# Probability of death before age 70: progress as years behind or ahead of the global average trend

**Authors**
Omar Karlsson, PhD [1,2*] (karlssono@outlook.com)
Prof Dean T Jamison, PhD [3,4] (meteor17@me.com)
Prof Gavin Yamey, MD [5,6] (gavin.yamey@duke.edu)
Sarah Bolongaita, SM [7,8] (sarah.bolongaita@uib.no)
Wenhui Mao, PhD [5,6] (wenhui.mao@duke.edu)
Angela Y Chang, ScD [9,10] (achang@health.sdu.dk)
Prof Ole Frithjof Norheim, MD, PhD [7,8] (ole.norheim@uib.no)
Osondu Ogbuoji, PhD [5,11**] (osondu.ogbuoji@duke.edu)
Stéphane Verguet, PhD [8**] (verguet@hsph.harvard.edu)

**Affiliations**
[1]Visiting Research Fellow, Duke University Population Research Institute, Duke University, 140 Science Dr, Durham, NC 27710, United States
[2]Centre for Economic Demography, School of Economics and Management, Lund University, P.O. Box 7083, 220 07 Lund, Sweden
[3]Department of Epidemiology and Biostatistics, University of California San Francisco, 550 16th Street, CA 94158, San Francisco, USA
[4]Institute for Global Health Sciences, University of California San Francisco, Mission Hall, Box 1224, 550 16th Street, Third Floor, San Francisco, CA 94158, San Francisco, USA
[5]Centre for Policy Impact in Global Health, Duke University, 310 Trent Dr, Durham, NC 27710, USA
[6]Duke Global Health Institute, Duke University, 310 Trent Dr, Durham, NC 27710, USA
[7]Bergen Centre for Ethics and Priority Setting (BCEPS), Department of Global Public Health and Primary Care, University of Bergen, Bergen, PO Box 7804, N-5020, Bergen, Norway
[8]Department of Global Health and Population, Harvard T.H. Chan School of Public Health, [4]
[9]Danish Institute for Advanced Study, University of Southern Denmark, Studiestræde 6, Copenhagen, Denmark
[10]Danish Centre for Health Economics, University of Southern Denmark, Campusvej 55, 5230 Odense M, Denmark
[11]Department of Population Health, Duke School of Medicine, Duke University, Durham, NC, USA.

*Corresponding author
**Joint senior authors.

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**Significance**

This study underscores persistent inequality in living standards and access to health enhancing technologies, which in turn impact long-run declines in the probability of premature death (PPD)—defined here as probability of dying before age 70 years. For example, sub-Saharan Africa was 44 years behind the global average PPD and 100 years behind the best performing country each year—the frontier. This suggests a combination of health-enhancing technologies and living standards that were last observed for the world average in 1975 and in 1919 in the frontier. When considering PPD expected based on economic development, the United States had per capita GDP reflecting health-enhancing technologies and living standards to the same extent as in the average country 45 years earlier.

**ABSTRACT**

Advances in health technology and living standards have reduced mortality worldwide but geographic disparities remain. This study examined uneven decline in probability of premature death (PPD)—before age 70 years—across regions, benchmarking progress as years behind or ahead of 1) global average PPD and 2) expected PPD given level of economic development, and 3) years behind PPD in the best performing country each year—the frontier. Global PPD fell from 67% to 32% 1950–2019. Sub-Saharan Africa, Central Asia, and India were behind the global PPD, both in 2000 and 2019. Sub-Saharan Africa's PPD in 2019 was 52%, corresponding to the 1975 global PPD, suggesting that sub-Saharan Africa had a combination of health-enhancing technologies and living standards observed for the world average 44 years earlier. Sub-Saharan Africa was 100 years behind the frontier PPD, suggesting its 2019 PPD was already achievable in 1919 among those with access to the best available health-enhancing technology and living standards. India converged somewhat towards the global PPD, being 20 years behind in 2000 and 13 years behind in 2019. The North Atlantic was the furthest ahead, 44 years, achieving the 2019 global PPD in 1975. Given GDP, in 2019, the United States had a PPD expected in 1974, which suggests that per capita GDP reflected health-enhancing technologies and living standards to the same extent as in the average country 45 years earlier. International cooperation should ensure that technological and medical advancements lead to universal health benefits that are rapidly and fairly disseminated.

## Introduction

Life expectancy has been on an upward trajectory for over two centuries, thanks to advances in medical science, public health, and living standards.[1,2] However, progress has been uneven across regions leading to stark disparities in mortality. For example, in 2019, the probability of premature death (PPD)—the chance of dying before age 70 years—was 15% in Western Europe and Canada, 22% in the United States, 36% in India, and 52% in sub-Saharan Africa.[3]

Development is by its nature a long-run process and gaps in important outcomes such as PPD across countries highlight unequal improvements of living standards and access to life-extending health technologies.[4–6] This study examined the uneven decline in the PPD across geographic regions. Our comparative analysis shows how many years behind or ahead of global PPD a region was in 2000 and 2019. For instance, if a region had a PPD in 2019 that was the same as the global PPD in 1999, we considered that region to be 20 years behind the global progress in PPD. Conversely, if a region had a PPD in 1999 that was equivalent to the global PPD of 2019, it was considered 20 years ahead. We show results for both 2000 and 2019 to explore whether regions are converging in terms of PPD: that is, whether regions that were behind in 2000 have been catching up and were fewer years behind in 2019. We also show years behind the "frontier" PPD—PPD in the country with the lowest PPD each year.

Economic growth and life expectancy improvements are both part of a broader development process with many shared explanatory factors. Causal links between economic growth and health have also been suggested, running in both directions: Improved health can increase growth, since healthier populations are more productive and have greater incentives to both save and invest in their human capital (as they expect to live longer).[2,7] Economic growth can also improve health, for example, by improving living standards, allowing building and maintenance of important public health infrastructure, and increasing spending on medical treatments.[2] Therefore, we also assessed the PPD performance relative to the expected level of progress given economic development. We did this by integrating Preston curves—which show the cross-sectional relationship between PPD and aggregate income[8]—into our examination. Ultimately, health enhancing activities will be bounded by income, but countries at the same level of economic development can still achieve vastly different health outcomes due to contextual factors, such as prioritization of health spending, sub-national inequalities, and cultural and environmental factors.

## Data and Methods

### *Data sources*

Mortality probabilities for single year age intervals were obtained for 236 countries and territories between 1950–2023 from the United Nations World Population Prospects (UN WPP) 2024 life tables.[9] These mortality probabilities were used to calculate the probability of dying before age 70 years (${}_{70}q_0$), or PPD. We obtained real per capita GDP (in 2011 international $) and total population, available for 169 countries from the 2023 version of the Maddison Project database.[11]

We follow the regional classification used in the third report of *The Lancet* Commission on Investing in Health: Central Asia, Central & Eastern Europe, Middle East & North Africa, sub-Saharan Africa, Latin America & the Caribbean, Western Pacific & Southeast Asia (excluding China) and the North Atlantic (Western Europe and Canada: see appendix table S1 for details). We also considered the three most populous countries separately: China, India, and the United States (for consciousness, we will refer to these countries as regions in the text). We also show results for the 30 most populous countries in 2019 based on UN WPP 2024 population estimates.[10]

*Estimating years behind or ahead of the global average PPD*

We restricted our main analyses to years before 2020 to avoid (presumably) temporary distortions due to the COVID-19 pandemic. Our main benchmark was the global PPD from 1950–2019. Since the life extending technologies generally only advance, we considered increases in PPD across years in this period to be temporary setbacks. Therefore, we removed increases in global PPD across years (which happened in 1959, 1960, and 1965): therefore, the benchmark is the lowest global average PPD ever observed for each year.

We determined how many years behind or ahead a region was compared with the global PPD. As an example, consider India in 2019. Since India had a PPD above the global PPD it was behind the global PPD benchmark (table S2). We then identified the most recent year that the global PPD was greater than India's 2019 PPD. That year was 2006 (figure 1). Therefore, in 2019, India was 13 years behind the global PPD. On the other hand, China was ahead of the benchmark since it had a PPD below the global PPD in 2019. We identified the most recent year that China's PPD was above the global 2019 PPD. That year was 1997, so, in 2019, China was 22 years ahead of the global PPD. We do the same for each region in 2000, which shows whether regions and countries that were behind are catching up.

As a supplementary analysis, we compare years behind global average PPD in 2019 to that of 2023 to assess the impact of the COVID-19 pandemic and show results separated for males and females (where separate benchmarks are used for males and females).

*Years behind the frontier PPD*

We also used the frontier PPD as a benchmark, instead of the global PPD. The frontier PPD was defined as the country with the lowest PPD within each year (excluding countries with a population below 3 million in 2019). Since the earliest PPD observed was 1950, and some regions were further behind the frontier PPD than 1950,  we supplemented the UN WPP data with data from the Human Mortality Database (HMD),[14] which provides age-specific mortality probabilities extending back to l751. The early HMD estimates were only available for a few countries: however, these now-high-income countries (eg, Sweden, Norway, France), were likely to be (or at least close to being) the global frontier before 1950. We removed increases in frontier PPD between years: therefore, the interpretation of the frontier is the lowest PPD demonstrated to be possible with the best living standards and most advanced technology available each year.

*Estimating years behind or ahead of Preston curves*

The Preston curve is a seminal concept relating life expectancy to per capita aggregate income.[8] With technological advancements, the Preston curve is expected to shift upwards across time, such that the same levels of income would result in better life expectancy in more recent years.[12,13]

For this analysis, we first estimated Preston curves for each year 1950–2019 to use as benchmarks. Pooling all years and the 169 countries with available GDP data (see table S1), we estimated a linear regression of PPD on (log) real per capita GDP and separate intercepts for each year (table S3 and figures S1–S3). Technological advancements result in the intercepts shifting downward, such that in more recent years, lower PPD should be achieved for the same level of GDP. This shift in the Preston curve across time allows us to estimate how far behind or ahead regions were from the 2000 and 2019 Preston curves given their

GDP and PPD. (We observed a few cases where the intercepts moved slightly upward across years, and adjusted these such that the intercept each year was the lowest ever observed since 1950.)

First, we determined whether the PPD observed in a region in 2019 was higher or lower than the PPD predicted by that region's 2019 per capita GDP. In other words, we determined whether a region was above (behind) or below (ahead) the 2019 Preston curve. The region was behind the Preston curve in 2019 if its observed PPD was greater than the PPD predicted from the Preston curve, meaning that the region had a higher PPD than expected given its level of income. Then, we identified the most recent Preston curve where the target region's 2019 per capita GDP predicted a greater PPD than was observed in that region in 2019. Conversely, the region was ahead of the Preston curve in 2019 if its observed PPD was lower than the PPD predicted from the 2019 Preston curve. Then, we identified the most recent Preston curve where the target region's 2019 per capita GDP predicted a PPD lower than that observed in that region in 2019.

As a sensitivity analysis, we moved away from Preston curves when estimating years behind relative to per capita GDP, and allowed for a more flexible relationship between per capita GDP and PPD. We regressed PPD on an intercept and log of per capita GDP for each year separately, obtaining year-specific intercepts and year-specific GDP slopes (table S3 and figures S1). Using this specification, the predicted PPD across the distribution of per capita GDP could intersect between different years, which goes against what would be suggested by the Preston curve (the same level of per capita GDP would generally not predict a lower PPD in an earlier year than a later year; in other words, the amount of health for a given per capita GDP should increase across years). Using this more flexible equation, we determined years behind or ahead for a given level of GDP the same as when using the Preston curves (referring to the most recent year a lower PPD was observed for a given GDP).

All analyses were conducted using Stata 16 (Stata Corp).

## Results

### *Years behind or ahead of the global average PPD*

The global PPD fell from 67% in 1950 to 32% in 2019 (figure 1). Three regions had a PPD behind the global PPD in 2019: sub-Saharan Africa, Central Asia, and India. For example, India's PPD was 36.9% in 2019: the most recent year the global PPD was greater than 36.9% was 2006 (when it was 37.2%, falling to 36.7% in 2007). The last year that the global PPD was as low as in sub-Saharan Africa in 2019 was 1975, when it was 52%. Central Asia had a PPD of 40% in 2019, which was last observed for the global PPD in 2000. This means that sub-Saharan Africa was 44 years behind the global PPD in 2019, while Central Asia was 19 years behind and India 13 years behind (figure 2). In 2000, sub-Saharan Africa was further behind the global PPD, or 48 years behind. India's relative gains were larger, having been 20 years behind in 2000.

