pour les pays de l'OCDE permet désormais de mieux examiner les tendances générales et les différences de mortalité au sein de l'OCDE au cours des trois années de la pandémie.

Soucieuse de surveiller l'impact de la pandémie, l'OCDE a exploité l'amélioration de la disponibilité et la ponctualité de données nationales pour suivre en continu les décès du COVID-19 et les décès toutes causes confondues dans la plupart des pays de l'OCDE. En 2020, une analyse des premières vagues de la pandémie utilisant des mesures hebdomadaires de la mortalité toutes causes confondues a été publiée dans un document de travail de l'OCDE sur la santé (Morgan, 2020[1]), et des estimations ultérieures des changements récents de la mortalité globale ont été incluses dans diverses publications de l'OCDE.

Si la simple comparaison du nombre brut de décès par rapport à une période historique de référence historique s'est avérée être un indicateur important pour évaluer l'impact global de la pandémie sur les populations, d'importantes différences dans l'approche méthodologique et la terminologie autour de la "surmortalité" ont soulevé des questions quant à l'interprétation des résultats. Notamment, de nombreux pays de l'OCDE ont connu des changements majeurs dans la taille et la structure de leur population au cours des dernières années en raison du vieillissement de la population et des migrations. Ces changements peuvent avoir une incidence significative sur la comparaison des chiffres absolus de la mortalité. Ce document de travail de l'OCDE sur la santé passe en revue la méthode de calcul des variations de la mortalité pour tenir compte des tendances démographiques et, en produisant une série révisée d'estimations du nombre ajusté de décès, met en évidence des différences importantes dans la mortalité entre les années, les pays et les groupes d'âge.

Le calcul des taux de mortalité standardisés par âge (ASMR) fournit en outre une indication de l'impact de la pandémie sur les tendances observées de la mortalité dans les différents pays et dans l'ensemble de l'OCDE. L'ensemble de données élargi couvrant la période de trois ans permet également de réexaminer l'analyse des facteurs sous-jacents liés à la santé et au système de santé qui contribuent aux résultats observés dans le cadre du travail sur la résilience en cours au sein de la division de la santé de l'OCDE.

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In brief

1. On average, an **additional 2 million deaths** were registered across the OECD in each of the years between 2020 and 2022, when compared to the average number of deaths during the five years leading up to the coronavirus pandemic. The number of registered **deaths peaked at around 13.5 million in 2021** - 19% more compared to average pre-pandemic levels.

2. Over the same three-year period, **more than 3 million COVID-19 deaths were recorded**, reaching more than 70 000 weekly deaths in January 2021. At its peak, COVID-19 was responsible for **almost 1 in 5 of all weekly deaths in the OECD** and reached a considerably higher share in some OECD countries. The number of deaths directly attributable to COVID-19 is however an underestimate with diagnosis and coding practices varying across countries, especially early in the pandemic.

3. The **patterns of mortality varied widely by year across the OECD** largely reflecting how successive waves of the pandemic affected different regions of the world as well as to what extent the stringency of containment measures and population behaviour impacted the spread of the virus in each country.

4. While the roll-out of mass vaccination programmes and the mutation of the original virus to less severe variants significantly reduced the case fatality rate, **mortality rates remained high in many OECD countries in 2022.** This was due, among many factors, to the continuing effects of COVID-19, health systems under pressure from postponed and backlogged care, the reappearance of respiratory and other infections, as well as the impact of heatwaves in some countries.

5. At the same time, nearly all OECD countries have seen **rapid demographic change** with the size of the 65+ population increasing by 19%, on average, between 2015 and 2022. Adjusting for this demographic change, the **average *adjusted* increase in the number of deaths for OECD would be +5.3%**. On a year-by-year adjusted basis, the increase in the number of deaths would be +5.8% in 2020, increasing to +7.2% in 2021 before dropping to +2.9% in 2022.[1]

6. While the focus here is on measures of mortality covering annual or three-year periods, it is important to note that the increases in **mortality observed at shorter frequencies** (e.g. on a weekly basis) were of a much greater degree of variance, leading to **acute pressures on health systems**, which may not be apparent from examining average annual mortality rates.

7. However, even taking account population change, Mexico and Colombia saw the highest increase in mortality of +30.5 and +23.5%, respectively, over the three-year period. On the other hand, **nine OECD countries saw an overall decrease in mortality** after adjustment. While overall mortality patterns are driven primarily by deaths occurring in the older age groups, **important increases in mortality in younger age groups** were also observed **in several countries**.

8. Age-standardised mortality rates (ASMR)[2] show a **decreasing trend in the mortality rate in most OECD countries prior to the pandemic**, with a notable jump in 2020 and 2021, before a decline in 2022, although the average level remained above that just prior to the pandemic (Figure 1). Notably, **countries**

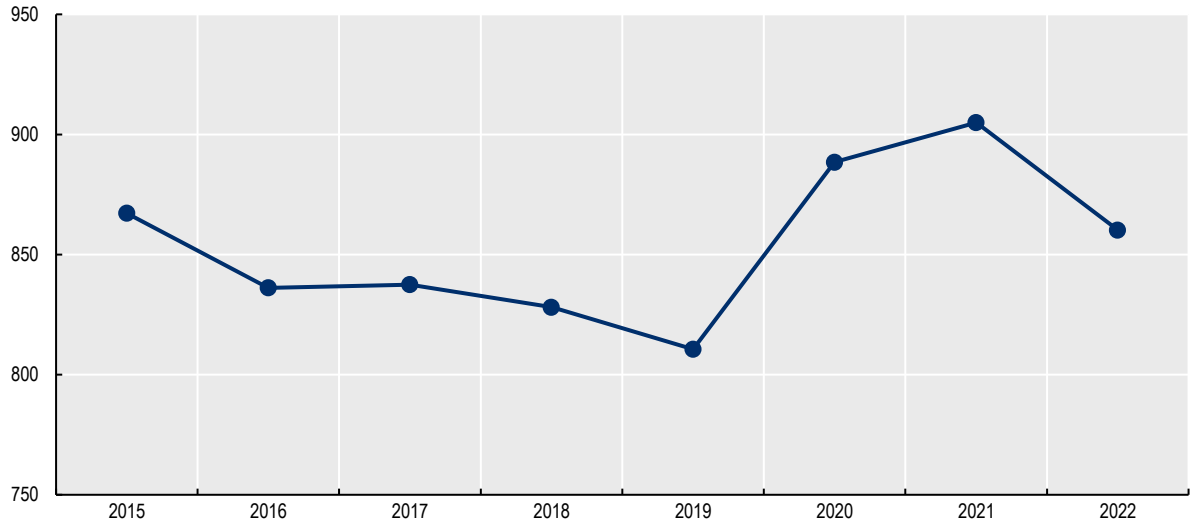
[1] In its simplest form, 'excess mortality' compares the number of reported deaths against a baseline figure (e.g., the average number of deaths registered in the years 2015 to 2019) without taking population change into account.

[2] Using the OECD 2015 Standard Population.

with higher mortality rates prior to the pandemic **observed the greater increases in mortality** during the three-year period.

Figure 1. The pandemic reversed the trend of gradually declining mortality across the OECD

Age-standardised mortality rate (ASMR) per 100 000 population, OECD average



Note: ASMR calculated using OECD 2015 Standard Population.
Source: Secretariat calculations based on methods and data sources detailed in Annex A.

9. Previous analyses of the preparedness of health systems in the face of the pandemic suggested that **health system capacity, access to quality healthcare and underlying population health were associated with COVID-19 outcomes** (OECD, 2023[2]). The extension of the analysis to capture mortality outcomes for 2022 and the adjustment for demographic change does not alter most of the associations.

1. Introduction

10. The COVID-19 pandemic was designated a public health emergency of international concern between January 2020 and May 2023, such that the calendar years from 2020 to 2022 might be considered as the *core* pandemic years. The availability of data on annual deaths by age and sex for OECD countries for all three years now offer an opportunity to review and assess overall mortality patterns over this period. COVID-19 was a major new cause of mortality and at times in some countries accounted for more than 4 out of 10 reported deaths as new waves and variants of the virus took hold. In all, close to six million additional deaths were reported in OECD countries during this three-year period compared to an equivalent three-year period prior to the pandemic. This equates to a 19% increase in the number of reported deaths.

11. Even as the direct impact of COVID-19 waned in many countries during the course of 2022, populations and health systems still struggled to recover fully from the pandemic. Ongoing COVID-19 infections and "Long-COVID", as well as delays and backlogs exacerbating pre-existing conditions continued to burden health systems. The return of seasonal respiratory infections, health-threatening climatic events and the increase of drug and alcohol deaths (in some countries) also impacted the patterns of mortality in 2022.

12. Over the course of the pandemic, the change in overall mortality has frequently been countenanced as an effective indicator to measure the overall impact of the virus, given the difficulties and differences in the direct reporting of deaths from COVID-19. That said, different methodological approaches used to determine 'excess mortality' by various national and international entities, including the OECD, have resulted in a array of published estimates. The choice of a baseline norm and the degree of sophistication in deriving an estimate of the expected number of deaths can severely impact the results (Box 1.1). Accounting for differences in age structure between countries and population changes due to ageing can also significantly impact the calculation of overall mortality rates. Data availability is also important, with information about actual demographic change (e.g., through censuses) typically lagging information about the number of recorded deaths.

13. From early in the pandemic, OECD collated and disseminated weekly counts of all-cause and COVID-19 deaths for nearly all OECD countries (OECD, 2023[3]). Using these data together with supplementary data from national and international sources, annual death numbers for the period 2015 to 2022 have been compiled for 41 countries (see 0) including breakdowns by gender and broad age category. Based on these data, population adjusted estimates of the number of deaths have been computed and age-standardised mortality rates (ASMR) calculated to provide an improved perspective on the patterns of overall mortality over this period.

14. As part of OECD's efforts to examine the lessons learnt and strengthen the resilience of health systems, changes in mortality have been used as an outcome measure to examine the link to certain heath system and population characteristics (OECD, 2023[4]). The availability of revised estimates of mortality over the extended time-period of the pandemic allows for a reassessment of these connections. While the initial analysis was embedded in assessing the impact of the pandemic, the extension to examine characteristics of resilient health systems in the face of new challenges, such as climate change, is equally relevant.

Box 1.1. Understanding different approaches to measure 'excess mortality'

15. Excess mortality typically refers to the difference between the observed number of deaths (either from all causes or a specific cause of death) over a defined period (ranging from a week to a multi-year period) compared to a estimate of the *expected* numbers of deaths for the same period.

16. An indicator of excess mortality is seen as an important and widely used measure to understand the overall change in mortality due to the impact of events in the short-term such as heatwaves or longer-term in the case of flu epidemics or more recently the COVID-19 pandemic. Different methodological approaches have been applied by various national and international organisations resulting in wide variations in the expected number of deaths, therefore raising some challenges in comparing and interpreting the results (The Lancet, 2023[5]).

Using a simple baseline

17. The simplest approach derives estimates over a period by comparing the number of deaths registered within that period with the average number of deaths that occurred in an equivalent period in the past (baseline). For example, the number of deaths recorded in Week 10 in 2022 can be compared with the average number of deaths reported in Week 10 during the years 2015 to 2019. The additional number of deaths during a period in which extreme events (e.g., heatwave) occurred in a country or region can give an indication of the overall impact of the event. This approach has been employed by a number of national and international agencies, especially since the onset of the pandemic. For example, Eurostat publishes monthly estimates of excess mortality as the percentage change in the number of deaths compared to the average number of deaths that occurred in the same month during the period 2016-2019 (Eurostat, 2023[6]).

