Assessing the Impact of the COVID-19 Pandemic on Mortality: A Comparative Analysis of Period and Cohort Life Expectancy

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INTRODUCTION

In addition to the socioeconomic (Padhan and Prabheesh, 2021) and health implications (del Rio et al., 2020), the COVID-19 pandemic precipitated a tremendous rise in mortality levels in the last few years, manifesting disparately among nations. The impact, usually measured as reductions in period life expectancy at birth, was significant enough to interrupt historical trends of mortality decline. Estimates show more than four years of declines in life expectancy at birth between 2019 and 2021 in Bolivia, Mexico, and the Russian Federation (United Nations, Department of Economics and Social Affairs, Population Division, 2022). Similar analyses show substantial life expectancy reductions in the United States between 2019 and 2021, but not among the Western European countries (Schöley et al., 2022).

Numerous factors, including age distribution, comorbidity profiles, and contextual circumstances, have produced disparities in the pandemic's impact across diverse nations (Dowd et al., 2020; Nepomuceno et al., 2020). Moreover, the pandemic has affected individuals differently based on socioeconomic and demographic attributes. Research has demonstrated that elderly and middle-aged adults, mainly men, have experienced higher fatality rates (Levin et al., 2020; Ramírez-Soto et al., 2021).

Assessing the immediate impact of COVID-19 was essential during the initial stages of the pandemic to inform decisions aimed at controlling the virus's spread. Such applications included implementation of lockdowns, restrictions, vaccination campaigns, and the provision of medical resources. Additionally, understanding the pandemic's long-term implications, including its effects on population size and structure, is crucial for the formulation and efficacy of public policies and pension systems (Tilstra et al., 2024).

However, accurately estimating the pandemic's impact on mortality remains challenging. Death counts from COVID-19 are likely underestimated due to inconsistencies in the testing system, and delays in death registration (Riffe et al., 2021), leading to observed excess all-cause mortality across many regions (COVID-19 Excess Mortality Collaborators, 2022; Karlinsky and Kobak, 2021). Also, assessing long-term implications remains challenging with the current period measures used.

The period life expectancy at birth, obtained by summarizing the mortality experience in a year, was also commonly used to measure the impact of temporary epidemic mortality, including the COVID-19 pandemic (Goldstein and Lee, 2020). Although it is a convenient way of summarizing current conditions and allowing the understanding of temporary changes due to a particular period condition, the measure must be interpreted carefully. The "period" life expectancy relies on the concept of the synthetic cohort, which is a hypothetical cohort of people who would be subject at each age to the age-specific rates of one particular period and does not describe the actual life course of a cohort (Aburto et al., 2021). Unless vital rates are constant over time, no individual faces rates observed during one period (Guillot, 2003). Notably, in pandemics such as COVID-19, life expectancy at birth can be a misleading indicator if considered as a lifespan measure. This happens because it implicitly assumes the epidemic is experienced yearly over and over again as a person ages (Goldstein and Lee, 2020).

Other indicators should be used to obtain more accurate measures for the life course impact of a mortality shock. For instance, one could use cohort measures, which totally incorporate the mortality experience of cohorts alive until a particular year (Kolk et al., 2022). While the period life expectancy at birth ($e_0^P(t)$) uses the mortality experience at a given year as input, cohort measures, such as the cohort life expectancy at birth ($e_0^C(t)$), use the mortality experience from birth to the end of a specific cohort. In this sense, the cohort measure could be seen as more realistic or appropriate to identify life course changes. Nevertheless, it needs the complete mortality experience as input. For incomplete cohorts, for instance, those alive during the pandemic, the measure relies on assumptions for future mortality. This can be complex given the uncertainty regarding the long-term impacts of a mortality shock.

Some authors have tried to disentangle these other perspectives of COVID-19's impact on mortality. For instance, Kolk et al. (2022) analysed changes in period life expectancy between 2019 and 2020, along with changes in cohort life expectancy, and in the Years of Potential Life Lost (YPLL) in Sweden. Despite recent efforts, it is still unsure the impact of the pandemic in lifespans of individuals exposed to it, specially in low- and middle-income countries.

DATA AND METHODS

We used data from the World Population Prospects (WPP) 2024. In particular, we used observed age-specific death rates, deaths and exposures by single age groups for ages 0 to 100+ from 1950 to 2023. We also used forecasted death rates from 2024 to 2100 for all countries in the world. For illustrative purposes, in this paper, we report results for a subset of countries across the globe that represent different mortality experiences during the pandemic, namely New Zealand, Japan, Italy, the United States, South Africa, and Peru. Results for all other countries are available at an online repository.

To supplement the age-specific death rates for the years prior to 1950, we used data from the Human Mortality Database (HMD). Given that the final age group in the dataset is 100+, the oldest cohort in the first year of the pandemic corresponds to individuals born in 1920. Consequently, we employed HMD data from 1920 onward, with variations based on each country's data availability. For the six countries examined in this study, the data began in 1920 for Italy, 1933 for the United States, 1947 for Japan, and 1948 for New Zealand (while South Africa and Peru are not available in the HMD).

A robustness check was conducted to assess the comparability of the two data sources. That involved selecting the year 1950 and visually examining the relative differences in age-specific death rates between the sources. The findings of this comparison are presented in Annex 1. The data sources appear to be consistent up to age 90 for both males and females. The discrepancies identified for ages over 90 do not impact our estimates, as these cohorts were not present in the year 2020.

In the following subsections, we describe the mortality measures used in this paper to estimate the impact of COVID-19 on mortality.

