Measuring health and economic wellbeing in the Sustainable Development Goals era: development of a poverty-free life expectancy metric and estimates for 90 countries

Carlos Riumallo-Herl, David Canning, Joshua A Salomon

Summary

Background The Sustainable Development Goals (SDGs), adopted in September, 2015, emphasise the link between health and economic development policies. Despite this link, and the multitude of targets and indicators in the SDGs and other initiatives, few monitoring tools explicitly incorporate measures of both health and economic status. Here we propose poverty-free life expectancy (PFLE) as a new metric that uses widely available data to provide a composite measure of population health and economic wellbeing.

Methods We developed a population-level measure of PFLE and computed this summary measure for 90 countries with available data. Specifically, we used Sullivan's method, as in many health expectancy measures, to incorporate the prevalence of poverty by age and sex from household economic surveys into demographic life tables based on mortality rates from the 2015 Global Burden of Disease Study (GBD). For comparison, we also recalculated all PFLE measures using life tables from WHO and the UN. PFLE estimates for each country, stratified by sex, are the average number of poverty-free years a person could expect to live if exposed to current mortality rates and poverty prevalence in that country.

Findings The average PFLE in the 90 countries included in this study was 66·0 years (95% uncertainty interval [UI] 64·5–67·3) for females and 61·6 years (60·1–62·9) for males, whereas life expectancy estimates were 76·3 years (95% UI 74·0–78·2) for females and 71·0 years (68·7–73·0) for males. PFLE varied widely between countries, ranging from 9·9 years (95% UI 9·1–10·5) for both sexes combined in Malawi, to 83·2 years (83·0–83·5) in Iceland, the latter differing only marginally from life expectancy in that country. In 67 of 90 countries, the difference between life expectancy and PFLE was greater for females than for males, indicating that women generally live more years of life in poverty than men do. Results were consistent when using GBD, WHO, or UN life tables.

Interpretation Differences in PFLE between countries are substantially greater than differences in life expectancy. Despite general improvements in survival in most regions of the world in the past decades, the focus in the SDG era on ending poverty brings into sharp relief the importance of ensuring that years of added life are lived with at least a minimum standard of economic wellbeing. Although summary measures of population health provide overall measures of survivorship and functional health, our new measure of PFLE provides complementary information that can inform and benchmark policies seeking to improve both health and economic wellbeing.

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Erasmus School of Economics, Erasmus University, Rotterdam, Netherlands (C Riumallo-Herl PhD); **Department of Global Health and Population, Harvard T H Chan School of Public Health, Boston, MA, USA** (C Riumallo-Herl, Prof D Canning PhD); **and Center for Health Policy** (Prof J A Salomon PhD) **and Center for Primary Care and Outcomes Research, Stanford University, Stanford, CA, USA** (Prof J A Salomon)

Correspondence to:
Prof Joshua A Salomon, Center for Health Policy and Center for Primary Care and Outcomes Research, Stanford University, Stanford, CA 94305, USA
salomon1@stanford.edu

Introduction

At the UN Sustainable Development Summit in September, 2015, leaders from all parts of the world adopted the Sustainable Development Goals (SDGs) as the embodiment of the global agenda for development through 2030. As in the preceding Millennium Development Goals (MDGs), ending poverty remained a fundamental objective in the SDGs, articulated in the first goal and, specifically, in the first target of reducing the number of people living below the international poverty line. The SDGs included numerous specific targets and indicators related to health under several of the 17 overarching goals, with one goal (goal 3) having a primary emphasis on health, articulated as "ensuring healthy lives and promoting wellbeing for all at all ages". One of the specific targets under goal 3 calls for universal health coverage, including financial risk protection, which highlights the explicit link between economic and health development policies. Despite this link, and despite the multitude of targets and indicators established through the SDGs and other global initiatives, most monitoring and benchmarking efforts rely on metrics that are highly specific to a single dimension of interest. Such an approach misses opportunities to understand the broader implications of development policies and other drivers of change in the wellbeing of populations, and this criticism of current efforts carries over from earlier critiques of the MDGs.[1,2]

Research in context

Evidence before this study

Adoption of the Sustainable Development Goals (SDGs) in September, 2015, has prompted increased attention to the need for rigorous measurement of progress in specific areas of development, including improving population health and reducing poverty. Efforts such as the Global Burden of Disease (GBD) study have been focused especially on comparable measurement of health-related SDG indicators. Fewer examples exist of measures that enable high-level comparative assessments of economic wellbeing, health, and other dimensions of development in a way that captures the combined effects of policies across these dimensions.

Added value of this study

We developed a new summary measure of health and economic wellbeing called poverty-free life expectancy (PFLE). PFLE quantifies, at the population-level, the average number of years a person could expect to live free of poverty given existing mortality rates and economic conditions. The measure combines information that is available from public data sources on mortality and prevalence of poverty by age and sex. In the 90 countries included in this study, we found larger variation in PFLE than in life expectancy or healthy life expectancy. In most countries, females can expect to live more years of their life in poverty than males can. In some African countries, more than half of the total lifespan on average is lived in poverty. This new indicator can aid in monitoring progress toward the linked global agendas of health improvement and poverty elimination and can strengthen accountability for development policies.

Implications of all the available evidence

Combined with existing measures on the burden of disease and on living standards and economic wellbeing, PFLE brings focus to health and wellbeing of populations in a way that encourages policy makers to consider the broad consequences of decisions, policies, and reforms. Disparities in PFLE magnify differences seen in narrower measures of health or economic outcomes alone. As the SDG era advances, there is additional value in a relatively simple composite measure of population welfare that combines important aspects of health and economic wellbeing and can be computed from readily available data that are feasible to collect using routine information systems and data platforms.