18. While the approach is advantageous due to its limited data requirements and simplicity to calculate and understand, changes in mortality are affected by many factors including population growth and ageing as well as longer-term trends in population health. The choice of a baseline period can also have an impact, for example, there may be good reason to exclude certain periods impacted by extreme events.

Adjusting for population change

19. Changes in population structure and size can impact mortality in a given country and over time. For example, if the overall population is growing over time, then it might be reasonably expected that the observed number of deaths would increase also. This is particularly important when the size of the population in older age groups, which account for most deaths, is increasing. This impact can be accounted for by adjusting the number of deaths by the size and age structure of the population in a country over time.

20. To compare mortality rates over time and between populations, age-standardised mortality rates (ASMR) have been used. The Office for National Statistics (ONS) in the United Kingdom regularly publishes monthly mortality analyses using both excess mortality by number of deaths and ASMRs, based on the 2013 European Standard Population (ONS, 2023[7]).

21. While ASMR is a robust and common statistical technique use by statisticians, demographers, and epidemiologists, it is sensitive to small numbers, for example shorter cumulative periods (weekly) and of rare events in narrow age groups. Thus, care sometimes needs to be taken in comparing ASMRs between countries and over time. Also, ASMR requires mortality and population data broken down by age.

Modelling expected deaths

22. While both approaches above compare to a past baseline period - even when adjusted for population change - other approaches attempt to 'predict' the expected mortality for the period by taking into account the trend over time. Thus, modelling of expected deaths can consider the longer-term trend, as well as accounting for factors such as population, deprivation and ethnicity (Disparities, 2023[8]). Different techniques have been used to estimate the number of excess deaths (including those related to heatwaves and pandemics. For example, as part of the World Mortality Dataset (WMD) estimates by Ariel Karlinsky and Dmitry Kobak use a regression model for each region using historical deaths data from 2015–2019 to project the number of deaths that might normally have been expected in 2020–2023. Their model captures both seasonal variation and year-to-year trends in mortality (Karlinsky, 2021[9]).

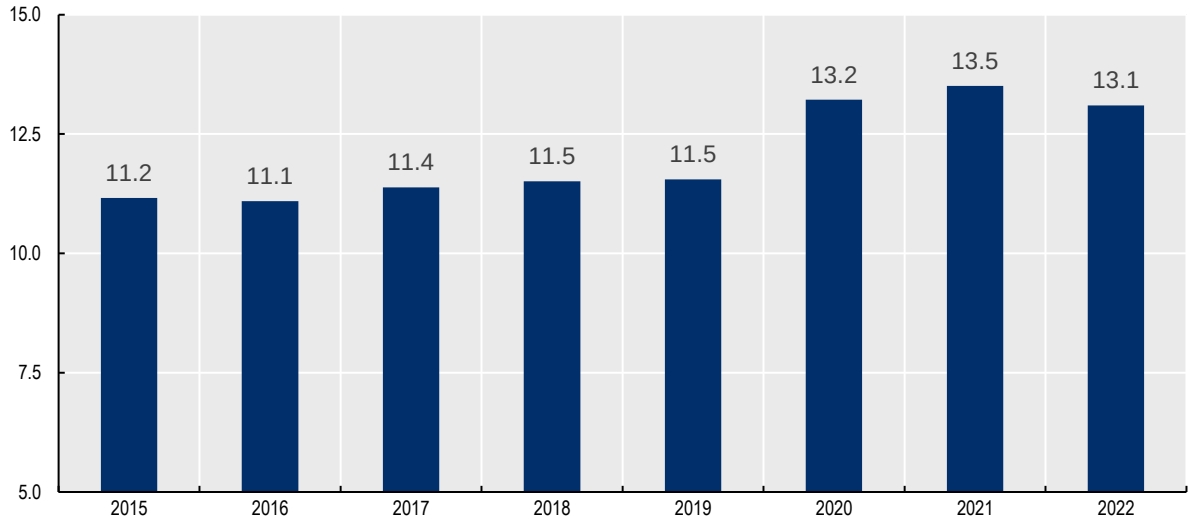
23. (Barnard S, 2022[10]) describe five different approaches to estimating excess mortality for the period March 2020 through March 2021 across England. The simple 5-year baseline approach, a quasi-Poisson model, a Poisson model, the European monitoring of excess mortality model (EuroMOMO) and a synthetic controls model. The variation between estimates reflects differences in the date of interest (date of occurrence or registration), population denominators and parameters in the model relating to seasonality and trend.

2. Tracking deaths through the pandemic

24. While the COVID-19 pandemic was officially declared no longer a public health emergency of international concern by the World Health Organization on 5 May 2023 after more than three years, the virus and its variants continued to circulate, with many countries treating COVID-19 as an endemic disease. During each of the three years from 2020 to 2022, the OECD counted around 2 million additional deaths compared to the 5-year pre-pandemic average, with an estimated peak of almost 13.5 million deaths recorded across the 38 OECD countries in 2021 (Figure 2.1).

Figure 2.1. Annual deaths jumped by up to 2 million across the OECD during the pandemic

Millions of registered deaths



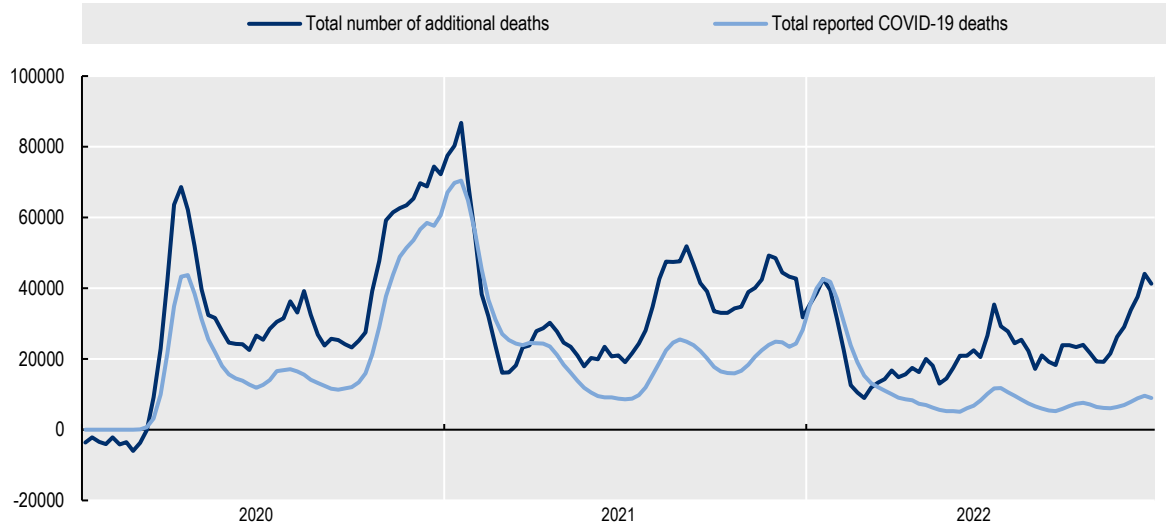
Source: (OECD, 2023[3]) and national sources (see Annex A).

25. A focus on calculating and tracking 'excess mortality', taken as the total number of deaths registered in a period (weekly, monthly and annually) compared to the number that might have been normally expected, came to the fore during the pandemic. Differences in testing capacity and how countries identified and coded deaths due to COVID-19 early on, and then later in assigning COVID-19 as the primary cause of death, led to questions around the degree of international comparability of reported numbers of deaths directly attributable to the virus. To avoid the cross-national differences in reporting of deaths due to any single cause, examining the total number of deaths from *all* causes can give a better understanding of the impact of, in this case, COVID-19, by not only comparing deaths that are directly attributable to the virus, but also by accounting for *indirect* mortality. For example, there may have been deaths due to under-pressure health systems unable to cope with non-COVID conditions, or to the longer-

term impact of the pandemic because of foregone or postponed care. In October 2020, the OECD released a Health Working Paper highlighting the use of all-cause mortality as an indicator to track the impact of COVID-19 across OECD countries (Morgan, 2020[1]). Throughout the pandemic and after, the OECD has continued to collect and disseminate weekly data on both all-cause and COVID-19 deaths (OECD, 2023[3]). OECD has also regularly incorporated updated estimates of recent mortality trends in various publications, such as *OECD Health at a Glance 2021* (OECD, 2021[11]) and *Ready for the Next Crisis? Investing in Health System Resilience* (OECD, 2023[4]).

Figure 2.2. The number of additional all-cause deaths and COVID-19 deaths peaked in early 2021

Total weekly deaths above the 2015-19 average and total reported COVID-19 deaths, OECD, 2020-2022

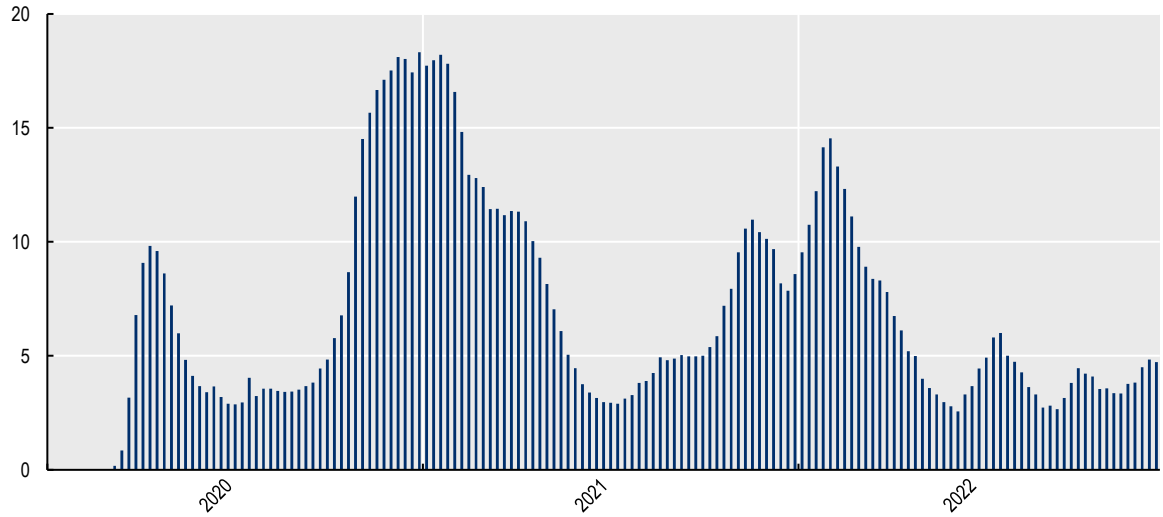


Note: Weekly data unavailable for Ireland, Japan, Korea and Türkiye. Additional deaths compared to the weekly deaths during 2015-19
Source: (OECD, 2023[3]).

26. Figure 2.2 shows the trends in the number of additional or excess deaths from all causes compared to pre-pandemic years and deaths attributed to COVID-19 across the OECD on a weekly basis. The main waves of the pandemic can be clearly discerned, and the two measures are closely aligned in 2020 and 2021, even if they may have impacted different regions at different times. While the overall peak in reported COVID-19 deaths in late 2020 and early 2021 was largely driven by the wave of deaths in North America, this period marked the point with the highest average share of overall deaths attributed to COVID-19 across 34 OECD countries, at more than 18% of total deaths (Figure 2.3).