Other regions were ahead of the global average PPD. For example, China had a PPD of 21% in 2019. The last year China had a PPD above the 2019 global PPD (32%) was in 1997, when it was 32.5% (falling to 31.9% in 1998), putting China 22 years ahead of the global PPD. China made gains in PPD relative to the global PPD, having been 13 years ahead in 2000. The North Atlantic was the furthest ahead of the global PPD both in 2000 and 2019, or 49 and 44 years ahead, respectively. The United States was 43 years ahead of the global PPD in

2000 and 39 years ahead in 2019. Central & Eastern Europe went from being 9 years behind in 2000 to three years ahead of the global PPD in 2019.

Among the 30 largest countries, Japan and Spain were furthest ahead of the global PPD in 2019, by 49 years and 48 years, respectively, followed by Italy at 47 years and France at 44 years ahead. Nigeria was the furthest behind, 65 years, followed by Kenya, 48 years behind, and the Democratic Republic of the Congo (Congo DR), 43 years (figure S4).

The North Atlantic was closest to the frontier PPD, having a PPD of 15%, last observed in the frontier in 2003 (figure 3). Sub-Saharan Africa was the furthest behind the frontier, with a PPD of 52% in 2019, last observed in the frontier in 1919.

*Changes 2019–2023 and sex-differences*

Regions that were the furthest ahead of the global average PPD in 2019, the North Atlantic, United States, and China, moved further ahead in 2023 (figure S5). Regions that less far ahead regressed closer to the global average PPD 2019–2023: Central & Eastern Europe (which was below the global average PPD in 2023), Western Pacific & Southeast Asia, and especially Latin America & the Caribbean and the Middle East & North Africa. Regions below the global average PPD in 2019—India, Central Asia, and sub-Saharan Africa—remained similarly positioned relative to the global average PPD in 2019 and 2023. Among the 30 most populous countries, those ahead of the global PPD in 2019 were further ahead in 2023 and those behind in 2019 were further behind in 2023 (figures S6).

Among the 10 regions highlighted, sex differences were particularly large in Central & Eastern Europe, where males were 14 years behind in 2019 while females were 13 years ahead (figures S7). In 2019, females were 13 years further ahead than men in the United

States, 12 in the North Atlantic, five in Latin America & the Caribbean, four in Western Asia & Pacific, two in China, and one in the Middle East & North Africa. Meanwhile, males were five years further behind than women in Central Asia, and females were six years further behind than males in India and four years in sub-Saharan Africa.

*Behind or ahead of the Preston curve*

The United States, Central & Eastern Europe, sub-Saharan Africa, Central Asia, and India were all above the 2019 Preston curve (figure 4). That is, they had a greater PPD than predicted by their GDP. For example, in 2019, India had a per capita GDP of around $7300 and a PPD of 37% (table S2). Meanwhile, the 2019 Preston curve predicted a PPD of 36% for a $7300 per capita GDP: therefore, India was behind (or above) the Preston curve in 2019. The most recent Preston curve to predict a PPD below 37% for a per capita GDP of $7300 was in 2000, putting India 19 years behind the 2019 Preston curve (figures S2–S3). The United States was the furthest behind considering its per capita GDP, being on the 1974 Preston curve in 2019. Meanwhile, Central & Eastern Europe was on the 1976 Preston curve, sub-Saharan Africa on the 1982 curve, Central Asia on the 1997 curve.

The United States had the largest shift backward, being 27 years behind the expected PPD given its GDP in 2000 and 45 years behind in 2019 (figure 5). Central & Eastern Europe also moved backward, from being 29 years behind in 2000 to being 43 years behind the Preston curve in 2019. Central Asia also had a large backward slide, from being 12 years behind in 2000 to 22 years behind in 2019. Sub-Saharan Africa witnessed a small improvement, being 39 years behind in 2000 and 37 in 2019.

Other regions were ahead of the Preston curve. For example, in 2019, China had a per capita GDP of almost $17 000 and a PPD of 21% (table S2). The 2019 Preston curve predicted a

PPD of 27% for $17 000 per capita GDP. The most recent year a GDP of $17 000 predicted a PPD above 21% was 2006, putting China 13 years ahead of the Preston curve in 2019. The North Atlantic was 1 year ahead of the Preston curve in 2000 and 12 years ahead in 2019.

Nigeria and South Africa were further behind the Preston curve than 1950, meaning the years behind could not be calculated (figure S8). Otherwise, Russia, Kenya, and the United States were the furthest behind the Preston curve in 2019, while Vietnam, Japan, Spain, and Italy were the furthest ahead.

Using a more flexible specification when predicting PPD for a given GDP shows largely similar results as using Preston curves with fixed slopes and non-decreasing intercepts across years (figure S9). The largest absolute difference between the two model specifications, among the 10 main regions studied was for the United States, which was eight fewer years behind, and slightly less behind than sub-Saharan Africa.

**Discussion**

The global average PPD fell from 67% in 1950 to 32% in 2019. However, the progress has been uneven, with sub-Saharan Africa, Central Asia, and India lagging. Sub-Saharan Africa and India converged somewhat towards the global PPD between 2000 and 2019. However, our supplementary analysis revealed that between 2019 and 2023, during the emergency phase of the COVID-19 pandemic, a small divergence occurred, where countries that were ahead moved further ahead and those behind moved further behind, among the 30 most populous countries. When considering the PPD expected for a given per capita GDP using Preston curves, sub-Saharan Africa, Central & Eastern Europe, and the United States were furthest behind (above) the 2019 PPD Preston curve.

Together these results highlight an uneven process of mortality improvements across regions, both overall and when considering the mortality expected for a given level of economic development. In 2019, sub-Saharan Africa, for example, had a combination of health enhancing technologies and living standards last observed for the world average in 1975. If considering the best PPD ever observed each year (the frontier PPD) instead of global PPD, sub-Saharan Africa could be considered hundred years behind the PPD possible if given the best available health enhancing technology and living standard. The relative lag in the mortality decline observed in sub-Saharan Africa, Central Asia, and India may reflect a wide range of factors, such as difficulties in implementing and accessing health enhancing innovation, low living standards, and unique challenges related to these contexts.

Despite enormous improvements, sub-Saharan Africa continues to have high mortality from infectious diseases and neonatal and maternal conditions, due to a lack of basic healthcare and public services for much of the population.[15] Although infectious diseases and neonatal conditions continue to play a sizable role in premature mortality in Central Asia and India, non-communicable diseases are increasingly driving premature mortality differentials, suggesting a need for control of risk factors, particularly to tackle early deaths from cardiovascular disease (eg, smoking, hypertension, high cholesterol).[16]

Early advances in agricultural technology improved nutrition[17] and discovery of the germ theory of diseases eventually led to improvements in sanitation, hygiene, and food standards, causing early declines in mortality and increased life expectancy in today's rich countries in the 19$^{th}$ and early 20$^{th}$ century.[18,19] Implementing these early technological innovations required public action and major investments into large scale projects. Health improvements were, therefore, somewhat more contingent on economic growth. Over time these costs go down. Also, in the later 20$^{th}$ century, health enhancing innovations were to a larger extent individually targeted medical interventions. For example, vaccines, oral rehydration therapy, and statins can have large health benefits at a low cost, enabling countries to achieve better health at a lower level economic development than before.[20] Therefore, the Preston curve has shifted, such that the same level of per capita GDP affords better health today than in the past.

The structural, historical, and sociopolitical context of each region plays a crucial role in shaping health outcomes at any level of economic development. Incomes may be unequally distributed, not spent on health, or even achieved through means that are detrimental to health. Conversely, countries can also make use of resources efficiently, prioritize health, implement cost-effective interventions, or practice healthy behaviors (eg, healthier diet and alcohol restrictions) and thereby achieve low mortality at low level of GDP.[21,22] However, ultimately, aggregate income constrains living standards and the ability to implement effective health interventions—such as healthcare, public safety, and establishment and maintenance of water, sanitation, and other important infrastructure. Taking these economic constraints into account suggests that China manages to ensure high level of health for its level of economic development. Conversely, the results suggest that the United States, Central & Eastern Europe, sub-Saharan Africa, and Central Asia were behind the PPD expected given their level of aggregate income. The reasons why economic development does not translate into low mortality are likely to vary across these regions.

In the United States, for example, per capita GDP translates into health enhancing technologies and living standards to the same extent as in the average country 45 years earlier. Despite a high per capita GDP (and the highest global health care spending[23]), the Unites States has high levels of economic inequality.[24] The individual income-health relationship tends to show diminishing marginal returns in health to increased income:

therefore, greater inequality at the same level of aggregate income will inevitably lead to higher observed mortality.[25–27] Further, the healthcare systems in the United States suffers from spending waste[28] and gun violence (homicide and suicide) and road traffic deaths cause an unusually high loss of life for a rich country.[15] Finally, the United States is going through a substance use epidemic, which has been claiming an increasing number of lives, especially since 2014.[29] In fact, despite continued economic growth, life expectancy in the United States has been declining.[30,31]

Central & Eastern Europe has witnessed rapid economic growth, especially since 1990, but continues to have a large number of deaths due to alcohol misuse and suicide, especially among males.[15,32] The prominence of the mining sector in sub-Saharan Africa and "the resource curse"—suggested to reduce human development by decreasing equality,[33] quality of institutions,[34] and public spending[35]—may to an extent explain why it remains far behind of the Preston curve.[36]

Our study has five key limitations. First, our conclusions rely on the quality and availability of mortality and economic data across regions. We relied on estimates from the UN WPP 2024 for the main analysis, which are widely used and generally considered reliable. Second, comparing regions based on years behind or ahead of global PPD progress simplifies complex temporal dynamics and regional disparities. Third, the links between per capita GDP and PPD estimated in our paper were not causal in either direction. However, our goal was to describe expected PPD for a given level of economic development, which does not imply causality. Fifth, the analyses were purely descriptive and do not provide explanations for the differences observed.

## Conclusions

In the context of long run and largely uninterrupted declines in premature mortality, our comparative analytic approach illuminates uneven progress across regions. By comparing mortality disparities as years behind or ahead of the global curve, this study highlights the temporal nature of mortality declines across the world.

**Competing interest**

None.

**Data availability**

United Nations Population Prospects single age life tables are available at population.un.org. The Maddison Project per capita GDP is available at https://www.rug.nl/. Human Mortality Database is available at https://www.mortality.org/.

**Code availability**

Codes used to produce the estimates in this paper is available at https://github.com/O-Karlsson/Probability-of-death-before-age-70-progress-as-years-behind-or-ahead-of-the-global-average-trend.

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**Role of the funding source**

The funders played no role in the data collection and analysis, reporting and interpretation of results, or the decision to submit the manuscript for publication. Authors were not precluded from accessing data in the study, and they accept responsibility to submit for publication.

**Contributions**

Omar Karlsson did data management, analyses, reporting, and wrote the manuscript. Dean Jamison, Stéphane Verguet, Osondu Ogbuoji, and Omar Karlsson devised the conceptual idea of the paper. Stéphane Verguet and Osondu Ogbuoji provided critical feedback and edited the first draft of the manuscript. Gavin Yamey made substantial edits and provided critical feedback on the manuscript. All authors provided critical feedback on the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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## Ethical considerations

This project used publicly accessible aggregate data from the United Nations World Population Prospects and the Maddison Project. These activities do not meet the regulatory definition of human subjects research. As such, an Institutional Review Board review was not required.

## Supplementary information

Supplements 1 and 2.

## REFERENCES


1 Oeppen J, Vaupel JW. Demography. Broken limits to life expectancy. *Science* 2002; **296**: 1029–31.

2 Weil DN. Chapter 3 - Health and Economic Growth. In: Aghion P, Durlauf SN, eds. Handbook of Economic Growth. Elsevier, 2014: 623–82.

3 Norheim O, et al. Halving premature death and improving the quality of life at all ages. Background paper for CIH 3.0. *Reference to be added* 2024.

4 Sicherl P. Time-Distance as a Dynamic Measure of Disparities in Social and Economic Development*. *Kyklos* 1973; **26**: 559–75.

5 Kulkarni SC, Levin-Rector A, Ezzati M, Murray CJ. Falling behind: life expectancy in US counties from 2000 to 2007 in an international context. *Popul Health Metrics* 2011; **9**: 16.

6 Verguet S, Jamison DT. Improving life expectancy: how many years behind has the USA fallen? A cross-national comparison among high-income countries from 1958 to 2007. *BMJ Open* 2013; **3**: e002814.

