A Comprehensive Measure of Lifeyears Lost due to COVID-19 in 2020: A Comparison across Countries and with Past Disasters

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Abstract

Typically, disaster damages are measured separately in four dimensions: fatalities, injuries, dislocations, and the financial damage that they wreak. Noy (2016) developed a lifeyears index of disaster damage which aggregates these disparate measures. Here, we use this lifeyears index to assess the costs of the COVID-19 pandemic across countries and compare these costs to the average annual costs of all other disasters that have occurred in all countries in the past 20 years. We find that the costs of the pandemic, measured for 2020, far outweigh the annual costs associated with other disasters in the past two decades. It is the economic loss that dominates this impact. The human and social implications of this economic loss are plausibly much greater than the direct toll in mortality and morbidity in almost all countries. Finally, it is small countries like the Maldives and Guyana that have experienced the most dramatic and painful crisis, largely under the radar of the world’s attention. Our conclusion from these findings is not that governments’ policy reactions were unwarranted. If anything, we find that the loss of lifeyears is correlated positively across the three dimensions we examine. Countries that experienced a deeper health crisis also experienced a deeper economic one.

1. Measuring disaster impacts

Typically, disaster damages are measured separately along several dimensions: The number of fatalities and injuries they cause, the number of people otherwise affected, and the financial damage that they wreak. When trying to evaluate the global burden of disasters, aggregating these disparate measures into a comprehensive index is challenging; but without an aggregate measure, a fuller picture of the burden of disasters over time and across countries is difficult to discern.

The usual approach to obtain this aggregate measure has been to attach a dollar value to mortality and morbidity, using the Value of a Statistical Life (VSL), and sum these together with the monetary assessment of damage to public and private infrastructure. The VSL approach makes comparison across countries very difficult, as different governments use very different values for (statistical) life, and any attempt to identify a unitary value cannot fit either domestic policy priorities or public perceptions. More importantly, many people are generally uncomfortable with this approach, which explains why governments are typically very discreet about the VSL ‘prices’ they use in their policy making processes.

As an alternative to the VSL approach, Noy (2016) developed a lifeyears index of disaster damage. This lifeyears index, in contrast to the VSL approach, aggregates the various ways in which years of life were lost to all members of a society because of a shock, such as an earthquake, or a pandemic.

In this paper, we use the lifeyears index to assess the costs of the COVID-19 pandemic across countries and compare these costs to the average annual costs of all other disasters that have occurred in all countries in the past 20 years (2000–2019). It will surprise no one, we think, to realise that the costs of the pandemic, measured only for 2020 (and excluding any predicted costs for 2021), far outweigh the average annual costs associated with all other disasters aggregated together.

To date, there have been attempts at projecting the economic costs of the pandemic using data from before the pandemic (e.g., Noy et al., 2020), estimating the cross-country economic costs with econometric modelling (e.g., Chudik et al., 2020), or focusing on specific countries with more detailed general equilibrium modelling (e.g., Martin et al., 2020; Walmsley et al., 2021). Another strand has emphasised that these economic costs will possibly last for a long time (Kosloski et al., 2020). But none of these projects had tried to assess the costs the world has already experienced, summed over their differing dimensions, and compared across countries and regions. This is our intent.
2. The lifeyears index

In developing the Lifeyears index, we relied on the World Health Organization methodology developed to measure the global burden of diseases using the Disability Adjusted Life Years (DALY) concept (Sassi, 2006; WHO, 2013). We adopt and adapt the assumptions developed by the WHO to construct our measures of the impact of COVID-19. Our unit of measurement is lifeyears. The WHO’s approach accounts for the impact of diseases exclusively on health, while the lifeyears measurement used here is aimed at accounting for the impact of disasters on human welfare more generally; and do so by calculating both the health impact and any economic damage that is caused by the events being quantified. But unlike the VSL approach that measures everything in monetary terms, the lifeyears index puts the impact on human lives as the focal point. Ultimately, this measure focuses on human potential to lead healthy and long lives, and the ways in which disaster risk more generally, and specifically the COVID-19 pandemic, interrupted this potential also through the economic disruptions it caused.

Our underlying premise is that the value of human life should be considered as equal everywhere, while the value of monetary damages is not. A dollar lost in a high-income country is associated with a much more minor adverse impact on society than a dollar lost in a low-income country (as the ratio of average incomes in rich and poor countries is astonishingly, and distressingly, high).