Figure 2.3. Nearly one in five deaths were reported as COVID-19 deaths around the end of 2020

COVID-19 deaths as a percentage of all-cause mortality, OECD average, by week



Note: Weekly mortality data unavailable for Ireland, Japan, Korea and Türkiye.
Source: (OECD, 2023[3]).

2.1. Heatwaves and the return of respiratory infections contributed to high mortality in 2022

27. As vaccination campaigns successfully reduced the risk of severe illness and death, there has been an increased decoupling between direct reported COVID-19 deaths and the overall levels of mortality. From early 2022 onwards, COVID-19 deaths typically accounted for less than 5% of overall deaths, on average, on a weekly basis. A range of factors, such as heatwaves and the return of seasonal influenza and other respiratory infections kept mortality rates high in many countries through the course of 2022. The pandemic also disrupted healthcare systems, making it harder for people to access medical care at times. This may have resulted in the deterioration of some existing chronic conditions, such as heart disease and possibly cancer and therefore may have made people more susceptible to dying from non-COVID-related causes (OECD, 2023[2]).

28. Heatwaves during the European summer and 'flu during the winter season likely played a key role in the peaks in mortality observed in 2022. Some of the hottest and most prolonged high temperatures seen in Europe caused substantial harm to human health with heat stress exacerbating chronic conditions, including cardiovascular, respiratory, and cerebrovascular diseases, as well as diabetes-related conditions. In August 2022, the EU's Copernicus Climate Change Service (C3S) reported on the heatwave stretching from the Iberian Peninsula north and eastwards towards France, the United Kingdom, Central Europe and Scandinavia. Across the affected region, all-time records for maximum temperature were broken and southwestern Europe experienced its warmest July on record in terms of maximum temperatures (Copernicus Climate Change Service, 2022[12]). It has been estimated that more than 60 000 heat-related deaths occurred in Europe between 30 May and 4 September 2022 (Ballester, 2023[13]).

29. There was also an unusually high incidence of respiratory disease towards the end of 2022 as countries in northern and Central Europe, such as Austria, France and Germany, registered a 30-50% increase in deaths in the final weeks of 2022 compared to the average number of deaths in the corresponding weeks during the years 2015 to 2019. In Germany, approximately 114 000 deaths were recorded in December 2022, a figure above the level reached in previous 'flu seasons (Destatis, 2023[14]).

3. Determining the impact of demographic change on mortality trends

30. All-cause mortality has proved to be an important indicator throughout the course of the pandemic, shedding light on both the direct and indirect impact of the virus. As deaths from COVID-19 have declined, the timely tracking of the overall number of deaths compared to what might normally be expected continues to be seen as a robust indicator, providing insights into the longer-term effects of the pandemic such as the impact of delays in the identification and treatment of other illnesses. Looking ahead, it can act as a potential indicator for the spread of viruses and pathogens even before the development and proper roll-out of testing capacity, and may help policy makers determine how strong response measures should be, where they should be applied, and for how long. Changes in overall mortality can also be useful for assessing the impact of acute shocks such as extreme meteorological events and natural disasters, as well as longer-term trends in mortality due to climate change and other external factors.

31. The previous section described how the number of deaths across OECD countries increased significantly during the pandemic and continued at a high level in 2022 due to a variety of factors compared with the pre-pandemic years (2015-19). As a result, there has been a high level of interest in understanding how changes in mortality can be best interpreted. Many national authorities (or even different agencies within the same government) as well as international organisations (including OECD) and researchers have produced different measures of 'excess mortality', based on different methodologies, in addition to using different data sources.

32. The approaches used to calculate the expected number of deaths vary in their complexity and draw on different data from different periods to make estimates of excess mortality (see Box 1.1). In common with many other estimates, the OECD previously adopted a simple approach to calculate excess mortality based on a raw count of the number of reported deaths in the study period and comparing against a previous baseline average (in this case the average number of deaths observed during the corresponding period between 2015 and 2019).

33. Figure 2.2 in the previous section uses this approach to show the additional number of deaths reported on a weekly basis for the OECD, compared with the average between 2015 and 2019 for the same week. A study by the UK's Office for National Statistics compared different international measures of excess mortality, including that used by OECD, and outlined the various strengths and limitations. Their report concluded that while the OECD analysis 'allowed for comparison of excess and COVID-19 deaths across several European and non-European countries', 'the differing population size and age-structures have not been taken into account.' (Office for National Statistics (ONS) and Government Office for Science (GOScience), 2022[15]).

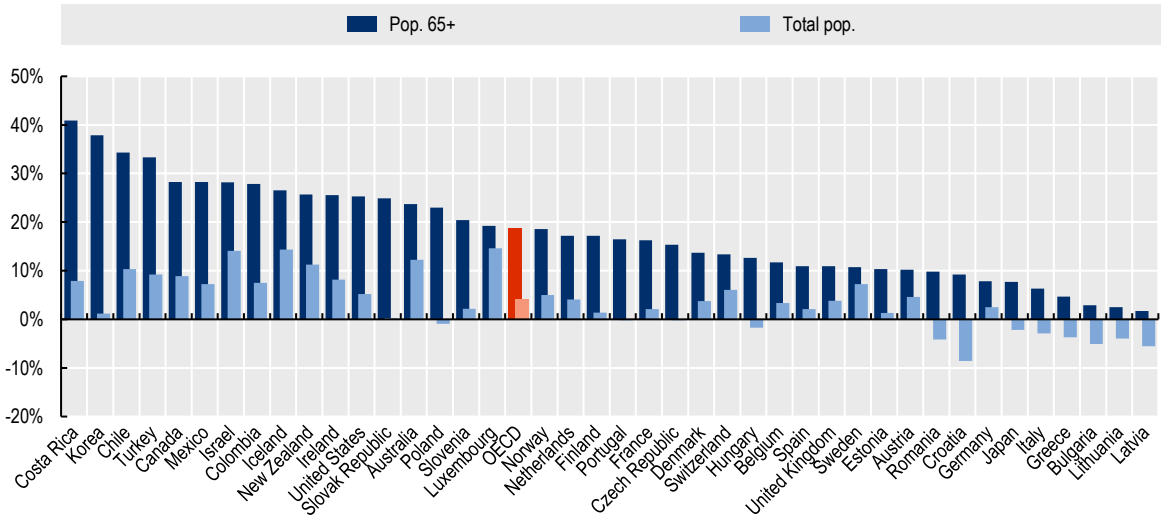
34. The importance of changes in population size and structure can be best understood by observing the change not only in overall population size but more importantly in the size of the 65+ age group between 2015 and 2022 (Figure 3.1). On average across OECD countries, overall populations grew by around 4%

during this period, with some countries in Southern and Central Europe observing a decline overall, while some of the smaller countries (e.g., Luxembourg and Iceland) and 'younger' nations, such as Israel, have seen double-digit growth due to a variety of factors.

35. On the other hand, *all* OECD countries have seen an increase in the size of the population aged 65+. While this age group grew by only around 2% in Latvia and Lithuania, it averaged an 19% increase across OECD countries, with Türkiye, Chile and Korea seeing a more than 30% increase, and Costa Rica counting 40% more people over 65 in 2022 compared to 2015. Combined with the fact that around 80% of deaths in the OECD typically occur in this 65+ age group, then the growth of the population in this age group can have a significant impact when examining overall mortality over the pandemic years from 2020 to 2022.

Figure 3.1. The number of people aged 65+ has risen significantly across the OECD since 2015

Percentage change in population size between 2015 and 2022



Note: OECD average excludes the three OECD accession countries: Bulgaria, Croatia and Romania.
Source: https://stats.oecd.org/Index.aspx?DataSetCode=HISTPOP and Eurostat.

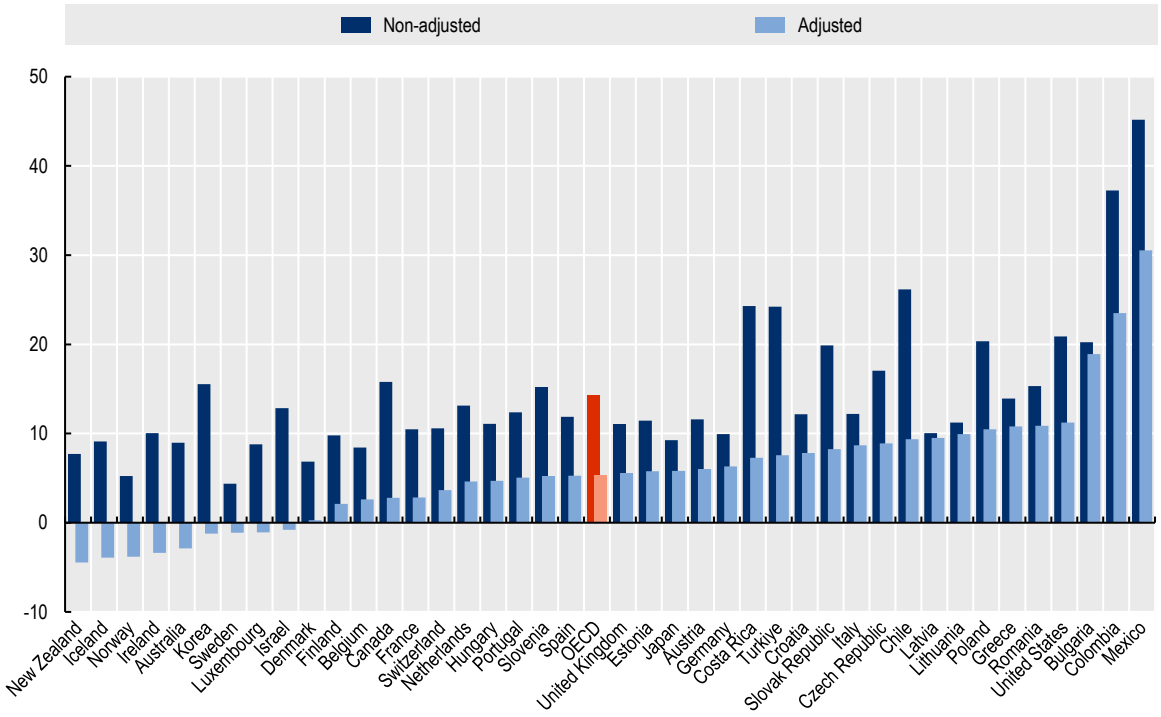
36. The OECD Health Working Paper published in 2020 included an initial sensitivity analysis looking at the impact of overall population growth and the share of the 65+ population on estimating excess mortality during the first wave of the pandemic (Morgan, 2020[1]). The following sections of this report go further by adjusting the observed mortality estimates to take into account changes in population size and structure (including disaggregation by sex), and then comparing population adjusted numbers of deaths during the three-year pandemic period against adjusted pre-pandemic levels. In addition, age-standardised mortality rates (ASMR) using the 2015 OECD Standard Population are calculated to examine the trends and levels of mortality over time and between OECD countries. Details of the methodology, which is close to that applied by the United Kingdom's Office for National Statistics in their regular reports (ONS, 2023[7]), are provided in Annex A.

3.1. Demographic change has a significant impact on mortality

37. Figure 3.2 shows the increase in the total number of deaths over the three-year period from 2020 to 2022 against the expected number of deaths based on the pre-pandemic years, 2015-19. The light blue bars show the crude increase in reported mortality with no adjustment. The dark blue bars adjust the number of deaths reported for changes in the population for three broad age groups (0-44, 45-64, 65+) and by sex. In countries where the population aged 65+ has grown substantially (e.g., Costa Rica and Türkiye), there is a marked decrease in the adjusted number of deaths. For those countries with much smaller changes both in structure and population size (e.g. Latvia and Lithuania), the differences between the unadjusted and adjusted figures are notably smaller.

