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COVID-19 Age-Mortality Curves for 2020 Are Flatter in Developing Countries Using Both Official Death Counts and Excess Deaths

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Abstract

Using official COVID-19 death counts for 64 countries and excess death estimates for 41 countries, this paper finds a higher share of pandemic-related deaths in 2020 were at younger ages in middle-income countries compared to high-income countries. People under age 65 constituted on average (1) 11 percent of both official deaths and excess deaths in high-income countries, (2) 40 percent of official deaths and 37 percent of excess deaths in upper-middle-income countries, and (3) 54 percent of official deaths in lower-middle-income countries. These contrasting profiles are due only in part to differences in population age structure. Both COVID-19 and excess death age-mortality curves are flatter in countries with lower incomes. This is a result of some combination of variation in age patterns of infection rates and infection fatality rates. In countries with very low death rates, excess mortality is substantially negative at older ages, suggesting that pandemic-related precautions have lowered non-COVID-19 deaths. Additionally, the United States has a younger distribution of deaths than countries with similar levels of income.

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Introduction

An important question for understanding the global impact of the COVID-19 pandemic is the disease's age pattern of mortality across countries. Early in the pandemic, case data from COVID-19 patients in mainland China showed that COVID-19 mortality risk increases rapidly with age.[1] This risk profile would tend to limit the death toll in developing countries, which generally have younger populations. But this prediction only holds if the age profile of COVID-19 mortality remains similar across countries.

Our study examines this question by comparing the age gradient of COVID-19 mortality in a broad set of countries using both official COVID-19 death counts and excess mortality estimates for 2020. Vaccine availability was very limited before 2021 and therefore is unlikely to affect the mortality patterns identified in this analysis.

Nearly all studies of the pandemic's age mortality patterns have used only official COVID-19 death data.[2–8] However, excess deaths at the aggregate population level during the pandemic exceed officially recognized COVID-19 deaths in most countries.[9] This is to our knowledge the first study that estimates COVID-19 excess mortality by age for a wide swath of countries.

Previous studies have found a pattern of flatter COVID-19 age-mortality curves among low- and middle-income countries (LMICs) using only official COVID-19 death counts.[4,8] It was unclear to what extent that finding may have been driven by data reporting issues. In particular, it is possible that deaths among older people in developing countries have been more likely to be under-attributed to the disease in official COVID-19 death counts. This paper addresses that concern by showing that the same pattern is found using both official COVID-19 death counts and excess mortality estimates.

Methods

Data sources

The analysis employs two main sources of data:

1. Official reported COVID-19 deaths drawn from the COVerAGE database, with death counts aggregated to 5-year age-groups.[10]

2. All-cause deaths by age drawn from national vital statistics records, aggregated in the Short-Term Mortality Fluctuations harmonized data series assembled as part of the Human Mortality Database.[11]

Additional all-cause death data from Colombia, Mexico, Brazil and Peru was obtained from national statistical offices. Population by age figures for each country from 2020 were taken from United Nations estimates.[12] A more detailed description of data sources is provided in an annex.

Standardized population

A standardized population analysis was conducted to assess the extent to which variation across countries in the age distribution of COVID-19 deaths was driven by variation in the population age distribution. First age-specific mortality rates were calculated by dividing the number of deaths attributed to COVID-19 for each age group by the population in each age group. These calculations were conducted for the following age groups: under 45, 45-54, 55-64, 65-74, 75-84, 85 and above. A hypothetical age distribution of deaths for each country was calculated by multiplying the age-specific COVID-19 mortality rates by corresponding population shares from the United States. A parallel calculation was carried out using estimates of excess mortality by age.

Excess mortality calculations

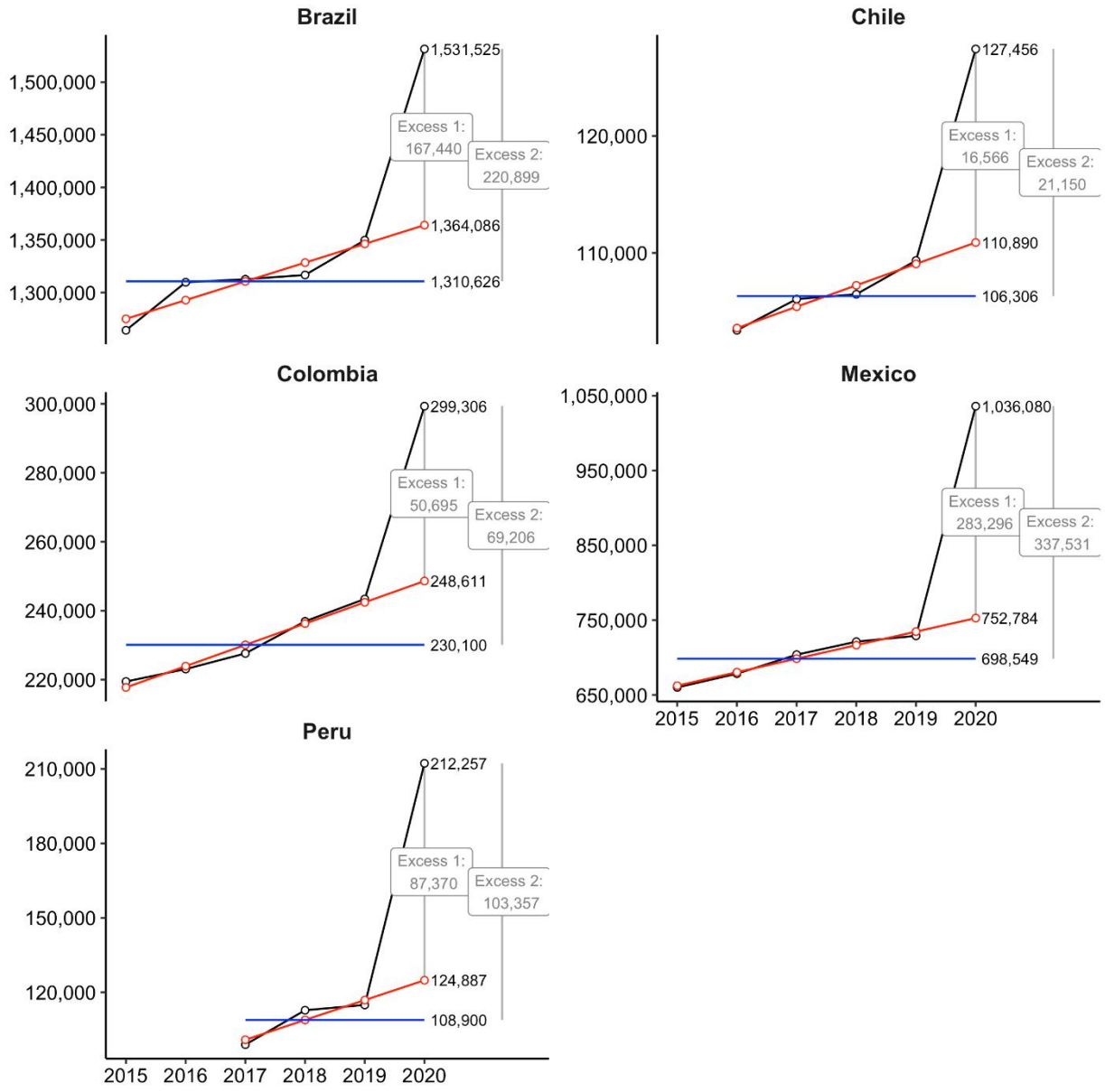
Excess mortality methods compare the number of deaths to the number of expected deaths during a period of interest. Excess mortality is often treated as the "gold standard" in analysis of COVID-19 mortality.[13] However, there are two issues that are often overlooked in the analysis of excess mortality.