For disasters caused by natural hazards, we obtain information for all disasters that occurred between 2000 and 2019 from the EMDAT database; we use their measures for mortality, the number of people affected, and the economic damage associated with each disaster. In adapting the lifeyears index to measure the costs associated with a pandemic, we focus on three measures: mortality from the disease (as identified by the WHO guidelines), the number of confirmed cases (i.e. those with a positive test), and the economic loss measured with declines in gross domestic product (GDP) that is associated with the pandemic.

3. The index for all disasters (2000–2019)

To quantify the combined health and economic impact of all disasters in 2000–2019, we use the same lifeyears index described in Noy (2016):

\[
\text{Lifeyears} = L(M, A^{\text{death}}, A^{\text{exp}}) + I(N) + DAM(Y, P),
\]

where \(L(M, A^{\text{death}}, A^{\text{exp}})\) indicates the lifeyears lost because of mortality and is a function of the total number of deaths \((M)\), the age at death \((A^{\text{death}})\), and the life expectancy at the time of death \((A^{\text{exp}})\). The age of people when they died is not available, so we refer to the median age of the population, implicitly assuming that mortality from disasters occurs randomly within the population (the median age by country is available from the UN Population Division). We use the median age in 2010 \((A^{\text{med}}_{2010})\), the midpoint of the period 2000–2019. For life expectancy, we use a uniform life expectancy of 92 for all countries. The implied assumption is that a healthy individual with adequate nutrition and healthcare is expected to live to 92 anywhere in the world (WHO, 2013). With this assumption, we follow the practice developed by the WHO in their periodic DALY reports.

The second component \(I(N)\) accounts for the lifeyears lost due to injuries and is defined as: \(I(N) = NeT.\) \(N\) is the number of people who were directly affected by the disasters. The coefficient \(e\) is the ‘welfare-reduction weight’ that is associated with how individuals were affected; proposed to be 0.054 by Noy (2016), based on guidelines from WHO (2013). \(T\) is the time it takes someone affected to bounce back in the aftermath of the disasters; for disasters, we assume \(T = 3\) (i.e. full personal recovery is achieved, on average, within three years).

Last, \(DAM(Y, P)\) counts the number of life-years lost owing to the economic damages caused by the disasters and is defined as: \(DAM(Y, P) = (1-c)Y/P.\) \(Y\) is the economic loss from the disaster. The losses are scaled by GDP per capita \((P)\), which proxies for the human efforts in a full year. The discounting rate \(c\) is associated to the value of time not spent in work-related activities (alternatively, it aims to measure how much GDP would have been higher had everyone worked all the time). These concepts are hypothetical, so determining an evidence-based value is impossible. Noy (2016) assumes an ad-hoc value for the discounting rate: \(c\) is 75 per cent; we view this as a conservative or cautious estimate.

We therefore measure the average number of Lifeyears lost from all disasters in 2000–2019 by the following equation:

\[
\text{Lifeyears}_{\text{all}} = \sum_{2000}^{2019} \left[\frac{M_i (2019 - A^{\text{med}}_{2010})}{20} + N_i \times 0.054 \times 3 + (1 - 0.75)Y_i/P_i\right].
\]

where \(Lifeyears_{\text{all}}\) is the yearly average of the lost lifeyears in country \(i\) in the 2000–2019 period from all disasters caused by natural hazards. \(M_i\) is the total number of deaths caused by these disasters in each country \(i\) from 2000 to 2019. \(N_i\) represents the total number of people affected by the disasters in each country \(i\) in 2010–2019. This measure includes the number of people directly affected, the injured, and those who were made homeless by the event. \(Y_i\) measures the total amount of physical damage (as measured in the EMDAT dataset).

4. The lifeyears index for COVID-19 (2020)

In order to calculate the total lifeyears lost from COVID-19, we obtain the data about the cumulative number of deaths and confirmed cases until 31 December 2020 from the Worldometers database, a website that provides up-to-date statistics for the COVID-19 pandemic. We use a modified version of Equation (1).

The median age of those who died from COVID-19 is not available by country (nor the complete age distribution of...
the pandemic’s victims in each country); and neither is the assumption that mortality is randomly distributed, by age, an appropriate assumption in this case. Mortality risk is very age-dependent, and that is one reason why the mortality rates vary with cross-country demographic differences. We calculate the global median age at death from COVID-19 based on share of deaths of each age group and find that $A^\text{med} = 71$. As discussed earlier, and following the conventions developed by the WHO, we assumed life expectancy to be 92.

As of 31 December 2020, there were more than 20 million active cases, about one-quarter of the total confirmed cases. About 0.5 per cent of confirmed cases are found to experience severe condition and 99.5 per cent of cases are mild. The time horizon, $T$, indicates how long people recover from a COVID-19 illness. On average, it takes 2 weeks for someone with mild symptoms, and 6 weeks or more for someone with severe symptoms to recover (according to the Johns Hopkins Coronavirus Resource Center).