Figure 3.2. Deaths from 2020 to 2022 were up by 5%, when adjusted for demographic change

Percentage increase in deaths in 2020-22 compared to the baseline years, 2015-19



Note: OECD average excludes three OECD accession countries: Bulgaria, Croatia and Romania.
Source: Secretariat calculations based on data sources detailed in Annex A. Overall, when the number of deaths from 2015 to 2022 are adjusted for changes in population size and structure, the OECD counted an increase in deaths of just over 5.3% on average during the period 2020-22, compared with the pre-pandemic period. When adjusted, nine OECD countries reported fewer deaths during this period than might have been expected, with estimates indicating New Zealand had around 4.4% fewer deaths over the three-year period than might have been expected if population structure and size had remained constant between 2015 and 2022. On the other hand, even when considering the significant changes in population size and structure, Mexico and Colombia recorded significantly higher numbers of deaths than expected, at +30.5% and +23.5%, respectively.

38. For some countries the impact of the change in population size and structure can be substantial. Korea, for example, reported 15% more deaths during the pandemic years compared to the average in the 2015-19 period. However, when considering the large changes in population size and structure, the adjusted number of deaths suggest that mortality in Korea between 2020 and 2022 decreased by more

than 1%. Similarly, in absolute numbers, Chile counted 26% more deaths overall, but the adjusted figures reduced this to a less than 10% increase.

39. The following sections consider mortality patterns for each year of the pandemic and across each age group, and refer to adjusted mortality rates only (unless specified).

3.2. Increasing mortality rates reached a peak in 2021

40. The patterns of mortality across the OECD varied by year and largely reflect how successive waves of the pandemic affected different regions and how different containment measures impacted the spread in specific countries (Figure 3.3).

41. The first waves of the pandemic through to the end of 2020 particularly affected North and South America. Mexico was by far the worst hit among OECD countries with (adjusted) deaths increasing by more than 40% in 2020, followed by Colombia at just over 20% and the United States at around 17%. In Europe, Italy, Spain, Belgium, and the United Kingdom were severely affected during the early wave (with increases of between 10 to 15%) but also later in 2020, when Central European countries, such as Poland and Czechia also experienced high increases in overall mortality.

42. On the other hand, countries which implemented prompt and stringent containment measures, and/or that are geographically isolated saw the number of deaths fall in 2020. New Zealand saw 9.5% less deaths than might have been expected, with falls of 6.5% and 5.3% estimated in Australia and Korea, respectively. In Europe, Norway, Denmark, Iceland, and Finland all experienced lower mortality than expected in the first year of the pandemic, despite different approaches to the enforcement of containment measures such as lock downs.

43. A complex situation occurred in 2021 but with overall evolving trends as the impact of vaccination programmes took hold. Mexico and Colombia continued to see significant levels of increased mortality, at over 40% above expected levels in both countries. The United States also continued to see estimated mortality rates around 15% higher than expected. Much of Central and Southeastern Europe also saw increased mortality, with the Slovak Republic, which had been generally spared from the worst effects of the pandemic in 2020, seeing an increase of more than 20% in reported deaths in 2021. The Baltic States, Greece and Türkiye also saw elevated levels of between 12-20% increased mortality.

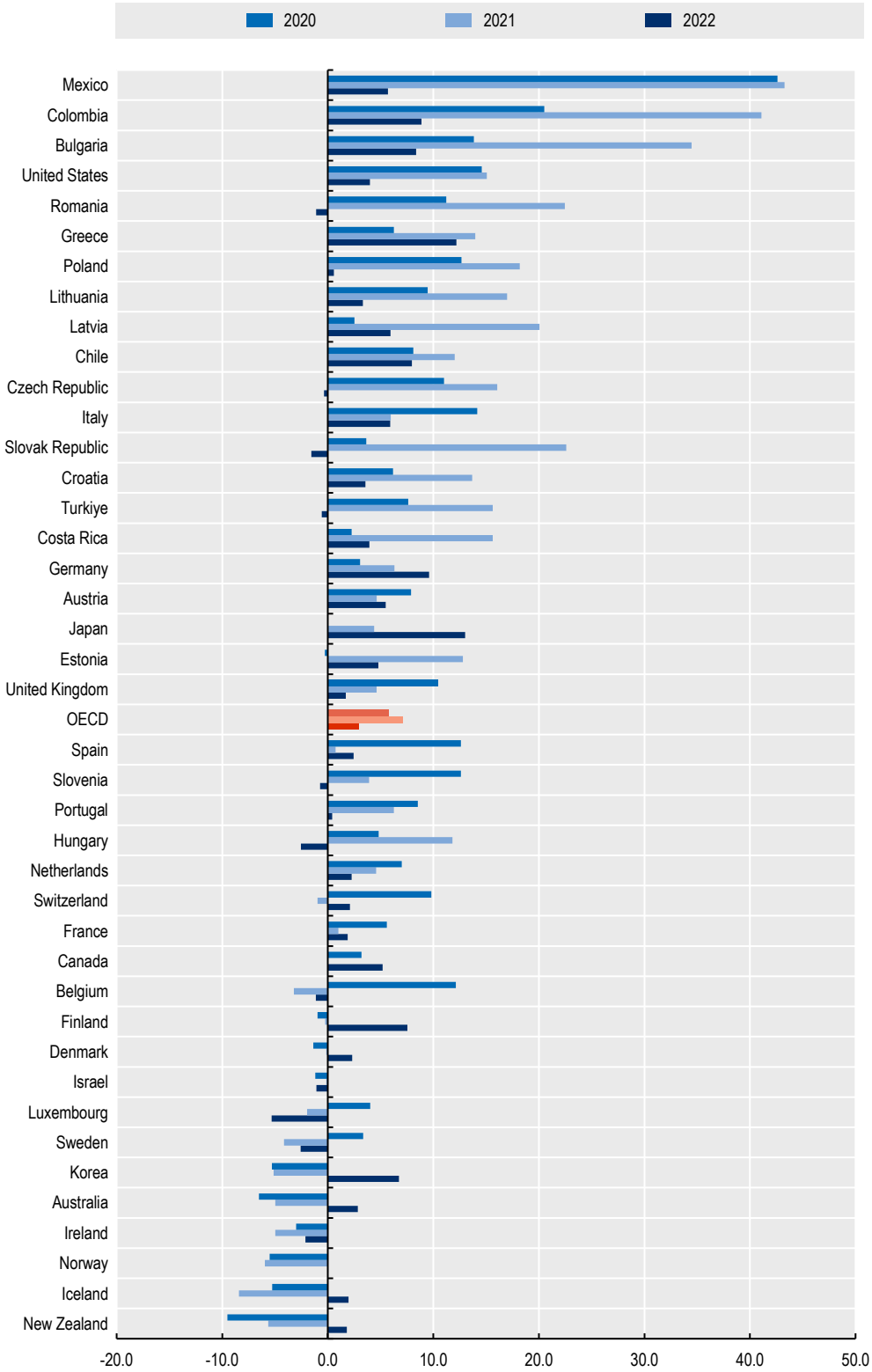
44. Some of the hard-hit countries in 2020, such as Spain, the United Kingdom and Italy saw significantly reduced excess mortality estimates, albeit still positive, of between 0.7-6.0%. Belgium, which had one of the highest increases in mortality in 2020, saw an estimated 3.6% fewer deaths than expected in 2021. With tight restrictions remaining in place, Australia, New Zealand and Korea all continued to see mortality 5% below expected levels in 2021, along with Norway and Iceland at -6.0% and -8.4%, respectively.

3.2.1. Many confounding factors shaped mortality patterns in 2022

45. The average rates in mortality across OECD countries dropped significantly in 2022, thanks to the continued roll-out of mass vaccination programmes and less deadly variants (Lorenzo-Redondo R, 2022[16]), while a relaxation in restrictions and a mix of other COVID-19 related and non-related factors helped determine the mortality patterns across countries and through the year.

Figure 3.3. Mortality reached a peak in most countries in 2021

Percentage increase in total number of deaths (adjusted) by year (2020-22).



Note: Countries are presented by decreasing overall 2020-22 change in mortality. Baseline refers to adjusted deaths from 2015-19.
Source: Secretariat's calculations based on data sources detailed in Annex A.

46. While figures still suggest higher than expected mortality rates in Mexico and Colombia in 2022, the estimates were at 5.7% and 8.9%, respectively. Greece saw the highest increase in mortality at more than 12%, driven by a still high number of COVID-19 reported deaths in the first part of the year, but also seeing a peak of deaths during the summer, possibly due to the excessive heatwave.

47. Many of the countries that saw reduced or minimal increases in mortality in 2020 and 2021, saw a reverse as 'the lid was lifted off', not only resulting in a rise in COVID-19 deaths, but also opening up the population to other viruses, infections and illnesses. While Finland and Korea saw an increase in mortality of around 7% in 2022, Australia and New Zealand experienced increases of 2.9% and 1.8%, respectively, albeit within the range of normal variation.

3.3. Overall mortality driven by deaths in older age groups

48. With most deaths naturally occurring in the older age groups, those countries with increased mortality in the age group 65+, combined with a large share of the population over 65, saw the highest overall excess mortality. However, excess mortality at younger ages – from COVID-19 and other causes - can have a significant impact overall, especially among countries with younger populations.