The first issue is that estimates are sensitive to the choice of method. Many COVID-19 excess mortality calculations have estimated expected deaths as the mean number of deaths over a corresponding period in previous years. If the number of deaths was trending upward in previous years, this common approach will over-estimate excess mortality.

This issue is illustrated in Figure 1 for five Latin American countries. All five countries show an increase in the number of annual deaths over 2015-19. Excess death estimates based on

predicting expected 2020 deaths using estimated 2015-19 linear trends (red lines) are shown as "Excess 1." Alternative excess death estimates using a prediction based on the 2015-19 mean death count (blue lines) are shown as "Excess 2." In all cases, ignoring the increase over time and using the historical mean to calculate expected deaths would result in substantial overestimation of excess deaths.

Figure 1: Actual and Predicted Total Deaths (All Causes) by Year, Select Countries



Notes: Actual deaths are shown in black. Predicted deaths based on a linear projection using annual mortality totals 2015-19 are shown in red. Mean deaths 2015-19 are shown in blue.

For the analysis in this paper, expected deaths are estimated using a simple regression using 2015-2019 historical data, run separately by country and age-group, where observed deaths are modeled as a linear function of year and an error term.

The second issue often neglected in COVID-19 excess mortality discussions is that excess mortality represents a combination of effects. Specifically,

Net excess deaths =

[Direct COVID-19 deaths] + [Indirect COVID-19 deaths] - [Averted deaths]

Direct COVID-19 deaths are those that are due to infection with the virus. *Indirect COVID-19 deaths* are those not due to the virus itself but in part due to factors such as congestion in the health system, delays in care-seeking, or mental health issues caused by the pandemic. *Averted deaths* are those that would have taken place in the absence of the pandemic but did not occur as a result of pandemic-induced measures. These could include deaths due to other infectious diseases, violence, or traffic injuries that were avoided due to voluntary or mandated social distancing. The possibility of non-zero indirect deaths and averted deaths makes the interpretation of excess deaths more complex than is often recognized.

Slope calculation

The shape of an age-mortality curve can be summarized in terms of the percent rate of increase in probability of death per year of additional age after age 45, calculated by fitting a line to the age-specific mortality rates as follows:

$$\log\big(r(x,i)\big) = \alpha_i + \beta_i x$$

where the age-specific mortality rate is $r(x,i) = \frac{D(x,i)}{N(x,i)}$ for the ten-year age group age x to age x + 9, (x = 45, 55, 65, 75, 85) in country i, $D(x,i)$ is the number of deaths in the age group and $N(x,i)$ is the population of the age group in country i.[2] The x = 85 points correspond to the group consisting of all ages 85 and above.

To take into account the varying age structure across countries within this open interval, an adjustment factor based on indirect standardization was calculated. Following Goldstein and Lee

[2] The slope is fitted starting at age 45 because there are few deaths in most countries below age 45.

(2020)[14], the indirect standardization was calculated using 2020 both-sex mortality from the United States as the standard mortality schedule ${}_5M_x^S$ by three 5-year age groups consisting of ages 85-89, 90-94, and 95-99. We define the share of each population k for each group $c_{x,k}$ such that $1 = \sum_x c_{y,k}$, summing up over the three 5-year age groups and where the shares for the United States age structure are referred to by $c_{x,R}$. The adjustment for population k is as follows:

$$\frac{\sum_x c_{x,R}\ {}_5M_x^S}{\sum_x c_{x,k}\ {}_5M_x^S}$$

These adjustment factors were multiplied by the observed age-specific COVID-19 mortality rates (and separately the estimated age-specific excess mortality rates) for the open interval 85+.

The coefficients, β_i , are the rates of increase per year of age in probability of death. This calculation was performed first defining $D(x,i)$ in terms of official COVID-19 counts by age for each country for which data was available. The calculation was also performed for each country defining $D(x,i)$ using excess mortality estimates by age as described in the previous section.[3] These results provide 1) the slope of the COVID-19 age-mortality curve according to official counts, and 2) the slope of the age-mortality curve for excess deaths.

Results

The left side of Figure 2 shows the age distribution of officially recorded COVID-19 deaths in 2020 by country along with the age distribution of excess deaths. According to official reports , on average across high-income countries, just 11 percent of deaths were among those under age 65.[4] In contrast, people under 65 constituted on average 40 percent of official COVID-19 deaths in upper-middle-income countries and 54 percent of deaths in lower-middle-income countries. The same pattern is observed using the distribution of excess deaths by age, shown on the right side of Figure 2. In high-income countries, those under 65 are also 11 percent of excess deaths. For the upper-middle-income countries for which data is available (Peru, Colombia, and

[3] In cases for which estimated excess deaths were zero or less, the value was coded as 0.001 in order to calculate logarithms.

[4] Note that all countries in Figure 2 from Chile downward with the exception of Turkey on the figure are classified as high-income countries. Turkey is classified as an upper-middle-income country. Bangladesh, India, the Philippines, Jordan, and Indonesia are lower-middle-income countries. World Bank classifications are based on GNI calculated by the Atlas method while the figure uses GNI calculated with purchasing power parity exchange rates.

Mexico), the age profiles of excess deaths are similar to those of official COVID-19 deaths, and those under age 65 account for on average 37 percent of excess deaths.[5]