See Online for appendix

Within the domain of health, examples exist of broad summary measures that seek to combine information on different aspects of population health to enable high-level comparative assessment of overall levels and trends. Healthy life expectancy, or health-adjusted life expectancy, is one such measure that combines information on age-specific mortality and the prevalence of and disability associated with a range of different sequelae from diseases and injuries into a single index that captures the number of years an individual would expect to live in good health under current patterns of mortality and morbidity.[3–5] Estimates of healthy life expectancy have been used by policy makers to identify health gaps between and within regions[6] and are incorporated as a summary outcome in research exploring the link between policies and population health.[7–9] A related measure of healthy life-years at age 50 years is included as one of the structural indicators the European Union uses to monitor progress in healthy ageing.[10–12]

By contrast with summary measures of population health, fewer measures provide high-level comparative assessments of economic wellbeing, health, and other dimensions of development to guide policy making. The most prominent of these measures is the Human Development Index (HDI), which integrates indicators of education, health, and income. Critiques of the HDI have noted the difficulty of collecting data pertaining to some of the measure's components and have raised concerns about its construction and interpretability.[13–16] As the SDG era advances, a need remains for a relatively simple composite measure of population welfare that combines important aspects of health and economic wellbeing and that can be computed from data that are readily available and feasible to collect using routine information systems and data platforms. Although one possibility is to create such a composite measure by transforming health outcomes into money equivalents, such an approach has raised important ethical concerns.[17–19] The objective of this study was to develop a new summary measure of economic wellbeing and health that uses years of life as the unit of account, analogous to life expectancy and healthy life expectancy measures. The overall goal in developing such a measure is to enable country progress and development to be tracked in two dimensions that are highly relevant to the international policy agenda.

To meet this objective, we propose the poverty-free life expectancy (PFLE) metric as a composite indicator of the average number of years an individual could expect to live without poverty in each country if exposed to prevailing economic and mortality conditions.

Methods

Overview

The PFLE metric builds on methods developed previously to construct measures of healthy life expectancy. Data inputs included estimates of age-specific and sex-specific mortality, by country, from the Global Burden of Disease (GBD) 2015 study[20] and measures of per-capita household income, by age and sex, from household and income expenditure surveys. We used Sullivan's method to combine information on age-specific survival with information on economic status.[21,22] The resulting measure can be interpreted as the average number of years a person could expect to live free of poverty if exposed to the current age-specific and sex-specific

mortality and the poverty prevalence in a country. Here we report PFLE estimates for a sample of 90 countries that have done household income and expenditure surveys since 2010, and that make their data publicly available for research purposes at no cost or without restrictions through the websites of their statistical institutes. The countries included in this study, the name of each survey, and the year in which data collection took place are listed in table 1. Collectively, the country sample in this study includes 5·4 billion people, or about 75% of the world's population.[81] For most regions, more than half of countries are included, with the exceptions of east Asia and the Pacific and of the Middle East and north Africa, for which the sample includes fewer than half of all countries but does include the most populous countries. With respect to levels of development, our sample includes more than 40% of countries in each of the four World Bank income groups (appendix p 98). Overall, our country sample reflects wide diversity across regions, health outcomes, and levels of economic development and supplies proof of concept for our proposed new measure of population health and economic wellbeing.

Estimates of age-specific and sex-specific mortality

Age-specific and sex-specific mortality data were taken from the GBD 2015 study,[20] provided by the Institute for Health Metrics and Evaluation (IHME) in the form of life tables by country and sex, with uncertainty around mortality expressed in multiple random draws from distributions around the rates. For comparison, all PFLE estimates were also calculated using life tables published by WHO[82] and the UN.[83]

Estimates of poverty prevalence

Poverty prevalence by age and sex was estimated using data from national household economic surveys. These surveys collect information on household income and consumption for nationally representative samples within a country on a regular basis. They also collect information on household composition, thus allowing the disaggregation of poverty prevalence by age and sex. An advantage of using data from household economic surveys is that many governments rely on these to produce national estimates of poverty, and estimated measures of poverty prevalence will therefore be similar to those published by national governments or the World Bank.[84,85]

Using the household-level data on income and consumption, we defined the age-specific and sex-specific poverty prevalence using the poverty headcount measure commonly used in the scientific literature,[86] which identifies households with per-capita income below a defined poverty threshold and assigns the same poverty status to all household members. Aggregating across individuals within an age–sex group produced national estimates of the prevalence of poverty by age and sex, which were also examined across groupings of countries defined by geography and income.

	Year	Survey name
Albania	2012	Living Standards Measurement Survey[23]
Angola	2010	Inquerito Integrado sobre o bem estar da Populaçao[24]
Argentina	2013	Encuesta Permanente de Hogares[25]
Armenia	2013	Household Integrated Living Conditions Survey[26]
Austria	2013	EU-Silc[27]
Bangladesh	2010	Household Income and Expenditure Survey[28]
Belgium	2013	EU-Silc[27]
Benin	2011	Enquête Modulaire Intégrée sur les Conditions de Vie des ménages[29]
Bhutan	2012	Living Standards Survey 2012[30]
Bolivia	2013	Encuesta de Hogares[31]
Brazil	2013	PNAD[32]
Bulgaria	2013	EU-Silc[27]
Burkina Faso	2013	Enquête Multisectorielle Continue[33]
Canada	2011	National Household Survey[34]
Chile	2013	CASEN[35]
China	2011	Chine Household Finance Survey[36]
Colombia	2014	Gran Encuesta de Hogares[37]
Costa Rica	2013	Encuesta Nacional de Hogares[38]
Croatia	2013	EU-Silc[27]
Cyprus	2013	EU-Silc[27]
Czech Republic	2013	EU-Silc[27]
Denmark	2013	EU-Silc[27]
Dominican Republic	2013	Encuesta Nacional de Fuerza de Trabajo[39]
Ecuador	2013	Encuesta de Hogares[40]
Egypt	2013	Household Income, Expenditure, and Consumption Survey[41]
El Salvador	2014	Encuesta de Hogares de Propósitos Múltiples[42]
Estonia	2013	EU-Silc[27]
Ethiopia	2014	Living Standards Measurement Survey[43]
Finland	2013	EU-Silc[27]
France	2013	EU-Silc[27]
Georgia	2013	Household Integrated Survey[44]
Ghana	2012	Living Standards Measurement Survey[45]
Greece	2013	EU-Silc[27]
Guatemala	2013	ENCOVI[46]
Guinea	2012	Enquête Légère pour l'Evaluation de la Pauvreté[47]
Honduras	2014	Encuesta Permanente de Hogares de Propósitos Múltiples[48]
Hungary	2013	EU-Silc[27]
Iceland	2013	EU-Silc[27]
India	2012	National Sample Survey[49]
Iraq	2012	Household Socio-Economic Survey[50]
Ireland	2013	EU-Silc[27]
Italy	2013	EU-Silc[27]
Jamaica	2012	Living Standards Survey 2012[51]
Jordan	2011	Household Expenditure and Income Survey[41]
Kenya	2013	National Housing Survey[52]
Kyrgyzstan	2012	Poverty Profile[53]
Latvia	2013	EU-Silc[27]
Liberia	2014	Household Income and Expenditure Survey 2014–15[54]
Lithuania	2013	EU-Silc[27]
Luxembourg	2013	EU-Silc[27]
Madagascar	2010	Enquête Periodique Auprès des Ménages[55]
Malawi	2013	Third Integrated Household Survey[56]