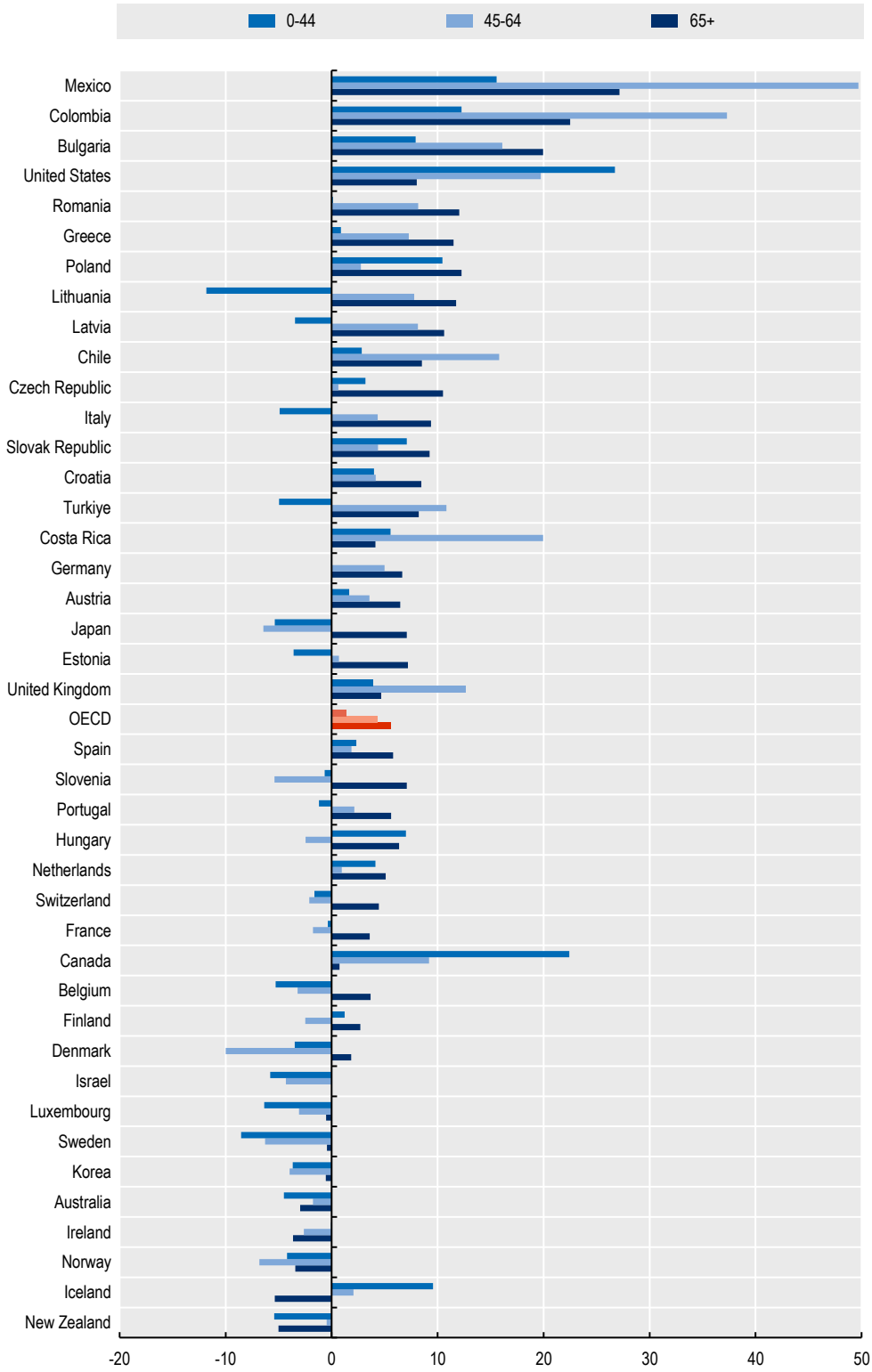
49. Average excess mortality over the three-year period was highest among the 65+ age group, at +5.6%, followed by the 45-64 age group at +4.5%, and an overall increase for the 0-44 age group of +1.1% (Figure 3.4). On a yearly basis, the highest average excess mortality was +9.4% for the 45-64 age group in 2021, while average excess mortality was -0.3% for the 0-44 age group in 2020 as containment measures were most stringent and exposure to accidents, violence and communicable diseases would have been lower than expected in many countries.

50. As in the case for the total population, Mexico and Colombia saw the highest excess mortality among the 65+ population among OECD countries. It is estimated that there were an additional 27.2% and 22.5% deaths, respectively, among the population aged 65+ during the period 2020-22 than might have been expected. This followed the same yearly pattern with the vast majority occurring during 2020 and 2021, with a large reduction in excess mortality in 2022. However, mortality among the age group 45-64 was particularly high during this period too, to register 50% excess mortality overall for Mexico, and +37% for Colombia. Both Mexico and Colombia show excess deaths at around +70% for the age group 45-64 in 2021. While accounting for a much smaller proportion of deaths overall, excess mortality among the 0-44 age group was still 12-15% higher overall.

51. Countries with large elderly populations such as Greece, Poland and Lithuania saw high increase in the mortality among the 65+ population (of 10-12%) contribute significantly to their overall increases. Many of the deaths would have occurred during 2020 and 2021, although as noted above, Greece continued to see high levels of mortality among the elderly population in 2022, because of COVID-19 but also possibly heat-related and other respiratory infections. This was similar for countries, such as Germany and Finland that saw higher mortality among the 65+ population in 2022. Notably, Sweden, which was under the spotlight at the beginning of the pandemic, saw excess mortality among 65+ age group below the OECD average in 2020 and negative in 2021 and 2022, as well as overall. Korea with the fastest growing share of the population aged 65+ also saw negative excess mortality over the three-year period, although with a strong positive rebound in 2022.

Figure 3.4. Most deaths occur at 65+, but some countries saw increased mortality at younger ages

Percentage increase in number of deaths (adjusted) by age group (2020-22).



Note: Countries are presented by decreasing overall 2020-22 change in mortality 2020-22. Baseline refers to adjusted deaths from 2015-19.
Source: Secretariat calculations based on data sources detailed in Annex A.

3.3.1. Higher mortality among younger age groups in the United States and Canada, partly driven by COVID-19 and substance abuse.

52. Excess mortality among the 45-64 age group, apart from Colombia and Mexico, was also high in several other countries such as Canada, Chile, Costa Rica, the United Kingdom, and the United States. While the highest rates were generally during 2020 and/or 2021, excess mortality remained relatively high among this age group in 2022.

53. Excess mortality among the 0–44 year age group in both Canada and the United States remained very high throughout the three-years. Analysis by Statistics Canada suggested that while COVID-19 was the main driver of excess deaths overall in 2022, other factors were also driving increased mortality, particularly among younger Canadians. The report indicated that deaths related to alcohol and drug use increased to new highs during the pandemic with younger age groups making up a disproportionate number of the deaths from overdoses (Statistics Canada, 2023[17]). Data on drug overdose death counts suggests that the number of deaths in the United States has more than doubled since 2015 to more than 105 000 deaths by the end of 2022 with a sharp increase during the pandemic years (Centers for Disease Control and Prevention, 2023[18]).

3.4. Mortality in 2022 remained higher than pre-pandemic rates

54. In the same vein, the calculation of age-standardised mortality rates (ASMRs) adjusts for differences in the age structure of populations using the standard OECD population that allows comparisons to be made between countries, over time and between sexes.[3] In this section, ASMRs are shown for the years 2015 to 2022, showing the pre-pandemic trends, the impact of COVID-19 from 2020 and what has happened subsequently as countries continue to meet the challenges of direct and indirect effects of COVID-19, as well as other confounding factors.

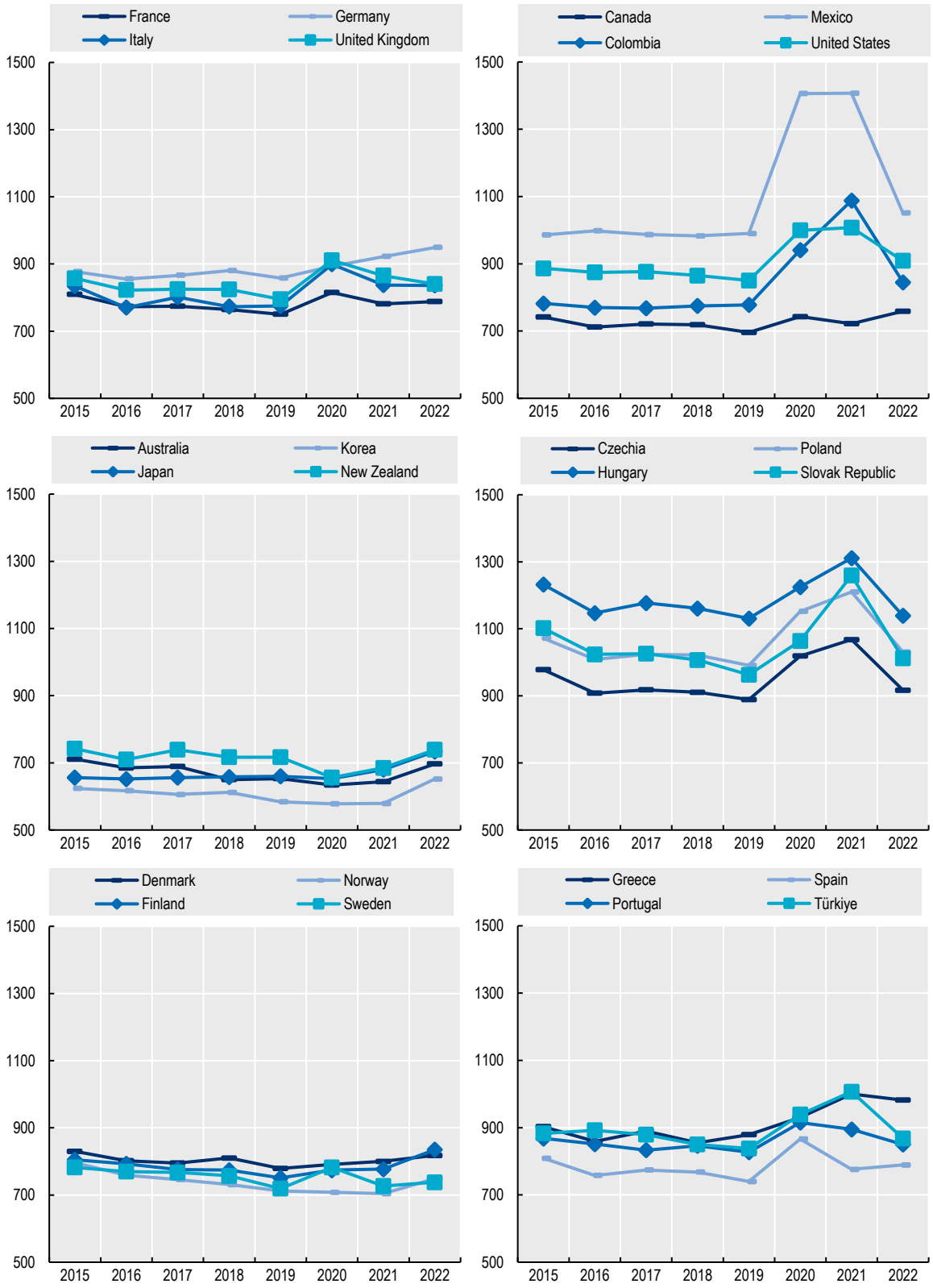
55. Most countries that were heavily impacted by the pandemic saw a notable rise in mortality rates in 2020 and/or 2021 and therefore may have expected sharp falls in 2022 to return to pre-pandemic levels. Instead, in 4 out of 5 OECD countries, mortality rates in 2022 remained higher than the average of the five years prior to the onset of the pandemic. Against the general decreasing trend in mortality in many countries pre-pandemic, only Luxembourg had a mortality rate in 2022 lower than that observed in 2019. On average, mortality rates in 2022 remained 6% higher than in 2019, and in seven OECD countries it was more than 10% higher.

56. Figure 3.5 shows the trends in ASMR for various geographical groups of OECD countries through the period from 2015 to 2022.[4] Among the major economies in Europe, a slow declining trend in mortality can be observed with a more or less rapid uptick, especially in Italy and the United Kingdom, in 2020. Thereafter, the rate decreases although remained above pre-pandemic levels in 2022. Germany, by contrast, continued to see an increasing trend in mortality over the three-year period with the expected decline delayed.

57. On the other side of the Atlantic, the huge increases observed, particularly in Mexico, can be seen, with a clear decline in 2022 – albeit staying above the levels observed in 2019. Canada, already with lower overall mortality observed a relatively small uptick in 2020, with mortality back close to pre-pandemic levels.

[3] ASMRs are calculated using the OECD 2015 population.
[4] Annex B provides ASMR for the 38 OECD countries and 5 EU Member States that are not members of OECD.

Figure 3.5. Age-standardised mortality rates across selected OECD countries, 2015-22



Note: Using OECD 2015 Standard Population.
Source: Secretariat's calculations based on data sources detailed in Annex A.

58. In the OECD countries of the Asia-Pacific region, characterised by low underlying mortality rates pre-COVID, and subject to strict containment measures during the pandemic, there was an increasing trend in ASMR on the back of the relaxation of restrictions in 2021, and especially 2022.

