Quantifying the economic value of mortality change and full income change for 1990-2019 and the COVID-19 pandemic 2020-2023

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Abstract

Background: The world has experience large declines in mortality rates over the past decades, but these gains are not reflected in commonly used economic welfare measures. This paper estimated the changes in full income, defined as the sum of income growth and the value of change in mortality rates for the three decades between 1990-2019, and the three years (2020, 2021, 2022) under the COVID-19 pandemic, by world regions.

Methods: For each region and top 30 most populous country, decade, and age group, we calculated the economic value of mortality risk change as a percentage of the starting income. For each region and decade, we then calculated the age-weighted value of mortality change and added the change in income in the same time period to estimate the change in full income. We estimated the proportion of change in full income is due to mortality risk reduction and calculated the value of a one-year gain in life expectancy (VLY).

Results: Globally, the value of decadal mortality change was 18% of the world income between 1990-2000, 24% in 2000-2010, and 14% in 2010-2019. In comparison, the average decadal change in global income was 14, 25, and 24% in the three decades, respectively. Changes in mortality risk contributed to 55, 48, and 40% of the change in full income in the three decades. The VLY was estimated globally at 7, 6, and 5% the starting income in the three decades. We observed wide variations across world regions and the top 30 countries.

Conclusion: Mortality changes play a large role in the measurement of population well-being. Our estimates of the full income change suggest a more comprehensive view of changes in population well-being than either income change or mortality change alone.

Abstract word count: 287

Main text word count: about 4500

Introduction

The world has experience large declines in mortality rates over the past decades. Globally between 1990 and 2019, life expectancy at birth increased rapidly from 64 to 73, and mortality rates declined by 57, 72, 43, 34, and 31% for ages 0, 1, 15, 35, and 70, respectively (United Nations Population Division 2022). However, commonly used economic welfare measures, such as the gross domestic product (GDP), do not reflect the value of such large gains in human lifespan. Composite indices, such as the Human Development Index, combine GDP with indices of education and life expectancy, and have been prominently featured in policy dialogues. In the academic literature, previous studies have assigned monetary values to the non-income components of the national account. This type of "full income approach" was introduced first by Usher, who calculated the value of changes in life expectancy and to compare it to the value of change in national income (Usher 1973) . Using similar approaches, Nordhaus (2002), Bloom, Canning, and Jamison (2004), Becker, Philipson, and Soares (2005), and Cutler and Richardson (1997) incorporated the value of gains in longevity to their full income measure (Nordhaus 2002; Bloom, Canning, and Jamison 2004; Becker, Philipson, and Soares 2005; Cutler et al. 1997). In 2013, the Lancet Commission on Investing in Health, co-chaired by two of the authors of this paper, defined growth in full income in a time period as the sum of the income growth (measured in the national income accounts) and the value of the change in mortality (Jamison et al. 2013). They found that 11% of recent welfare growth in low- and middle-income countries can be attributed to reduction in mortality. They further introduced a metric called value of a life year (VLY), which is the value in a country or region of a one-year increase in life expectancy. They estimated that in low- and middle-income countries, one VLY was 2.3 times per person income. Other studies included sectors beyond health in their full income, such as natural capital, leisure, and human capital (Arrow et al. 2012; Fleurbaey and Gaulier 2009; Jones and Klenow 2016).

This paper builds and improves on the methodologies proposed by previous studies. We have identified two major limitations in the existing literature. First, most of the aforementioned papers apply the value per statistical life (VSL) approach to value gains in life expectancy, and not the change in mortality risk. The VSL captures an individual's marginal rate of substitution between income and the risk of dying in a defined time period (Robinson, Hammitt, and

O'Keeffe 2019). It reflects the value an individual place on the change (mostly reduction) in mortality risk, and not the level of the risk itself. However, the concepts of levels and changes in mortality risk (or life expectancy) are often conflated in the existing literature. Several previous work assign the VSL to a person's remaining life years without defining the comparator (i.e., is the change calculated from a reference year or a reference population?) (Jones and Klenow 2016; Cutler et al. 1997). While Becker, Philipson, and Soares (2005) acknowledged this difference by first stating that their objective is to estimate the monetary value of longevity gains, they nevertheless assign the VSL to the level instead of change in longevity(Becker, Philipson, and Soares 2005). [1] Bloom, Canning, and Jamison (2004) estimated the economic impact of AIDS epidemic in Kenya by calculating the change in full income between 1990 and 2000 (Bloom, Canning, and Jamison 2004). They (appropriately) assigned the VSL to the changes in AIDS mortality rates and found that the impact corresponded to a decline in income of 1.7 percent a year during the decade, which was higher than existing estimates of the effect of AIDS on national income. Second, there is a lack of thorough discussion on the choice of appropriate VSL for low- and middle-income countries. Given the lack of high-quality, country-specific estimates for VSL, a common approach is to choose a base value estimated for a high-income country (typically United States or OECD countries) and extrapolate it based on income difference to lower-income countries. Full income estimates are sensitive to the assigned VSL: the choice of using gross domestic product (GDP) versus gross national income (GNI), purchasing power parity (PPP), income elasticity, whether to adjust for baseline risk, size of mortality risk change, and whether to apply minimum floor to the extrapolated VSL are thus critical (Robinson, Hammitt, and O'Keeffe 2019; Chang et al. 2017). Yet, in existing studies, limited justification is provided on how these choices were made. We will closely follow the recommendations from the Harvard BCA reference case and provide results base on the standard reference cases (Robinson et al. 2019).

Full income measures and related metrics, such as the VLY, have played a significant role in recent global health priority setting discussions. For example, based on the VLY estimates, Jamison et al. (2013) estimated that the economic benefits of a set of recommended health investments could yield a benefit-cost ratio of between 9-20 during the period of 2015-2035 (Jamison et al. 2013). The World Health Organization's (WHO) Global Investment Framework

[1] Becker, Philipson, and Soares (2005) P.283 "Since the approach discussed in Section I does not allow us to calculate the value of given levels of life expectancy, but only the value of changes in life expectancy, we are forced to use the 1960 value of income per capita rather than "full income."

for women's and children's health used the VLY to estimate the socioeconomic returns of a set of health interventions (Stenberg et al. 2014). Similar approaches were recently taken for the investment case for the WHO and adolescent health (Sheehan et al. 2017; 2022). As such, updated estimates of the VLY will be a timely contribution for future benefit cost analyses in global health.