(Table 1 continues on next page)

	Year	Survey name
(Continued from previous page)		
Mali	2013	Enquête Modulaire et Permanente Auprès des Ménages[57]
Malta	2013	EU-Silc[27]
Mexico	2012	ENIGH[58]
Mongolia	2014	Survey of Household Expenditure[59]
Namibia	2010	Household Income and Expenditure Survey[60]
Netherlands	2013	EU-Silc[27]
Nicaragua	2014	Encuesta Nacional de Hogares sobre Medición de Nivel de Vida[61]
Niger	2011	Enquête Nationale sur les Conditions de Vie des Ménages et l'Agriculture[62]
Nigeria	2013	General Household Survey, Wave 2[63]
Norway	2013	EU-Silc[27]
Pakistan	2012	Household Income and Expenditure Survey[64]
Panama	2014	Encuesta de Proposito Multiples[65]
Paraguay	2013	Encuesta Permanente de Hogares[66]
Peru	2013	Encuesta Nacional de Hogares[67]
Poland	2013	EU-Silc[27]
Portugal	2013	EU-Silc[27]
Romania	2013	EU-Silc[27]
Russia	2013	Longitudinal Monitoring Survey[68]
Rwanda	2014	Integrated Household Living Conditions Survey[69]
Senegal	2014	Enquete a l'ecoute du Senegal[70]
Serbia	2013	EU-Silc[27]
Slovakia	2013	EU-Silc[27]
Slovenia	2013	EU-Silc[27]
South Africa	2013	General Household Survey[71]
Spain	2013	EU-Silc[27]
Sri Lanka	2010	Household Income and Expenditure Survey[72]
Sweden	2013	EU-Silc[27]
Switzerland	2013	EU-Silc[27]
Tajikistan	2010	Household Budget Survey[73]
Tanzania	2012	Household Budget Survey[74]
Timor Leste	2010	Household and Income Survey[75]
Togo	2011	Base des Indicateurs de Base du Bien-être[76]
Tunisia	2011	National Survey on Household Budget[41]
Uganda	2013	Uganda National Household Survey[77]
UK	2013	EU-Silc[27]
USA	2013	SIPP[78]
Uruguay	2014	Encuesta Continua de Hogares[79]
Zambia	2015	Living Conditions Monitoring Survey[80]

Table 1: **Household economic surveys used in the analysis, by country**

An important methodological choice was the definition of the poverty line, which varies between studies with different purposes. Although many alternatives exist, we used two alternative approaches in this study. The first approach used the World Bank poverty line, often referred to as the international poverty line, at US$1·90 per day in 2011 purchasing power parity (PPP) units. This poverty line was updated in October, 2015, and is constructed as an average of the poverty lines in the 15 poorest countries.[87–89] Each of these countries has constructed its poverty line on the basis of the amount of income a person would need to satisfy the minimum caloric consumption of food.[89] Consequently, falling below the World Bank poverty line would imply not being able to meet the basic daily needs, on average, for the poorest 15 countries. To identify households under the poverty line in our sample, we therefore first converted household consumption per-capita measures into 2011 US PPP values, using inflation indexes and PPP conversion factors published by the World Bank.[90] The advantage of this approach is that it allows for crossnational comparisons and is in line with the poverty threshold values established in the international agenda.

As an alternative, we also computed PFLE defined by national poverty lines. Household income and expenditure surveys usually incorporate variables identifying poor households in accordance with nationally defined poverty lines. In cases where this has not been done, we used the average national poverty line defined in official documents.

Statistical analysis

To estimate PFLE for a given country, and for each sex, we incorporated the age–sex-specific poverty prevalence estimates into life tables using Sullivan's method.[21,22] First, we computed the probability of living without poverty simply as 1 minus the age-specific and sex-specific poverty prevalence. In the life table, we multiplied each value for L_x (which represents life-years lived during the age interval that begins at exact age x) by the probability of being poverty-free within that age group. We then summed over all remaining ages and divided by the number of individuals alive at age x to yield the average expectation of future years of poverty-free life. Equations for the calculations are detailed in the appendix (p 2).

We accounted for uncertainty using a Monte Carlo simulation approach that produced a distribution of values around all quantities of interest.[91,92] For age-specific and sex-specific mortality, IHME provided 1000 life tables for each country and sex that reflected the joint uncertainty around estimated age-specific mortality in that country. For poverty prevalence estimates, we applied bootstrap methods in analysing the primary survey data on household income and consumption, which yielded 1000 bootstrapped estimates for each set of age-specific poverty prevalence values.

To illuminate the comparative effect of differences in poverty levels versus differences in mortality rates on the overall observed variation between countries, we estimated the PFLE for all countries under two illustrative counterfactuals: one in which every country had the mortality rates from Japan (which has one of the highest overall life expectancies worldwide); and another in which every country had the age-specific and sex-specific poverty prevalence from the USA (which has a headcount poverty prevalence less than 5%).

We used Stata MP version 14.2 for all statistical analyses.

Role of the funding source
There was no funding source for this study.

Results

Descriptive statistics of the age-specific and sex-specific World Bank poverty prevalence, using data from the household income surveys, showed that poverty rates were highest in young age groups, which is explained in part by higher fertility rates in poorer households (figure 1; appendix p 3–94).[93–95] Across countries, the poverty prevalence typically decreases between birth and age 60 years and then increases again at retirement ages.

Combining the information on poverty with age-specific mortality rates summarised in life tables by country, the unweighted average PFLE at birth across countries in our dataset based on the World Bank poverty line was 66·0 years (95% uncertainty interval [UI] 64·5–67·3) for females and 61·6 years (60·1–62·9) for males, compared with life expectancy estimates of 76·3 years (95% UI 74·0–78·2) for females and 71·0 years (68·7–73·0) for males. For females, the average PFLE was 12·3 years less than the average life expectancy, and the difference was 9·4 years for males.