7 Bloom DE, Canning D. The Health and Wealth of Nations. *Science* 2000; **287**: 1207–9.

8 Preston SH. The changing relation between mortality and level of economic development. *Population studies* 1975; **29**: 231–48.

9 United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects 2024, Online Edition. 2024. https://population.un.org/wpp/Download/Standard/MostUsed/ (accessed July 14, 2024).

10 United Nations, Department of Economic and Social Affairs, Population Division. Total population (both sexes combined) by single age. Population Division: World Population Prospects 2022. 2022. https://population.un.org/wpp/DataQuery/ (accessed April 24, 2023).

11 Bolt J, Van Zanden JL. Maddison-style estimates of the evolution of the world economy: A new 2023 update. *Journal of Economic Surveys* 2024; : joes.12618.

12 Jamison DT, Sandbu M, Wang J. Cross-country variation in mortality decline, 1962-87: The role of country-specific technical progress. *Commission on Macroeconomics and Health, Working Paper WG1* 2001.

13 Schultz TP. Population and health policies. In: Rodrik D, Rosenzweig M, eds. Handbook of development economics. Elsevier, 2010: 4785–881.

14 Max Planck Institute for Demographic Research (Germany), University of California, Berkeley (USA), French Institute for Demographic Studies (France). Human Mortality Database (HMD). 2024. www.mortality.org (accessed June 1, 2024).

15 World Health Organization. Global Health Estimates. 2022. https://www.who.int/data/global-health-estimates (accessed Dec 14, 2023).

16 Karlsson O, et al. Priority health conditions and life expectancy deficits by cause of death: a life table decomposition. *CIH backrground paper* forthcoming.

17 Fogel RW. Health, Nutrition, and Economic Growth. *Economic Development and Cultural Change* 2004; **52**: 643–58.

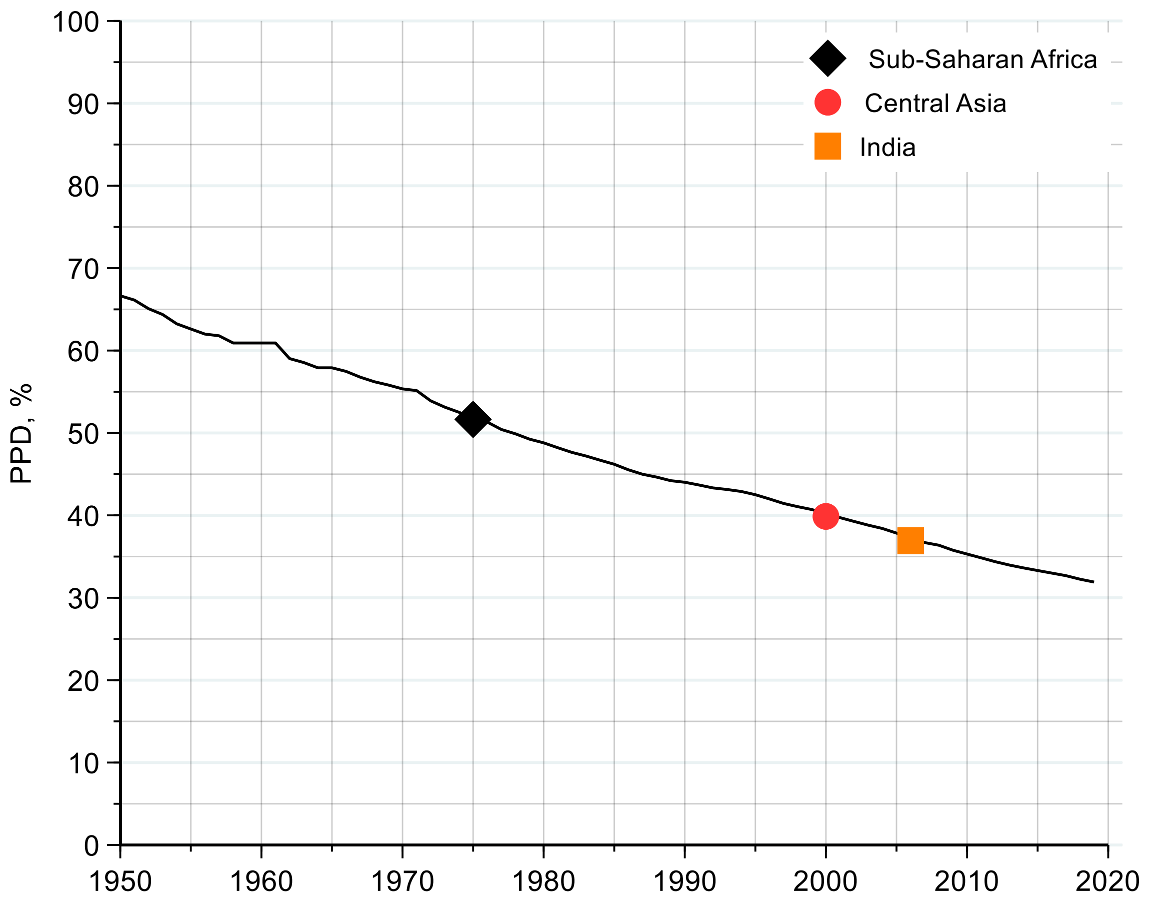
18 Cutler D, Miller G. The role of public health improvements in health advances: The twentieth-century United States. *Demography* 2005; **42**: 1–22.

19 Bhatia A, Krieger N, Subramanian S. Learning From History About Reducing Infant Mortality: Contrasting the Centrality of Structural Interventions to Early 20th-Century Successes in the United States to Their Neglect in Current Global Initiatives. *The Milbank Quarterly* 2019; **97**: 285–345.

20 Kremer M, Glennerster R. Chapter Four - Improving Health in Developing Countries: Evidence from Randomized Evaluations11We are grateful to Jacobus de Hoop, Ludovica Gazze, Martin Rotemberg, Mahvish Shaukat, and Anna Yalouris for excellent research assistance. This chapter draws on Ahuja et al. (2010); Holla and Kremer (2009); Glennerster et al. (2009); and Bates et al. (2011). In: Pauly MV, Mcguire TG, Barros PP, eds. Handbook of Health Economics. Elsevier, 2011: 201–315.

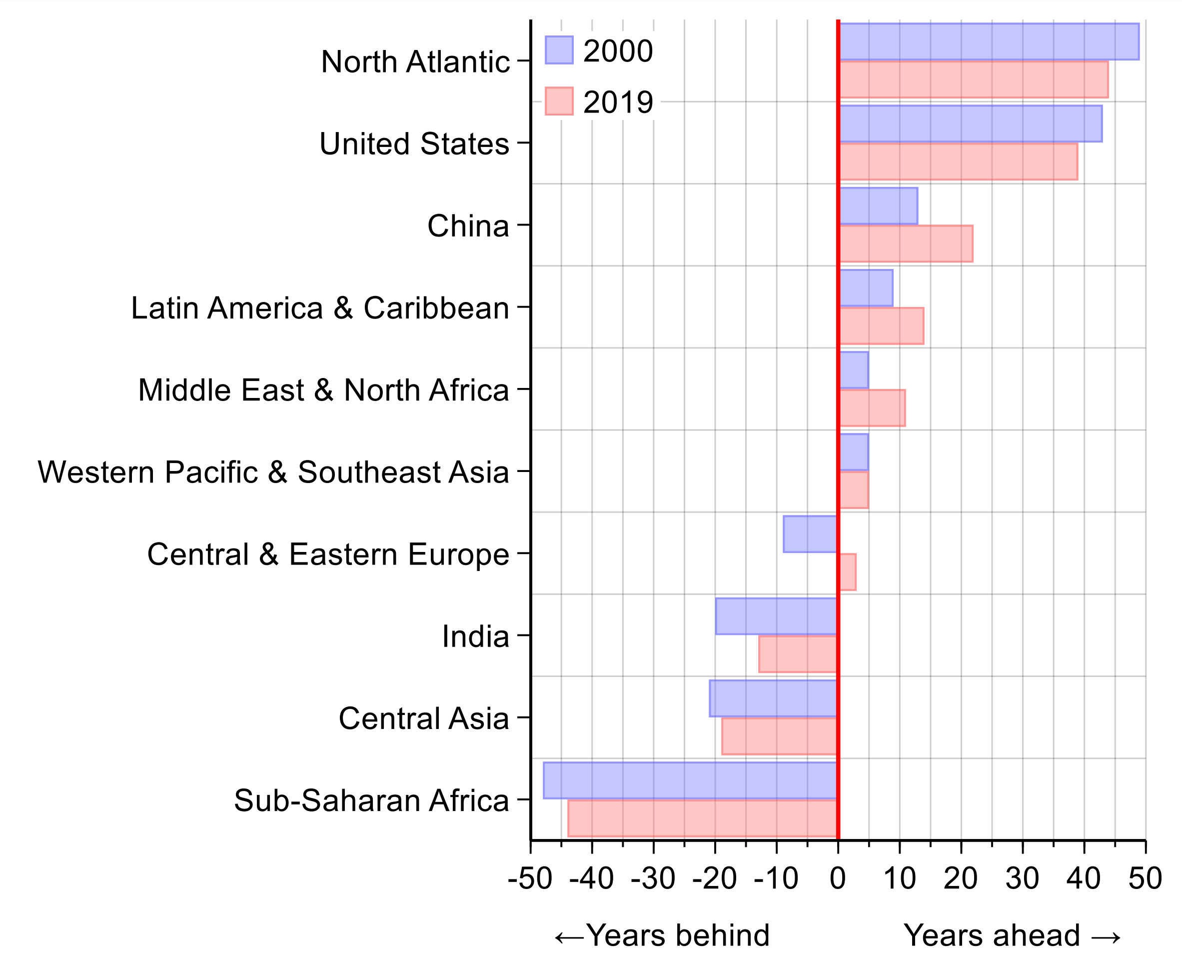
21 Jamison DT, Alwan A, Mock CN, *et al.* Universal health coverage and intersectoral action for health: key messages from Disease Control Priorities, 3rd edition. *Lancet* 2018; **391**: 1108–20.
22 Watkins DA, Msemburi WT, Pickersgill SJ, *et al.* NCD Countdown 2030: efficient pathways and strategic investments to accelerate progress towards the Sustainable Development Goal target 3.4 in low-income and middle-income countries. *The Lancet* 2022; **399**: 1266–78.
23 World Health Organization. Global Health Expenditure Database. 2023. https://apps.who.int/nha/database (accessed Dec 22, 2023).
24 World Bank. Gini index. World Development Indicators. 2024. https://databank.worldbank.org/reports.aspx?source=2&type=metadata&series=SI.POV.GINI (accessed Feb 15, 2024).
25 Linden M, Ray D. Aggregation bias-correcting approach to the health–income relationship: Life expectancy and GDP per capita in 148 countries, 1970–2010. *Economic Modelling* 2017; **61**: 126–36.
26 Deaton A. Global Patterns of Income and Health: Facts, Interpretations, and Policies. Cambridge, MA: National Bureau of Economic Research, 2006.
27 Deaton A. Health, inequality, and economic development. *Journal of economic literature* 2003; **41**: 113–58.
28 Shrank WH, Rogstad TL, Parekh N. Waste in the US Health Care System: Estimated Costs and Potential for Savings. *JAMA* 2019; **322**: 1501–9.
29 National Center for Health Statistics. Drug Overdose Deaths. 2023. https://www.cdc.gov/nchs/nvss/drug-overdose-deaths.htm (accessed Feb 15, 2023).
30 Venkataramani AS, O'Brien R, Tsai AC. Declining Life Expectancy in the United States: The Need for Social Policy as Health Policy. *JAMA* 2021; **325**: 621–2.
31 Institute of Medicine and National Research Council. Health in International Perspective: Shorter Lives, Poorer Health. Washington, DC: The National Academies Press, 2013 https://doi.org/10.17226/13497.
32 Shield K, Manthey J, Rylett M, *et al.* National, regional, and global burdens of disease from 2000 to 2016 attributable to alcohol use: a comparative risk assessment study. *The Lancet Public Health* 2020; **5**: e51–61.
33 Carmignani F. Development outcomes, resource abundance, and the transmission through inequality. *Resource and Energy Economics* 2013; **35**: 412–28.
34 Bulte EH, Damania R, Deacon RT. Resource intensity, institutions, and development. *World development* 2005; **33**: 1029–44.
35 Gylfason T, Zoega G. Natural resources and economic growth: The role of investment. *World Economy* 2006; **29**: 1091–115.
36 Edwards RB. Mining away the Preston curve. *World Development* 2016; **78**: 22–36.