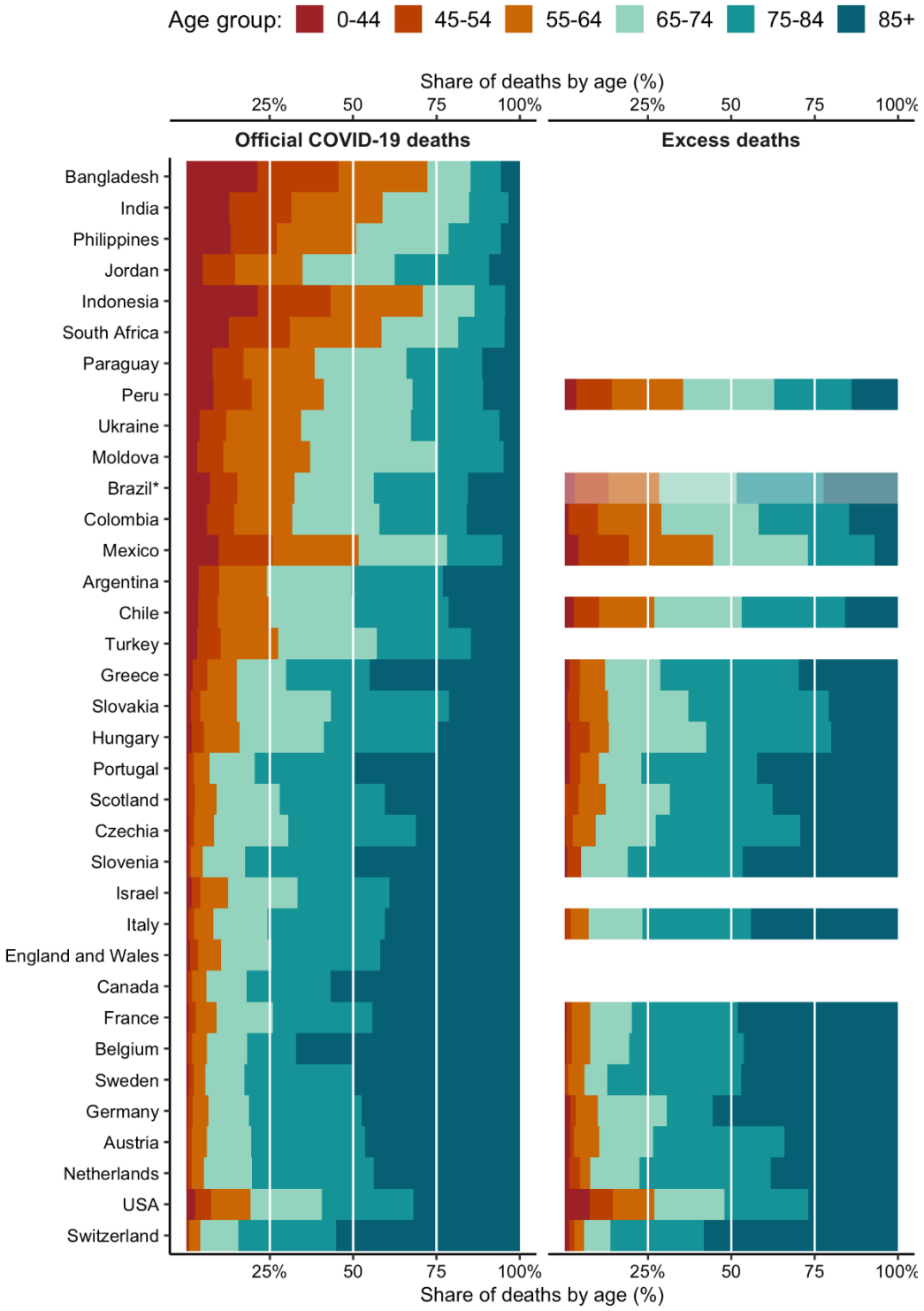
Figure 3 shows the hypothetical age distribution of COVID-19 deaths according to official reports, as well as excess deaths, applying the United States standardized age distribution. This controls for the differing population age distributions across countries. Unsurprisingly, as compared to the actual, observed distributions, these figures show an older profile of deaths in low- and middle-income countries. However, the pattern of a younger profile of deaths in less wealthy countries remains, both with official data and with excess mortality data. The numbers shown in Figures 2 and 3 can also be found in Appendix Tables A1 and A2.

Notably the United States has a much younger profile of death—using both official COVID-19 death counts and excess mortality—than countries with similar income levels. This is the case even after controlling for differences in population age distribution. The age distribution of deaths in the United States is roughly similar to that of Chile. In both countries, 27 percent of excess deaths were among those under age 65.

Figure 4 presents a visual representation of all the mortality rates by age group across all countries and economies with available data. The vertical axis represents mortality rates per 100,000, and it is important to note that the scale varies widely across countries, reflecting the different levels of exposure to the pandemic and to its related mortality across the globe. Overall, mortality rates increase with age, albeit with different gradients. With the excess mortality data, a few deviations from this gradient are likely due to the relatively low mortality as well as the overall small number of deaths (e.g. Iceland). Australia, New Zealand and Taiwan, China have close to zero official COVID-deaths and show negative estimates of excess mortality rates, especially for the older age groups, likely reflecting averted deaths due to isolation policies.

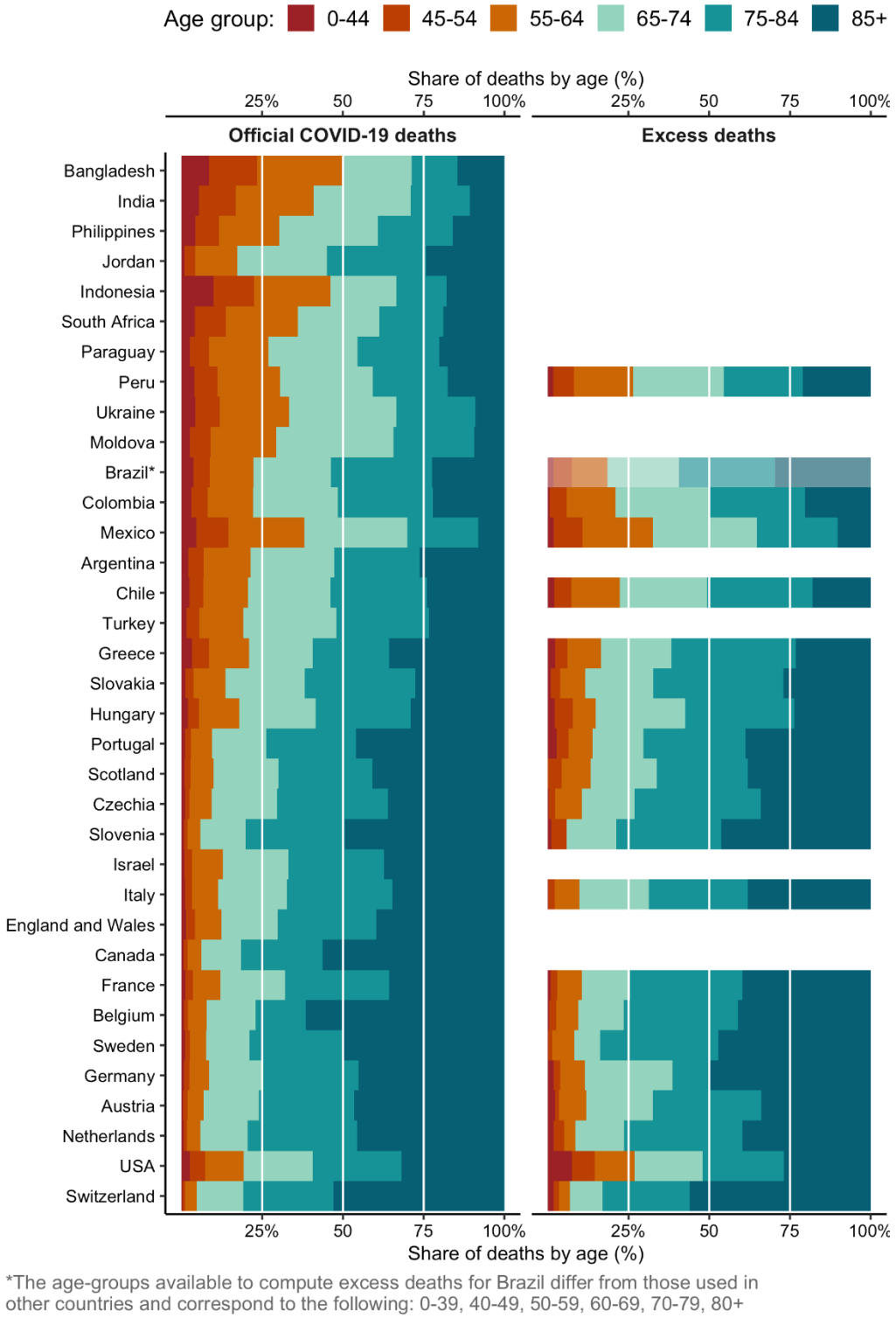
[5] Data is also available to produce excess death estimates by age for Brazil, but not with our preferred age group breakdown.