Substantial differences in estimated PFLE were observed across countries for both males and females, and the range between countries was considerably larger than the range in life expectancies. The PFLE for both sexes combined is shown in figure 2, and detailed estimates by sex are listed in table 2. The lowest PFLE at birth was in Malawi (9·9 years [95% UI 9·1–10·5]), driven largely by a poverty prevalence greater than 70% at all ages and high infant mortality.[81] PFLE was highest in Iceland (83·2 years [95% UI 83·0–83·5]), only marginally different than life expectancy and reflecting low levels of poverty.

For both sexes combined, the PFLE exceeded 70 years in 54 of the 90 analysed countries. For males, 45 countries had PFLE at 70 years or higher, and most of these countries were in Europe, North America, and South America. In 59 countries, females had a PFLE of 70 years or more. At the lower extreme of PFLE, both males and females would expect to live for less than 30 years poverty-free in 11 African countries (Burkina Faso, Ethiopia, Kenya, Liberia, Madagascar, Malawi, Mali, Rwanda, Senegal, Togo, and Zambia); in addition to these 11 countries, PFLE was also less than 30 years for males but not females in Benin.

PFLE was higher for males than for females in only six countries (Burkina Faso, Dominican Republic, Kenya, Liberia, Malawi, and Mali). Since life expectancy at birth was higher for females than for males in each of these countries, the results indicate that females are disproportionately affected by poverty in these six countries. Overall, in 67 of 90 countries in our sample, the number of years lost to poverty was higher in females than in males.

By contrast with the results of PFLE using the World Bank poverty line, the country with the lowest PFLE according to national standards was Togo (12·8 years [95% UI 11·9–13·6]), with similar estimates for males and females (figure 3; table 3). In Malawi, PFLE estimates based on national criteria (32·1 years [95% UI 29·3–34·3]) were three times higher than those based on the World Bank poverty line. Using the national poverty standard, Malta had the highest PFLE (79·2 years [95% UI 79·0–79·5]). On the basis of national criteria, life-years lost to poverty were higher for females than for males in 88 of 90 countries, with Angola and Nicaragua being the exceptions. Seven countries had higher overall PFLE for males than for females (Burkina Faso, Dominican Republic, Kenya, Liberia, Mali, Namibia, and Togo).

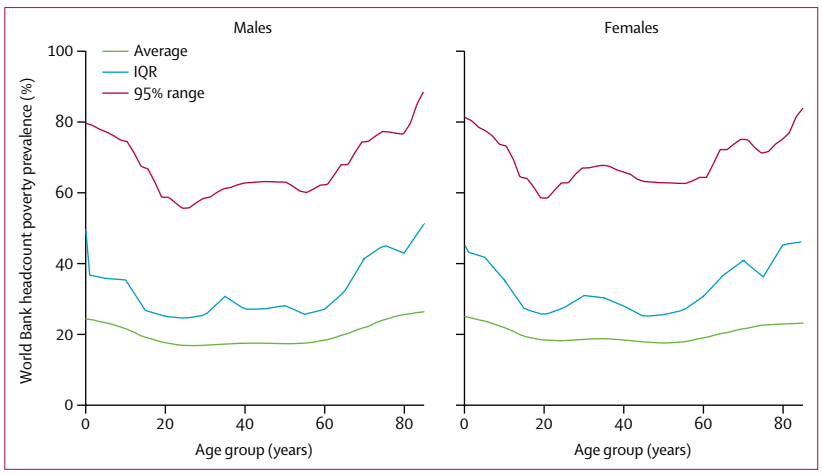

Figure 1: **Distribution of World Bank poverty rates in 90 countries, by age and sex**

Aggregating countries within regions or income groupings, similar conclusions emerge with respect to variation in PFLE (figure 4). Across regions, the highest PFLE estimates were found in North America, Europe, and central Asia; the lowest estimates were for sub-Saharan Africa, where PFLE is just more than 30 years. Across country income groupings, a strong gradient appears, from the high-income group having a PFLE of about 80 years, to the upper-middle-income group with a PFLE of about 70 years, to the lower-middle-income countries with a PFLE less than 60 years, and finally, the low-income group with a PFLE less than 30 years.

Overall, results were similar when using WHO or UN life tables as alternatives to GBD life tables (appendix pp 99–108). Results for the three different sets of life tables are compared in the appendix (pp 95–96). To understand how the new measure relates to other indicators that are used to benchmark progress in development, we present a range of comparisons in figure 5 (comparisons of PFLE using national poverty lines are shown in the appendix p 97). PFLE is positively correlated with life expectancy, gross domestic product (GDP) per capita, healthy life expectancy, and the HDI, and PFLE is negatively correlated with the World Bank

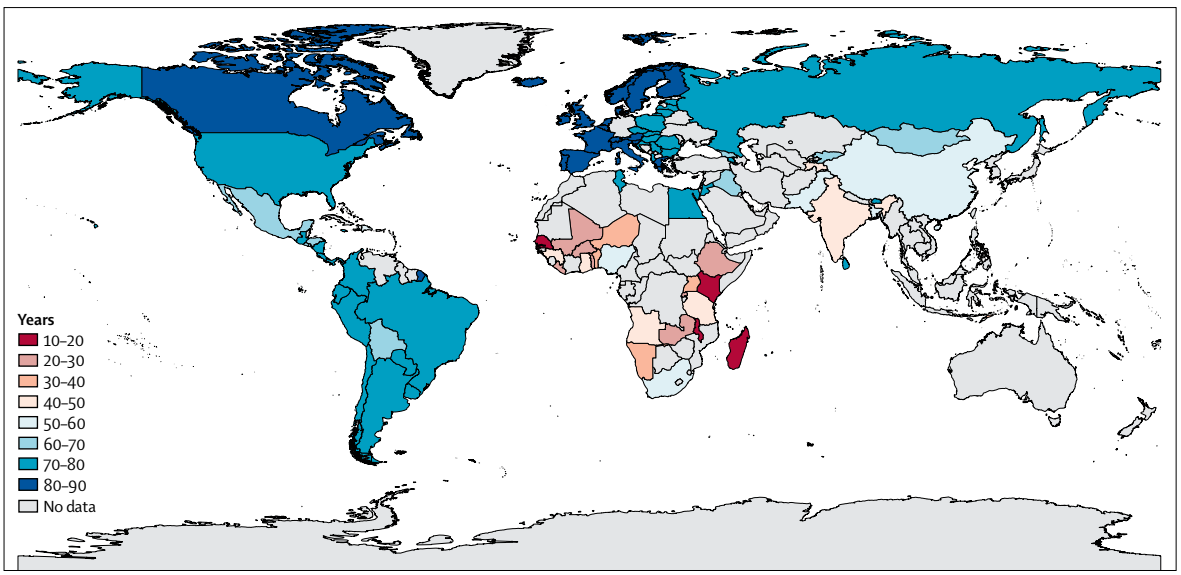

Figure 2: **Poverty-free life expectancy at birth based on World Bank poverty lines, both sexes combined**