59. OECD countries in Central Europe, which tended to have high ASMR prior to 2020, albeit on a generally declining trend, saw mortality rates increase in 2020 and then increase further in 2021, with successive pandemic waves and new variants taking effect, coupled with relatively low vaccine uptake (OECD, 2023[2]). However, 2022 saw sharp declines in the mortality rates, close to the average rates before 2020.

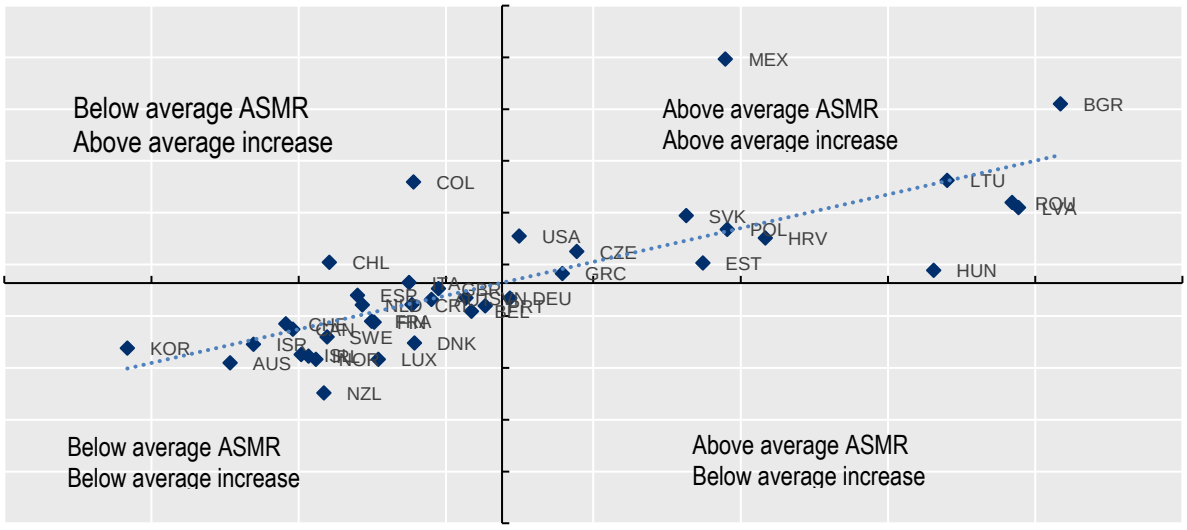
60. In a similar pattern to the Asia-Pacific region, the Scandinavian countries saw relatively low ASMR resist any major increase in 2020 and 2021, followed by a slight increase in 2022; Finland had its highest mortality rate registered over the whole 8 years in 2022. By contrast, Sweden saw a modest increase early in the pandemic, but saw an equal decline in 2021 to leave mortality at about the same level as before the pandemic.

61. Finally, in Southern Europe, Spain and Portugal were among the countries badly hit in 2020, but with significant declines in the following year - both had relatively successful vaccination campaigns. Greece and Türkiye were less impacted in the early stages but saw an increasing ASMR in 2021, which has continued to increase further in Greece in 2022 due to both COVID-19 and other non-COVID factors.

62. As often indicated above, countries with higher underlying mortality rates tended to experience the largest increase in mortality during the three-year period from 2022 to 2022, and vice versa. Figure 3.6 shows the relationship between the ASMR in 2019 and the increase in the rate on average over the subsequent three-year period. All but three countries fall within the two quadrants of either below average ASMR and below average increase, or above average ASMR and above average increase.

Figure 3.6. Countries with high mortality rates pre-pandemic saw the greatest increases

Pre-pandemic ASMR in 2019 against the average change in ASMR over the period 2020-22



Note: The x-axis and y-axis indicate the average ASMR and change in ASMR, respectively.
Source: Secretariat's calculations based on data sources detailed in Annex A.

3.5. Greater health system capacity continues to be associated with better health outcomes

63. Resilient health systems are better able to cope with compounding threats (such as heatwaves and influenza in addition to COVID-19) while limiting the burden of recovery (Thomas et al., 2020[19]). Analyses contained in the OECD 2023 report on resilience outlined the associations between several characteristics of health systems and societies, and outcomes from the COVID-19 pandemic (OECD, 2023[2]).

64. Greater pre-existing health system capacity, greater access to quality healthcare and reduced population vulnerabilities at a country level were all associated with improved COVID-19 outcomes. If the conclusion is that these associations found in earlier studies were broad indicators of resilience, then it would be expected that those associations would continue with a longer and expanded dataset.

65. Previous analysis was based on two years of data (2020 and 2021) with the outcome variables of excess deaths and COVID-19 mortality per 100 000 population. These variables were not adjusted for population change. The conclusions of the analyses conducted were consistent with evidence discussed in the remainder of the report.

72. The analysis was repeated to assess whether these associations remain when looking at a longer time period (2020-2022) and with mortality adjusted for demographic change (see Box 3.1 for methods). The inclusion of an additional year of data and adjustment for demographic change did not alter the majority of the associations. Measures of workforce capacity, access and quality of care remained important factors.

Box 3.1. Methodology to explore associations with changes in ASMR

66. The average ASMR for 2020-2022 was compared to the average of 2015-2019 and a percentage point change produced for the dependent variable. The initial analysis used cumulative rates per 100 000 population for COVID-19 deaths and excess mortality and compared individual years.

67. Information from 2019 was used as the basis for pre-existing characteristics. If no data was available for 2019 it was replaced by the most recent data from 2018 or 2017. The initial analysis used 2018 data.

68. A log transformation of GDP per capita was undertaken. Remaining independent and dependant variables were not altered. The initial analysis log transformed most variables.

69. Control variables (or adjustment for confounders) was undertaken using GDP per capita. The initial analysis used GDP per capita and the share of population over 65. Because of the adjustment for demographic differences in the ASMR the share of the population over 65 was removed from the analysis.

70. The analysis was run in Stata 17.0. Robust standard errors were used, and a p-value of 0.05 or less was regarded as significant.

71. The same dependent variables were used, and the countries restricted to the OECD members. The choice of replacing an absolute measure (per 100 000) with a relative change (percentage point increase) may alter some of the relationships between dependent and independent variables. For countries with different ASMRs a one percentage point increase represents a different absolute change in ASMR. A sensitivity analysis was conducted using the absolute change in ASMR. An additional sensitivity analysis was conducted using the log of Gross National Income (GNI) per capita as adjustment for confounders.

73. Similar associations were found for some variables, for example, the same variables were found to be significant for workforce capacity (total health and social employment per 1 000 population and as a percentage), and access and quality of care (treatable mortality and percentage coverage of the population).

74. Some potential indicators of resilience such as the density of hospital beds or physicians remained as a non-significant association after adjustment for the potentially confounding GDP per capita (Fleming et al., 2022[20]).There were, however, some changes in the results. Some variables that appeared significant in the previous analysis were no longer significant - specifically, hospital capacity as measured by the number of hospitals per million population. There were also a number of changes regarding the various population health characteristics (for example, obesity became non-significant over the three-year period). Most population health characteristics were associated with an increased ASMR in 2021, but this association reversed in 2022, as would be expected given the trends observed in ASMR over 2020 to 2022. Using the sensitivity analysis of the absolute change in ASMR, population health characteristics were associated with worse outcomes over the three years.

75. The use of GNI rather than GDP as an adjustment for confounding altered the results. The co-efficients for treatable mortality and workforce capacity became non-significant, the co-efficient for health care expenditure as a percentage of GDP became significant and the co-efficient for population coverage remained significant.

76. These results cannot be used to infer causality. The small sample size continues to be a limitation. However, greater data availability has reduced the amount of missing data and potentially decreased selection bias. There were changes in the association with population health characteristics with less consistency over the full three years than seen in the earlier work, this is partly due to the change in the dependent variable – a percentage point change. As shown in Figure 3.6. higher pre-pandemic ASMR is associated with a greater increase in ASMR, suggesting pre-pandemic population health still has an important association with outcomes.

77. While these results are supportive of the earlier work, there are some limitations. The dynamic nature of the health system and its response has not been modelled. The modelling of threats impacting some but not all countries, such as heatwaves have not been included and data limitations in both the dependent and the independent variables, while partially mitigated, remain.

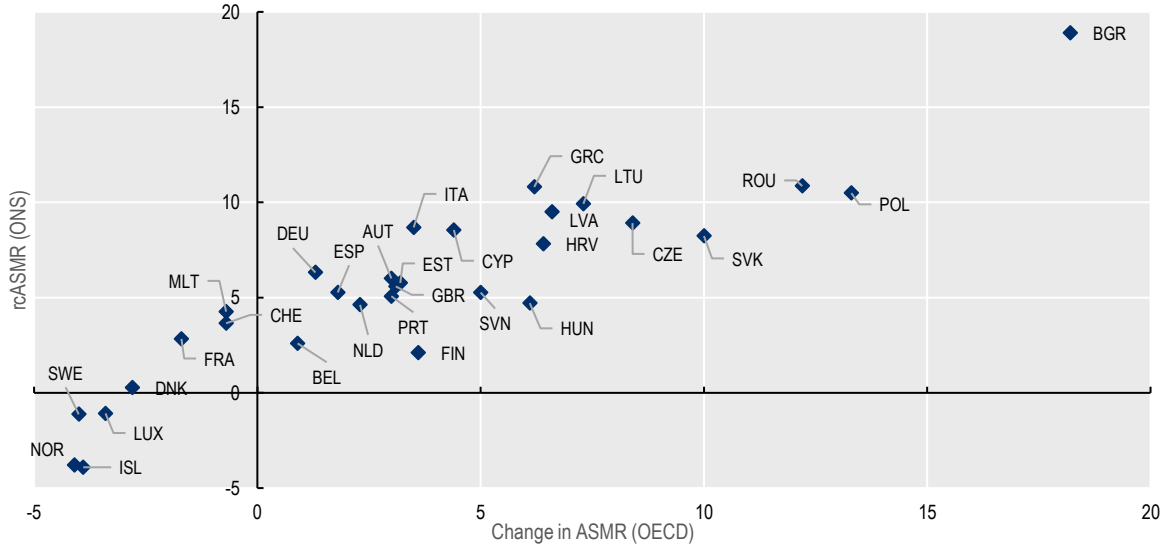
4. Limitations and discussion

78. The main objective of the paper is to highlight that many of the conclusions made around the increases in mortality during the pandemic based on simply comparing the number of reported deaths during a period (week, month or year) against a baseline average of the same period in the years prior to the pandemic neglect to take changes in population size and structure into consideration.

79. With rapid population ageing in many OECD countries and the majority of deaths highly concentrated in the older age groups, the impact on mortality over time can be significant. The estimates in this paper have taken the simple next step of calculating adjusted numbers of deaths by standardising the population structure over time, either using the 2022 national populations or across the board with the OECD 2015 Standard Population to calculate Age Standardised Mortality Rates (ASMRs). However, these adjusted statistics on mortality should not lead to complacency and underplay the impact of the pandemic, noting that mortality rates remained above pre-pandemic levels in 2022 (The King's Fund, 2023[21]).

80. To ensure the greatest possible coverage (i.e., including all OECD countries), three relatively broad age groups (0-44, 45-64, 65+) also broken down by sex have been employed to calculate the adjusted deaths and rates. While these three groupings capture the principal differences in mortality in a country – on average across OECD countries, the mortality rate is around 8 times higher among the 45-64 population, and 80 times higher in the 65+ population compared to the 0-44 age group – a greater disaggregation of deaths by age, particularly at older age groups would be desirable for a more precise examination of the age groups and more sensitivity analysis of the results.