To determine which weights are compatible for the coefficient, $e$, for patients with confirmed COVID-19, we use the list of disability weights for sequelae included in the Global Burden of Disease Study. We suggest the coefficients for those with mild and severe symptoms are 0.152 and 0.613 respectively (i.e. we assume that the symptoms of mild COVID-19 cases are most similar to measles and severe cases are most similar to streptococcus pneumonia). These coefficients are typically applied for patients experiencing the illness for a whole year, so they need to be reduced appropriately (2 weeks for mild symptoms, 6 weeks for severe ones). Along with the average recovery time of COVID-19, the lifeyears lost from confirmed cases is therefore measured as follows:

$$N_i eT = N_i \left[ 0.5\% \times 0.613 \times \frac{1.5}{12} + 99.5\% \times 0.152 \times \frac{0.5}{12} \right] = 0.00668 N_i.$$  

(3)

For the discounting rate of the economic impact, as above, we utilise the same rate ($c = 75\%$) as in Noy (2016) and for the disaster losses. $Y_{i,2020}$ is the predicted decline in GDP in 2020 and is scaled by the 2020 GDP per capita ($P_{i,2020}$). We employ the percentage point differences of the 2020 GDP growth rates estimated by the January 2021 Global Economic Prospects Outlook and those projected by the January 2020 Global Economic Prospects Outlook, the latter produced before the spread of COVID-19. The estimated decline in 2020 GDP caused by COVID-19 is calculated as the GDP of 2019 multiplied by the change of forecasted GDP growth rates of 2020:

$$Y_{i,2020} = \left( \frac{GDP_{i,2019}}{GDP_{i,2020}} \right) \times \left( \Delta GDP_{i,2020}^{\text{projection}} - \Delta GDP_{i,2020}^{\text{estimate}} \right).$$

(4)

Putting Equations (1), (3) and (4) together, we end up with a COVID-19 lifeyears index for each country, defined by:

$$\text{Lifeyears}_{i}^{\text{cov}} = M_i (92 - 71) + N_i (0.00668) + (0.25)Y_{i,2020}/P_{i,2020},$$

(5)

where $\text{Lifeyears}_{i}^{\text{cov}}$ is the lost life-years from COVID-19 in each country $i$ in 2020. $M_i$ is the total number of deaths in 2020 from COVID-19 in country $i$. $N_i$ is the total number of recorded cases in country $i$ ($N_i = \text{Confirmed Cases}_i \times \text{Recovery rate}$).

Figure 1. Total lost lifeyears, by region

Note: The figure presents the LLY cost in 2020 for COVID-19, and the average annual loss from other disasters (2000–2019).
5. Results

Figure 1 displays the total lifeyears lost from COVID-19 in 2020 (grey bars) in comparison to all other disasters annually averaged over the last two decades (maroon bars), across continents. Compared to the average yearly lost from all other disasters, the total lifeyears lost from COVID-19 are vastly higher; more than threefold in Asia, the most populous continent, and even more for other regions (Americas, Africa, Europe, and Oceania). The most relevant comparison, however, might be in per capita terms; this is presented in Figure 2. The comparison across regions is now somewhat different, though the ratio of losses from COVID-19 to annual average of disaster losses across regions is identical to what we observed in Figure 1. In per capita terms, it is noticeable that Americas stands out as the continent with the highest per capita lifeyears lost from COVID-19, followed by Europe; by contrast, Africa is the least-affected

Note: The figure presents the LLY cost in 2020 for COVID-19 per capita, and the average annual loss from other disasters per capita (2000–2019).
continent globally. However, even Africa is greatly affected, much more than the continent’s average annual toll of costs from all other disasters.

Instead of across regions, we can also distinguish between income groups (following the World Bank’s definitions of high-income, upper-middle-income, lower-middle-income, and low-income countries). Figure 3 shows there are significant differences in the distribution of lifeyears lost, with the highest (per capita) loss from COVID-19 experienced in the high-income countries, and maybe surprisingly, this is different from the pattern that is observed for other disasters where high-income countries have the lowest per capita annual losses. Another noticeable observation is that in comparison to annual costs of disasters, the COVID-19 pandemic has more substantial adverse impact in high-income countries relative to low-income countries.12