Following the general framework of the full income approach and addressing the limitations listed above, we will estimate the economic value of mortality changes between 1990-2000, 2000-2010, and 2010-2019 for world regions. We will measure the changes in full income (by adding income changes) for each decade and estimate the VLY. We separately estimate the values for years 2020-2023 to illustrate changes in income, mortality, and full income during the COVID-19 pandemic.

Methods

The model

We first define the economic value of remaining lifetime income for an individual for each age with current annual survival probabilities and annual income. We consider a one-period substitution in which the individual can trade off a share of their current income in exchange for an increased or decreased survival probability. We identify the point at which she is indifferent between continuing under the current and future survival probabilities. If the future survival probabilities are higher (i.e., lower mortality rates), she will be willing to forgo a proportion of this year's income in exchange. Conversely, if the future survival are lower (i.e., higher mortality rates), she will expect to be compensated. The economic value of mortality change in a given year is thus measured as the percentage of annual income an individual is willing to forgo/accept to live that year at the future survival probabilities. We take the value of statistical life year (VSLY) approach, in which the value is proportional to multiplying the VSLY by the expected change in life years.

Under our model, two inputs determine the level of value. The first input is the functional form of the utility function. Typical economic models used in global health apply a linear relationship between the size of risk change and its associated economic value. Some have suggested non-linear functions, such as a logarithmic form, is more suitable (Cardoso and Dahis 2024)(Chang et al. 2024 to be added) For simplicity, we maintain the linear model because the mortality risk changes during the time periods are relatively small. The second

input is the empirical value per statistical life (VSL) estimate. The VSL is defined as the marginal rate of substitution of income for survival probability, and typically VSL estimates come studying working age populations in high-income settings.

For each region, decade, and age group, we calculate the economic value of mortality risk change as a percentage of the starting income (for example, for decade 2000-2010, the value will be presented as a percentage of 2000 GNI per capita). For each region and decade, we then calculate the age-weighted value, and present this figure as the headline result. The estimate therefore reflects not only the changes in age-specific mortality rates, but also the population age structure. As an example, even if two countries experienced the same mortality rate changes in each age group, the country with a younger population will have higher economic value of mortality change (because younger populations have longer remaining life years).

Changes in full income

We define changes in full income as the sum of the change in levels of income (measured in GNI per capita) and the value of mortality change between two time periods. We emphasize that the level of full income cannot be estimated due to methodological issues in estimating the level of the value of mortality risk. We present the proportion of the change in full income that come from change in mortality risk.

Value of a life year (VLY)

We define VLY as the value of a one-year increase in life expectancy. Following previous notations, VLY is calculated as:

$$VLY = \frac{v}{\tilde{e}_0 - e_0}$$

where v is the value of mortality change in the decade as a proportion of starting income and $\tilde{e}_0 - e_0$ is the difference in life expectancy at birth during the time period. The VLY reflects a related but different concept than the other measures presented above. It is derived from life expectancy at birth, which is a summary measure that reflects age-specific mortality rates but not the age structure of the underlying population (v still reflects the population structure). Note that this current definition of the VLY is different from what was introduced in the first CIH report (Jamison et al. 2013).

The three decades and the COVID-19 years

We conduct the analysis for the three decades 1990-2000, 2000-2010 and 2010-19 separately, and then estimate the annual value by dividing the decade value by the number of years in the period. [This will be updated once the new WPP is released] For the COVID-19 years, we estimate the value comparing to 2019 as the base mortality (i.e., 2020/2021/2022 versus 2019). First, we estimated age-specific mortality rates in 2020, 2021, and 2022 had COVID-19 not occurred by applying the annual average rate of change between 2015-2019 to the 2019 levels. Second, we calculated the differences in age-specific mortality rates between 2020/2021/2022 to 2019 levels, and applied the same modeling approach described above to calculate the value of change in mortality risk. We present the results as the sum of the value between 2020-2022 as percentage of the 2019 income level.

Input parameters and data sources

Age-specific mortality rates and population age distribution for all years came from the World Population Prospects 2022 (WPP2022) (United Nations Department of Economic and Social Affairs, Population Division, n.d.). On estimating economic value, we closely followed the recommendations made by the Harvard Benefit Cost Analysis Reference Case (Robinson et al. 2019). We set the ratio between VSL and income per capita (VSLr) at 160 (the ratio comes from a United States VSL of $9.4 million and GNI per capita of $57,900), and income elasticity of 1.0. Income is expressed as GNI per capita in 2017 constant international dollars and adjusted for purchasing power parity (PPP), as recommended by the reference case. Data on GNI per capita between 2000-2021 came from the World Bank (World Bank 2021). The initial VSLr for all ages were set as equal. We applied a discount rate of 0%.

We reported all outcomes by the 3rd Commission on Investing in Health (CIH) world regions: Central and Eastern Europe, Central Asia, China, India, Latin America and Caribbean, Middle East and North Africa, North Atlantic, sub-Saharan Africa, United States, and Western Pacific and Southeast Asia (list of countries in each region in Table A1). We further provide results for the top 30 most populous countries in the world in the Appendix (Tables A2-3).

Sensitivity analyses [This will be conducted with new WPP 2024 data]

The Harvard Benefit Cost Analysis Reference case recommends the following standard sets of sensitivity analyses: VSLr at 160 and extrapolated from the US to other countries with an

income elasticity of 1.5; VSLr at 100. Discount rates 0 and 3%, and twice the projected near-term GDP per capita growth rate. (Robinson et al. 2019)

Results

Changes in life expectancy and age-specific mortality rates

Between 1990 and 2019, globally life expectancy at birth increased by 8.8 years, with 2.5, 3.7 and 2.7 years in the first, second, and third decade, respectively. The largest gains were experienced in sub-Saharan Africa (1.5, 5.7, 4.4 years in the three decades), India (4.0, 4.2, 4.0), and China (3.9,3.7, 2.4). The smallest gains were found in the United States (1.4, 2.0, 0.4) and North Atlantic (2.3, 2.4, 1.4).

We estimated the changes in age-specific mortality rates by region and decade and report the changes for ages 0, 1, 15, 50, and 70. In the first decade, globally the declines were 18, 24, 15, 9, and 10% for the age groups, respectively. In the second decade, globally the declines were 31, 43, 18, 12, and 13%, respectively. In the third decade, the declines were 23, 35, 18, 18, and 12%, respectively. Cumulatively between 1990-2019, age-specific mortality rates declined by 57, 72, 43, 34, and 31%, respectively across each age. In the most recent decade, the largest declines were observed in China, India, and Central and Eastern Europe in younger age groups, and Central and Eastern Europe, Middle East and North Africa, and the North Atlantic in older age groups. The smallest declines instead were observed in United States, North Atlantic, and Middle East and North Africa in the younger age groups, and Latin America and Caribbean, Central Asia, and the United States in the older age groups.