	Females				Males				Both sexes			
	Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy		
		Estimate	Lower	Upper		Estimate	Lower	Upper		Estimate	Lower	Upper
Albania	81·3	78·4	77·8	79·1	75·0	72·6	71·6	73·5	78·0	75·4	74·7	76·0
Angola	61·3	45·9	33·5	54·4	60·8	45·3	33·9	51·5	61·0	45·6	33·6	52·7
Argentina	79·7	79·0	78·8	79·3	73·0	72·3	72·1	72·6	76·4	75·7	75·5	75·9
Armenia	78·3	74·4	73·8	75·1	70·7	67·4	66·6	68·2	74·7	71·1	70·5	71·6
Austria	83·6	83·3	83·2	83·5	78·8	78·7	78·5	78·8	81·3	81·1	80·9	81·2
Bangladesh	72·5	60·4	58·7	62·1	68·5	57·7	56·0	59·3	70·4	59·0	57·8	60·2
Belgium	83·2	83·1	82·7	83·5	77·8	77·8	77·3	78·2	80·5	80·5	80·1	80·8
Benin	65·4	32·4	26·7	36·5	60·5	29·5	24·5	33·6	62·6	30·5	26·8	34·0
Bhutan	74·3	71·8	69·1	74·0	71·5	69·2	66·8	71·7	72·7	70·3	68·5	72·1
Bolivia	74·2	70·0	67·9	72·2	72·1	68·0	65·5	70·0	73·1	69·0	67·4	70·5
Brazil	78·2	73·6	73·0	74·2	70·7	67·0	66·3	67·6	74·4	70·2	69·7	70·7
Bulgaria	78·3	77·0	76·5	77·6	71·3	70·1	69·5	70·6	74·8	73·5	73·1	73·9
Burkina Faso	62·3	29·2	25·5	32·2	60·4	29·8	26·3	32·5	61·2	29·4	26·8	31·7
Canada	83·8	83·3	83·0	83·5	79·5	78·9	78·6	79·1	81·7	81·1	80·9	81·2
Chile	82·0	81·7	81·1	82·1	76·5	76·2	75·6	76·8	79·3	79·0	78·6	79·4
China	79·9	61·5	60·6	62·3	73·2	56·5	55·7	57·2	76·2	58·7	58·2	59·3
Colombia	80·8	77·0	76·5	77·4	75·1	71·8	71·2	72·3	78·0	74·4	73·9	74·8
Costa Rica	82·6	79·6	79·1	80·1	78·1	75·1	74·5	75·6	80·3	77·3	76·9	77·7
Croatia	80·9	80·3	79·9	80·7	74·6	74·1	73·7	74·5	77·8	77·3	77·0	77·6
Cyprus	85·0	85·0	84·8	85·2	78·7	78·7	78·3	79·0	81·8	81·7	81·5	81·9
Czech Republic	81·6	81·6	81·4	81·8	75·9	75·8	75·6	76·0	78·8	78·8	78·6	78·9
Denmark	82·4	82·4	82·1	82·6	78·3	78·2	78·0	78·5	80·3	80·3	80·1	80·5
Dominican Republic	77·9	55·1	54·5	55·6	72·8	56·5	55·7	57·1	75·3	55·8	55·3	56·3
Ecuador	78·5	76·1	75·1	77·0	73·3	70·8	69·5	71·8	75·9	73·4	72·6	74·1
Egypt	74·4	74·3	73·7	74·8	68·7	68·6	68·0	69·1	71·5	71·3	70·8	71·8
El Salvador	78·9	72·6	71·7	73·5	70·6	64·6	63·4	65·9	74·9	68·7	68·0	69·5

(Table 2 continues on next page)