**Figure 1. Global PPD across time (line) and for regions in 2019 (markers)**



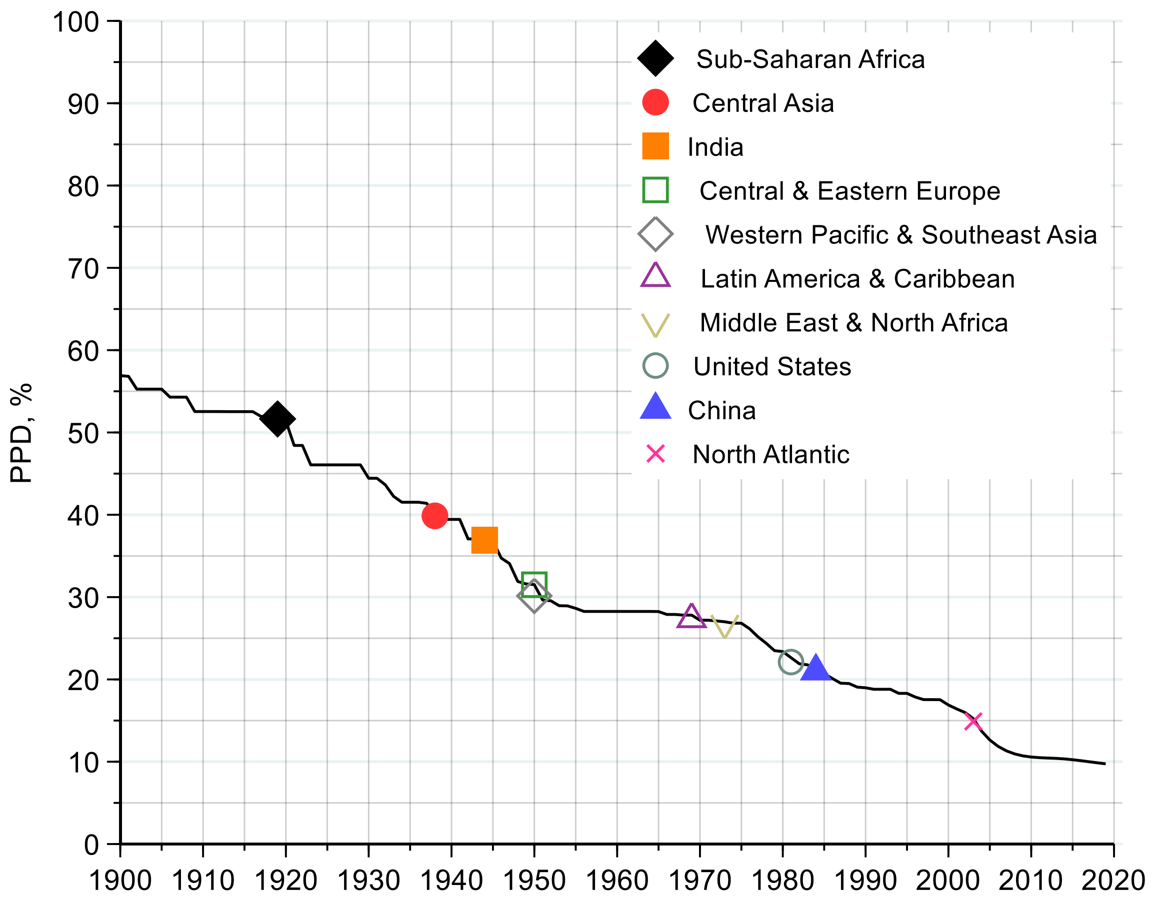

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. The line shows Global PPD each year while the markers indicate PPD in 2019 for each location. The lowest global PPD ever observed is shown (ie, increases across years were removed). Regions with lower PPD than the global average are not shown. Data source: UN WPP 2024.

**Figure 2. Years behind or ahead of the global PPD**



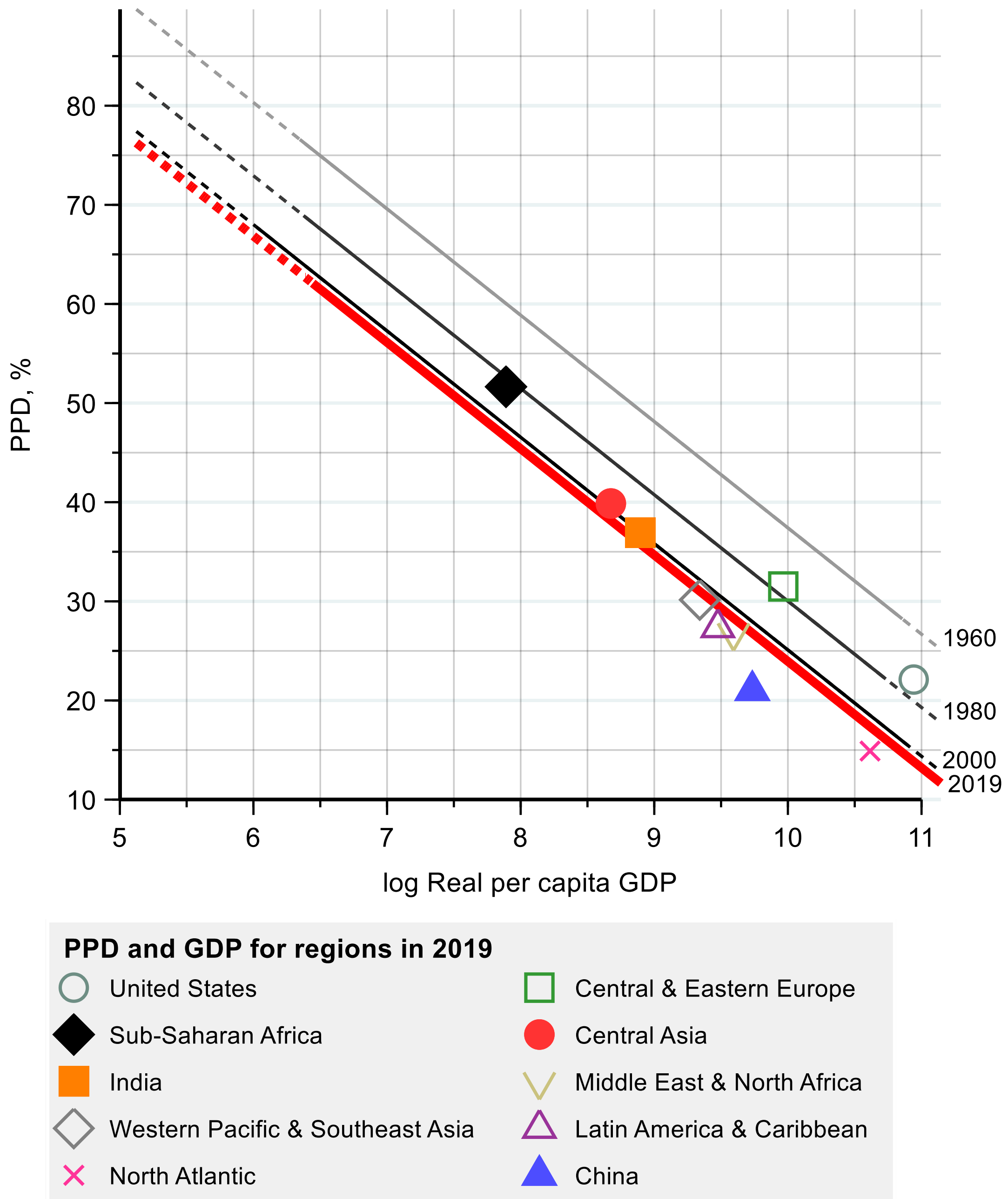

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Data source: UN WPP 2024.

**Figure 3. Frontier PPD across time (line) and for regions in 2019 (markers)**



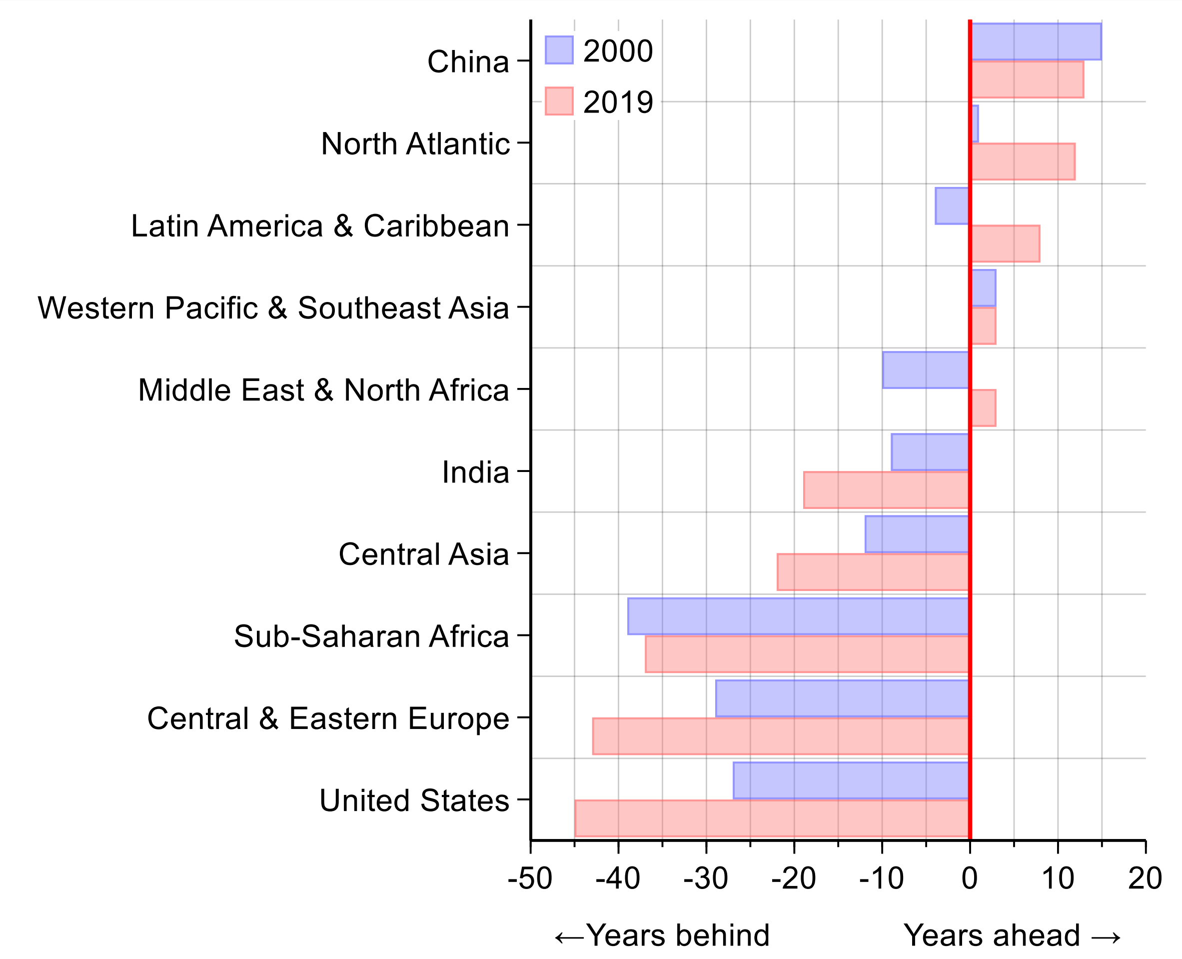

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. The line shows Frontier PPD each year while the markers indicate PPD in 2019 for each location. The frontier is the lowest PPD ever observed (ie, increases across years were removed). Countries with a population below 3 million in 2019 were not considered for being a frontier. Data source: UN WPP 2024 after 1950 and HMD 2024 before 1950.

**Figure 4. Preston curve (red line) and observed PPD and GDP for regions (markers) in 2019**




Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Markers indicate PPD and GDP for each region in 2019. Red line shows the 2019 Preston curve. Preston curves for the years 1960, 1980, and 2000 are shown in gray for comparison. The dashed line indicates GDP beyond what was observed in that year. Preston curves were estimated for each year by regressing PPD on log of GDP with a separate intercept for each year. The slope for GDP is constant across years while the intercept varies across years. The intercepts were adjusted such that they never increased across years.

**Figure 5. Years behind or ahead of the Preston curve**




Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Data source: UN WPP 2024 and the Maddison Project 2023.