Changes in income

Globally there was an increase of approximately $7000 during the three decades, with 13, 24, and 22% increase (relative to the starting income level of the decade) in each decade, respectively (Table 1). In the first decade, the largest gains were observed in China (143%) and India (42%), and negative gains (decrease in income) in Central Asia (-22%), Central and Eastern Europe (-22%), and sub-Saharan Africa (-5%). In the second decade, the largest gains were found in China (159%) and India (64%), and smallest gains in North Atlantic (8%) and United States (10%). In the third decade, the largest gains were found in China (80%) and India

(57%), and the smallest gains in Latin America and Caribbean (7%) and sub-Saharan Africa (10%).

Changes in mortality rates

We report the economic value of mortality change and full income for each decade. Globally between 1990-2000, the average value of decadal mortality change was estimated at 18% of the starting income, ranging from -7% (of the regional income) in Central and Eastern Europe to 36% in India (Table 2, Figure 1). The negative value shows that there was a decline in mortality risk in Central and Eastern Europe. Between 2000-2009, the average value of mortality change was estimated globally at 24% of the starting income, ranging from 8% in United States to 64% in sub-Saharan Africa. Between 2010-2019, globally it was estimated at 14%, ranging from 0% in the United States to 38% in sub-Saharan Africa. For many regions, there has been a decrease in the estimated value of mortality change as percentage of starting income have decreased over time, reflecting both the slowing rates of mortality decline and shifting of the population age structure towards older ages. The exceptions include Central Asia, Central and Eastern Europe, and sub-Saharan Africa.

Full income

Between 1990-2000, the global average of decadal change in income (as percent of starting income) was 14%, ranging from -22% in Central Asia and Central and Eastern Europe to 143% in China (Table 2). Together with the numbers on the value of mortality change from the previous section, the value of full income change was 32% globally, ranging from -29% in Central and Eastern Europe to 164% in China. The value of mortality change as a proportion of change in full income was 55%, meaning that changes in mortality risks accounted for 55% of the full income gain (Figure 2). This proportion ranged from 13% in China to 64% in Middle East and North Africa (regions with negative income growth – Central Asia, Central and Eastern Europe, and sub-Saharan Africa were excluded). In the second decade, global value of income change was 25% of the starting income, ranging from 8% in North Atlantic to 159% in China. Combined with mortality values, the value of full income change ranged from 17% in United States to 176% in China. The proportion of mortality change in full income change was 48% globally, ranging from 10% in China to 70% in sub-Saharan Africa. Finally, in the last decade, the value of income change was 22% globally, ranging from 7% in Latin America and Caribbean to 80% in China. The value of full income change was 36%, ranging from 15% in

United States to 90% in China. The proportion of mortality change in full income change was 40% globally, ranging from 3% in United States to 79% in sub-Saharan Africa.

VLY

The VLY, expressed as a percentage of the starting income, was estimated globally at 7, 6, and 5% in the three decades respectively (Table 2). The VLY ranged from the lowest in United States (5, 4, 1% in the three decades) to the highest in sub-Saharan Africa (19, 11, 9% in the three decades).

COVID-19 pandemic, 2020-2023 [To be updated based on WPP 2024]

Globally, life expectancy at birth in 2019 (baseline year) was 72.8. During the COVID-19 years, it declined slightly to 72.0, 71.0, and 71.7 in 2020, 2021, and 2022, respectively. Proportionally, the largest declines were found in Central and Eastern Europe (2.6, 4.4, 4.4%), Latin America and Caribbean (2.6, 3.9, 1.8%), United States (2.2, 2.5, 1.2%), and India (1.1, 5.2, 4.5%). The smallest changes were seen in China (increase of 0.1, 0.3, 0.8%), Western Pacific and Southeast Asia (decrease of 0.5, 1.8, 0.5%), and sub-Saharan Africa (decrease of 0.7, 1.7, 0.8%). COVID-19 primarily impacted older age mortality rates. Globally we found increased age-specific mortality rates at age 65, 75, and 85 by approximately 9-11% in 2020, 17-22% in 2021, and 9-14% in 2022. The highest increases were observed in India (42-59% increase in 2021), Latin America and Caribbean (15-39% increase in 2021), Central and Eastern Europe (27-34% increase in 2022), sub-Saharan Africa (19-22% increase in 2021), and United States (15-20% in 2020).

The values of such mortality changes during the COVID-19 pandemic were estimated at -3.5, -9.3, and -7.9% of the 2019 global income in 2020, 2021, and 2022, respectively (negative meaning there was loss in economic value) (Table 4). In total, we estimated the value of mortality change due to COVID to be 21% of the global income in 2019. The largest losses were found in Central and Eastern Europe (-27 to -13%, the sum of -65% across three years), India (-18 to -3%, the sum of -38% across three years), Latin America and Caribbean (-13 to -7 %, sum of -29%), and United States (-11 to -6%, sum of -24%). In contrast, the smallest losses were observed in China (-0.8 to -0.3%, sum of -1.5%) and sub-Saharan Africa (-5 to -1%, sum of -11.4%).

Sensitivity analyses

[to be added]

Discussion

We estimated the average change in income and value of mortality change, and jointly estimated the change in full income. One advantage of doing so is to be able to use the same unit (in monetary terms) to compare how populations have advanced in broader well-being (not just income), and estimate how much of the change in full income can be attributed to mortality decline. We also derived the value of a one-year gain in life expectancy.

To demonstrate the use of the full income approach, we took two countries – United States and France – and compared their changes in income, value of mortality change, and changes in full income over time in Figure 3. For illustration we started with the year 2000 and presented all values as percentage of the 2000 GNI per capita. On the income side, United States had experienced larger gains since 2000 with approximately 25% growth by 2019, while France experienced about 17% increase. On the value of mortality change, United States gained approximately 8% while France gained 16%. In other words, while income growth in the US exceeded that in France, the value of mortality change in France exceeded that in the US. Summing the two together, the two countries experienced approximately similar growth in full income growth of approximately 33%. Typically we are accustomed to measuring population well-being using either GDP growth (in which one will conclude that United States have performed well since 2000 than France) or gains in life expectancy (in which France has increased by 3.7 years compared to 2.3 years in United States). Having both aspects jointly presented using the same unit allows for an enhanced and more accurate measure of population well-being.