	Females				Males				Both sexes			
	Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy		
		Estimate	Lower	Upper		Estimate	Lower	Upper		Estimate	Lower	Upper
(Continued from previous page)												
Estonia	81·4	81·1	80·6	81·5	73·4	73·0	72·6	73·4	77·7	77·4	77·1	77·7
Ethiopia	67·2	23·3	20·5	25·6	64·0	21·4	18·7	23·5	65·4	22·3	20·4	24·0
Finland	83·8	83·8	83·5	84·1	77·9	77·9	77·6	78·2	80·9	80·9	80·6	81·1
France	85·1	85·1	85·0	85·3	78·4	78·4	78·1	78·6	81·8	81·8	81·6	81·9
Georgia	78·0	74·2	73·4	74·8	67·8	64·1	63·1	65·3	72·8	69·1	68·4	69·8
Ghana	68·1	47·7	41·9	51·8	63·6	45·9	39·8	50·4	65·5	46·6	42·3	50·3
Greece	83·5	82·8	82·5	83·1	78·4	77·7	77·4	78·1	80·9	80·3	80·0	80·5
Guatemala	75·2	73·7	72·1	75·5	69·8	68·4	66·3	70·4	72·6	71·1	69·8	72·4
Guinea	60·9	50·9	45·5	56·2	58·2	49·0	42·6	54·4	59·3	49·7	45·7	53·5
Honduras	74·0	61·3	59·2	63·7	72·1	59·5	56·7	61·7	73·0	60·4	58·5	62·0
Hungary	79·9	79·9	79·5	80·3	73·2	73·1	72·7	73·6	76·7	76·7	76·3	77·0
Iceland	85·8	85·7	85·2	86·2	80·9	80·8	80·5	81·1	83·3	83·2	83·0	83·5
India	69·5	50·7	50·0	51·4	65·2	48·0	47·4	48·6	67·2	49·3	48·7	49·8
Iraq	70·7	70·5	67·3	73·4	64·4	64·2	60·6	68·3	67·4	67·2	64·5	69·8
Ireland	84·3	84·0	83·3	84·7	79·2	78·9	78·7	79·2	81·7	81·4	81·1	81·8
Italy	84·5	84·0	83·9	84·2	79·6	79·2	79·0	79·4	82·1	81·7	81·5	81·8
Jamaica	76·9	75·1	73·8	76·4	73·0	71·1	69·8	72·4	74·9	73·1	72·1	74·1
Jordan	80·7	80·7	79·6	81·7	76·4	76·4	75·1	77·6	78·5	78·5	77·6	79·3
Kenya	67·6	16·4	15·9	17·1	62·8	18·5	17·9	19·1	65·1	17·9	17·4	18·4
Kyrgyzstan	74·1	73·4	72·8	74·1	65·6	64·9	64·1	65·7	69·8	69·1	68·5	69·7
Latvia	79·7	79·1	78·7	79·5	70·6	69·9	69·4	70·3	75·4	74·7	74·4	75·1
Liberia	63·7	19·7	17·9	21·4	63·3	22·5	20·4	24·5	63·3	21·0	19·5	22·4
Lithuania	80·4	79·9	79·6	80·2	69·7	69·5	69·2	69·8	75·2	74·9	74·7	75·1
Luxembourg	84·3	84·2	83·9	84·5	79·8	79·8	79·5	80·0	82·1	82·1	81·9	82·3
Madagascar	65·5	17·4	14·8	19·7	62·4	16·1	13·7	18·3	63·7	16·7	14·9	18·3
Malawi	63·3	9·8	8·9	10·6	58·5	10·0	8·9	10·9	60·7	9·9	9·1	10·5
Mali	60·8	20·6	18·5	22·6	60·3	21·0	18·9	22·6	60·4	20·7	19·2	22·2
Malta	84·4	84·4	84·1	84·8	79·6	79·6	79·2	80·0	82·1	82·0	81·8	82·3
Mexico	78·3	69·9	69·5	70·2	73·4	65·6	65·2	65·9	75·8	67·7	67·4	68·0
Mongolia	71·8	69·7	68·8	70·4	62·8	60·8	59·9	61·7	67·1	65·0	64·3	65·7
Namibia	68·7	37·3	33·3	39·8	60·3	35·2	30·9	38·8	64·3	36·1	33·1	38·7
Netherlands	83·4	83·4	83·0	83·7	79·1	79·1	78·8	79·5	81·3	81·3	81·0	81·5
Nicaragua	80·7	80·0	79·1	80·9	75·0	74·1	72·9	75·3	77·9	77·1	76·3	77·8
Niger	62·7	39·8	35·8	43·3	59·9	38·1	33·5	41·7	61·1	38·8	35·6	41·6
Nigeria	66·6	54·9	48·8	58·1	63·1	51·9	47·1	54·2	64·7	53·1	49·2	55·6
Norway	84·0	84·0	83·7	84·3	79·9	79·9	79·6	80·1	82·0	82·0	81·8	82·2
Pakistan	67·4	51·0	49·3	52·8	64·6	49·3	47·5	50·8	65·9	50·1	48·9	51·3
Panama	81·0	77·0	75·8	78·2	75·5	71·9	70·3	73·3	78·1	74·4	73·3	75·3
Paraguay	76·9	74·9	73·5	76·3	72·1	70·1	68·2	71·8	74·4	72·4	71·1	73·6
Peru	81·1	77·3	76·2	78·4	77·8	74·3	72·8	75·5	79·5	75·8	74·9	76·6
Poland	81·6	81·2	81·0	81·4	73·4	73·1	72·8	73·3	77·6	77·2	77·0	77·4
Portugal	83·8	83·2	82·9	83·4	77·6	77·2	76·9	77·4	80·8	80·2	80·1	80·4
Romania	79·0	75·0	74·4	75·5	71·5	68·5	67·9	69·1	75·2	71·9	71·4	72·3
Russia	76·5	76·4	76·0	76·7	65·3	65·1	64·7	65·6	71·0	70·8	70·5	71·1
Rwanda	68·1	27·4	24·1	29·9	64·1	26·4	23·2	28·6	66·0	26·9	24·4	28·8
Senegal	67·3	18·3	15·4	20·8	64·4	18·1	15·3	20·4	65·6	18·1	16·1	19·9
Serbia	78·8	78·6	78·4	78·8	73·5	73·3	73·0	73·5	76·2	76·0	75·8	76·1
Slovakia	80·9	80·7	80·5	81·0	73·9	73·8	73·6	74·0	77·5	77·4	77·2	77·6

(Table 2 continues on next page)

	Females				Males				Both sexes			
	Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy			Life expectancy	Poverty-free life expectancy		
		Estimate	Lower	Upper		Estimate	Lower	Upper		Estimate	Lower	Upper
(Continued from previous page)												
Slovenia	83·8	83·8	83·6	84·0	77·9	77·9	77·7	78·1	80·9	80·9	80·7	81·0
South Africa	64·0	53·0	51·6	54·1	58·6	49·7	48·4	50·8	61·3	51·3	50·2	52·1
Spain	85·2	84·7	84·6	84·9	79·8	79·4	79·2	79·5	82·6	82·1	82·0	82·2
Sri Lanka	81·2	79·5	77·4	81·5	74·1	72·7	69·7	75·5	77·6	76·1	74·3	77·9
Sweden	83·9	83·8	83·5	84·1	80·2	80·1	79·8	80·3	82·1	81·9	81·8	82·1
Switzerland	85·1	85·1	84·8	85·4	80·6	80·6	80·3	81·0	82·9	82·9	82·7	83·2
Tajikistan	74·8	47·3	45·9	48·6	70·1	44·4	43·1	45·7	72·3	45·8	44·7	46·8
Tanzania	66·1	41·1	35·5	45·1	63·1	40·4	35·0	43·9	64·3	40·6	36·5	43·8
Timor Leste	73·0	39·1	37·1	41·0	72·0	38·2	36·2	40·1	72·4	38·6	37·1	40·1
Togo	64·9	26·7	24·3	28·9	58·8	25·7	23·1	28·4	61·7	26·1	24·2	27·9
Tunisia	80·7	79·1	77·1	80·9	74·7	73·2	70·6	75·5	77·6	76·1	74·5	77·7
Uganda	64·8	40·3	35·1	44·7	58·9	37·2	32·1	42·0	61·5	38·5	34·8	42·3
UK	82·8	82·7	82·5	82·8	79·0	78·9	78·8	79·0	80·9	80·8	80·7	80·9
USA	81·5	78·6	78·5	78·7	76·7	74·4	74·3	74·6	79·1	76·5	76·4	76·6
Uruguay	80·5	80·4	80·0	80·8	72·9	72·8	72·4	73·3	76·7	76·6	76·3	77·0
Zambia	60·2	28·7	25·7	31·7	54·3	26·7	23·7	30·1	56·9	27·6	25·4	29·8

Estimate refers to the mean, and lower and upper refer to bounds for the 95% uncertainty interval.