Figure 2: Age Distribution of Official COVID-19 Deaths and Excess Deaths in 2020



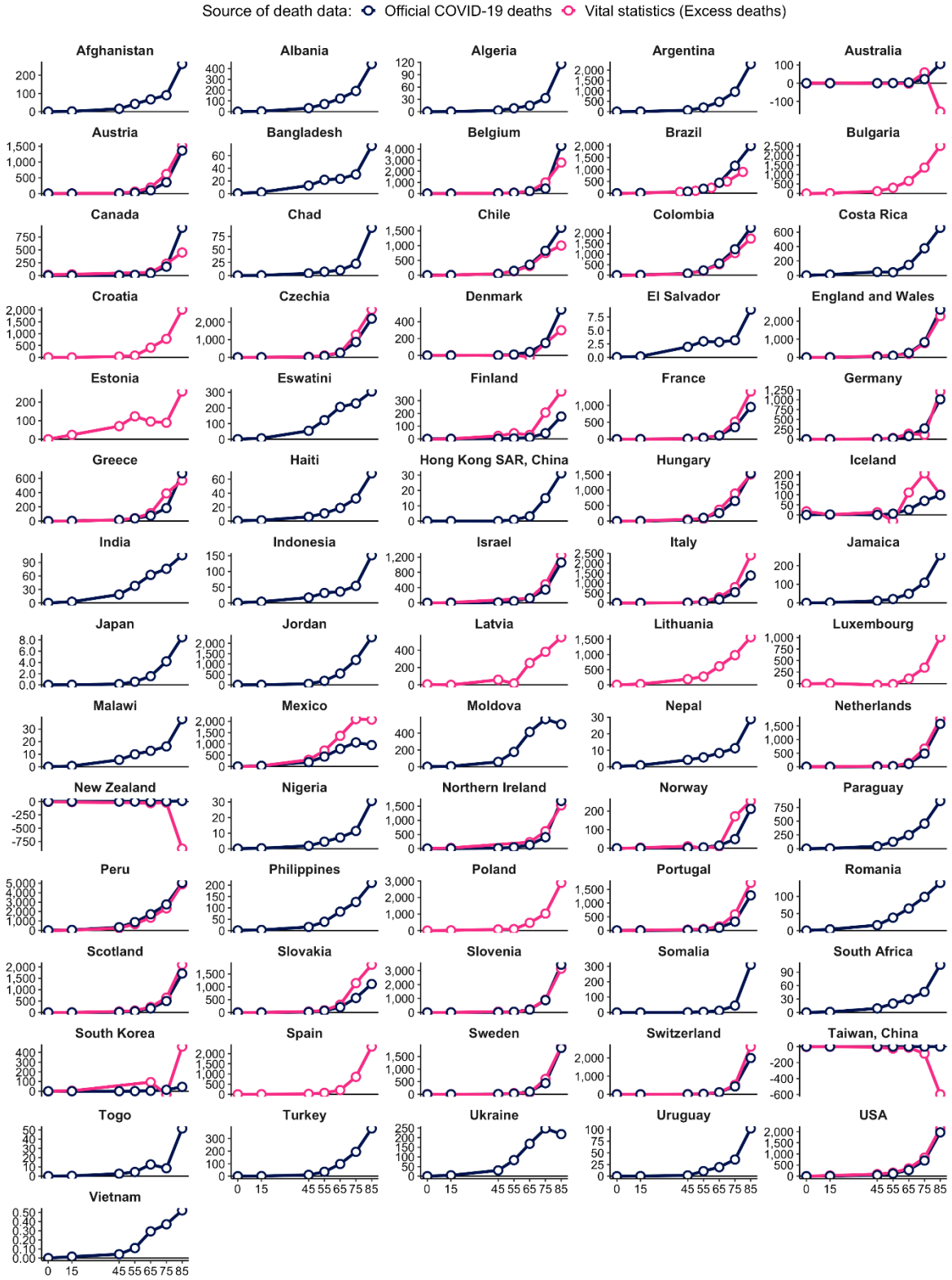
Notes: Countries with fewer than 2000 official COVID-19 deaths are excluded. Country-age group combinations with negative excess deaths are shown as zeroes. Countries are sorted by 2019 GNI per capita (PPP).

Figure 3: Hypothetical Age Distribution of Official COVID-19 and Excess Deaths in 2020, Using Country Age-Specific Mortality Rates and the US Population Age Distribution



Notes: Countries with fewer than 2000 official COVID-19 deaths are excluded. Country-age group combinations with negative excess deaths are shown as zeroes. Countries are sorted by 2019 GNI per capita (PPP).

Figure 4: Official COVID-19 vs Excess Deaths by Age Group (Per 100,000 Population)



Note: Points are plotted at the start of each age group: 0-14, 15-44,45-54,55-64,65-74,75-84, 85+

Figure 5 shows a more detailed comparison of results for five Latin American countries and the United States, using the same log scale for all countries. To add perspective on the extent of COVID-19 related mortality compared to what might have been the mortality experience in the absence of the COVID-19 pandemic, each figure adds in grey the expected all-cause mortality for 2020, based on levels and trends in the 5 preceding years. For each country, the figure also reports the total cumulative deaths for 2020 using both official COVID-19 deaths and excess mortality. Points for the age group 0-14 are not shown because for that age group official COVD-19 death rates are very low and excess mortality rates are negative for all countries shown.

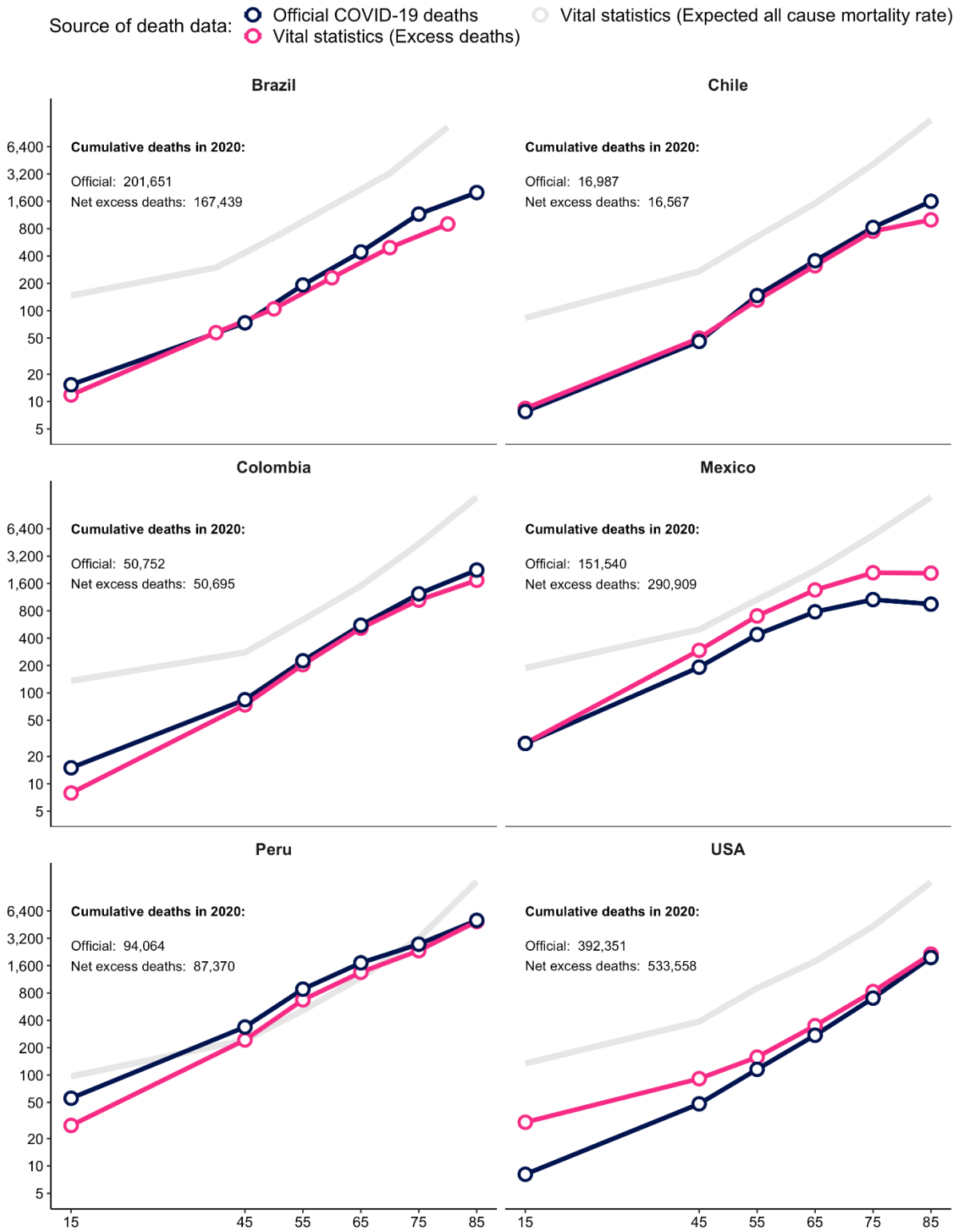
Official COVID-19 death counts are higher than excess-mortality estimates in many cases. This is the case for most age groups in Brazil, the oldest age group in Chile, all but the oldest age group in Peru, and all age groups in Colombia. These patterns indicate that for these country-age group combinations, the number of deaths averted as a consequence of the pandemic exceeds the sum of direct and indirect COVID-19 deaths. This could have occurred, for example, due to a decline in driving and exposure to violence during lockdowns and a reduction in transmission of other infectious diseases as a result of pandemic precautions.