The Period Life Expectancy at Birth

One of the most widely used demographic measures to assess mortality trends is the period of life expectancy at birth. Let $\mu(x)$ denote the force of mortality in a population at age $x = 0, \ldots, 100+$. Period life expectancy at birth at time $t = 2015, \ldots, 2023$ is:

$$e_0^P(t) = \int_0^w \exp\left(-\int_0^x \mu(a)da\right)dx \tag{1}$$

For this study, we approximated $\mu(x)$ using the observed age-specific death rates m_x^P obtained from the WPP between 2015 and 2023. Indeed, m_x^P is the maximum-likelihood estimator of $\mu(x)$ when the force of mortality is assumed to remain constant over each age class (see, e.g., Currie, 2016). We summarized period age-specific death rates into life tables using standard demographic methods (Preston et al., 2001), and estimates for the life expectancy at birth were obtained by sex. Following previous work that tried to measure the pandemic's impact (Schöley et al., 2022), we subtracted life expectancy at birth estimates of the years 2020 onward from estimates of 2019, the last year before the COVID-19 pandemic.

Given the observed association between COVID-19 fatality rates and age (Levin et al., 2020; Ramírez-Soto et al., 2021), we also analysed the contribution of different age groups to the change in life expectancy between 2019 and 2021. For that, we applied Arriaga (1984)'s age decomposition of differences in life expectancy comparing the change in the levels from 2019 to 2021 by sex.

The Cohort Life Expectancy at Birth

As an alternative method for evaluating the pandemic's impact on mortality, we propose the use of cohort life expectancy estimates. Cohort life expectancy, which accounts for the entire mortality experience of a specific cohort, provides a more realistic measure of life course changes. However, the measure requires complete mortality experiences as input. For incomplete cohorts, such as those that were still alive during the pandemic, the estimates depend on assumptions regarding future mortality. Additionally, to assess the effect of a period shock, a counterfactual scenario is needed, removing the influence of the disturbance.

In this study, we estimated cohort life expectancies using two distinct approaches: one based on the forecasts provided by the WPP, and the other using age-specific death rates forecasted with the Smooth Poisson Lee-Carter method (Delwarde et al., 2007).

Linear Interpolation with WPP forecasts

The first approach assumes that cohorts will experience the forecast mortality levels provided by the WPP until 2100 as the baseline scenario. We also constructed a counterfactual scenario to estimate mortality levels in the absence of the pandemic. This approach follows the methodology outlined in the World Population Prospects 2022 report (United Nations, Department of Economic and Social Affairs, Population Division, 2022), in which most mortality levels are assumed to return to pre-pandemic levels after 2024. Therefore, we estimated a new set of age-specific mortality rates for the years 2020, 2021, 2022, and 2023 by performing a linear interpolation of age-specific death rates between 2019 and 2024, disaggregated by age group, sex, and country.

We performed a robustness check to evaluate the accuracy of the interpolation. Specifically, we selected the age of 60 and visually compared the linear interpolation with the WPP age-specific death rate estimates between 2020 and 2023. We present the results of this comparison for both males and females in Annex 2. Additional results for other age groups are available in the online repository. The findings indicate that the interpolation provides consistent results. The trends observed up to 2019 were effectively extrapolated, gradually aligning with the forecasted mortality levels for 2024.

Subsequently, we converted the WPP period age-specific death rates (m_x^P) between 1950 and 2100 into cohort age-specific death rates (m_x^C). This same transformation was applied to m_x^P between 1950-2100 with the linear interpolation in 2020, 2021, 2022, and 2023. To approximate the cohort rates, we calculated the average of two diagonals across the years, thereby capturing the life course of the respective cohorts, as suggested by Schmertmann (2024).

Figure 1 presents how these estimates were obtained with the period data for the cohort born in 1950. It should be noted that using the age-specific death rates by single age groups instead of by Lexis diagrams introduces a small bias in the derivation of cohort death rates (van Raalte et al., 2023), which is however significantly reduced by taking the average of two diagonals (Schmertmann, 2024). Further research could, for instance, use deaths and exposures by Lexis diagrams, which were, however, unavailable to us.

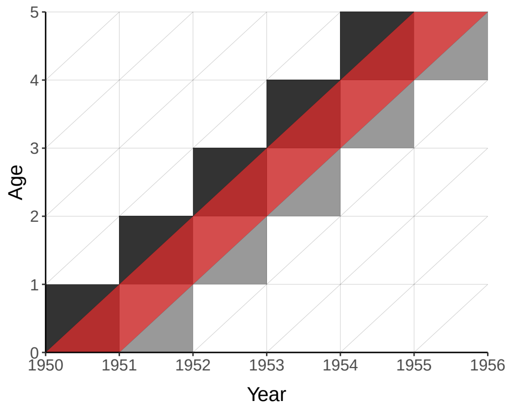

Figure 1: Lexis representation of the difference between the two data structures. Properly structured age–cohort data are represented in red, and approximating cohorts by averaging the diagonals of age–period data are represented in dark and light gray.

The m_x^C from both the WPP estimates and the counterfactual scenario were later summarized into life tables, from which the cohort life expectancy at birth (e_0^C) was calculated for all cohorts. The impact of the pandemic was assessed by subtracting the e_0^C obtained using the WPP estimates from the e_0^C derived from the counterfactual scenario. Negative differences in the measure indicates losses in life expectancy at birth for the respective cohort, attributable to unexpected deaths during COVID-19 years.

In this approach, we opted not to use the forecasts provided by the World Population Prospects (WPP) 2019 (obtained before any influence of the pandemic) as a counterfactual due to some methodological considerations. Firstly, the WPP 2019 forecasts are presented in 5-year intervals. In order to obtain single-year estimates, additional assumptions would be necessary, which introduces potential inaccuracies. Moreover, our supplementary material demonstrates the efficacy of the applied linear interpolation in approximating demographic trends. Finally, WPP 2024 incorporates adjustments for pre-pandemic years and re-calibrations reflecting changes in migration, fertility, and mortality patterns during the pandemic period, which significantly impacts mortality rates.