Table 2: **Poverty-free life expectancy (years) at birth based on the World Bank poverty line and life expectancy at birth using Global Burden of Disease 2015 life tables**

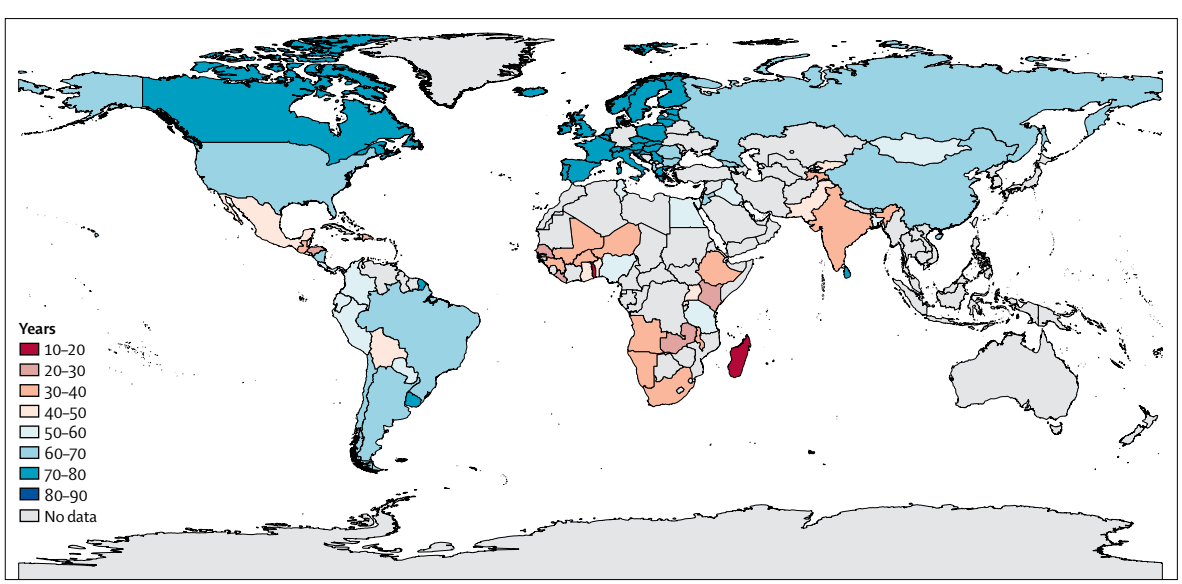

Figure 3: **Poverty-free life expectancy at birth based on national poverty lines, both sexes combined**

headcount poverty prevalence, as expected in view of shared inputs. Although correlated, however, none of these other measures explains more than 80% of the variation in PFLE between countries (appendix p 109). Rankings of countries in terms of PFLE vary considerably from the rankings using other measures of health and development, indicating that household economic wellbeing complements the information on mortality and morbidity (appendix p 110–113). For example, the ranking for the Czech Republic across all of the measures ranges from one to 26 out of 90. Although World Bank poverty explains about 80% of the variation in PFLE, poverty itself provides virtually no differentiation between high-income countries.

Insight into how PFLE estimates would change on the basis of specific improvements in health or economic