In Mexico, the mortality estimates using excess deaths is consistently higher than that using the official COVID-19 death count, and the gap between both measures increases with age. In the United States, mortality estimates using excess deaths are also higher than using official COVID-19 deaths, but that difference decreases with age and becomes minimal for older age groups. The especially extreme impact of the pandemic in Peru is evident in Figure 5. Among those ages 45-74, both deaths attributed to COVID-19 and excess deaths exceeded total expected all-cause mortality for 2020.

Another notable pattern evident in Figure 5 is the large gap between the two measures for the United States at younger age groups. For the 15-44 age group, the excess death estimate is four times the official COVID-19 death count. Given that testing of patients with COVID-19 symptoms has been widespread in the United States in all but the early stages of the pandemic, the jump in excess mortality among young people most likely reflects indirect COVID-19 deaths.

Figure 5: Official COVID-19 vs Excess Deaths by Age Group, Select Latin American Countries and the United States (Per 100,000 Population)

Log scale



Note: Points are plotted at the start of each age group: 15-44,45-54,55-64,65-74,75-84, 85+.

Figure 6 explores how the slope of the age-mortality gradient for each country varies with its level of income. More precisely, it shows the exponential rate of increase in mortality by age in percent per year starting at age 45 against 2019 GNI per capita. The left panel presents this plot for the 64 countries with official COVID-19 deaths data and the right displays the corresponding plot for the 33 countries with excess deaths estimates available for a consistent set of age-groups as follows: 45-54, 55-64, 65-74,75-84, 85+. Using all available data, we find that the increase in mortality risk with each additional year of age above 45 typically ranges (IQR) from 7.9 to 12.2 percent (median = 10.9) using excess deaths and 6.6 to 12.6 percent (median = 9.2) using official deaths.

Both plots show a positive association between income per capita and the age-mortality gradient, indicating that COVID-19 mortality increases more steeply for older age groups in richer countries. Using official death rate data, across countries the rate of increase of mortality risk per year of age rises by 0.14 percent for each US$1,000 of GNI. Using excess mortality data, it rises by 0.21 percent for each US$1,000 of GNI.

To verify that this observed association is not driven by the composition of both sets of countries/economies, Figure 7 repeats the same exercise with the common set of 25 countries/economies. The conclusions taken from Figures 6 and 7 are similar: COVID mortality is more concentrated among older individuals in richer countries. With the more limited set of countries the gradient is less steep and more consistent between the methods for estimating mortality. Using official death rate data, across countries the rate of increase of mortality risk per year of age rises by 0.12 percent for each US$1,000 of GNI. Using excess mortality data, it rises by 0.10 percent for each US$1,000 of GNI.

Figure 6: Slope of the Age-Mortality Curve vs GNI per capita, Official COVID-19 Deaths vs Excess Deaths, All Data