We highlight some of our key findings. First, the value of mortality risk reduction is comparable to income growth in most regions over the past decades. In the first decade, 1990-2000, globally the value of mortality change was higher than the value of income change, and accounted for more than half of the change in full income. In the second (2000-2010) and third decades (2010-2019), the value of mortality change was 48 and 40% of the change in full income, respectively. Second, there is a large variation across regions in both changes in income and mortality risks. This is reflected in the wide range of the value of mortality change as percent of change in full income (Figure 2). In the first decade, this proportion ranged from 13% in China to over 100% in regions with negative income growth, such as sub-Saharan

Africa and Central Asia. Central and Eastern Europe had negative growths in both income and mortality risk in this decade. In the second and third decade, it ranged from 10 and 11% in China to 70 and 79% in sub-Saharan Africa. Broadly, this reflects the relatively larger gains in income in countries with low percentages, and relatively larger mortality reductions in regions with high percentages. In China, income grew between 80 and 159%, while life expectancy increased by 2.4 to 3.9 years each decade. In comparison, in sub-Saharan Africa income growth ranged between -5% to 28% while life expectancy increased between 1.6 and 5.6 years.

The economic value of mortality change is likely going to decline in the coming decades in most parts of the world, mostly due to changing population age structure and partly due to deceleration of reductions in age-specific mortality rates in the older ages. Rapid economic development and successes in reducing deaths at younger ages in the past decades mean that deaths are postponed to older ages. Globally in 2019, the median age of death is 76, and it is projected to increase to 82 by 2050. The highest and lowest median age of death in 2019 are found in North Atlantic (at 84) and sub-Saharan Africa (at 65), and they are projected to increase to 89 and 69, respectively. In our model, older populations are assigned less economic value given the same proportion of mortality rate reduction because they have fewer life years remaining. With population aging, the proportion of older populations will increase, leading to decreasing national/regional population-weighted economic value. In addition, historically the rate of decline in mortality rates have been slower in older ages, so the value assigned to a smaller size of mortality reduction will naturally be smaller.

The COVID-19 pandemic had a large impact globally. Cumulatively between 2020 and 2022, the impact measured in economic value of mortality risk change ranged was the highest in Central and Eastern Europe (mortality due to COVID-19 was valued at 65% of the 2019 income level), India (38%), Latin America and Caribbean (28%), and United States (24%). Central and Eastern Europe had experienced some of the largest gains in both mortality reduction and income, but we observe lack of discussion on the performance of this region.

Despite applying different methods and using different data sources, our results are qualitatively similar to more recent papers that estimated the economic value of mortality reduction and other welfare. Jones and Klenow concluded that the welfare estimates (which includes life expectancy) for Western Europe is much closer to the United States than just income alone, in line with our observation in Figure 3 (2016). Cutler and Summers (2020)

estimated the value of health loss during COVID-19 for the US at about 8.5 trillion USD (approximately 48% of US GDP). Health loss during the pandemic included premature death, long-term health impairment, and mental health impairment. For comparability, just looking at the value of premature deaths would amount to about 4.4 trillion USD, or approximately 24% of US GDP, which is in line with our estimate (Table 3).

Limitations

There are several limitations to our approach. First, we did not analyze the changes in full income by sex because we do not have good sex-specific income nor VSL estimates. Mortality declines in females have generally been faster than males (Chang et al. 2024). Second, we only focused on mortality and not morbidity, suggesting that the results likely underestimate the actual economic value of preventing and treating diseases and injuries. Third, the VSL approach to assigning monetary values to risk reduction is not without its limitations.(Viscusi and Aldy 2003) Many have been critical about extrapolating the VSL from the United States to other countries (Robinson, Hammitt, and O'Keeffe 2019). To partly address this limitation, we applied an income elasticity of 1.0 and presented all results in relation to local income. Fourth, we calculated the COVID-19 excess mortality rates based on our own projections using recent growth rates from the WPP and projecting a counterfactual scenario between 2020 and 2022. We did not rely on excess mortality estimates from other data sources, such as Msemburi et al. and the Economist, because of the lack of the age distribution of COVID-19 deaths (Msemburi et al. 2023; The Economist 2024). Globally, the difference in the cumulative deaths by 2022 between our method and Msemburi et al. is about 6%, but it varies significantly across regions and countries. We provide a comparison of the excess death numbers between our estimates and the other sources in the Appendix [to be added with WPP 2024].

Conclusion

This paper offers an examination of the economic values of mortality change over the past three decades and of the COVID-10 pandemic. We highlight the large role that mortality changes play in the measurement of population well-being alongside traditional economic indicators.

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Figure 1. Average decadal value of mortality change as percentage of starting income