# Supplement: Probability of death before age 70: progress as years behind or ahead of the global average trend

## Table S1: Regions and availability of GDP data in parentheses*

| Central & Eastern Europe | Central Asia | Latin America & the Caribbean | Middle East & North Africa | North Atlantic | Sub-Saharan Africa | Western Pacific & Asia |
|---|---|---|---|---|---|---|
| Albania | Afghanistan | Anguilla (No GDP) | Algeria | Andorra (No GDP) | Angola | American Samoa (No GDP) |
| Armenia | Azerbaijan | Antigua & Barbuda (No GDP) | Bahrain | Austria | Benin | Australia |
| Belarus | Kazakhstan | Argentina | Egypt, Arab Rep. | Belgium | Botswana | Bangladesh |
| Bosnia & Herzegovina | Kyrgyz Republic | Aruba (No GDP) | Iran, Islamic Rep. | Bermuda (No GDP) | Burkina Faso | Bhutan (No GDP) |
| Bulgaria | Mongolia | Bahamas, The (No GDP) | Iraq | Canada | Burundi | Brunei Darussalam (No GDP) |
| Croatia | Pakistan | Barbados | Israel | Cyprus | Cabo Verde | Cambodia |
| Czechia | Tajikistan | Belize (No GDP) | Jordan | Denmark | Cameroon | Cook Islands (No GDP) |
| Estonia | Turkmenistan | Bolivia | Kuwait | Faroe Islands (No GDP) | Central African Republic | Fiji (No GDP) |
| Georgia | Uzbekistan | Bonaire, Sint Eustatius & Saba (No GDP) | Lebanon | Finland | Chad | French Polynesia (No GDP) |
| Hungary | | Brazil | Libya | France | Comoros | Guam (No GDP) |
| Kosovo (No GDP) | | British Virgin Islands (No GDP) | Morocco | Germany | Congo, Dem. Rep. | Hong Kong SAR, China |
| Latvia | | Cayman Islands (No GDP) | Oman | Gibraltar (No GDP) | Congo, Rep. | Indonesia |
| Lithuania | | Chile | Qatar | Greece | Côte d’Ivoire | Japan |
| Moldova | | Colombia | Saudi Arabia | Greenland (No GDP) | Djibouti | Kiribati (No GDP) |
| Montenegro | | Costa Rica | Syria | Guernsey (No GDP) | Equatorial Guinea | Korea, Dem. People's Rep. |
| North Macedonia | | Cuba | Tunisia | Iceland | Eritrea (No GDP) | Korea, Rep. |
| Poland | | Curaçao (No GDP) | Türkiye | Ireland | Eswatini | Lao PDR |
| Romania | | Dominica | United Arab Emirates | Isle of Man (No GDP) | Ethiopia | Macao SAR, China (No GDP) |
| Russia | | Dominican Republic | West Bank & Gaza | Italy | Gabon | Malaysia |
| Serbia | | Ecuador | Yemen, Rep. | Jersey (No GDP) | Gambia, The | Maldives (No GDP) |
| Slovak Republic | | El Salvador | | Liechtenstein (No GDP) | Ghana | Marshall Islands (No GDP) |
| Slovenia | | Falkland Islands (No GDP) | | Luxembourg | Guinea | Micronesia, Fed. Sts. (No GDP) |
| Ukraine | | French Guiana (No GDP) | | Malta | Guinea-Bissau | Myanmar |
| | | Grenada (No GDP) | | Monaco (No GDP) | Kenya | Nauru (No GDP) |
| | | Guadeloupe (No GDP) | | Netherlands | Lesotho | Nepal |
| | | Guatemala | | Norway | Liberia | New Caledonia (No GDP) |

| Central & Eastern Europe | Central Asia | Latin America & the Caribbean | Middle East & North Africa | North Atlantic | Sub-Saharan Africa | Western Pacific & Asia |
|---|---|---|---|---|---|---|
| | | Guyana (No GDP) | | Portugal | Madagascar | New Zealand |
| | | Haiti | | Saint Pierre & Miquelon (No GDP) | Malawi | Niue (No GDP) |
| | | Honduras | | San Marino (No GDP) | Mali | Northern Mariana Islands (No GDP) |
| | | Jamaica | | Spain | Mauritania | Palau (No GDP) |
| | | Martinique (No GDP) | | Sweden | Mauritius | Papua New Guinea (No GDP) |
| | | Mexico | | Switzerland | Mayotte (No GDP) | Philippines |
| | | Montserrat (No GDP) | | United Kingdom | Mozambique | Samoa (No GDP) |
| | | Nicaragua | | | Namibia | Singapore |
| | | Panama | | | Niger | Solomon Islands (No GDP) |
| | | Paraguay | | | Nigeria | Sri Lanka |
| | | Peru | | | Reunion (No GDP) | Taiwan, China |
| | | Puerto Rico | | | Rwanda | Thailand |
| | | Saint Barthelemy (No GDP) | | | Saint Helena (No GDP) | Timor-Leste (No GDP) |
| | | Sint Maarten (Dutch part) (No GDP) | | | Senegal | Tokelau (No GDP) |
| | | St. Kitts & Nevis (No GDP) | | | Seychelles | Tonga (No GDP) |
| | | St. Lucia | | | Sierra Leone | Tuvalu (No GDP) |
| | | St. Martin (French part) (No GDP) | | | Somalia (No GDP) | Vanuatu (No GDP) |
| | | St. Vincent & the Grenadines (No GDP) | | | South Africa | Vietnam |
| | | Suriname (No GDP) | | | South Sudan (No GDP) | Wallis & Futuna (No GDP) |
| | | Trinidad & Tobago | | | Sudan | |
| | | Turks & Caicos Islands (No GDP) | | | São Tomé & Príncipe | |
| | | Uruguay | | | Tanzania | |
| | | Venezuela, RB | | | Togo | |
| | | Virgin Islands (U.S.) (No GDP) | | | Uganda | |
| | | | | | Western Sahara (No GDP) | |
| | | | | | Zambia | |

| Central & Eastern Europe | Central Asia | Latin America & the Caribbean | Middle East & North Africa | North Atlantic | Sub-Saharan Africa | Western Pacific & Asia |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | | Zimbabwe | |

Notes: *Countries without a year range in parentheses have complete GDP data 1950–2019. India, China, and the United States were considered separately and had complete GDP data.

## Table S2. PPD and GDP in 2000 and 2019

| | PPD 2000 | GDP 2000 | PPD 2019 | GDP 2019 |
|---|---|---|---|---|
| Central & Eastern Europe | 43.63 | 9,168 | 31.50 | 21,282 |
| Central Asia | 48.84 | 2,958 | 39.87 | 5,856 |
| China | 30.75 | 4,730 | 21.01 | 16,880 |
| India | 48.57 | 2,753 | 36.92 | 7,294 |
| Latin America & Caribbean | 35.20 | 9,380 | 27.35 | 13,042 |
| Middle East & North Africa | 36.98 | 8,299 | 26.87 | 14,665 |
| North Atlantic | 20.56 | 32,588 | 14.91 | 40,716 |
| Sub-Saharan Africa | 64.99 | 1,523 | 51.65 | 2,672 |
| United States | 25.13 | 45,886 | 22.11 | 56,469 |
| Western Pacific & Southeast Asia | 37.92 | 5,868 | 30.15 | 11,387 |
| World | 40.17 | 5,625 | 31.91 | 10,954 |

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. GDP was per capita in 2011$.

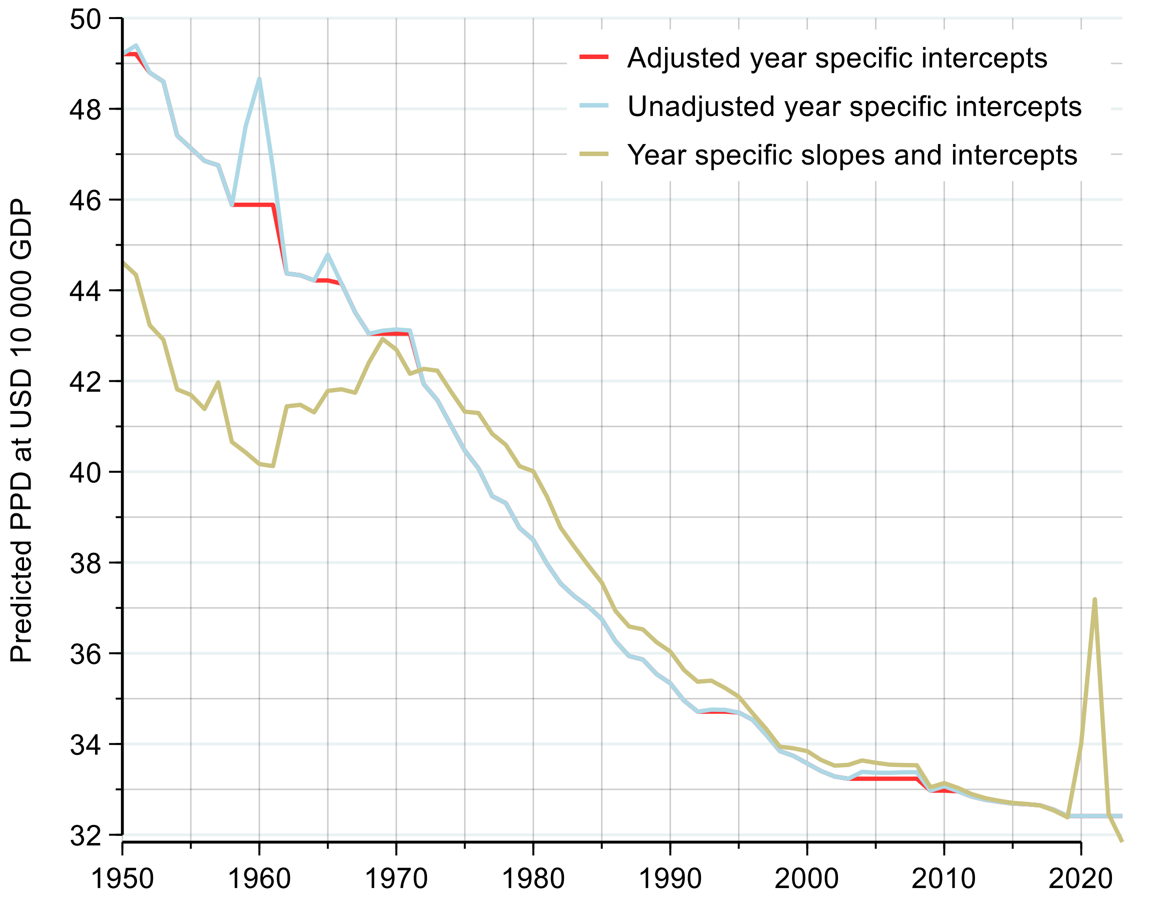
## Table S3. Results from linear regressions of PPD on log of real GDP per capita