Smoothed Lee-Carter

Our second approach uses death and exposure data up to 2023, applying a smoothed version of the Poisson Lee-Carter model, as proposed by Delwarde et al. (2007), to project future mortality levels until 2100. This method is an extension of the Lee-Carter method (Lee and Carter, 1992) in a Poisson framework (Brouhns et al., 2002) in which the age-specific components α_x and β_x are smoothed penalizing the (log-)likelihood (Delwarde et al., 2007). The smoothing parameters are selected through Bayesian Information Criterion (BIC) minimization.

The decision to use the smoothed Poisson Lee-Carter model was motivated by the fact that transitioning from a Gaussian to a Poisson framework allows for a more accurate modelling of human mortality (Basellini et al., 2023). Additionally, smoothing can be particularly relevant when modelling periods characterized by significant disruptions in mortality rates, such as the pandemic. Without smoothing, the original Lee-Carter model could produce unrealistic forecasted age profiles in response to such pronounced changes.

We applied the Smooth Lee-Carter model in two distinct scenarios. First, we used data up to 2023 to forecast mortality rates until 2100. Second, we applied the method to data up to 2019, excluding the effects of COVID-19, and obtained a counterfactual scenario until 2100. By obtaining our own forecasts in the two scenarios, we were able to consider the possibility that the mortality shock caused by the pandemic would not necessarily be absorbed in years after 2024 (as in the WPP forecasts), leading to a shift in the mortality rates.

Following the same procedure outlined in the previous subsection, we approximated the cohort rates (m_x^C) by calculating the average of two diagonals across the years in the period data, and computed the estimated e_0^C for all cohorts under the two scenarios. We then estimated the impact of the COVID-19 pandemic as the differences between the two measures.

In this case, however, the impact of COVID-19 is not only assumed for the years between 2019 and 2024. Instead, the effect could be reflected in all the forecasted years, as there is no assumption on the return of mortality to pre-pandemic levels, leading to a potentially lasting impact of the pandemic over the life courses.

RESULTS

We assess the impact of COVID-19 by deriving estimates from various measures, as detailed in the Data and Methods section. As a baseline, Figure 2 presents the results on period life expectancy at birth. The data indicate a consistent increase in life expectancy between 2015 and 2019, followed by divergent trends across the six selected countries after 2020.

In New Zealand and Japan, increases in period life expectancy were observed during the first years of the pandemic. Due to stringent restrictions and high vaccination rates since 2021, both countries experienced low COVID-19 mortality between 2020 and 2021 (Baker et al., 2020; Munira et al., 2023). Additionally, behavioural changes induced by the pandemic, along with reduced social and work activities, may have contributed to a decline in deaths from other causes, thereby lowering overall mortality levels (Castro et al., 2023). Between 2019 and 2021, male life expectancy at birth in New Zealand increased by approximately seven months (from 80 in 2019 to 80.6 in 2021), while female life expectancy increased by around four months (from 83.7 to 84 years). Similarly, in Japan, life expectancy at birth for both males and females increased by about one month, from 81.4 years in 2019 to 81.5 years in 2021 for males and from 87.5 years to 87.6 years for females over the same period.

After 2021, however, both countries experienced a decline in life expectancy levels, potentially due to a reverse harvesting effect or postponement of deaths during pandemic years. In New Zealand, period life expectancy at birth declined by around 13 months for males and 17 months for females in 2022, reaching levels of 79.5 and 82.6, respectively. In Japan, declines of around 5 months for males and 6 months for females were observed between 2021 and 2022, with life expectancy reaching levels of 81,1 and 87,1 respectively. In 2023, life expectancy at birth seem to return to pre-pandemic levels in both countries.

In Italy, a significant impact was observed in 2020, followed by a partial rebound in 2021. The difference in period life expectancy at birth between 2019 and 2021 was approximately 7 months for males (from 81.2 in 2019 to 79.9 in 2020, and 80.6 in 2021) and 4 months for females (from

85.4 in 2019 to 84.5 in 2020, and 85.1 in 2021). In 2022, however, life expectancy levels seem to decline again, returning to levels observed in 2020 (79.6 for males, and 84.5 for females). After 2023, life expectancy seem to increase, reaching 81.6 for males and 85.8 for females in 2023, higher than pre-pandemic levels.

The United States experienced a substantial decline in life expectancy during the first year of the pandemic, a trend that continued into 2021 (Schöley et al., 2022). Reductions of approximately 35 months for males (from 76.5 to 73.6 years) and 25 months for females (from 81.5 to 79.4 years) were estimated between 2019 and 2021. After 2021, however, life expectancy at birth presented a continuous increase in 2022 and 2023, reaching levels of approximately 76.9 for males and 81.9 for females in 2023.

In South Africa and Peru, period life expectancy witnessed a continuous decline throughout 2020 and 2021. This outcome underscores the severe impact of the pandemic on Latin American and African countries. Structural inequalities in Latin America and the Caribbean exacerbated the region's vulnerability to the pandemic. In Peru, the healthcare system struggled to cope with the surge in cases, leading to delays and disruptions in both COVID-19 and non-COVID-19 healthcare services (Ezequiel et al., 2020). By June 2021, Peru reported the highest excess mortality per 100,000 inhabitants globally (Karlinsky and Kobak, 2021).