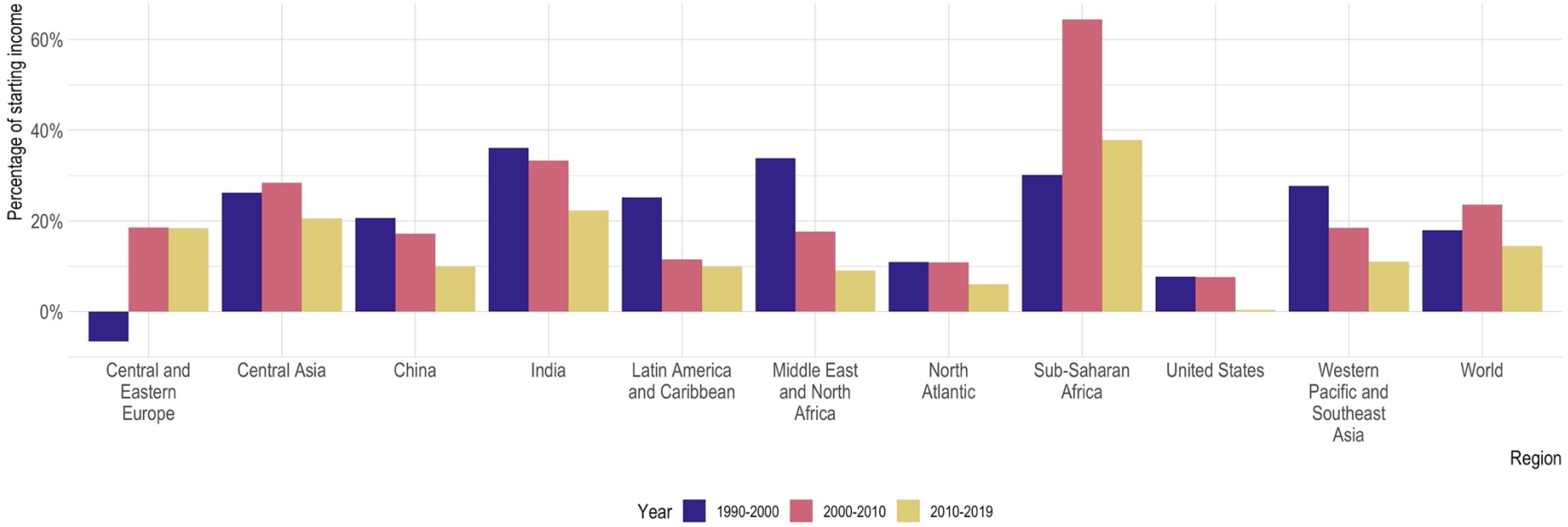
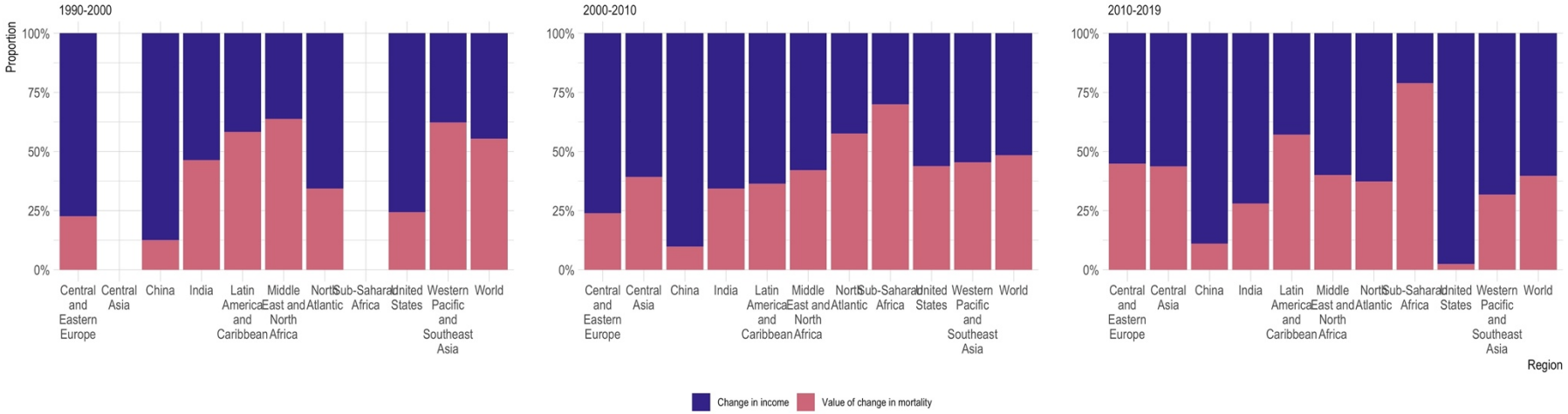


Figure 2. Proportion of change in full income due to change in income and value of change in mortality risk



Note: In Panel A 1990-2000, Central Asia and sub-Saharan Africa have been removed due to negative income growth in the decade