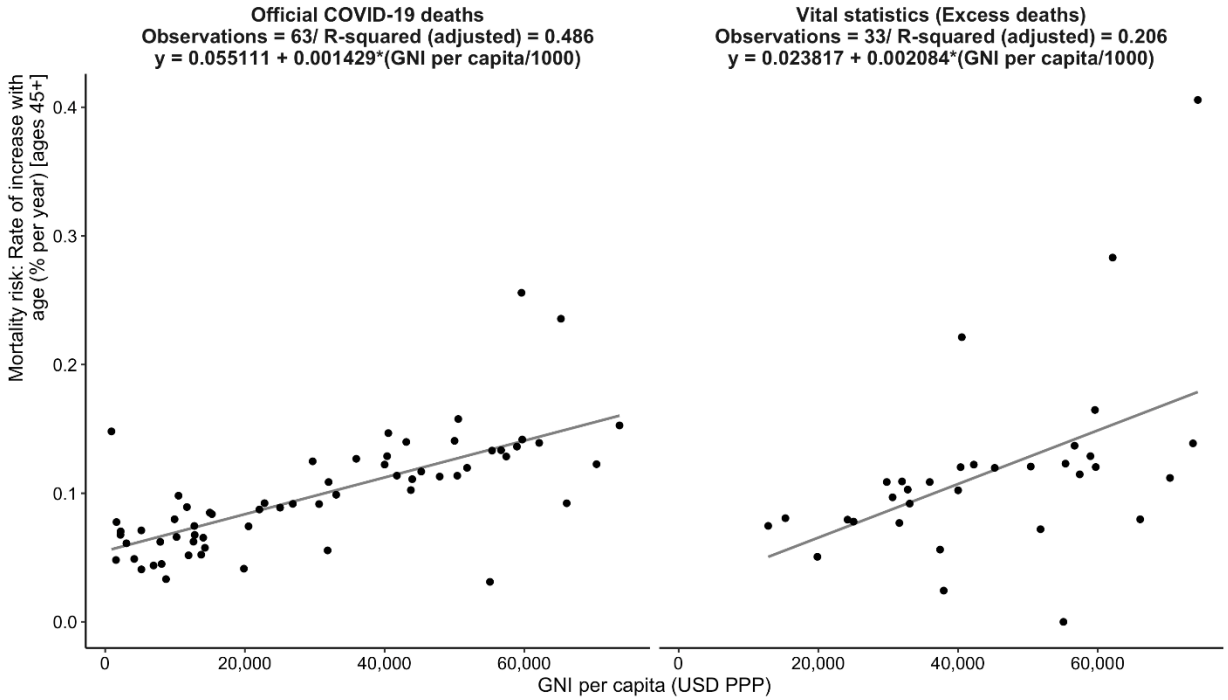
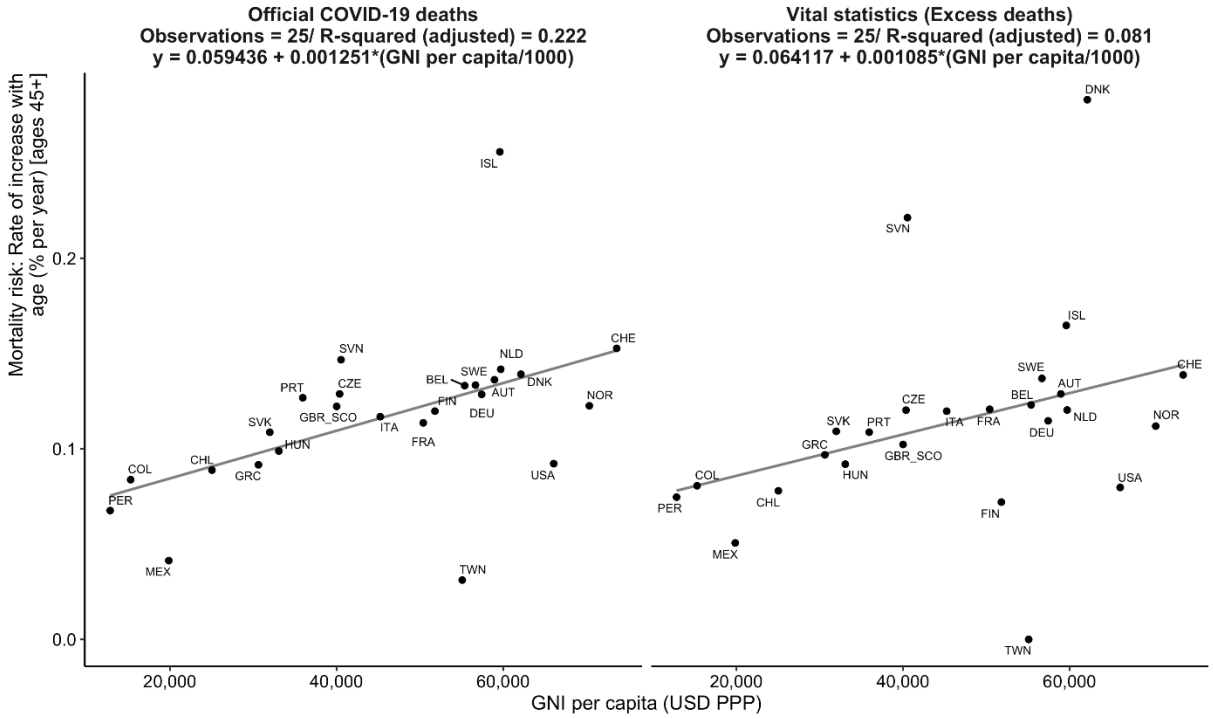


Figure 7: Slope of the Age-Mortality Curve vs GNI per capita, Official COVID-19 Deaths vs Excess Deaths, Common Set of Countries/Economies



Discussion

The age profile of COVID-19 mortality risk in 2020 was flatter (with relatively higher mortality at younger ages) in countries with lower incomes. This pattern is found using official COVID-19 death data from a large set of countries as well as excess mortality from a smaller set of countries which include high-income countries plus Colombia, Mexico, and Peru. Our analysis concerns the year 2020 and is therefore almost entirely unaffected by the arrival of COVID-19 vaccines and their unequal distribution across countries.

The findings in this paper can provide the basis for a more comprehensive accounting of the impact of COVID-19. For example, the younger mortality profile in developing countries means that in those countries the pandemic has killed large numbers of people who of working age, many of whom were their families' breadwinners. Earlier global estimates suggest that more than 1.5 million children have experienced the death of at least one caregiver as a consequence of the pandemic.[18] This raises the concern that long-term impacts via lower investments in human capital of orphaned children will be particularly deep in developing countries. This is highly worrisome given the already massive declines in school enrollment and learning losses generated by the pandemic in developing countries.[15–17]

A full understanding of age-specific patterns of excess mortality will require country-by-country analysis using cause-of-death data, where available, to pull apart estimates of direct COVID-19 deaths, indirect COVID-19 deaths, and averted deaths. A brief comparison of Colombia and the United States highlights how components of excess mortality can vary widely by country. In Colombia, both vehicular and homicide deaths fell during the country's lockdown, reducing its excess mortality count. For 2020 vehicular deaths dropped 18.2 percent, and the number of homicides fell 5.4 percent, causing Colombia's murder rate to reach its lowest level since 1979.[19,20] In contrast, the United States excess mortality estimate for 2020 reflects in part a 7.2 percent increase in motor vehicle deaths, a 29.4 percent increase in homicides, and a 30.0 percent spike in drug overdose deaths.[21–23]

Official COVID-19 death reports and excess mortality estimates show broadly similar age patterns country-by-country. This finding, along with the fact that direct COVID-19 deaths account for the large share of excess mortality deaths, suggests that the flatter profile of excess mortality in lower income countries is driven principally by direct COVID-19 deaths. To

consider drivers of the direct COVID-19 age pattern it is useful to note that the age-specific mortality rate is the product of the age-specific cumulative infection rate (*IR*) and the age-specific cumulative infection fatality rate (*IFR*). Using the notation employed earlier and where $I(x,i)$ designates the cumulative number of infections of age group *x* in country *i*, this can be expressed as follows:

$$r(x,i) = \frac{D(x,i)}{N(x,i)} = \frac{I(x,i)}{N(x,i)} * \frac{D(x,i)}{I(x,i)}$$

$$= IR(x,i) * IFR\ (x,i)$$

The greater flatness of direct COVID-19 age-specific mortality rates in lower income countries could result from differing patterns across countries by age of *IR*, *IFR*, or both. A number of studies have documented possible contributing factors to variation across countries in overall COVID-19 mortality and those same factors could generate different patterns in mortality by age.[24–28]

The relative IR of younger vs. older people may vary across countries for many reasons. First, in lower income countries, a large share of the population cannot work remotely.[29] Second, in developing countries, a lower share of older people are long-term care facility residents, who are at high risk for infection and death. One-quarter of recognized COVID-19 deaths during the first few months of the pandemic in the United Kingdom were residents of care facilities, and 31 percent of recognized COVID-19 deaths in the United States as of June 1, 2021 were care facility residents or staff.[30,31] Both of these characteristics of developing countries would tend to increase the relative risk of infection for younger people. On the other hand, in low- and middle-income countries, intergenerational households are more common. This means older people are more exposed to infection risk, particularly because in those countries people are more likely to live in crowded conditions. Roughly 20 percent of households in LMICs have at least one household member under age 20 and one over age 60, as compared to just 5 percent in high-income countries.[32] In 54 LMICs with recent Demographic and Health Surveys, just half of the households have no more than two people per sleeping room.[27]

Among those infected, age-specific IFRs may vary by age due to many different factors. One systematic review found that overall IFRs in developing countries are 1.3-2.5 times higher than in high-income countries.[33] Country-level factors like the profile of comorbidities, differences in

health system capacity, quality of care, infection prevention and control practices, and availability of personal protective equipment, could have age-specific effects on the IFR .[28,34] A form of survivor bias may be a factor as well. High quality medical care in wealthier countries keeps many older people alive despite weak health conditions that make them vulnerable to COVID-19. It may be that older people in developing countries are on average healthier than those in wealthier countries because those with ailments would have been at high risk for death at a younger age. If this is the case, older people in developing countries might be more resilient to the disease.