In South Africa, the decline in life expectancy was pronounced. Between 2019 and 2021, male life expectancy at birth decreased by approximately 41 months (from 62.8 to 59.4 years), while female life expectancy decreased by around 52 months (from 69.3 to 65 years). In Peru, similar trends were observed, with life expectancy decreasing by approximately 64 months for males and 47 months for females (from 74.1 to 68.8 years for males, and from 78.6 to 74.7 years for females). For 2022 and 2023, life expectancy presents a continuous increase in both countries. In South Africa, male life expectancy in 2023 was estimated at 62.6, while female life expectancy was estimated around 69.6, levels similar to the ones observed pre-pandemic. In Peru, male life expectancy at birth in 2023 was estimated around 75.4, and female life expectancy was estimated around 80.1, levels higher than pre-pandemic.

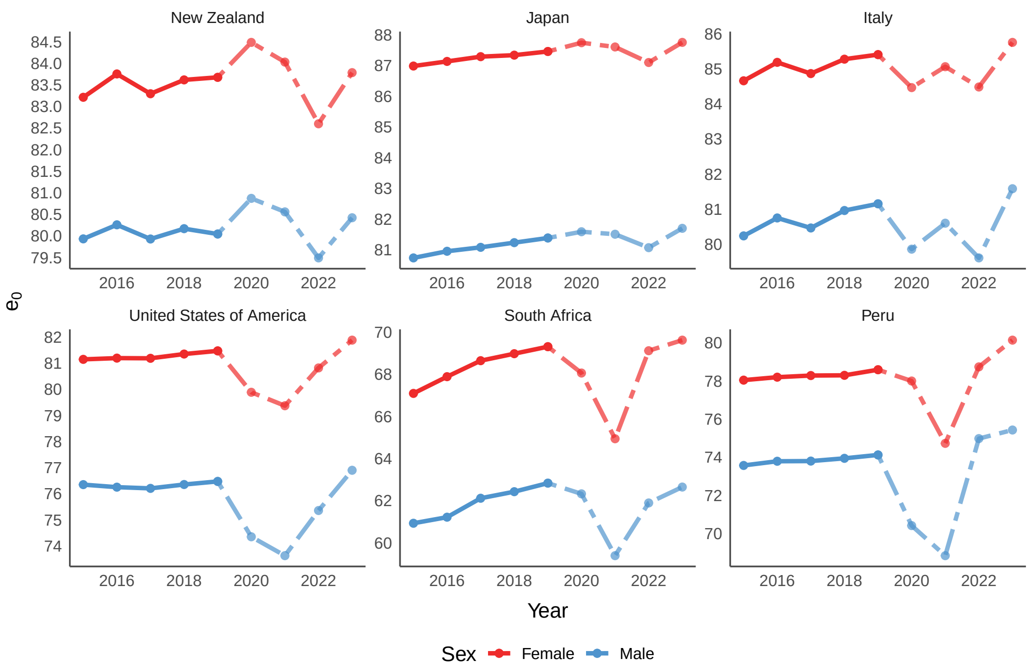

Figure 2: Trends in period life expectancy at birth, 2015-2023

Given the age-related variations in COVID-19 fatality rates, we analyzed the contribution of each age group to the differences in life expectancy at birth between 2019 and 2021 and between 2021 and 2023 using Arriaga (1984)'s age decomposition method. The results are depicted in Figure 3. As anticipated from the increases in life expectancy over the first period (2019-2021), almost all age groups in New Zealand and Japan showed positive contributions to the change in life expectancy. In New Zealand, minor negative contributions were observed among females around age 80. Notably, the contributions of males were higher than those of females.

In Italy, the most significant negative contributions were observed in the age range of 60 to 85 years old. Positive contributions were observed among older adults. Additionally, there were no significant contributions observed up to approximately 50 years of age. In the United States, all age groups exhibited significant negative contributions to the change in life expectancy at birth.

In South Africa, substantial negative contributions were noted at older ages for both males and females, especially between 55 and 90 years. Unlike the other countries, a significant positive contribution was also observed in the youngest age group among both males and females.

In Peru, which exhibited the most significant decrease in period life expectancy between 2019 and 2021, the age groups between 55 and 70 years were primarily responsible for the negative change. Compared to the other countries, Peru showed a marked concentration of contributions within certain age groups, especially among men. For example, at around 65 years of age, negative contributions of approximately 0.4 years were observed. Conversely, a small positive contribution was observed in younger male age groups, potentially due to reductions in deaths from external causes during the pandemic, particularly traffic accidents (Calderon-Anyosa and Kaufman, 2021).

Overall, in the first period analyzed, the negative contributions exhibited different age patterns across countries. For instance, in Italy, negative contributions were more pronounced at older ages compared to the United States, South Africa, and Peru. Furthermore, contributions were more dispersed across age groups in the United States, whereas in South Africa and Peru, significant changes in life expectancy were concentrated within a few age groups. Additionally, positive contributions were observed among older age groups in Italy, and the first age groups in South Africa and Peru.

For the second analyzed period, between 2021 and 2023, results present a different pattern. With the exception of the first age group in Peru, all age groups from all countries seem to present contributions on the opposite direction of the ones obtained in the first period. This result aligns with the trend observed for period life expectancy over these four years. Due to a process called harvesting effect (Schwartz, 2000), life expectancy levels tend to return to previous levels after the occurrence of a shock, such as during the pandemic.

As discussed, although it is helpful to compare changes in mortality rates over the years or between populations, the period life expectancy at birth can be a misleading indicator in the context of a mortality shock if considered as a lifespan measure. The previous results do not indicate that among Peru's male population alive during the pandemic years, there was an average loss of 64 months of life. Instead, they indicate losses in the average length of life of a hypothetical cohort of individuals if they had experienced the mortality conditions observed in a pandemic year throughout their lives. It is doubtful that this would be the case for any cohort of individuals. Additionally, the decomposition results indicates that the same way period life expectancy was extremely affected during the first years of the pandemic, the measure is also very affected on the following years due to a stability process affecting the mortality rates after a shock. This sensibility of the measure indicates again that other measures might be more appropriate for evaluating mortality changes in periods of shocks.