Figure 4 displays the top ten countries with highest total lost lifeyears from COVID-19. It is clear that by far most is associated with the economic loss (blue dots). COVID-19, as a global crisis, was maybe most importantly an economic crisis. This list is mostly composed, of course, of the biggest countries in terms of their population and their relative poverty (since the loss in GDP is scaled by per capita income). Furthermore, the size of the Indian and Chinese economies, which contribute more than half of the GDP of Asia, dominates the statistics for Asia.13 The equivalent statistic for the United States is lower, largely because it has higher income per capita, so every dollar lost is ‘worth’ less in terms of the lifeyears lost. Figure 5 provides a striking evidence of these patterns. The loss of lifeyears due to mortality is much higher in the United States that in China or India; though India, Brazil and Mexico still have quite a high number of Lifeyears lost to mortality.14

In the online Appendix, we provide the distribution of the per capita lifeyears lost from COVID-19 by each of its components for all the 153 countries in the sample. We find a similar pattern that the loss associated with the economic loss dominating the total loss. The per capita mean of lost Lifeyears associated with the economic loss is 0.0237, while the means associated with mortality and morbidity are only 0.0066 and 0.0001, respectively.

Figure 6 provides a similar statistic as Figure 4, but for lost lifeyears per capita. This country list is radically different, with no country included in both. Small countries appear especially vulnerable to the loss from this pandemic, and this is especially true for small open economies that rely a lot on the export of various services, especially tourism (e.g., Fiji, Maldives, Seychelles, and Belize).15 For these countries, as well, the loss is dominated by the economic crisis that was caused by this pandemic. Figure 7 examines this list of ten highest per capita losses from COVID-19 and compares their loss in 2020 to their loss from the most catastrophic disaster they experienced between 2000 and 2019. For most, COVID-19 was worse than their worst disaster during the preceding two decades.

Figure 8 maps the global distribution of per capita lost lifeyears (LLY) from COVID-19 (in 2020). It shows that the per capita LLY associated to COVID-19 is particularly high in most of Latin America, Southern Africa, Southern Europe, India, and some of the Pacific Islands. A comparable map for annual averages for other disasters is presented in online Appendix Figure A3. There, the highest annual loss is observed in Sub-Saharan Africa, South Asia, and East Asia.
Figure 9 provides a scatterplot of all the countries in our sample, comparing their costs. Almost all are below the diagonal, so that the 2020 Lifeyears lost from COVID-19 per capita are larger than their average loss from disasters per capita. The one notable exception is Haiti, which experienced a catastrophic earthquake in 2010 (hitting mostly the capital, Port-au-Prince) and whose experience from the pandemic was relatively (!) more benign because of its very young population (though the disease prevalence there might also be underestimated).16

6. Discussion and conclusion
Two caveats are worth noting. For COVID-19, we are only measuring the impact in 2020 (as this paper’s data was collected in early 2021). Obviously, the pandemic has
continued in 2021, as we write this in April 2021, and will most likely continue to have an impact on the global economy well into 2022, and maybe much later. As such, our estimate should be viewed within this context; it measures the impact of the pandemic only in its first year.

On the other hand, our estimate for the pandemic is potentially double counting the mortality/morbidity and the reduction in economic activity associated with this mortality/morbidity. Previous evidence from past pandemics, however, suggests that the vast majority of their economic impact is associated with changing behaviour and policies.
they engender, rather than from direct mortality/morbidity (Noy and Shields, 2019; Noy and Uher, 2021).

In addition, the comparison we are making between the COVID-19 and past disasters’ toll is imperfect. While the data on mortality and the population being directly affected are likely comparable, we are using different concepts to measure the lifeyears loss that is associated with economic impact. In the case of the pandemic, we are measuring the economic loss that is associated with decline in economic activity and the disruption that was initiated by the onset of the pandemic. In contrast, the EMDAT measure for economic loss focuses on the direct damage to assets (a stock measure) rather than the decline in economic activity (a flow measure) that is associated with these events. While this is an important distinction, most assessments find the loss in the flow of economic activity not much larger, in monetary terms, than the stock of damaged assets for most disasters. As such, we believe our conclusions from these (imperfect) comparisons still stand.

To summarise, three important observations are worth repeating: the first is that the loss associated with COVID-19 in 2020 is much larger than the annual loss associated with disasters worldwide. Second, it is the economic loss that dominates this crisis, while most of the public’s and media’s attention is understandably turned to the human health toll, especially the individuals who tragically died. The human and social implications of the economic loss, however, are potentially much greater. Third, it is small countries that have borne a very heavy load that is, to some extent, overlooked. Countries like Guyana and the Maldives are experiencing a very dramatic and painful crisis, largely under the radar of the world’s attention.