Figure 4.1. Comparing OECD and ONS estimates of change in mortality, European countries



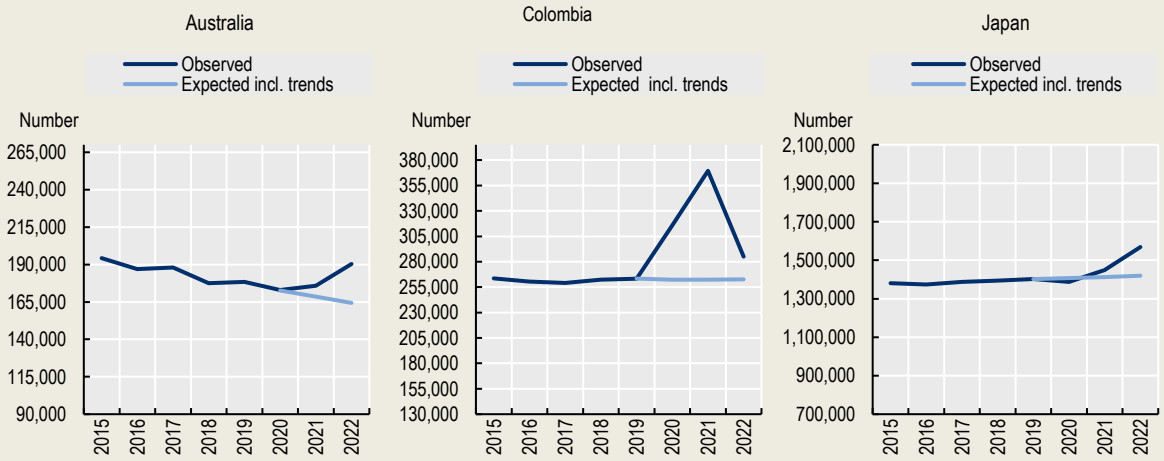
Note: The x-axis refers to the change in ASMR based on 3 broad age-groups and annual mortality data for 2020-22 (OECD) while the y-axis refers to the relative cumulative age-standardised mortality rate (rcASMR) for week 1, 2020 to week 26, 2022 based on 5-year age groups and weekly mortality data (ONS).
Source: OECD estimates and (ONS, 2022[22]).

81. The Office for National Statistics calculated relative cumulative age-standardised mortality rates (rcASMRs) for 30 European countries using weekly 5-year age group all-cause mortality and population data to construct cumulative excess mortality compared with the 2015 to 2019 average mortality rates (ONS, 2022[22]). The latest analysis for the period beginning the week ending 3 January 2020 to the week ending 1 July 2022 provides results closely aligned with the overall results presented in this paper. Thus, the use of broad age groups and annual data does not appear to significantly impact on the overall measure and country ranking.

Box 4.1. The impact of pre-pandemic mortality trends

82. Overall mortality trends in most OECD countries showed a decreasing trend prior to the pandemic, which is not taken into account when comparing against a flatline average on 2015-19. By applying a simple linear extrapolation to pre-pandemic age-specific mortality rates for the three different broad age groups by sex, derived mortality rates can be applied to the respective population by age group and sex to obtain a rudimentary estimate of 'expected' deaths.* The charts below are based on a strong decreasing mortality trend pre-pandemic in Australia, a slight increasing trend for Japan and a relatively stable trend for Colombia. This would therefore result in an increase in excess mortality in Australia (in contrast to an overall negative mortality, a slight reduction in Japan, and very similar results for Colombia.

Figure 4.2. Mortality trends impact for selected countries



Source: Secretariat's calculations based on data sources detailed in Annex A.

Note: * The use of a simple linear extrapolation is solely for illustrative purposes. Expected mortality is typically estimated using a Poisson or quasi-Poisson regression model (Barnard S, 2022[10])

83. Adjusted deaths and ASMRs use an established methodology to directly standardise the mortality data and the impact of taking population change into account reduces the increase in mortality on average from around 14% to 5%, relative to 2015-19. In line with many national and international agencies, a simple baseline average has been used for comparisons. As discussed in Box 1.1, other approaches are applied to model expected mortality taking into account underlying trends in mortality, among other factors. Prior to the pandemic, as shown in Figure 1, the mortality rate in almost all OECD countries was trending lower, such that, in the absence of COVID-19, this might have been expected to continue through 2020 to 2022.

Comparing to a flat average of the years prior to the pandemic may be considered as an underestimate of the full impact. How far the trend deviates from the average will help determine its ranking relative to other countries (Box 4.1). While the overall magnitude of different estimates of 'excess mortality' stemming from different approaches may diverge, the main objective of this study has been to examine the impact of population change on observed mortality and highlight the variations between countries and over time.

84. It is planned to continue to collect and disseminate high-frequency data on all-cause deaths to monitor mortality patterns as long as national authorities continue to publish available and detailed data in a timely fashion. This is expected to be used in the context of ongoing work by the OECD on health system resilience as well as other upcoming indicator development work, for example, on climate impact on health.

85. Finally, it is important to reiterate that the focus of this study is on mortality patterns measured at an annual or three-year frequency. The tracking of weekly data on deaths has shown that the variance is naturally of a much higher magnitude and that countries may have experienced significant peaks in mortality that caused acute pressures on health systems and emergency services. The examination of annual mortality rates does not indicate the variability in mortality on a weekly basis and the resulting impact on health systems and society at specific times.

Bibliography

Ballester, J. (2023), "Heat-related mortality in Europe during the summer of 2022", *Nat Med*, Vol. 29, pp. 1857–1866, https://doi.org/10.1038/s41591-023-02419-z. [13]

Barnard S, C. (2022), "Methods for modelling excess mortality across England during the COVID-19 pandemic", *Stat Methods Med Res.*, Vol. 31/9, pp. 1790-1802, https://doi.org/Barnard S, Chiavenna C, Fox S, Charlett A, Waller Z, Andrews N, Goldblatt P, Burton P, De Angelis D. Methods for modelling excess mortality across England during the COVID-19 pandemic. Stat Methods Med Res. 2022 Sep;31(9):1790-1802. doi: 10.1177/096228022. [10]

Centers for Disease Control and Prevention (2023), *Provisional Drug Overdose Death Counts*, https://www.cdc.gov/nchs/nvss/vsrr/drug-overdose-data.htm. [18]

Copernicus Climate Change Service (2022), *Copernicus: Prolonged and intense heatwave affecting parts of western and northern Europe breaks temperature records; globally, July 2022 was one of three warmest Julys on record*, https://climate.copernicus.eu/copernicus-prolonged-and-intense-heatwave-affecting-parts-western-and-northern-europe-breaks. [12]

Destatis (2023), *Ad-hoc evaluation of mortality figures for 2020 to 2023*, https://www.destatis.de/EN/Themes/Society-Environment/Population/Deaths-Life-Expectancy/mortality.html#636726. [14]

Disparities, O. (2023), *Excess mortality in England and English region*, https://www.gov.uk/government/statistics/excess-mortality-in-england-and-english-regions. [8]

Eurostat (2023), *Excess mortality in August 2023*, https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Excess_mortality_-_statistics. [6]

Fleming, P. et al. (2022), "Metrics and indicators used to assess health system resilience in response to shocks to health systems in high income countries—A systematic review", *Health Policy*, https://doi.org/10.1016/j.healthpol.2022.10.001. [20]

Karlinsky, A. (2021), "Tracking excess mortality across countries during the COVID-19 pandemic with the World Mortality Dataset", *eLife*, https://doi.org/10.7554/eLife.69336. [9]

Lorenzo-Redondo R, O. (2022), "Covid-19: is omicron less lethal than delta?", *BMJ*, https://doi.org/10.1136/bmj.o1806. [16]

Morgan, D. (2020), *Excess mortality: Measuring the direct and indirect impact of COVID-19*, OECD Publishing, https://doi.org/10.1787/c5dc0c50-en. [1]

OECD (2023), *COVID-19 Health Indicators - Mortality by week*, https://stats.oecd.org/Index.aspx?DataSetCode=HEALTH_MORTALITY (accessed on 19 May 2023). [3]

OECD (2023), *Ready for the Next Crisis? Investing in Health System Resilience*, OECD Publishing, https://doi.org/10.1787/1e53cf80-en. [4]

OECD (2023), *Ready for the Next Crisis? Investing in Health System Resilience*, OECD Health Policy Studies, OECD Publishing, Paris, https://doi.org/10.1787/1e53cf80-en. [2]

OECD (2021), *Health at a Glance 2021: OECD Indicators*, OECD Publishing, https://doi.org/10.1787/ae3016b9-en. [11]

Office for National Statistics (ONS) and Government Office for Science (GOScience) (2022), *Comparing Different International Methods of Measuring Excess Mortality*. [15]

ONS (2023), *Monthly mortality analysis, England and Wales: July 2023*, https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/monthlymortalityanalysisenglandandwales/july2023#measuring-the-data. [7]

ONS (2022), *Comparisons of all-cause mortality between European countries and regions: 28 December 2019 to week ending 1 July 2022*, https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/articles/comparisonsofallcausemortalitybetweeneuropeancountriesandregions/latest#comparisons-of-all-cause-mortality-across-european-countries-data. [22]

Statistics Canada (2023), *Provisional death counts and excess mortality, January 2020 to October 2022*, https://www150.statcan.gc.ca/n1/en/daily-quotidien/230112/dq230112c-eng.pdf?st=5zPB0luO. [17]

The King's Fund (2023), *The King's Fund responds to the latest ONS mortality data*, https://www.kingsfund.org.uk/press/press-releases/december%202021-latest-ons-mortality-data. [21]

The Lancet (2023), *Conflicting COVID-19 excess mortality estimates*, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9910840/pdf/main.pdf. [5]

Thomas, S. et al. (2020), *Strengthening health systems resilience: Key concepts and strategies*. [19]

Annex A. Methodological note

Overall approach

86. This section presents the population adjusted method used to calculate excess mortality and age-standardised mortality rates (ASMR) by sex and three broad age groups (0-44, 45-64, 65+), currently for 43 countries, from 2015 to 2022. Thirty-eight of these are the OECD countries plus three OECD accession countries (Bulgaria, Croatia and Romania) in addition to Cyprus and Malta.

Direct age-standardisation was used to age-adjust mortality data and create age-standardised mortality rates (ASMRs).

Population and deaths data

87. Historical population data including from the OECD, national and international statistical agencies from 2015 to 2022 by sex and age groups[5] were used to adjust the number of deaths calculate and age-standardised mortality rates (ASMR) for each country. The OECD 2015 Standard Population were used to calculate the ASMRs.

88. Table 1 provides an overview of the mortality and population data sources used in this analysis.

Method

89. Using population data from 2015 to 2022, annual population growth rates relative to the 2022 population by age and sex for each country were calculated. These growth rates were applied to the corresponding numbers of deaths for each age and sex groups, to take into consideration the population growth and changes in age composition of the population. The adjusted numbers of deaths by sex and age for each country were calculated for the period 2015 to 2022.