| Year | Main model | | Sensitivity check | |
|---|---|---|---|---|
| | Intercept | Coefficient | Intercept | Coefficient |
| 1950 | 148.013 | -10.728 | 169.436 | -13.552 |
| 1951 | 148.204 (148.013) | -10.728 | 173.061 | -13.976 |
| 1952 | 147.605 | -10.728 | 175.859 | -14.400 |
| 1953 | 147.407 | -10.728 | 177.395 | -14.601 |
| 1954 | 146.220 | -10.728 | 175.590 | -14.524 |
| 1955 | 145.941 | -10.728 | 175.269 | -14.503 |
| 1956 | 145.660 | -10.728 | 175.912 | -14.606 |
| 1957 | 145.563 | -10.728 | 172.269 | -14.147 |
| 1958 | 144.692 | -10.728 | 173.964 | -14.474 |
| 1959 | 146.419 (144.692) | -10.728 | 186.977 | -15.911 |
| 1960 | 147.470 (144.692) | -10.728 | 196.097 | -16.929 |
| 1961 | 145.492 (144.692) | -10.728 | 182.395 | -15.447 |
| 1962 | 143.178 | -10.728 | 160.075 | -12.880 |
| 1963 | 143.139 | -10.728 | 160.220 | -12.892 |
| 1964 | 143.025 | -10.728 | 161.185 | -13.015 |
| 1965 | 143.595 (143.025) | -10.728 | 162.747 | -13.133 |
| 1966 | 142.956 | -10.728 | 157.983 | -12.612 |
| 1967 | 142.320 | -10.728 | 153.808 | -12.167 |
| 1968 | 141.851 | -10.728 | 146.014 | -11.249 |
| 1969 | 141.917 (141.851) | -10.728 | 143.164 | -10.883 |
| 1970 | 141.945 (141.851) | -10.728 | 145.111 | -11.120 |
| 1971 | 141.922 (141.851) | -10.728 | 148.840 | -11.583 |
| 1972 | 140.741 | -10.728 | 138.294 | -10.426 |
| 1973 | 140.386 | -10.728 | 135.448 | -10.121 |
| 1974 | 139.824 | -10.728 | 134.117 | -10.027 |
| 1975 | 139.275 | -10.728 | 132.609 | -9.911 |
| 1976 | 138.881 | -10.728 | 129.321 | -9.557 |
| 1977 | 138.271 | -10.728 | 127.191 | -9.376 |
| 1978 | 138.116 | -10.728 | 127.328 | -9.417 |
| 1979 | 137.568 | -10.728 | 126.008 | -9.325 |
| 1980 | 137.306 | -10.728 | 124.203 | -9.141 |
| 1981 | 136.780 | -10.728 | 123.852 | -9.163 |
| 1982 | 136.344 | -10.728 | 125.440 | -9.410 |
| 1983 | 136.064 | -10.728 | 126.247 | -9.544 |
| 1984 | 135.842 | -10.728 | 127.381 | -9.711 |
| 1985 | 135.559 | -10.728 | 127.839 | -9.802 |
| 1986 | 135.075 | -10.728 | 128.572 | -9.950 |
| 1987 | 134.744 | -10.728 | 128.185 | -9.945 |
| 1988 | 134.670 | -10.728 | 127.764 | -9.906 |
| 1989 | 134.348 | -10.728 | 126.949 | -9.848 |
| 1990 | 134.146 | -10.728 | 126.779 | -9.852 |
| 1991 | 133.765 | -10.728 | 126.710 | -9.889 |
| 1992 | 133.521 | -10.728 | 126.517 | -9.896 |
| 1993 | 133.565 (133.521) | -10.728 | 126.593 | -9.901 |
| 1994 | 133.560 (133.521) | -10.728 | 128.146 | -10.088 |
| 1995 | 133.501 | -10.728 | 129.380 | -10.242 |
| 1996 | 133.344 | -10.728 | 131.557 | -10.518 |
| 1997 | 133.013 | -10.728 | 131.380 | -10.537 |
| 1998 | 132.653 | -10.728 | 131.414 | -10.583 |
| 1999 | 132.544 | -10.728 | 130.309 | -10.467 |
| 2000 | 132.378 | -10.728 | 128.547 | -10.282 |
| 2001 | 132.213 | -10.728 | 128.590 | -10.308 |
| 2002 | 132.091 | -10.728 | 128.339 | -10.295 |

| Year | Main model |  | Sensitivity check |  |
|---|---|---|---|---|
|  | Intercept | Coefficient | Intercept | Coefficient |
| 2003 | 132.042 | -10.728 | 126.867 | -10.133 |
| 2004 | 132.193 (132.042) | -10.728 | 127.425 | -10.183 |
| 2005 | 132.174 (132.042) | -10.728 | 127.459 | -10.192 |
| 2006 | 132.172 (132.042) | -10.728 | 127.673 | -10.220 |
| 2007 | 132.184 (132.042) | -10.728 | 127.469 | -10.199 |
| 2008 | 132.186 (132.042) | -10.728 | 127.146 | -10.164 |
| 2009 | 131.780 | -10.728 | 129.129 | -10.432 |
| 2010 | 131.877 (131.780) | -10.728 | 128.787 | -10.385 |
| 2011 | 131.766 | -10.728 | 127.642 | -10.272 |
| 2012 | 131.649 | -10.728 | 127.905 | -10.315 |
| 2013 | 131.577 | -10.728 | 128.282 | -10.366 |
| 2014 | 131.533 | -10.728 | 128.669 | -10.414 |
| 2015 | 131.493 | -10.728 | 128.314 | -10.381 |
| 2016 | 131.480 | -10.728 | 127.786 | -10.326 |
| 2017 | 131.456 | -10.728 | 127.512 | -10.300 |
| 2018 | 131.360 | -10.728 | 127.018 | -10.258 |
| 2019 | 131.220 | -10.728 | 126.535 | -10.222 |
| 2020 | 131.220 | -10.728 | 127.705 | -10.174 |
| 2021 | 131.220 | -10.728 | 135.249 | -10.646 |
| 2022 | 131.220 | -10.728 | 117.674 | -9.252 |
| 2023 | 131.220 | -10.728 | 117.185 | -9.267 |

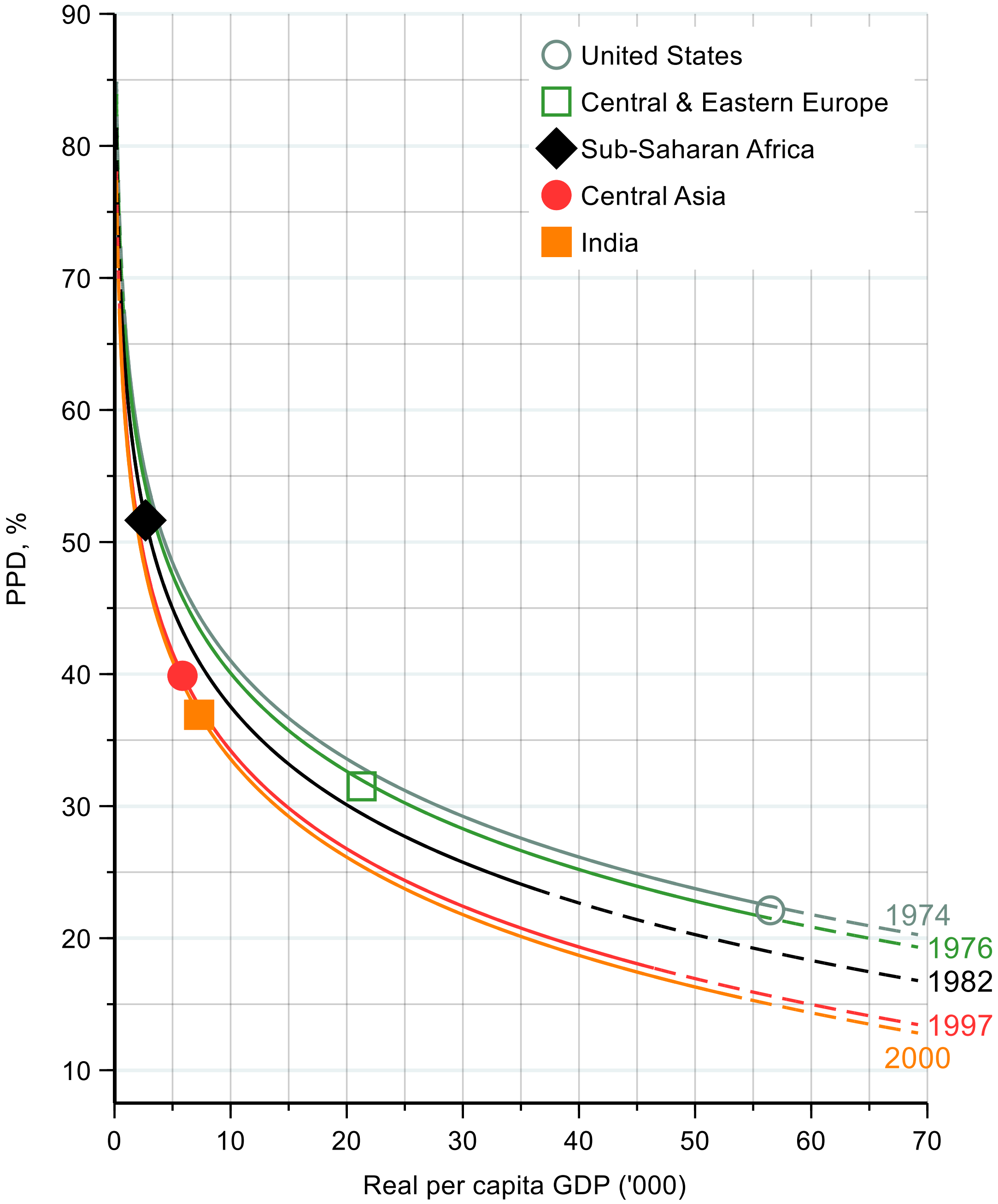
Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Main model: Preston curves were estimated for each year by regressing PPD on log of real GDP per capita with a separate intercept for each year but a coefficient for GDP that was constant across years. In the main model, the intercepts shown in parenthesis were adjusted such that they never increased across years. The sensitivity check estimated the same models allowing the coefficient for GDP to vary across year. No adjustments were made to the intercepts in the sensitivity check. Data source: UN WPP 2022 and the Maddison Project 2023.

**Figure S1. Predicted PPD at USD 10 000 GDP per capita from main model (before and after adjusting the year specific intercepts) and the sensitivity specification**



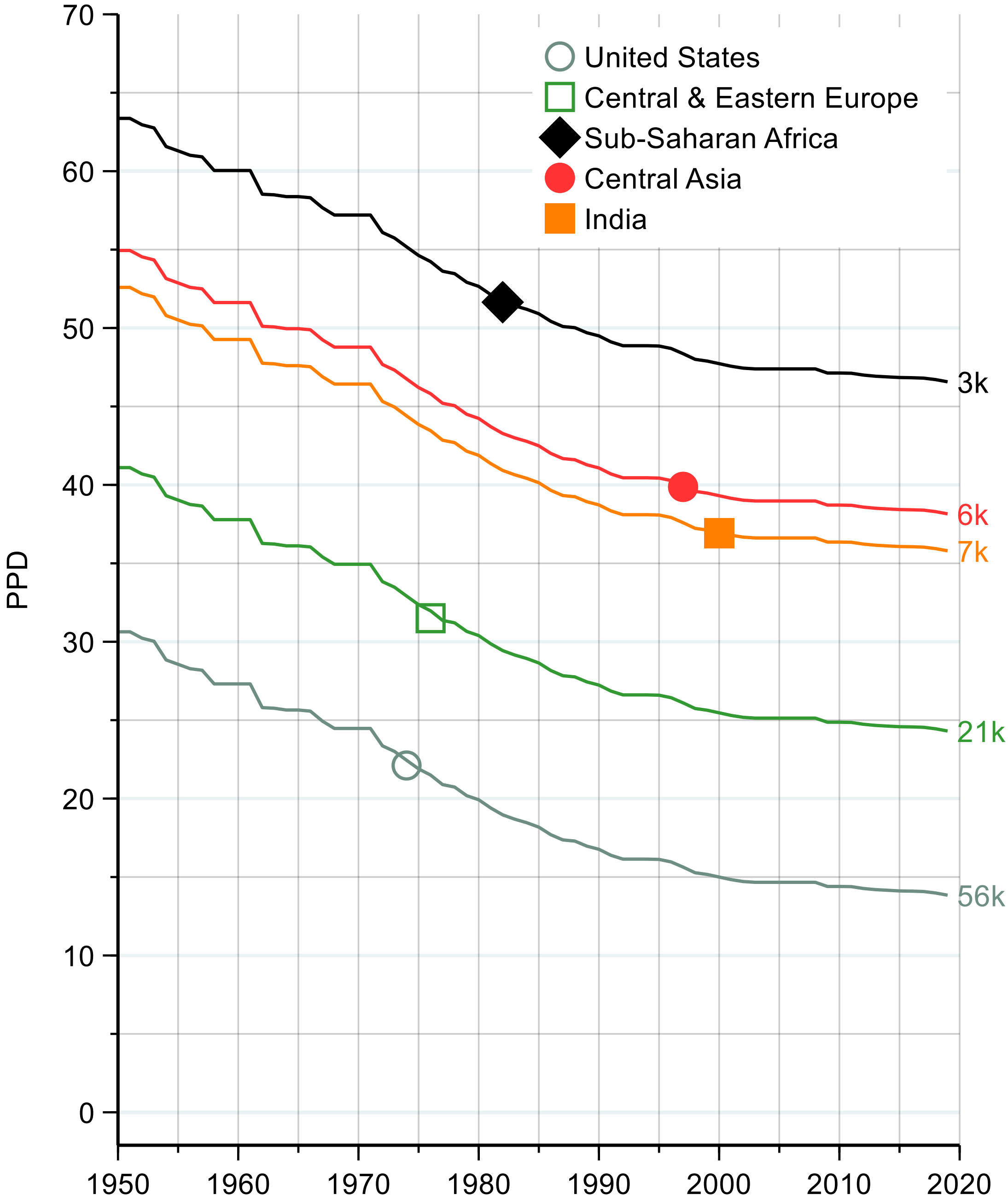

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Predicted PPD was estimated as PPD on log real GDP per capita and a separate intercept for each year. The year specific intercepts were adjusted such that they never decreased across years.