Distinguishing various explanations for the observed age patterns of mortality identified in this paper should be a topic for further research. The analysis in this paper is also a reminder of the value of demographic data and in particular vital statistics as a tool amid the COVID-19 crisis. Excess mortality analysis by age presented here is only possible for countries that have well-functioning vital statistics systems and that have made their data widely available. Investments in vital statistics systems and greater data transparency should be encouraged as a global public good.

Data Availability

Data sources

Official reported COVID-19 deaths aggregated in the COVerAGE database For this analysis the output file with death counts aggregated to 5-year age-groups is used.

There are 114 countries in the COVerAGE database (excluding England and United Kingdom). For this analysis, the political units that make up the United Kingdom are treated separately as follows: England and Wales, Scotland, and Northern Ireland.

84 countries have at least one record of cumulative deaths during 2020 or 2021.

64 countries have a record of cumulative deaths that covers at least 6 months since the first case was detected in the country (per case-data derived from Our World in Data). Countries with an "exposure" of less than 6 months as of the end of 2020 are excluded from the analysis.

The following is the set of 64 countries and economies with official reported deaths used in the analysis: Afghanistan; Albania; Algeria; Argentina; Australia; Austria; Bangladesh; Belgium; Brazil; Canada; Chad; Chile; Colombia; Costa Rica; Czechia; Denmark; El Salvador; England and Wales; Eswatini; Finland; France; Germany; Greece; Haiti; Hong Kong SAR, China; Hungary; Iceland; India; Indonesia; Israel; Italy; Jamaica; Japan; Jordan; Malawi; Mexico; Moldova; Nepal; Netherlands; New Zealand; Nigeria; Northern Ireland; Norway; Paraguay; Peru; Philippines; Portugal; Romania; Scotland; Slovak Republic; Slovenia; Somalia; South Africa; Republic of Korea; Spain; Sweden; Switzerland; Taiwan, China; Togo; Turkey; Ukraine; Uruguay; United States; Vietnam.

Excess all-cause deaths from vital statistics records, from the following sources:

Short term mortality fluctuations (STMF) harmonized data series from the Human Mortality Database

- For this analysis; the STMF input files are used. These input files cover 38 countries and economies: Australia; Austria; Belgium; Bulgaria; Canada; Switzerland; Chile; Czech Republic; Germany; Denmark; Spain; Estonia; Finland; France; Northern Ireland; Scotland; England and Wales; Greece; Croatia; Hungary; Iceland; Israel; Italy; Republic of Korea; Lithuania; Luxembourg; Latvia; Netherlands; Norway; New Zealand; Poland; Portugal; Russian Federation; Slovak Republic; Slovenia; Sweden; Taiwan, China; United States.
- Russia does not have data for 2020.
- Chile and Germany do not have data for 2015.

Colombia vital statistics tabulations (*Defunciones no fetales*) were compiled by DANE. 2019 and 2020 tabulations are preliminary.

Historic (2015-2019) Mexico vital statistics microdata are those compiled (*Defunciones registradas, mortalidad general*) by INEGI, 2020-21 deaths microdata based on death certificates compiled by RENAPO and accessed via the government of Mexico's open data platform.

Peru death certificate microdata were compiled by SINADEF obtained via correspondence with University of Toronto researchers.

Together there are 39 countries and economies with excess death estimates: Austria; Belgium; Bulgaria; Switzerland; Chile; Czech Republic; Germany; Denmark; Spain; Estonia; Finland; France; Scotland; Greece; Croatia; Hungary; Iceland; Italy; Lithuania; Luxembourg; Latvia; Netherlands; Norway; Poland; Portugal; Slovak Republic; Slovenia; Sweden; Taiwan, China; Colombia; Peru; Mexico; England and Wales; United States; Australia; Canada; Israel; Republic of Korea; New Zealand.

Of these, nine do not have corresponding official death records from the coverage database: Bulgaria, Czech Republic, Estonia, Croatia, Lithuania, Luxembourg, Latvia, Poland, Slovak Republic.

The preferred age group categories for the analyses conducted in this paper were as follows: 0-14, 15-44, 45-54, 55-64, 65-74, 75-84, 85+. However, since the reporting of all-cause deaths by age used by the Human Mortality Database is not consistent from country to country (not all countries report death counts tabulated at 5-year intervals or less), successively broader age-groupings are used in cases where the preferred age groups could not be constructed directly from the STMF input data. These countries include the United States, England and Wales, Australia, Canada, New Zealand, Israel, the Republic of Korea, and Northern Ireland. We compute excess mortality rates for all unique country-age group combinations (as shown in Figure 4) but to estimate the age gradient of mortality, we only include countries for which we could construct the preferred age-group categories as described above. Countries for which we could not construct the preferred age-group categories are Brazil, Israel, and New Zealand. To avoid excluding the United States from this analysis, we use mortality data from the CDC which reports deaths for finer age groups for 2015 through 2019.

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Annex Table A1: Age Distribution of Official COVID-19 Deaths and Excess Deaths in 2020 (Data Shown in Figure 2)

			Share (%) of official COVID-19 deaths by age group						Share (%) of excess mortality deaths by age group					
Country	**GNI PPP$**	**Group**	0-44	45-54	55-64	65-74	75-84	85+	0-44	45-54	55-64	65-74	75-84	85+
Bangladesh	5190	LMIC	21	24	26	13	9	6						
India	6930	LMIC	13	19	27	26	12	3						
Philippines	10220	LMIC	13	14	24	28	16	6						
Jordan	10500	UMIC	5	10	20	28	28	9						
Indonesia	11940	LMIC	21	22	28	16	9	4						
South Africa	12640	UMIC	13	18	27	23	14	5						
Paraguay	12760	UMIC	8	9	21	27	23	11						
Peru	12820	UMIC	8	11	22	27	21	11	4	11	21	27	23	14
Ukraine	13750	LMIC	4	8	23	33	27	6						
Moldova	14280	LMIC	3	8	26	38	20	5						
Brazil*	14980	UMIC	7	8	17	24	28	16	3	10	15	23	26	22
Colombia	15280	UMIC	6	8	17	26	26	16	1	9	19	29	27	15
Mexico	19860	UMIC	10	16	26	27	17	5	4	15	25	28	20	7
Argentina	22080	HIC	4	6	14	25	28	23						
Chile	25040	HIC	4	6	16	25	29	21	3	7	17	26	31	16
Turkey	26860	UMIC	3	7	17	30	28	15						
Greece	30620	HIC	2	4	9	15	25	45	1	3	7	17	42	30
Slovakia	31980	HIC	1	3	11	28	36	21	1	4	9	24	42	21
Hungary	33070	HIC	2	4	11	25	34	25	2	6	6	29	38	20
Portugal	35940	HIC	1	1	5	14	30	49	2	3	6	13	35	42
Scotland	40000	HIC	1	2	7	19	32	40	0	4	8	19	31	38
Czechia	40360	HIC	1	1	6	22	38	31	0	2	7	18	43	29
Slovenia	40530	HIC	1	1	3	13	33	50	1	4	0	14	34	47
Israel	41750	HIC	1	3	8	21	28	39						
Italy	45240	HIC	1	2	6	16	35	41	0	2	5	16	33	44
England & Wales	47880	HIC	1	3	7	15	33	42	0	0	0	0	0	0
Canada	50010	HIC	0	1	4	12	25	57	0	0	0	0	0	0
France	50400	HIC	1	2	6	17	30	44	1	2	5	12	32	48
Belgium	55370	HIC	0	1	5	12	15	67	0	2	6	12	34	46
Sweden	56670	HIC	1	1	4	12	32	50	0	1	5	7	40	47
Germany	57410	HIC	0	1	5	12	34	47	2	2	7	21	14	56
Austria	58940	HIC	0	1	4	13	34	46	2	1	8	16	39	34
Netherlands	59700	HIC	0	1	4	14	36	44	1	3	3	15	39	38
USA	66060	HIC	3	5	12	21	28	32	7	7	12	21	25	27
Switzerland	73620	HIC	0	1	3	12	29	55	1	1	3	8	28	58

* The age groups available to compute excess deaths for Brazil differ from those used in other countries and correspond to the following: 0-39, 40-49, 50-59, 60-69, 70-79, 80+. GNI is from 2019.