We present alternative results for the impact of the COVID-19 pandemic on mortality using the cohort life expectancy at birth. For that, we used two methodologies. The first, with results presented on Figure 4 uses WPP 2024 forecasts until 2100 and a linear interpolation to create a counterfactual scenario during COVID-19 years. In this approach, we consider that the pandemic's impact would be absorbed over 2020-2023, and that from 2024, mortality levels would return to pre-

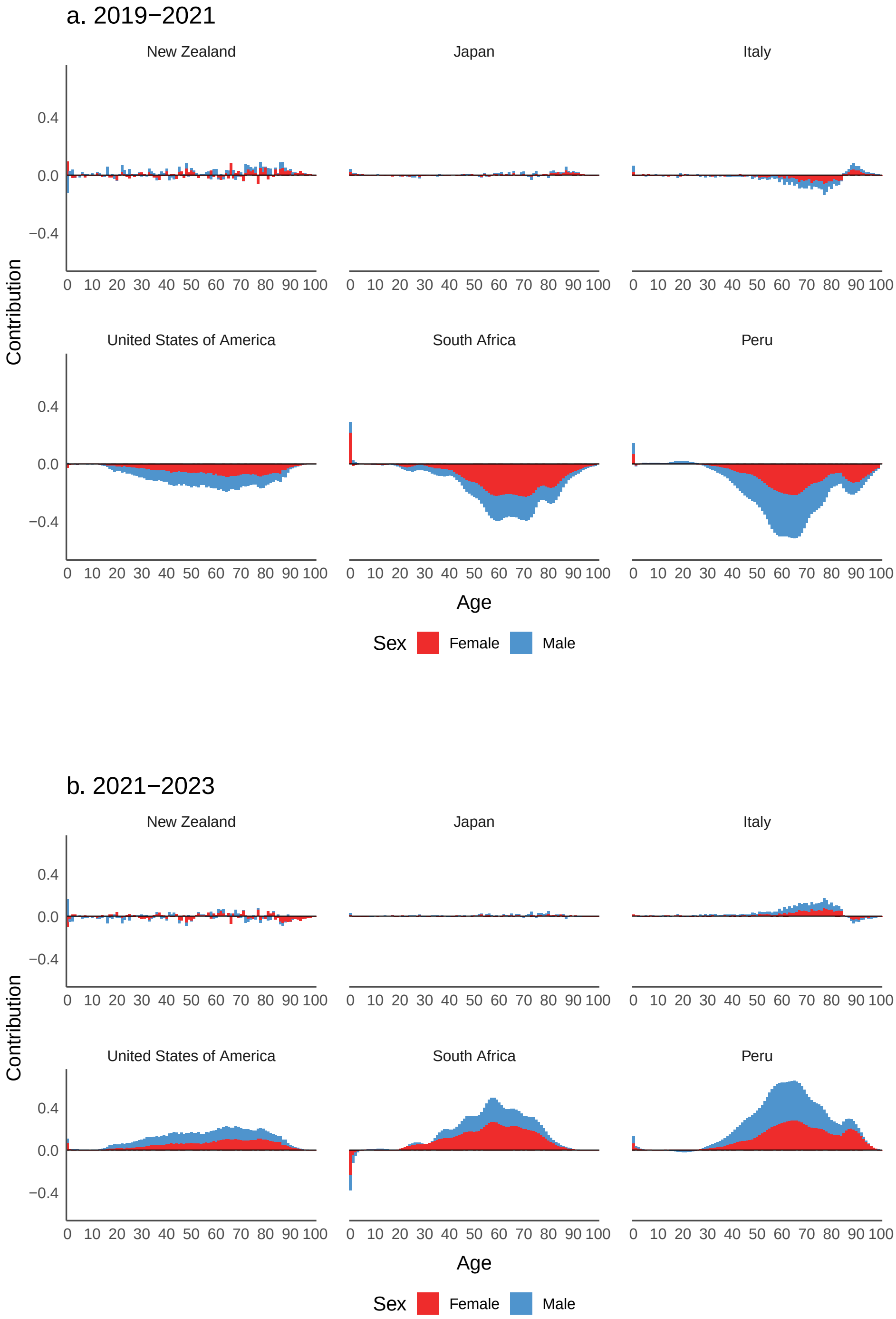

Figure 3: Age-Decomposition of differences in life expectancy at birth between (a) 2019 and 2021, and (b) 2021 and 2023

pandemic, following the methodology adopted by WPP 2022. The results are presented in months of change in cohort life expectancy by birth cohort from the counterfactual scenario that excludes the impact of the pandemic.

From the results is possible to observe that in New Zealand and Japan, as expected, the change in cohort life expectancy was close to zero for most cohorts. For some cohorts in New Zealand estimates of positive changes of one month in cohort life expectancy are also observed among males, such as for those born around 1950, 1960 and around 2000. In Italy, the change in cohort le for those born around 1920 was close to zero. The impact increases until cohorts born around 1950 (70 years in 2020), with changes around -1.5 among males. The change slowly decreases, until approaching close to zero again for those born around 2000.

Similar results were found in the United States, but at higher levels. For those born around 1930 in the country, the change in cohort life expectancy when considered the effects of the pandemic were close to -0.5. The change decreases until around -2 for those born around 1960 (60 years in 2020), especially among males, and increases again until reaching -1 month for males born around 2000 and -0.5 for females born in the same year.