**Figure S2. Preston curves for different years (lines) and observed PPD and GDP for regions in 2019 (markers)**



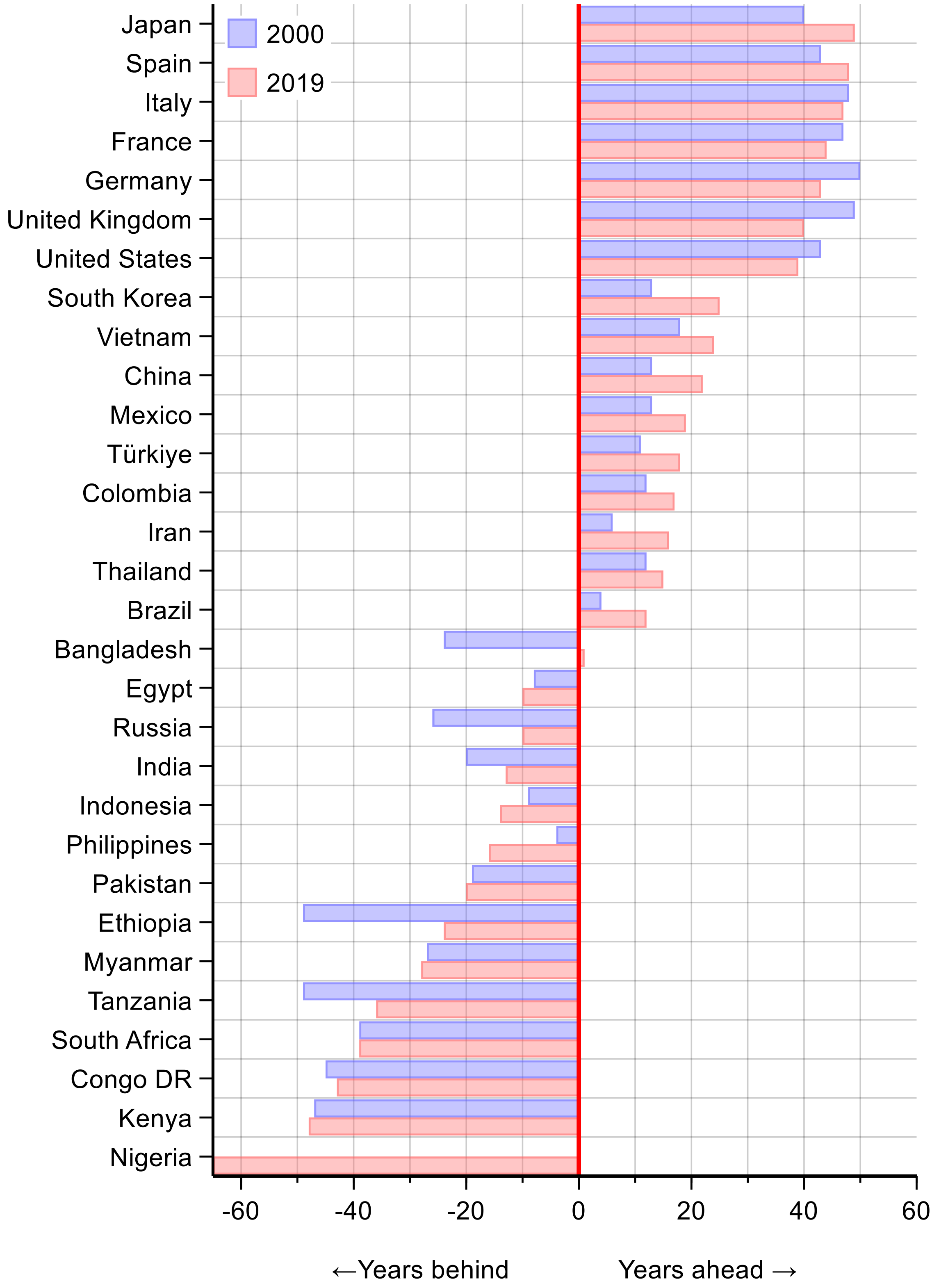

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Preston curves are shown for years which correspond to PPD and GDP in each region in 2019 (indicated at the bottom of each curve). Preston curves were estimated for each year by regressing PPD on log of GDP with a separate intercept for each year. The slope for GDP is constant across years while the intercept varies across years. The intercepts were adjusted such that they never increased across years. The dashed line indicates GDP beyond what was observed in that year. Regions with PPD below the 2019 Preston curve are not shown. Data source: UN WPP 2022 and the Maddison Project 2023.

**Figure S3. PPD predicted by Preston curves across years for different levels of GDP (lines) and observed PPD for regions in 2019 (markers)**



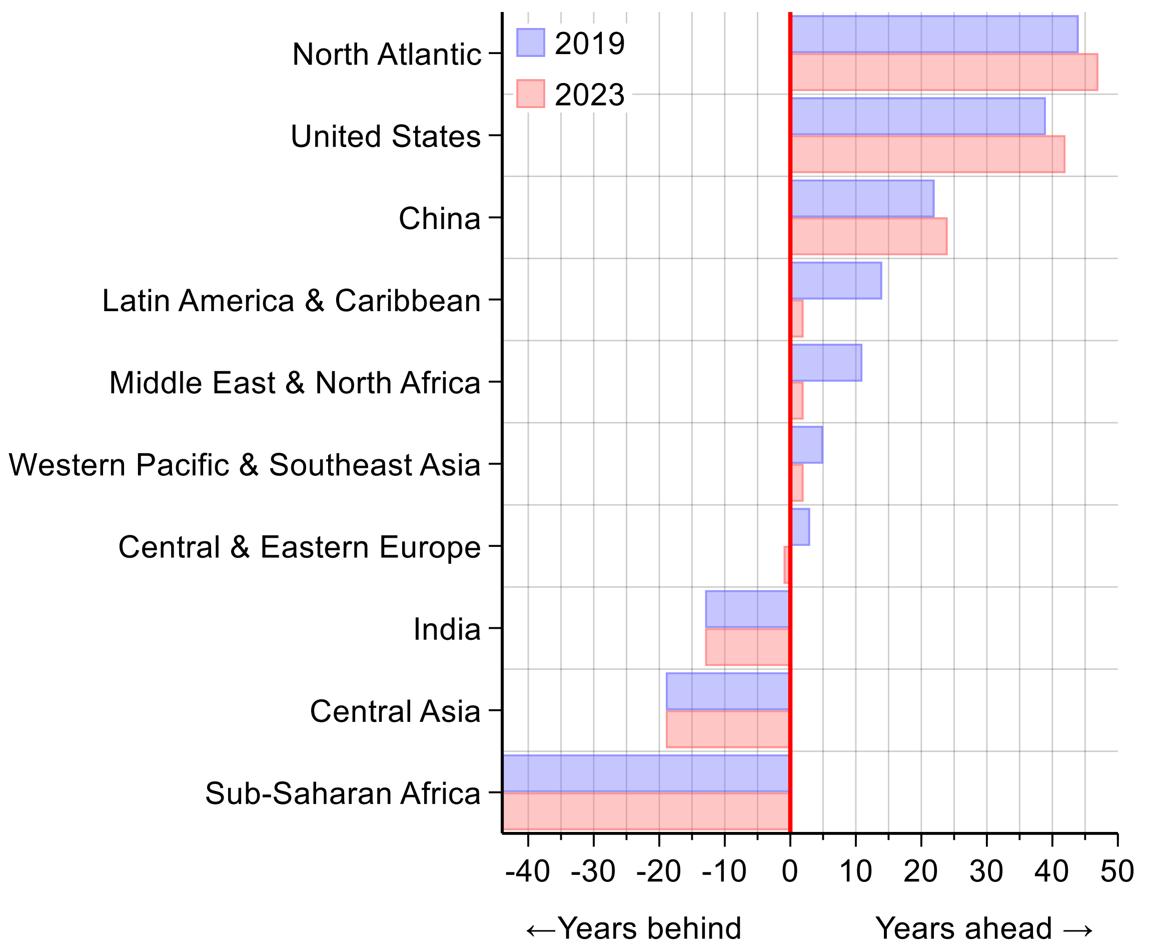

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Preston curves were estimated for each year by regressing PPD on log of GDP with a separate intercept for each year. The slope for GDP is constant across years while the intercept varies across years. The intercepts were adjusted such that they never increased across years. Regions with probability below the 2019 Preston curve are not shown. Data source: UN WPP 2022 and the Maddison Project 2023.

**Figure S4. Years behind or ahead of the global PPD: 30 most populous countries**



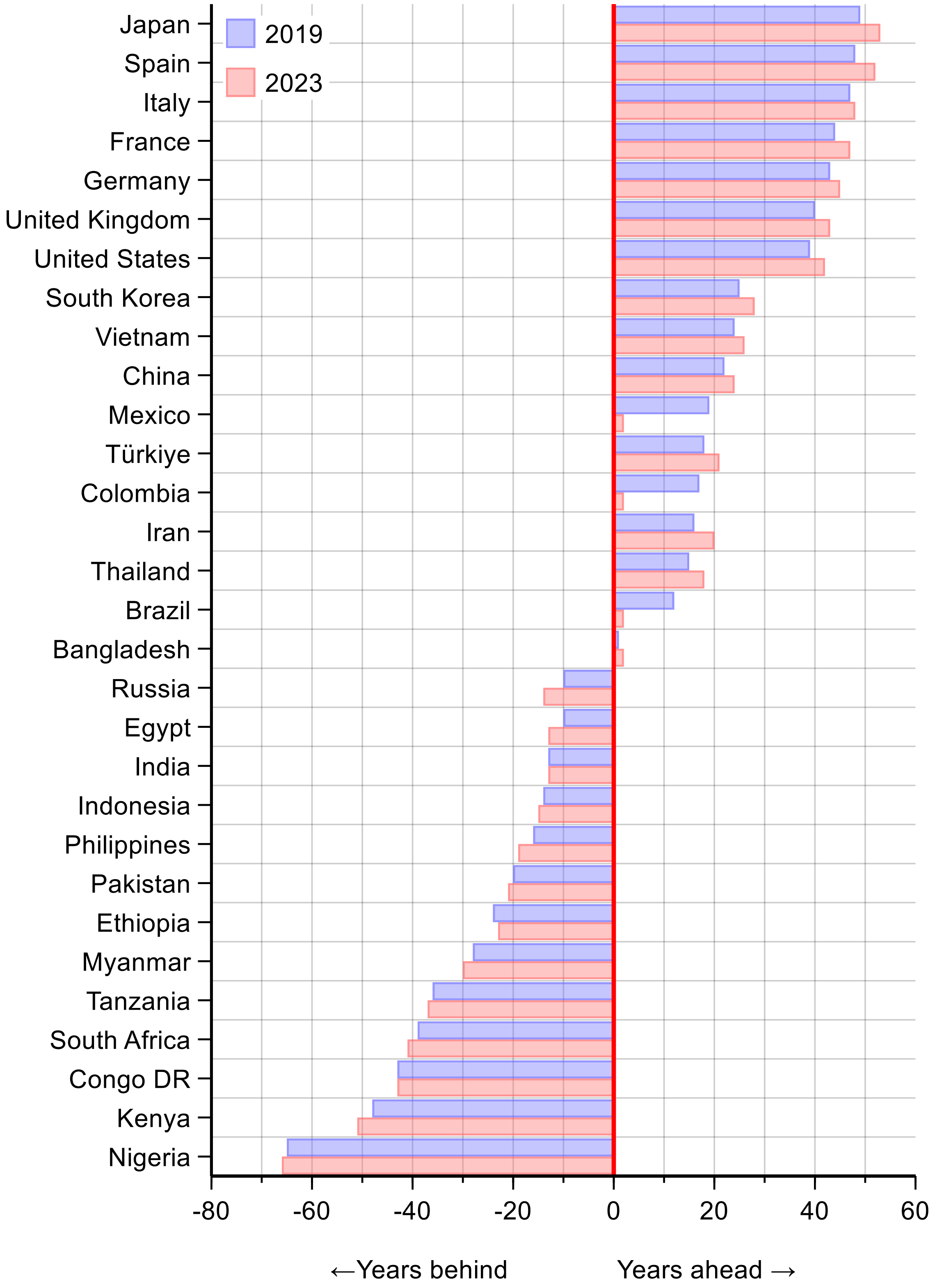

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Missing bars indicate being further behind than 1950 (the earliest available data). Data source: UN WPP 2022.