Annex Table A2: Hypothetical Age Distribution of Official COVID-19 and Excess Deaths in 2020, Using Country Age-Specific Mortality Rates and the US Population Age Distribution (Data Shown in Figure 3)

			Share (%) of official COVID-19 deaths by age group						Share (%) of excess mortality deaths by age group					
Country	**GNI PPP$**	**Group**	0-44	45-54	55-64	65-74	75-84	85+	0-44	45-54	55-64	65-74	75-84	85+
Bangladesh	5190	LMIC	9	15	26	22	14	15						
India	6930	LMIC	5	11	24	30	18	11						
Philippines	10220	LMIC	4	7	19	31	23	16						
Jordan	10500	UMIC	1	3	13	28	31	24						
Indonesia	11940	LMIC	10	12	24	21	16	18						
South Africa	12640	UMIC	4	10	22	25	20	19						
Paraguay	12760	UMIC	3	6	18	28	25	20						
Peru	12820	UMIC	4	7	19	29	23	18	2	6	18	28	24	21
Ukraine	13750	LMIC	4	8	22	33	25	9						
Moldova	14280	LMIC	3	6	20	36	25	9						
Brazil*	14980	UMIC	4	5	14	24	31	22	2	6	11	22	30	30
Colombia	15280	UMIC	3	5	14	26	29	22	1	5	15	29	30	20
Mexico	19860	UMIC	5	10	24	32	22	8	2	9	22	32	25	10
Argentina	22080	HIC	2	5	14	26	27	26						
Chile	25040	HIC	2	4	14	26	30	24	2	5	15	27	33	18
Turkey	26860	UMIC	2	4	14	29	29	23						
Greece	30620	HIC	3	5	12	20	24	36	2	4	10	22	38	23
Slovakia	31980	HIC	1	2	10	25	34	28	1	3	8	21	40	27
Hungary	33070	HIC	2	3	13	24	30	29	2	6	7	28	34	24
Portugal	35940	HIC	1	2	7	17	28	46	3	4	7	16	32	39
Scotland	40000	HIC	1	2	7	20	29	41	0	4	9	21	28	38
Czechia	40360	HIC	1	1	7	20	34	36	0	2	8	16	39	34
Slovenia	40530	HIC	1	1	4	14	31	49	1	5	0	15	33	46
Israel	41750	HIC	1	2	10	20	30	37						
Italy	45240	HIC	1	2	8	21	33	35	0	2	8	22	31	38
England & Wales	47880	HIC	1	3	8	17	30	40						
Canada	50010	HIC	1	1	4	12	25	56						
France	50400	HIC	1	2	9	20	32	36	1	2	8	15	35	40
Belgium	55370	HIC	1	1	6	15	16	62	0	2	7	14	35	41
Sweden	56670	HIC	1	2	5	13	29	50	0	1	7	8	37	47
Germany	57410	HIC	1	2	6	17	30	45	2	2	8	27	11	50
Austria	58940	HIC	0	1	5	17	29	47	2	1	9	21	34	34
Netherlands	59700	HIC	1	1	4	15	34	46	2	3	3	15	37	40
USA	66060	HIC	3	5	12	21	28	32	7	7	12	21	25	27
Switzerland	73620	HIC	0	1	4	14	28	53	2	2	3	10	27	56

* The age groups available to compute excess deaths for Brazil differ from those used in other countries and correspond to the following: 0-39, 40-49, 50-59, 60-69, 70-79, 80+. GNI is from 2019.

Annex Table A3: Rate of Increase in Risk of Death by Age and Ratio of Mortality Risk Between Age Groups

Country/economy	Official deaths		Excess deaths	
	Exponential rate of increase in risk of death for each year of age	Ratio (MR 75-84/ MR 45-*54*)	Exponential rate of increase in risk of death for each year of age	Ratio (MR 75-84/ MR 45-54)
Afghanistan	0.07	6	--	
Albania	0.07	6	--	
Algeria	0.09	11	--	
Argentina	0.09	14	--	
Australia	0.16	104	--	
Austria	0.14	58	0.13	76
Bangladesh	0.04	2	--	
Belgium	0.13	29	0.12	43
Brazil	0.08	16	--	
Bulgaria	--		0.08	12
Canada	0.14	53	--	
Chad	0.08	6	--	
Chile	0.09	18	0.08	15
Colombia	0.08	15	0.08	14
Costa Rica	0.07	8	--	
Croatia	--		0.11	24
Czechia	0.13	62	0.12	49
Denmark	0.14	75	0.28	-
El Salvador	0.03	2	--	
England and Wales	0.11	28	--	
Estonia	--		0.02	1
Eswatini	0.05	4	--	
Finland	0.12	27	0.07	9
France	0.11	34	0.12	43
Germany	0.13	45	0.11	14
Greece	0.09	11	0.10	26
Haiti	0.06	5	--	
Hong Kong SAR, China	0.24	-	--	
Hungary	0.10	22	0.09	15
Iceland	0.26	-	0.16	16
India	0.04	4	--	
Indonesia	0.05	3	--	
Israel	0.11	33	--	
Italy	0.12	40	0.12	39
Jamaica	0.08	9	--	
Japan	0.10	30	--	

Jordan	0.10	24	--	
Latvia	--		0.08	6
Lithuania	--		0.06	5
Luxembourg	--		0.41	-
Malawi	0.05	3	--	
Mexico	0.04	6	0.05	7
Moldova	0.06	10	--	
Nepal	0.05	3	--	
Netherlands	0.14	74	0.12	28
New Zealand	0.11	28	--	
Nigeria	0.07	6	--	
Northern Ireland	0.12	36	--	
Norway	0.12	32	0.11	17
Paraguay	0.07	11	--	
Peru	0.07	8	0.07	10
Philippines	0.07	8	--	
Poland	--		0.10	16
Portugal	0.13	39	0.11	21
Romania	0.06	6	--	
Scotland	0.12	38	0.10	17
Slovak Republic	0.11	34	0.11	34
Slovenia	0.15	81	0.22	18
Somalia	0.15	57	--	
South Africa	0.06	5	--	
Korea, Rep.	0.14	80	--	
Spain	0.12	37	0.12	45
Sweden	0.13	47	0.14	78
Switzerland	0.15	97	0.14	43
Taiwan, China	0.03	1	0.00	15
Togo	0.07	3	--	
Turkey	0.09	18	--	
Ukraine	0.05	8	--	
Uruguay	0.09	20	--	
United States	0.09	15	0.08	9
Vietnam	0.06	9	--	