In South Africa, women seem to have been the most affected by changes in cohort life expectancy. For those born around 1950 (70 years in 2020), decreases of more than two months were observed, and around 1.5 among males. This change increases until reaching 0.5 months added in cohort life expectancy for males born around 1975, and 1 month for females born around 1980. Female changes in cohort le maintain positive until around cohort 200, while for males, negative changes of -1 month in cohort le are observed until cohort 2000. In Peru, the most affected cohorts were born around 1955, with decreases of around 3.5 months in cohort le for males and 1.5 for females. The change decreases, until reaching close to zero for both males and females born around 1990. Among all countries, the difference between cohorts reflects the age-pattern of changes in mortality during the pandemic.

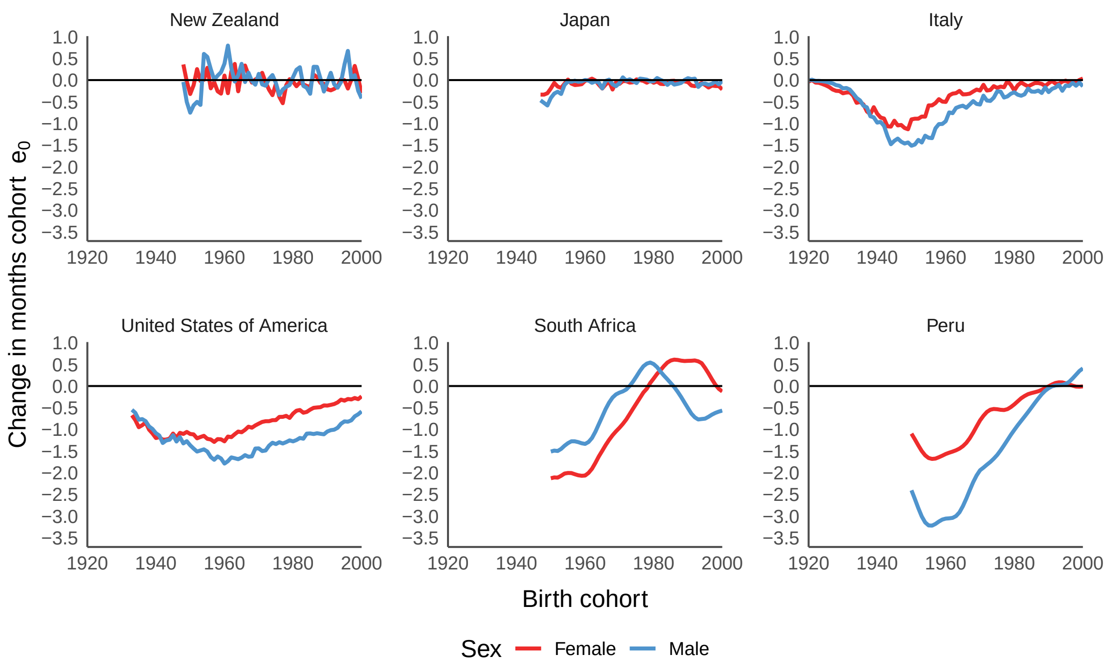

Figure 4: Change in cohort life expectancy at birth by birth cohort

We also obtained estimates of cohort life expectancy using the Smoothed Poisson Lee-Carter (Delwarde et al., 2007) to obtain forecasted age-specific death rates until 2100. In this approach, we use data starting in 1950 for all countries and finishing either in 2019, to obtain a counterfactual scenario with no influence of Covid-19 in the forecasts, or in 2023. For each forecasted scenario, we transformed the period into cohort rates and obtained estimates of cohort life expectancy at birth. The impact of the pandemic was measured by subtracting the estimates obtained with data until 2023 from the ones obtained with the counterfactual scenario with no Covid-19 influence. Results are depicted in Figure 5.

For this approach, the impact of the pandemic can be reflected in all forecasted years, as there is no assumption for the return of mortality rates to pre-pandemic levels. In this sense, in comparison to the previous results obtained with the linear interpolation, estimates of changes in cohort le can present a continuous growth, as the earliest cohorts are longer exposed to potential lasting effects of the pandemic. This pattern was observed in New Zealand, Japan, Italy, South Africa and Peru. In those countries, the change in cohort le for those born around 1950 or earlier is close or smaller than -5 months. This change increases over the most recent cohorts, and effects around -15 months are estimated for cohorts born around 2000n in South Africa and Japan, for example. In the United States the effect is estimated to be around 1 month for all cohorts analyzed, with small variations for those born around 1960 and 1990. In Peru, positive changes in cohort life expectancy are observed for all cohorts. This result could be reflecting the significant increase in period life expectancy in 2023, in which levels were estimated to be higher than pre-pandemic. Since forecasts for the scenario with influence of COVID-19 includes the year of 2023, which in this case reflects a significant mortality improvement in the country, forecasts lead to potential gains in cohort life expectancy during Covid-19. Future steps in this project aims to better understand the mechanisms leading to this positive result.

To summarize, even when considering a potential lasting effect of the pandemic in mortality, when accounting for the whole mortality experience of cohorts exposed to the pandemic, the impact on mortality is estimated to be around 15 months among the most affected ones in South Africa, while changes of around 64 months in period life expectancy are reported during the pandemic. When considering the impact of the pandemic only over 2019-2024, changes in cohort life expectancy falls to around 4 months.