90. Average adjusted number of deaths for the years 2015-2019 were calculated, providing an adjusted baseline with which to compare deaths from 2020 to 2022. To estimate adjusted excess mortality for each year (from 2020 to 2022) by sex and age for each country, the average adjusted number of deaths that occurred in the years 2015-2019 were subtracted from the corresponding yearly adjusted number of deaths for each country. For example, the average adjusted number of deaths that occurred in the years 2015-2019 were subtracted from 2021 adjusted deaths. The percentage change in deaths for both unadjusted and adjusted were calculated and compared for the years 2020 to 2022.

91. After the population-based adjustment of deaths, direct standardisation was also applied to age-adjust and compare mortality rates for the 43 countries, from 2015 to 2022. Calculated age-specific deaths rates for each country by sex (where available), from 2015 to 2022 were applied to the corresponding age groups' ratios of 2015 OECD standard population. The calculated expected deaths were then aggregated to obtain age-adjusted mortality rates for each country by sex, from 2015 to 2022.

92. **Note:** The total number of deaths and population used in this study are the sums of the sex and age components which may not add to totals published elsewhere as both population and mortality data missing sex and age information have been excluded.

[5] Except for the United States where totals were only available by age group.

Notes and caveats

93. Standardisation of the deaths data is based on three broad age groups (0-44. 45-64 and 65+) and by sex to ensure maximum country coverage. Deaths data are typically available by 5-year age groups for many countries and greater granularity could provide further precision to the estimates, particularly in the 65+ age group where population growth has been generally highest and accounts for the vast majority of recorded deaths.

94. A baseline of 5 years, covering deaths from 2015-19 has been used in this report. Note that different baselines are used by different countries and organization. For instance, Eurostat currently uses the period from 2016 to 2019 as a baseline, while the Australian Bureau of Statistics recently changed its baseline from 5 years to 7 years, covering the period 2013-2019. Choosing baselines that include years with severe or mild flu seasons can affect the baseline average, as well as pandemic years (in this case, 2020 might be included in future analyses but subtracting direct COVID deaths). Thus, estimates produced here may differ significantly from those reported by national or international agencies due to differences in techniques and data sources used.

95. Finally, the approach taken is to compare adjusted estimates against a flat baseline (i.e., an average over the pre-pandemic years, 2015-19). While this is a standard approach, other methodologies take into account the underlying mortality trends (and other factors) to model the expected deaths in the reference period in order to calculate excess mortality. In summary, differences in the underlying data, assumptions made, and approaches used should be taken into account when comparing results.

Table 1. Key all-cause mortality and population data sources

	Mortality source	Population source
Australia	Australian Bureau of Statistics	Australian Bureau of Statistics
Austria	Eurostat	Eurostat
Belgium	Eurostat	Eurostat
Canada	Statistics Canada	OECD Historical population and OECD population
Chile	Departamento de Estadisticas de Informacion de Salud	OECD Historical population and OECD population
Colombia	DEPARTAMENTO ADMINISTRATIVO NACIONAL DE ESTADÍSTICA - DANE Datos de defunciones en Colombia	OECD Historical population and OECD population
Costa Rica	Instituto Nacional de Estadística y Censos, INEC - Costa	OECD Historical population and OECD population
Czechia	Eurostat	Eurostat
Denmark	Eurostat	Eurostat
Estonia	Eurostat	Eurostat
Finland	Eurostat	Eurostat
France	Eurostat	Eurostat
Germany	Eurostat	Eurostat

Greece	Eurostat	Eurostat
Hungary	Eurostat	Eurostat
Iceland	Eurostat	Eurostat
Ireland[6]	CSO - Central Statistics Office, Ireland	CSO - Central Statistics Office, Ireland
Israel	Request from – Israel Central Bureau for Statistics	OECD Historical population and OECD population
Italy	Eurostat	Eurostat
Japan	Statistics of Japan and e-Stat	OECD Historical population and OECD population
Korea	Statistics Korea	OECD Historical population and OECD population
Latvia	Eurostat	Eurostat
Lithuania	Eurostat	Eurostat
Luxembourg	Eurostat	Eurostat
Mexico	Instituto Nacional de Estadística y Geografía, INEGI	OECD Historical population and OECD population
Netherlands	Eurostat	Eurostat
New Zealand	Stats NZ Tatauranga Aotearoa COVID-19 data portal	Stats NZ Tatauranga Aotearoa COVID-19 data portal
Poland	Eurostat	Eurostat
Portugal	Eurostat	Eurostat
Slovak Republic	Eurostat	Eurostat
Slovenia	Eurostat	Eurostat
Spain	Eurostat	Eurostat
Sweden	Eurostat	Eurostat
Switzerland	Eurostat	Eurostat
Türkiye	TURSTAT MAIN Page Data Portal	OECD Historical population and OECD population
United Kingdom[7]	ONS	Office for National Statistics
United States	National Center for Health Statistics – Mortality Data on CDC WONDER	National Center for Health Statistics

[6] Ireland: Data for 2021 to 2022 are provisional and subject to change. Registrations of deaths lags occurrence, as Ireland has a legal period of 3 months for deaths to be registered. Also, due to the Health Service Executive cyber-attack in May 2021, General Register Offices in Ireland were closed. As such the registration of births/deaths/marriages were not possible at that time.

[7] Estimates for the United Kingdom are based on provisional data. UK populations are subject to revision once the ONS publish their intercensal population estimates.

Bulgaria	Eurostat	OECD Historical population and OECD population
Croatia	Eurostat	OECD Historical population and OECD population
Romania	Eurostat	OECD Historical population and OECD population

Annex B. ASMR by country, 2015-22

Table B.1. Age-standardised mortality rates (ASMR)

	2015		2016		2017		2018		2019		2020		2021		2022	
	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI	Rate	95% CI
Australia	711	708/715	685	681/688	689	685/692	650	647/653	653	650/657	634	631/637	644	641/647	697	694/700
Austria	846	840/852	793	787/798	807	802/813	805	799/810	790	785/796	871	865/877	846	840/851	853	847/858
Belgium	897	892/903	846	841/852	848	843/853	844	839/849	817	812/822	951	946/956	824	819/828	841	836/845
Bulgaria	1293	1286,1301	1225	1218/1232	1244	1237/1252	1,228	1221/1235	1217	1210/1224	1,11	1403/1418	1667	1659/1676	1339	1332/1347
Canada	742	739/745	712	709/715	721	719/724	719	717/722	696	693/699	743	741/746	722	719/724	759	757/762
Chile	796	791/801	760	755/764	754	750/759	729	724/733	721	717/725	813	809/818	842	837/846	814	809/818
Colombia	782	779/785	770	767/774	768	765/771	775	771/778	778	775/781	941	937/944	1,088	1085/1092	845	841/848
Costa Rica	776	765/786	803	793/813	799	788/809	777	767/787	777	767/787	803	793/813	898	888/908	814	804/823
Croatia	1126	1116/1135	1038	1029/1047	1070	1061/1079	1047	1038/1056	1017	1008/1026	1124	1115/1133	1205	1195/1214	1099	1090/1108
Czechia	978	973/984	908	902/913	918	912/923	911	906/917	889	884/894	1019	1014/1025	1,068	1062/1074	917	912/922
Denmark	830	823/837	802	795/808	795	788/802	810	803/817	779	772/785	791	784/797	800	793/806	818	812/825
Estonia	1038	1021/1054	1,015	998/1031	1010	994/1025	1009	993/1025	974	959/990	1008	992/1023	1139	1122/1155	1059	1044/1075
Finland	805	799/812	793	787/800	776	770/783	774	767/780	751	745/758	774	767/780	777	771/784	835	829/842
France	809	807/811	773	771/775	774	772/776	764	762/766	750	748/751	815	813/817	781	779/783	788	786/790
Germany	877	875/879	855	853/857	866	864/867	880	878/882	858	856/860	893	891/895	922	920/924	949	947/950
Greece	903	898/908	859	854/863	890	885/895	855	850/860	879	874/884	930	925/935	1,000	994/1005	982	976/987
Hungary	1,32	1226/1239	1147	1141/1153	1177	1171/1184	1161	1154/1167	1131	1125/1137	1225	1219/1231	1311	1305/1318	1139	1133/1145
Iceland	779	746/811	781	749/813	738	707/768	721	691/751	702	673/731	705	676/733	681	654/709	759	730/788

Ireland	765	757/774	757	749/766	727	719/735	720	712/728	697	689/705	711	704/719	697	690/705	718	711/726
Israel	742	735/749	709	703/716	694	688/701	670	663/676	669	663/675	690	684/696	696	690/702	690	684/696
Italy	834	832/836	770	768/772	801	799/803	773	771/775	775	773/777	899	897/902	837	835/839	836	834/838
Japan	656	655/658	652	651/653	656	655/657	658	657/659	660	659/661	653	652/654	680	678/681	734	732/735
Korea	624	622/626	617	615/620	606	604/608	612	610/614	584	581/586	578	575/580	579	577/581	652	650/654
Latvia	1252	1237/1266	1227	1213/1241	1234	1220/1249	1237	1223/1251	1189	1175/1203	1256	1241/1270	1474	1458/1489	1302	1287/1317
Lithuania	1277	1265/1289	1226	1214/1237	1196	1184/1208	1179	1168/1191	1140	1129/1152	1315	1303/1328	1406	1394/1419	1243	1231/1255
Luxembourg	788	764/812	747	723/770	785	762/809	775	752/798	754	731/777	802	779/825	755	733/777	729	708/751
Mexico	986	983/988	998	996/1000	987	985/989	983	981/985	990	987/992	1406	1404/1409	1407	1405/1410	1051	1048/1053
Netherlands	800	796/804	774	770/778	766	762/770	765	761/769	743	739/747	823	819/826	805	801/809	787	783/791
N. Zealand	742	734/750	710	702/718	739	731/746	717	709/725	717	710/725	656	649/664	685	677/692	739	731/746
Norway	796	789/804	759	751/766	746	739/753	731	724/739	712	705/719	708	701/715	704	697/711	749	742/756
Poland	1072	1068/1075	1009	1006/1012	1024	1021/1027	1022	1019/1026	991	988/994	1152	1148/1155	1210	1207/1214	1031	1028/1034
Portugal	868	863/873	851	846/856	833	828/838	846	841/851	827	822/831	915	910/920	895	890/900	850	845/854
Romania	1270	1265/1275	1206	1201/1211	1211	1206/1216	1208	1203/1212	1184	1180/1189	1352	1347/1357	1488	1483/1493	1199	1195/1204
Slovak Rep.	1102	1093/1111	1024	1015/1032	1026	1018/1035	1007	999/1016	963	955/971	1064	1055/1072	1259	1250/1268	1012	1004/1020
Slovenia	876	864/888	830	819/842	847	836/859	829	817/840	813	802/825	942	930/953	872	861/884	834	823/845
Spain	809	806/811	758	756/761	774	771/776	768	766/771	740	738/742	866	864/868	776	774/778	789	787/791
Sweden	782	777/787	770	765/775	767	762/771	757	752/762	719	714/724	782	778/787	727	722/732	738	733/743
Switzerland	755	749/760	696	691/701	706	700/711	696	691/701	691	686/696	777	772/783	702	697/707	723	718/729
Türkiye	883	881/886	892	890/895	879	877/882	850	847/852	838	835/840	939	937/942	1007	1004/1009	868	865/870
UK	857	855/859	822	820/824	825	823/827	824	821/826	795	793/797	911	908/913	865	862/867	840	838/842
USA*	887	886/888	875	874/876	876	875/877	865	864/866	850	849/851	1000	999/1001	1008	1007/1009	909	908/910

Source: Secretariat estimates.

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