Figure 3. US versus France comparison

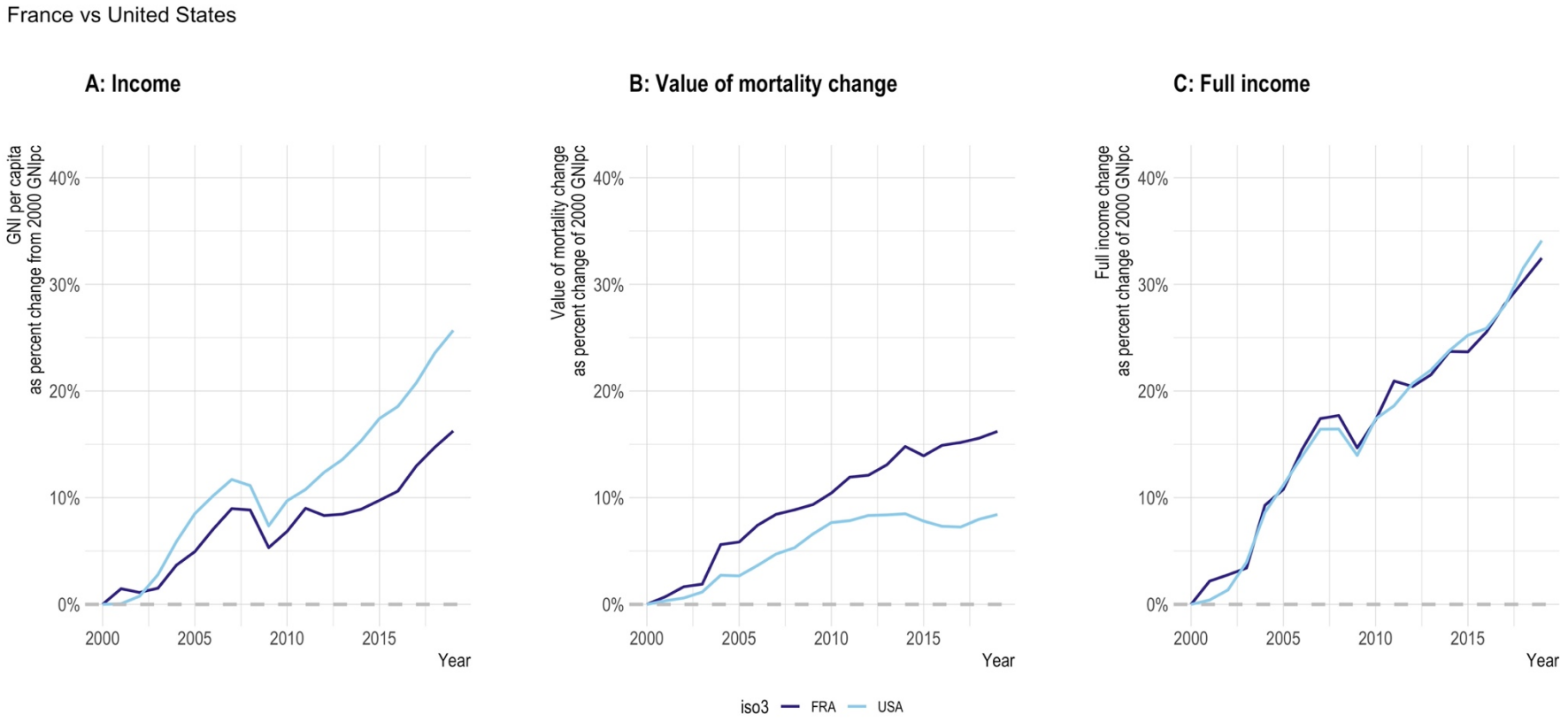


Table 1. Income and life expectancy at birth by decade and region

	Income (GNI per capita, PPP, constant 2017 USD)				**Life expectancy at birth (year)**			
	1990	**2000**	**2010**	**2019**	**1990**	**2000**	**2010**	**2019**
Central Asia	4490	3510	5050	6380	60	61.8	64.9	67.4
Central and Eastern Europe	16640	12900	20480	25100	69.5	68.5	71.8	75.2
China	1410	3420	8850	15930	68	71.9	75.6	78
India	1800	2550	4170	6550	58.7	62.7	66.9	70.9
Latin America and Caribbean	10150	11980	14390	15450	67.6	71.1	73.1	75
Middle East and North Africa	11760	14010	17410	19770	65.4	69.6	72.4	74.5
North Atlantic	33880	40970	44230	48680	76.3	78.6	81	82.4
Sub-Saharan Africa	2800	2650	3380	3720	49.2	50.8	56.4	60.9
United States	40920	50650	55570	63650	75.4	76.8	78.8	79.1
Western Pacific and Southeast Asia	9630	11250	13730	16950	65.9	69.9	72.9	75.2
World	9670	11060	13830	16850	64	66.5	70.1	72.8
Decade change	**1990-2000**	**2000-2010**	**2010-2019**		**1990-2000**	**2000-2010**	**2010-2019**	
Central Asia	-980 (-22%)	1540 (44%)	1330 (26%)		1.9 (3%)	3.1 (5%)	2.5 (4%)	
Central and Eastern Europe	-3740 (-22%)	7580 (59%)	4620 (23%)		-1 (-1%)	3.3 (5%)	3.4 (5%)	
China	2010 (143%)	5430 (159%)	7080 (80%)		3.9 (6%)	3.7 (5%)	2.4 (3%)	
India	750 (42%)	1620 (64%)	2380 (57%)		4 (7%)	4.2 (7%)	4 (6%)	
Latin America and Caribbean	1830 (18%)	2410 (20%)	1060 (7%)		3.5 (5%)	2 (3%)	1.9 (3%)	
Middle East and North Africa	2250 (19%)	3400 (24%)	2360 (14%)		4.2 (6%)	2.8 (4%)	2.1 (3%)	
North Atlantic	7090 (21%)	3260 (8%)	4450 (10%)		2.3 (3%)	2.4 (3%)	1.4 (2%)	
Sub-Saharan Africa	-150 (-5%)	730 (28%)	340 (10%)		1.6 (3%)	5.6 (11%)	4.5 (8%)	
United States	9730 (24%)	4920 (10%)	8080 (15%)		1.4 (2%)	2 (3%)	0.3 (0%)	
Western Pacific and Southeast Asia	1620 (17%)	2480 (22%)	3220 (23%)		4 (6%)	3 (4%)	2.3 (3%)	
World	1390 (14%)	2770 (25%)	3020 (22%)		2.5 (4%)	3.6 (5%)	2.7 (4%)	

Table 2. Values of income, mortality, and full income change, and the value of a life year by decade and region

	1990-2000				2000-2010				2010-2019			
	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year
CIH Region												
Central Asia	-22%	26%	4%	14%	44%	28%	72%	9%	26%	21%	47%	8%
Central and Eastern Europe	-22%	-7%	-29%	6%	59%	19%	77%	6%	23%	18%	41%	5%
China	143%	21%	164%	5%	159%	17%	176%	5%	80%	10%	90%	4%
India	42%	36%	78%	9%	64%	33%	97%	8%	57%	22%	80%	6%
Latin America and Caribbean	18%	25%	43%	7%	20%	12%	32%	6%	7%	10%	17%	5%
Middle East and North Africa	19%	34%	53%	8%	24%	18%	42%	6%	14%	9%	23%	4%
North Atlantic	21%	11%	32%	5%	8%	11%	19%	5%	10%	6%	16%	4%
Sub-Saharan Africa	-6%	30%	25%	19%	28%	64%	92%	11%	10%	38%	48%	9%
United States	24%	8%	31%	5%	10%	8%	17%	4%	15%	0%	15%	1%
Western Pacific and Southeast Asia	17%	28%	45%	7%	22%	18%	40%	6%	23%	11%	34%	5%
World	14%	18%	32%	7%	25%	24%	49%	6%	22%	14%	36%	5%

[1] Numbers expressed relative to the level of income in the starting year of each decade, and expressed as average decadal value

Table 3. Value of mortality change during the COVID-19 pandemic by region and top 30 most populous countries [pending WPP2024]

Annual estimates comparing observed age-specific mortality rates in 2020, 2021, and 2022 to counterfactual age-specific mortality rates estimated by using the 3- year average annual rates of change (between 2016 and 2019) to project to 2020, 2021, and 2022.

Value presented as percentage of 2019 income levels

	Year			
	2020	2021	2022	**2020-2022**
Central Asia	-2.7%	-4.0%	-3.6%	-10.3%
Central and Eastern Europe	-12.6%	-24.8%	-27.1%	-64.5%
China	-0.5%	-0.8%	-0.3%	-1.5%
India	-2.7%	-17.3%	-17.6%	-37.6%
Latin America and Caribbean	-8.0%	-13.3%	-7.1%	-28.3%
Middle East and North Africa	-3.7%	-5.3%	-4.6%	-13.6%
North Atlantic	-3.8%	-4.2%	-1.5%	-9.5%
Sub-Saharan Africa	-1.3%	-5.0%	-5.1%	-11.4%
United States	-7.7%	-10.5%	-5.5%	-23.8%
Western Pacific and Southeast Asia	-2.2%	-7.4%	-4.4%	-14.0%
World	-3.5%	-9.3%	-7.9%	-20.7%

Appendix Tables and Figures

Table A1. Commission on Investing in Health 3.0 locations by region

Central Asia		
Afghanistan	Azerbaijan	Kazakhstan
Kyrgyz Republic	Mongolia	Pakistan
Tajikistan	Turkmenistan	Uzbekistan
Central and Eastern Europe		
Albania	Armenia	Belarus
Bosnia and Herzegovina	Bulgaria	Croatia
Czech Republic	Estonia	Georgia
Hungary	Latvia	Lithuania
Moldova	Montenegro	North Macedonia
Poland	Romania	Russian Federation
Serbia	Slovak Republic	Slovenia
Ukraine		
China		
India		
Latin America and Caribbean		
Argentina	Bahamas, The	Belize
Bolivia	Brazil	Chile
Colombia	Costa Rica	Cuba
Dominican Republic	Ecuador	El Salvador
Guatemala	Guyana	Haiti
Honduras	Jamaica	Mexico
Nicaragua	Panama	Paraguay
Peru	Suriname	Trinidad and Tobago
Uruguay	Venezuela, RB	
Middle East and North Africa		
Algeria	Bahrain	Egypt, Arab Rep.
Iran, Islamic Rep.	Iraq	Israel
Jordan	Kuwait	Lebanon
Libya	Morocco	Oman
Qatar	Saudi Arabia	Syrian Arab Republic
Tunisia	Türkiye	United Arab Emirates
Yemen, Rep.		