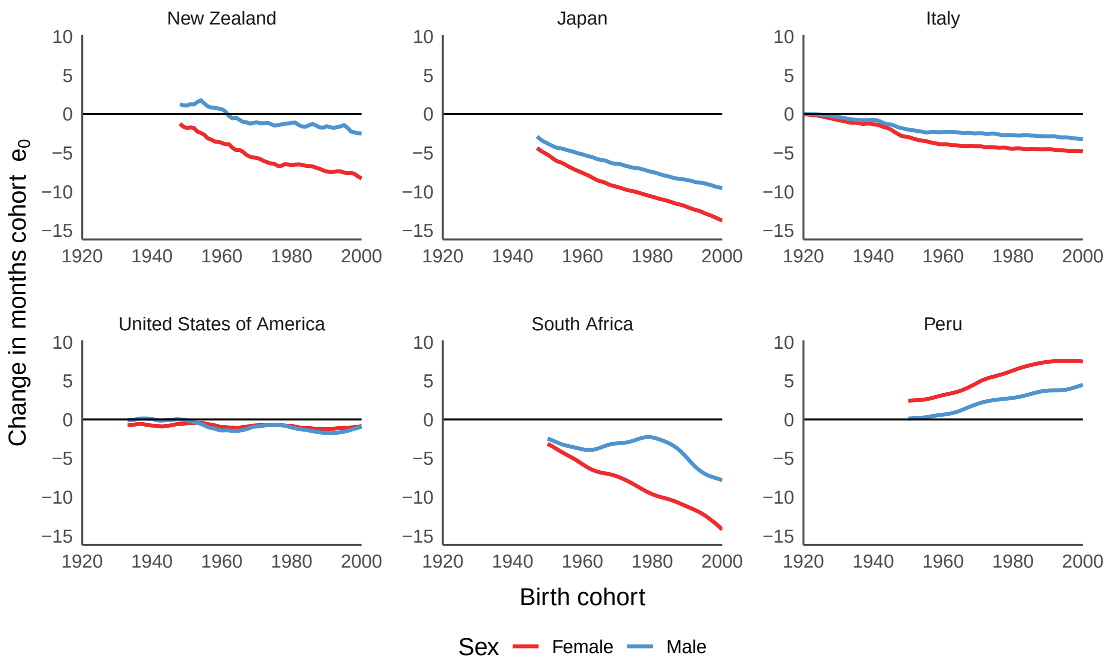

Figure 5: Change in cohort life expectancy at birth by birth cohort - Smoothed Lee-Carter

CONCLUSIONS

Measuring the short- and long-term impact of a mortality shock, such as the COVID-19 pandemic, is essential, but challenging. Despite the data issues and difficulty in removing the interaction with other causes of death, different measures can summarize the influence of a pandemic on mortality. For instance, to intermediate immediate actions to control the virus spread, several estimates of changes in excess mortality, period life expectancy, and years of life lost were obtained. Although they are convenient ways of summarizing current conditions and allowing the understanding of temporary changes due to a particular period condition, these measures don't offer assessments on the long-term implications of the pandemic on mortality.

Given the strong association between fatality rates and age, it is expected that the effects of the pandemic will be perceived differently by each birth cohort. Therefore, it is essential to consider together with standard period measures such as the period life expectancy and excess mortality measures that capture the real lifespan impact of the pandemic on mortality.

This study uses data from the World Population Prospects (WPP) 2024 and the Human Mortality Database (HMD). We compute estimates of cohort life expectancy at birth using two approaches for all countries available in the WPP dataset. Results were obtained using the WPP forecasts and a linear interpolation to obtain estimates in a counterfactual scenario with no influence of COVID-19, and by forecasting the death rates until 2100 using the Smoothed Poisson Lee-Carter. We highlight the results obtained for New Zealand, Japan, Italy, the United States, South Africa, and Peru. Results for other countries can be obtained in an online repository.

Despite the reductions of more than 40 months in male life expectancy at birth between 2019 and 2021 in Peru, South Africa, and more than 35 months in the United States, we estimate that the most expressive change in cohort life expectancy, when subtracting from a conterfactual scenario in the absence of the pandemic, was close to four months for males born around the 50's in Peru. Additionally, estimates with an approach that considers a lasting effect of the pandemic presents changes of 15 months in cohort life expectancy among the most affected cohorts in South Africa.

This result highlights the necessity of interpreting period measures carefully in the context of a mortality shock and contributes to the discussion of the mortality impact of the pandemic by including other measures, such as the cohort life expectancy at birth. Additional analysis are still to be conducted to better understand the mechanisms behind the results obtained with the Smoothed Lee-Carter.

It is important to note that all measures have limitations. For this work, our approach relied on future assumptions for the mortality levels and the use of a contrafactual scenario, which is a hypothetical situation where the pandemic did not occur, removing excess deaths from the expected mortality in the years of COVID-19.

It is uncertain what the long-term impacts of the pandemic on mortality will be. Although the results indicate that the effects of the pandemic were not expressive in terms of months lost over the life course of individuals exposed to it, it is essential to be aware that COVID-19 had several impacts in other spheres, such as in physical and mental health, economics, besides the massive loss of life, especially in developing countries.