**Figure S5. Years behind or ahead of the global PPD: 2019 and 2023**



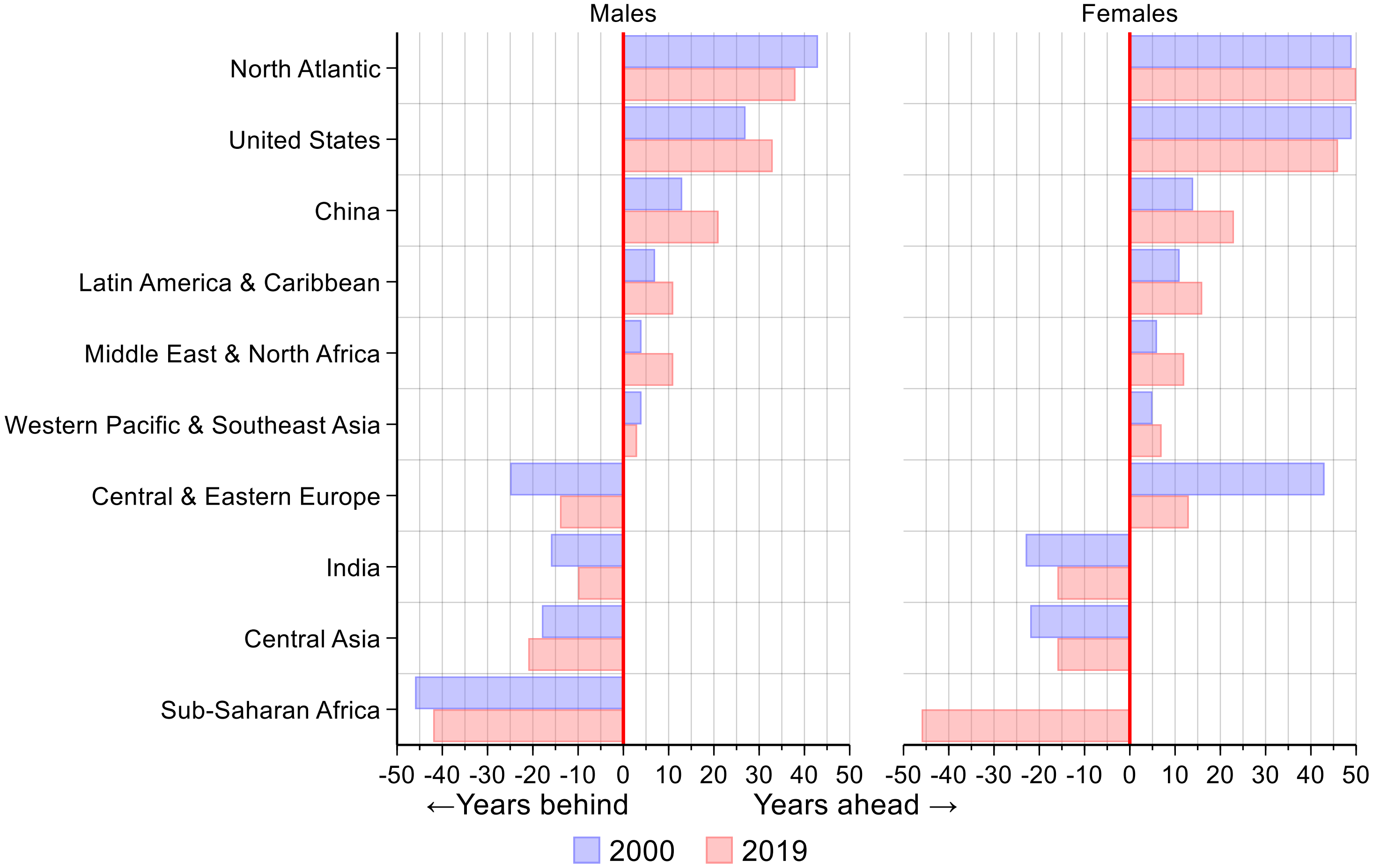

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Data source: UN WPP 2022.

**Figure S6. Years behind or ahead of the global PPD: 30 most populous countries: 2019 and 2023**



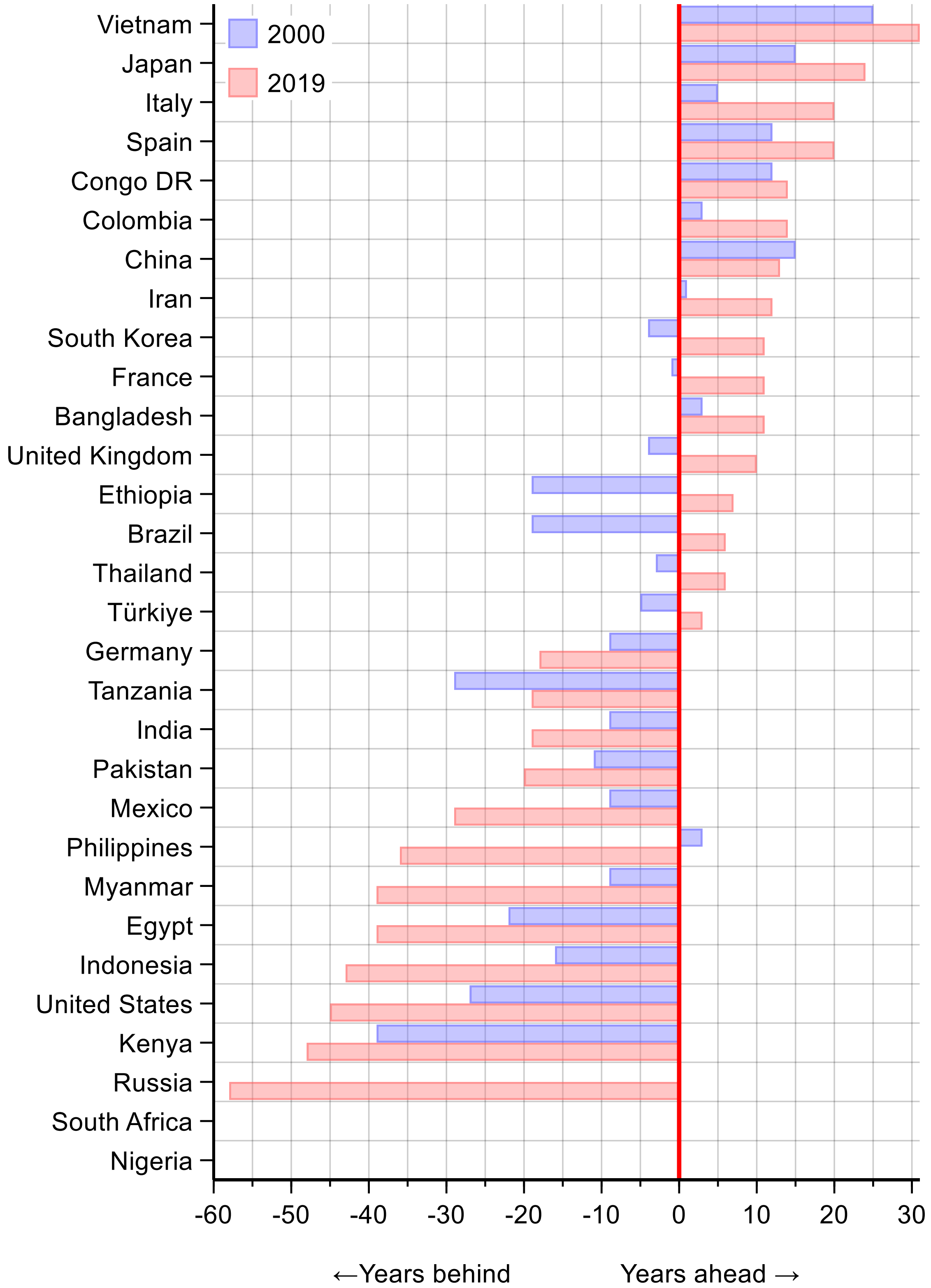

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Missing bars indicate being further behind than 1950 (the earliest available data). Data source: UN WPP 2022.

**Figure S7. Years behind or ahead of the global PPD by sex**



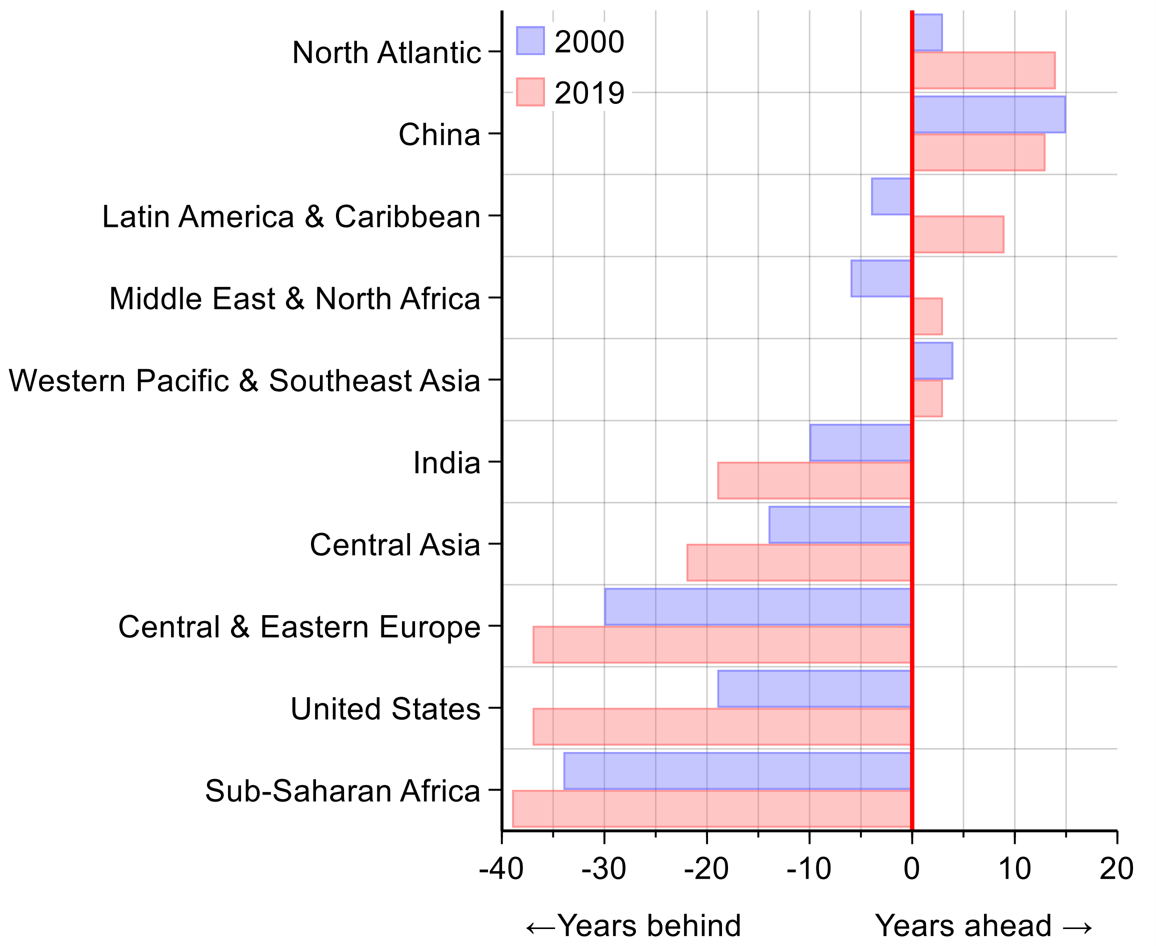

Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Data source: UN WPP 2022.

**Figure S8. Years behind or ahead of the Preston curve: 30 most populous countries**




Notes: Probability of premature death (PPD) was defined as dying before age 70 years. Missing bars indicate being further behind than 1950 (the earliest available data). Data source: UN WPP 2022 and the Maddison Project 2023.

**Figure S9. Years behind or ahead relative to PPD predicted by current GDP: Alternative specification of PPD-GDP relationship**




Notes: Probability of premature death (PPD) was defined as dying before age 70 years. See Sensitivity analyses section for details. Data source: UN WPP 2022 and the Maddison Project 2023.