North Atlantic		
Austria	Belgium	Canada
Cyprus	Denmark	Finland
France	Germany	Greece
Iceland	Ireland	Italy
Luxembourg	Malta	Netherlands
Norway	Portugal	Spain
Sweden	Switzerland	United Kingdom
Sub-Saharan Africa		
Angola	Benin	Botswana
Burkina Faso	Burundi	Cabo Verde
Cameroon	Central African Republic	Chad
Comoros	Congo, Dem. Rep.	Congo, Rep.
Côte d'Ivoire	Djibouti	Equatorial Guinea
Eritrea	Eswatini	Ethiopia
Gabon	Gambia, The	Ghana
Guinea	Guinea-Bissau	Kenya
Lesotho	Liberia	Madagascar
Malawi	Mali	Mauritania
Mauritius	Mozambique	Namibia
Niger	Nigeria	Rwanda
Senegal	Sierra Leone	Somalia
South Africa	South Sudan	Sudan
Tanzania	Togo	Uganda
Zambia	Zimbabwe	
United States		
Western Pacific and Southeast Asia		
Australia	Bangladesh	Bhutan
Brunei Darussalam	Cambodia	Fiji
Indonesia	Japan	Korea, Dem. People's Rep.
Korea, Rep.	Lao PDR	Malaysia
Maldives	Myanmar	Nepal
New Zealand	Papua New Guinea	Philippines
Singapore	Solomon Islands	Sri Lanka
Thailand	Timor-Leste	Vanuatu
Vietnam		

Countries were included in a CIH region if they were United Nations Member States with populations of at least 300 000 in 2022. For the CIH World region, if an input dataset contained a World region, those

values were used for the CIH World region; if a dataset did not contain a World region, values for the CIH World region were calculated from all locations with available data, regardless of UN Member State status or population size.

Table A2. Income and life expectancy at birth by decade and top 30 most populous countries

	Income (GNI per capita, PPP, constant 2017 USD)				**Life expectancy at birth (year)**			
	1990	**2000**	**2010**	**2019**	**1990**	**2000**	**2010**	**2019**
Bangladesh	1770	2340	3670	5690	56	65.8	68.6	72.8
Brazil	10130	11210	14360	14290	66	69.7	73.2	75.3
China	1410	3420	8850	15930	68	71.9	75.6	78
Colombia	8050	8950	11470	14290	68.6	71.3	75	76.8
Congo, Dem. Rep.	1570	720	810	1000	48.6	51.8	56.4	60.3
Egypt, Arab Rep.	6130	7910	10130	11380	64.1	68	69.7	71.4
Ethiopia	770	720	1230	2170	44.6	50.5	59.7	65.8
France	33960	40350	43110	46910	76.8	79	81.4	82.7
Germany	37290	42690	47930	55690	75.4	78.1	80.1	81.6
India	1800	2550	4170	6550	58.7	62.7	66.9	70.9
Indonesia	4400	5470	7990	11500	63.2	66.4	68.7	70.5
Iran, Islamic Rep.	9440	11050	15100	14130	64.4	69.7	73.1	76.1
Italy	36110	42890	42570	43100	77	79.6	82.1	83.6
Japan	33100	36870	39080	43280	79	81.2	82.9	84.4
Kenya	3530	3270	3290	4530	58.6	54.4	60.6	62.9
Korea, Rep.	12640	22800	34440	43120	71.9	76.5	80.8	83.7
Mexico	14740	17560	17820	19470	70	73.6	74.2	74.2
Myanmar	560	940	2730	4670	56.7	60.2	63.3	66.6
Nigeria	3070	2640	4570	4910	46	47.2	50.9	52.9
Pakistan	2980	3280	3980	5070	60.1	62.1	64.4	66.8
Philippines	4160	4900	6550	9590	65.9	69.4	70.8	71.9
Russian Federation	21450	14190	23190	26360	68.5	65.3	69.4	73.9
South Africa	10090	10400	13210	13510	63.4	58.5	58.9	66.2
Spain	27270	34510	36770	40850	77	79.4	82	83.5
Tanzania	1290	1360	1940	2540	51.5	52.4	60.1	67
Thailand	6950	9350	13540	17160	70.4	72.3	76.1	79
Türkiye	12380	15030	19540	27790	67.7	71.9	75.1	77.8
United Kingdom	31080	38950	42040	47070	75.7	77.9	80.4	81.7
United States	40920	50650	55570	63650	75.4	76.8	78.8	79.1
Vietnam	2100	3650	6140	9730	69.2	72.5	73.5	74.1
Decade change	**1990-2000**	**2000-2010**	**2010-2019**		**1990-2000**	**2000-2010**	**2010-2019**	
Bangladesh	571 (32%)	1331 (57%)	2016 (55%)		9.8 (17%)	2.9 (4%)	4.2 (6%)	
Brazil	1079 (11%)	3155 (28%)	-74 (-1%)		3.8 (6%)	3.4 (5%)	2.2 (3%)	
China	2011 (143%)	5430 (159%)	7087 (80%)		3.9 (6%)	3.7 (5%)	2.4 (3%)	
Colombia	896 (11%)	2521 (28%)	2822 (25%)		2.7 (4%)	3.7 (5%)	1.7 (2%)	
Congo, Dem. Rep.	-852 (-54%)	91 (13%)	188 (23%)		3.2 (7%)	4.6 (9%)	3.9 (7%)	