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SUPPORTING INFORMATION

Annex 1

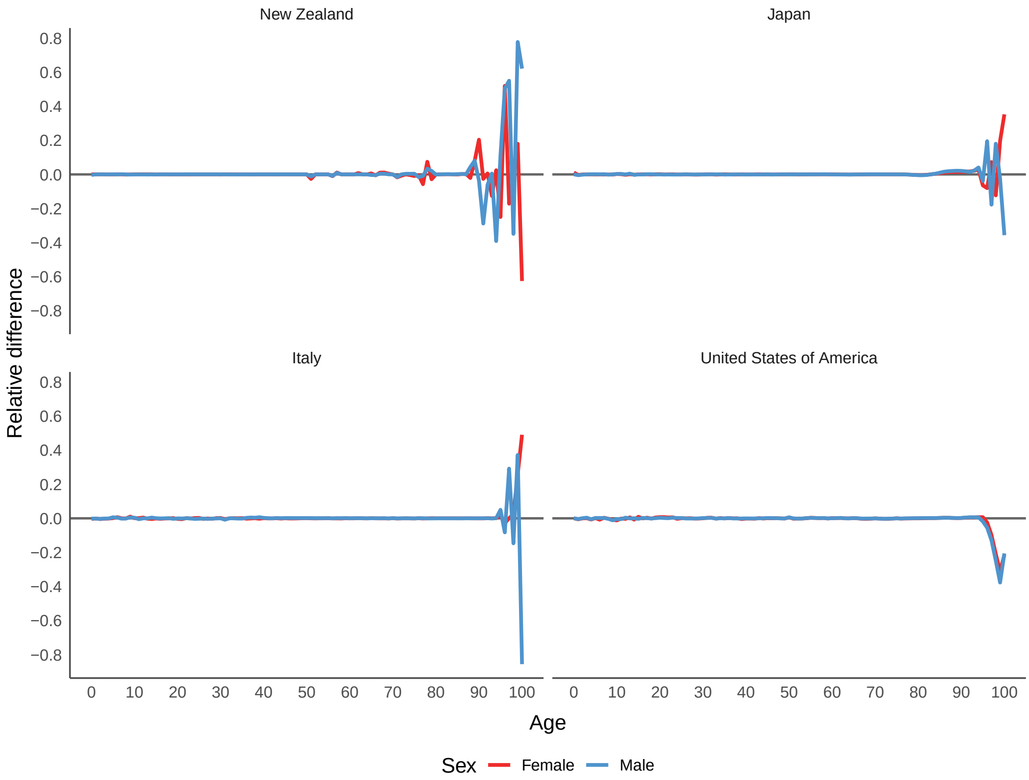

Figure 6: Relative age-specific mortality rates difference between HMD and WPP 2024 in 1950 with reference to WPP 2024

Annex 2

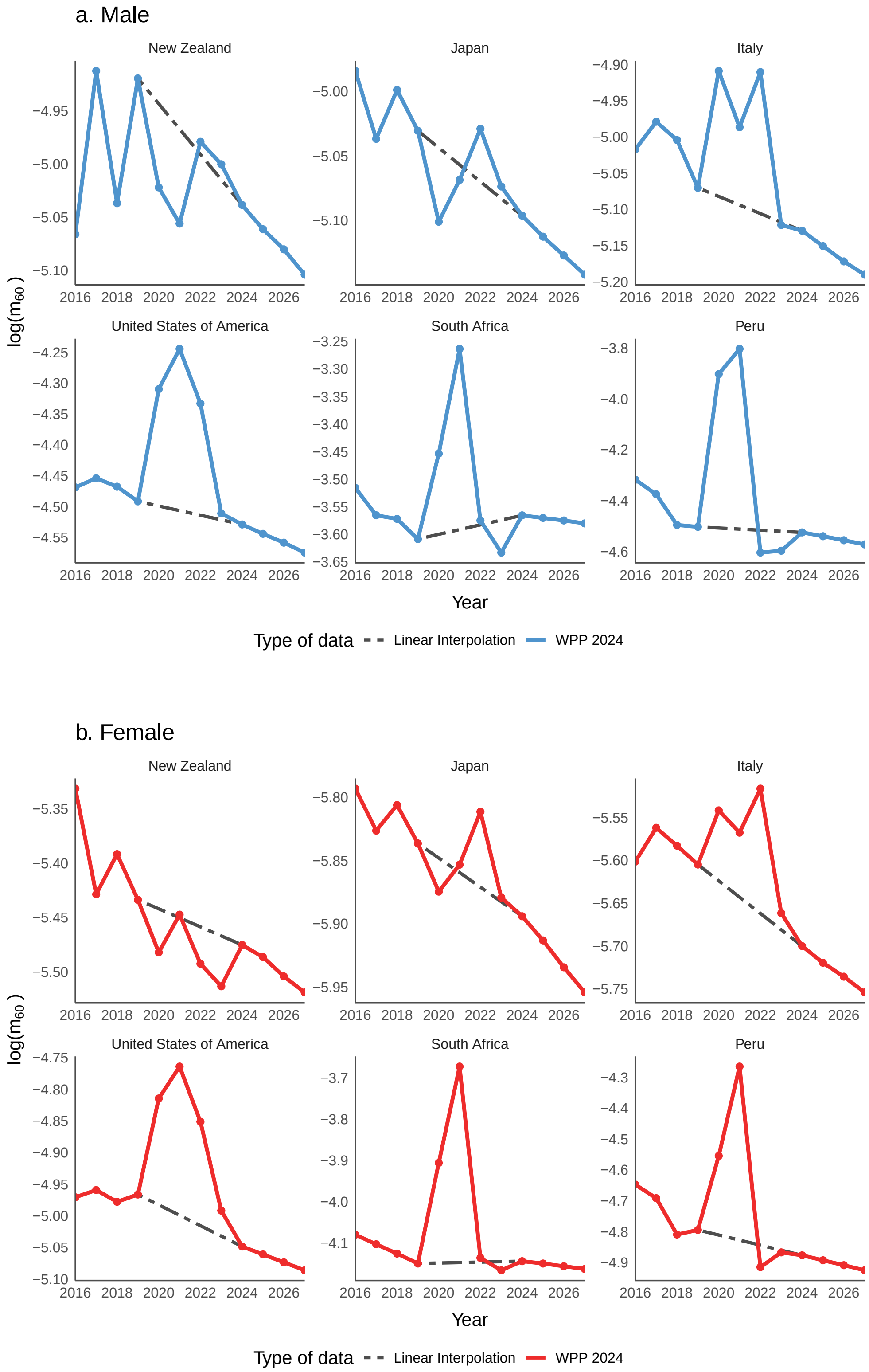

Figure 7: Linear Interpolation at age 60, Males and Females, 2016-2027