We want to emphasise that our conclusion from these finding – that the economic loss is much larger – is not that public policies like lockdowns, border restrictions, and quarantines, were unwarranted. If anything, we observe that the loss of lifeyears is positively correlated across the three dimensions we examine. Generally, countries that experienced a deeper health crisis also experienced a deeper economic crisis. We leave the very important question of what policy responses could have minimised the lifeyears lost to future work.

Notes
1. We thank colleagues who supported the original development of this lifeyears index for the 2015 Global Assessment Report (UNDRR, 2015), particularly Bina Desai, JC Gaillard, Allan Lavell, Moshe Malal, Andrew Maskrey, Aromar Revi, and Julio Serje. Our sincere thanks also go to the editor, Eva-Maria Nag for her patience with our mistakes. Contact: ilan.noy@vuw.ac.nz. EMDAT, published by CRED in UCLouvain, Brussels, Belgium – www.emdat.be (D. Guha-Sapir).
2. An equally valid alternative, if ethically distinct, would be to use life expectancy at the median age (but not life expectancy at birth), instead of 92. However, most of the variability in life expectancy across countries is associated with very different infant and child mortality rates, and thus life expectancy at the median age is not that different across countries. Therefore, using this different assumption would not generate very different results, across countries, or when comparing to the COVID-19 toll.
3. Muir-Wood (2019) points out that there are implicit (and troubling) ethical choices inherent in these measures of DALYs or Lifeyears, as is done here. In particular, there is an implicit decision to put less value on the life of the elderly (implicitly, someone who is 92 years old is completely ignored in both these indices).
4. This number implies that anyone affected would lose 5.4 per cent of a year, if they were affected by the event for the whole year. This is a fairly conservative assessment, since many of those affected by disasters are temporarily relocated (most are not physically injured). See Noy (2016) for more discussion on this assumption.
5. This value may be under-estimated, as not all disaster records in EMDAT contain a value for the amount of physical damage. However, the data is missing for smaller disasters, so overall the under-estimation is likely not very large for most countries.

6. https://www.worldometers.info/coronavirus/.

7. \[ A_{\text{med}}^\text{med} = \sum \text{Age}_{\text{med}} x \%\text{Deaths}_{\text{g}} \], where \( \text{Age}_{\text{med}} \) and \( \%\text{Deaths}_{\text{g}} \) are the median age and share of deaths of age group \( g \). For age group 75+, we assume the median age is 83.5. According to the Worldometers database, the mortality breakdown is 3.9% (for those aged 18-44), 22.4% (for 45-64 years old), 24.9% (for 65-74 years old), and the rest are those older than 74. Children consist of a very small share (0.06%) of the COVID-19 mortality.

8. https://www.hopkinsmedicine.org/health/conditions-and-diseases/coronavirus/diagnosed-with-covid-19-what-to-expect#:~:text=If%20I%20have%20COVID%2C%20when%20will%20I%20feel%20better,whether%20I%20will%20die%20from%20COVID-19%20disease.

9. These assumptions are based on conversations with Ami Neuberger, an infectious disease specialist who headed a COVID-19 unit in a big hospital in Israel during the peak of the pandemic.

10. https://www.worldbank.org/en/publication/global-economic-prospects.

11. The January 2020–2021 Global Economic Prospects Outlook do not provide the GDP growth rate projections for each member country in the eurozone, but the whole area. We invoke the November 2019 and December 2020 OECD Economic Outlook to retrieve the 2020 growth rates forecast before and after the pandemic for each country in the eurozone. Cyprus and Malta are in the eurozone, but not the OECD.

12. There are some obvious explanations for these observations. High-income countries have, on average much lower temperatures facilitating the spread of the virus, much older populations that is more vulnerable to it, and their economies are dependent on service sectors that are more exposed to the disruption associated with the pandemic. It is unclear, however, whether these differences fully explain why, for example, Sub-Saharan African countries have been hit relatively less severely by this pandemic.

13. Compared to the GDP growth rate projected in January 2020, the estimated GDP growth rate of India and China in Jan 2021 falls by 14.6 and 3.9 percentage-points respectively.

14. The differences across countries in the identified case load (morbidity) might be partially due to very different testing regimes across countries. In the case of COVID-19, and many other diseases, morbidity is generally much more precisely identified than mortality.

15. Peru and Spain are the exceptions in this list.

16. In the online Appendix, we include a table that details our sums for each country, both for disasters averaged over the last two decades, and for COVID-19, and calculated separately for the three components of the Lifeyears index. As can be seen in these data, most countries have lost 0.02-0.04 Lifeyears (around 7–14 days), per capita, from the pandemic, most of it associated with the catastrophic economic collapse. The per capita annual losses associated with disasters are an order of magnitude smaller.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1 Total lost lifeyears, by income group.

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