Egypt, Arab Rep.	1775 (29%)	2224 (28%)	1246 (12%)		3.9 (6%)	1.7 (2%)	1.7 (2%)	
Ethiopia	-48 (-6%)	516 (72%)	935 (76%)		6 (13%)	9.2 (18%)	6.1 (10%)	
France	6389 (19%)	2763 (7%)	3794 (9%)		2.2 (3%)	2.4 (3%)	1.3 (2%)	
Germany	5393 (14%)	5248 (12%)	7751 (16%)		2.7 (4%)	2 (3%)	1.5 (2%)	
India	749 (42%)	1623 (64%)	2386 (57%)		4 (7%)	4.2 (7%)	4 (6%)	
Indonesia	1071 (24%)	2520 (46%)	3512 (44%)		3.3 (5%)	2.2 (3%)	1.8 (3%)	
Iran, Islamic Rep.	1608 (17%)	4057 (37%)	-972 (-6%)		5.3 (8%)	3.4 (5%)	3 (4%)	
Italy	6783 (19%)	-315 (-1%)	529 (1%)		2.6 (3%)	2.5 (3%)	1.4 (2%)	
Japan	3773 (11%)	2216 (6%)	4192 (11%)		2.2 (3%)	1.7 (2%)	1.5 (2%)	
Kenya	-259 (-7%)	14 (0%)	1242 (38%)		-4.2 (-7%)	6.2 (11%)	2.3 (4%)	
Korea, Rep.	10160 (80%)	11642 (51%)	8673 (25%)		4.5 (6%)	4.3 (6%)	2.9 (4%)	
Mexico	2827 (19%)	257 (1%)	1652 (9%)		3.6 (5%)	0.6 (1%)	0 (0%)	
Myanmar	378 (67%)	1793 (191%)	1935 (71%)		3.5 (6%)	3.2 (5%)	3.3 (5%)	
Nigeria	-424 (-14%)	1921 (73%)	349 (8%)		1.2 (3%)	3.8 (8%)	2 (4%)	
Pakistan	298 (10%)	703 (21%)	1083 (27%)		2 (3%)	2.3 (4%)	2.3 (4%)	
Philippines	735 (18%)	1656 (34%)	3036 (46%)		3.5 (5%)	1.3 (2%)	1.1 (2%)	
Russian Federation	-7262 (-34%)	9000 (63%)	3179 (14%)		-3.3 (-5%)	4.1 (6%)	4.5 (7%)	
South Africa	307 (3%)	2812 (27%)	298 (2%)		-4.9 (-8%)	0.4 (1%)	7.3 (12%)	
Spain	7241 (27%)	2256 (7%)	4084 (11%)		2.4 (3%)	2.6 (3%)	1.5 (2%)	
Tanzania	67 (5%)	579 (43%)	600 (31%)		0.9 (2%)	7.7 (15%)	6.9 (11%)	
Thailand	2406 (35%)	4184 (45%)	3624 (27%)		1.9 (3%)	3.8 (5%)	2.8 (4%)	
Türkiye	2654 (21%)	4510 (30%)	8244 (42%)		4.2 (6%)	3.2 (4%)	2.8 (4%)	
United Kingdom	7877 (25%)	3088 (8%)	5026 (12%)		2.1 (3%)	2.5 (3%)	1.3 (2%)	
United States	9728 (24%)	4920 (10%)	8087 (15%)		1.4 (2%)	2 (3%)	0.4 (0%)	
Vietnam	1551 (74%)	2490 (68%)	3590 (58%)		3.2 (5%)	1.1 (1%)	0.6 (1%)	

Table A3. Values of income, mortality, and full income change, and the value of a life year by decade and top 30 most populous countries

	1990-2000				2000-2010				2010-2019			
Top 30 country	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year[1]	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year[1]	Value of income change[1]	Value of mortality change[1]	Value of full income change[1]	Value of a life year[1]
Bangladesh	32%	78%	110%	8%	57%	30%	87%	11%	55%	21%	76%	5%
Brazil	11%	28%	39%	8%	28%	20%	48%	6%	-1%	10%	10%	5%
China	143%	21%	164%	5%	159%	17%	176%	5%	80%	10%	90%	4%
Colombia	11%	14%	25%	5%	28%	18%	47%	5%	25%	7%	32%	4%
Congo, Dem. Rep.	-54%	41%	-14%	13%	13%	61%	73%	13%	23%	42%	65%	11%
Egypt, Arab Rep.	29%	41%	70%	11%	28%	18%	46%	11%	12%	11%	24%	7%
Ethiopia	-6%	85%	79%	14%	72%	93%	165%	10%	76%	49%	125%	8%
France	19%	10%	29%	5%	7%	10%	17%	4%	9%	6%	14%	4%
Germany	14%	13%	28%	5%	12%	10%	23%	5%	16%	7%	23%	4%
India	42%	36%	78%	9%	64%	33%	97%	8%	57%	22%	80%	6%
Indonesia	24%	28%	52%	9%	46%	16%	62%	7%	44%	10%	54%	6%
Iran, Islamic Rep.	17%	36%	53%	7%	37%	14%	51%	4%	-6%	13%	6%	4%
Italy	19%	12%	31%	5%	-1%	12%	11%	5%	1%	6%	7%	4%
Japan	11%	8%	19%	4%	6%	8%	14%	5%	11%	7%	18%	5%
Kenya	-7%	-18%	-26%	4%	0%	59%	60%	10%	38%	18%	56%	8%
Korea, Rep.	80%	21%	101%	5%	51%	17%	68%	4%	25%	11%	36%	4%
Mexico	19%	24%	43%	7%	1%	6%	7%	9%	9%	1%	11%	110%
Myanmar	67%	29%	97%	8%	191%	24%	215%	8%	71%	21%	91%	6%
Nigeria	-14%	23%	9%	20%	73%	52%	125%	14%	8%	23%	30%	12%
Pakistan	10%	33%	43%	16%	21%	24%	45%	10%	27%	20%	48%	9%

Philippines	18%	28%	45%	8%	34%	9%	43%	7%	46%	6%	52%	5%
Russian Federation	-34%	-21%	-55%	7%	63%	24%	88%	6%	14%	25%	39%	6%
South Africa	3%	-41%	-37%	8%	27%	6%	33%	14%	2%	47%	49%	6%
Spain	27%	11%	38%	5%	7%	12%	18%	5%	11%	6%	17%	4%
Tanzania	5%	34%	39%	38%	43%	81%	124%	11%	31%	44%	75%	6%
Thailand	35%	13%	47%	7%	45%	17%	62%	4%	27%	12%	39%	4%
Türkiye	21%	33%	54%	8%	30%	19%	49%	6%	42%	11%	53%	4%
United Kingdom	25%	10%	36%	5%	8%	11%	19%	4%	12%	5%	17%	4%
United States	24%	8%	31%	5%	10%	8%	17%	4%	15%	0%	15%	1%
Vietnam	74%	22%	96%	7%	68%	6%	74%	6%	58%	3%	61%	5%

[1] Numbers expressed relative to the level of income in the starting year of each decade, and expressed as average decadal value.