	Females				Males				Both sexes			
	Life expectancy	Estimate	Lower	Upper	Life expectancy	Estimate	Lower	Upper	Life expectancy	Estimate	Lower	Upper
Albania	81·3	70·9	70·2	71·6	75·0	65·3	64·4	66·2	78·0	68·0	67·3	68·7
Angola	61·3	37·7	27·3	44·8	60·8	37·2	27·7	42·3	61·0	37·4	27·4	43·4
Argentina	79·7	68·5	68·3	68·8	73·0	62·4	62·1	62·7	76·4	65·5	65·3	65·7
Armenia	78·3	53·6	52·8	54·4	70·7	49·0	48·1	49·9	74·7	51·4	50·8	52·1
Austria	83·6	78·8	78·3	79·3	78·8	75·6	75·2	76·0	81·3	77·3	76·9	77·6
Bangladesh	72·5	51·8	50·2	53·2	68·5	49·5	47·9	50·8	70·4	50·5	49·5	51·6
Belgium	83·2	80·0	79·5	80·6	77·8	75·4	74·8	75·9	80·5	77·7	77·4	78·1
Benin	65·4	43·6	36·2	48·9	60·5	40·2	33·7	45·8	62·6	41·5	36·5	46·2
Bhutan	74·3	69·5	66·9	71·6	71·5	67·3	64·9	69·7	72·7	68·2	66·5	69·9
Bolivia	74·2	48·9	47·4	50·5	72·1	49·0	47·0	50·6	73·1	49·0	47·8	50·1
Brazil	78·2	71·9	71·3	72·4	70·7	65·3	64·6	65·9	74·4	68·5	68·0	69·0
Bulgaria	78·3	71·9	71·2	72·5	71·3	66·8	66·1	67·5	74·8	69·3	68·8	69·8
Burkina Faso	62·3	31·1	27·2	34·3	60·4	31·6	27·8	34·6	61·2	31·2	28·5	33·7
Canada	83·8	74·6	74·4	74·8	79·5	71·6	71·4	71·8	81·7	73·1	72·9	73·3
Chile	82·0	68·3	67·8	68·8	76·5	64·8	64·2	65·4	79·3	66·6	66·2	67·0
China	79·9	63·0	62·2	63·7	73·2	58·0	57·2	58·8	76·2	60·3	59·7	60·8
Colombia	80·8	58·0	57·6	58·3	75·1	54·7	54·2	55·1	78·0	56·3	56·0	56·6
Costa Rica	82·6	59·7	59·0	60·4	78·1	57·4	56·8	58·1	80·3	58·5	58·0	59·0
Croatia	80·9	74·2	73·6	74·8	74·6	69·8	69·2	70·4	77·8	72·0	71·6	72·4
Cyprus	85·0	78·7	78·0	79·3	78·7	75·8	75·3	76·3	81·8	77·2	76·8	77·7
Czech Republic	81·6	79·2	78·9	79·5	75·9	74·7	74·4	74·9	78·8	76·9	76·7	77·2
Denmark	82·4	77·6	77·0	78·1	78·3	75·4	74·9	75·9	80·3	76·6	76·2	77·0
Dominican Republic	77·9	35·3	34·7	35·8	72·8	38·5	37·9	39·1	75·3	36·9	36·5	37·3
Ecuador	78·5	53·6	52·8	54·3	73·3	49·8	48·8	50·6	75·9	51·6	51·0	52·2
Egypt	74·4	55·5	54·7	56·2	68·7	51·7	51·0	52·4	71·5	53·5	53·0	54·1
El Salvador	78·9	44·8	44·0	45·4	70·6	39·7	38·8	40·6	74·9	42·3	41·7	42·9
Estonia	81·4	74·3	73·7	74·9	73·4	68·4	67·8	68·9	77·7	71·6	71·1	72·0
Ethiopia	67·2	33·3	29·1	36·6	64·0	31·1	27·0	34·1	65·4	32·1	29·3	34·6
Finland	83·8	77·6	77·1	78·1	77·9	73·9	73·5	74·4	80·9	75·9	75·6	76·2
France	85·1	81·4	81·0	81·7	78·4	75·9	75·6	76·2	81·8	78·7	78·5	78·9
Georgia	78·0	67·0	66·2	67·7	67·8	57·6	56·6	58·6	72·8	62·2	61·5	62·9
Ghana	68·1	46·3	40·5	50·4	63·6	42·9	37·2	47·1	65·5	44·4	40·3	48·1
Greece	83·5	76·5	76·0	77·0	78·4	72·4	71·9	72·9	80·9	74·5	74·1	74·9
Guatemala	75·2	35·6	34·4	36·8	69·8	31·4	30·2	32·5	72·6	33·5	32·7	34·3
Guinea	60·9	31·1	27·5	34·6	58·2	29·9	25·9	33·3	59·3	30·1	27·6	32·4
Honduras	74·0	25·9	24·7	27·3	72·1	25·6	24·2	26·8	73·0	25·7	24·8	26·5
Hungary	79·9	77·7	77·3	78·2	73·2	71·4	70·9	72·0	76·7	74·7	74·4	75·1
Iceland	85·8	79·8	78·9	80·7	80·9	77·3	76·6	77·9	83·3	78·7	78·1	79·2
India	69·5	40·2	39·6	40·7	65·2	38·2	37·7	38·7	67·2	39·1	38·7	39·5
Iraq	70·7	55·7	53·0	58·0	64·4	51·1	48·1	54·5	67·4	53·3	51·0	55·4
Ireland	84·3	79·5	78·7	80·2	79·2	74·8	74·2	75·3	81·7	77·1	76·7	77·5
Italy	84·5	76·9	76·6	77·3	79·6	74·4	74·1	74·7	82·1	75·7	75·5	75·9
Jamaica	76·9	61·8	60·6	63·0	73·0	59·2	57·9	60·4	74·9	60·5	59·6	61·4
Jordan	80·7	69·5	68·2	70·6	76·4	65·9	64·6	67·3	78·5	67·6	66·7	68·5
Kenya	67·6	21·7	21·0	22·4	62·8	22·8	22·0	23·5	65·1	22·6	22·0	23·1
Kyrgyzstan	74·1	50·1	49·2	50·9	65·6	43·3	42·4	44·3	69·8	46·7	46·1	47·4
Latvia	79·7	74·8	74·3	75·3	70·6	66·6	66·0	67·2	75·4	70·9	70·5	71·3
Liberia	63·7	23·3	21·3	25·1	63·3	24·6	22·3	26·6	63·3	23·9	22·3	25·4

(Table 3 continues on next page)

	Females				Males				Both sexes			
	Life expectancy	Estimate	Lower	Upper	Life expectancy	Estimate	Lower	Upper	Life expectancy	Estimate	Lower	Upper
(Continued from previous page)												
Lithuania	80·4	75·3	74·8	75·8	69·7	66·7	66·2	67·1	75·2	71·2	70·8	71·5
Luxembourg	84·3	80·6	79·9	81·2	79·8	76·8	76·3	77·3	82·1	78·8	78·4	79·2
Madagascar	65·5	18·9	16·2	21·3	62·4	17·6	15·0	20·0	63·7	18·2	16·3	20·0
Malawi	63·3	33·1	29·5	35·9	58·5	31·3	27·6	34·3	60·7	32·1	29·3	34·4
Mali	60·8	33·2	29·7	36·4	60·3	33·3	30·1	35·7	60·4	33·1	30·7	35·3
Malta	84·4	81·0	80·5	81·7	79·6	77·4	76·8	77·9	82·1	79·2	78·8	79·6
Mexico	78·3	41·7	41·4	42·0	73·4	39·8	39·4	40·1	75·8	40·7	40·5	40·9
Mongolia	71·8	53·9	53·1	54·6	62·8	47·0	46·2	47·7	67·1	50·3	49·7	50·8
Namibia	68·7	37·6	33·5	40·1	60·3	35·4	31·1	39·1	64·3	36·4	33·4	39·0
Netherlands	83·4	79·6	79·1	80·1	79·1	76·8	76·4	77·2	81·3	78·3	78·0	78·6
Nicaragua	80·7	66·6	65·6	67·5	75·0	60·8	59·7	62·0	77·9	63·7	63·0	64·5
Niger	62·7	34·0	30·5	37·1	59·9	32·7	28·9	35·6	61·1	33·2	30·5	35·6
Nigeria	66·6	52·8	46·9	56·0	63·1	49·8	45·3	52·1	64·7	51·1	47·2	53·5
Norway	84·0	77·1	76·5	77·8	79·9	76·0	75·5	76·4	82·0	76·7	76·4	77·1
Pakistan	67·4	47·1	45·6	48·8	64·6	45·6	43·8	47·0	65·9	46·3	45·1	47·3
Panama	81·0	58·5	57·4	59·6	75·5	55·1	53·8	56·4	78·1	56·7	55·9	57·6
Paraguay	76·9	59·2	57·8	60·6	72·1	55·5	53·7	57·0	74·4	57·2	56·1	58·3
Peru	81·1	60·1	59·3	61·1	77·8	58·1	57·0	59·1	79·5	59·2	58·4	59·8
Poland	81·6	76·7	76·4	77·1	73·4	70·2	69·9	70·5	77·6	73·5	73·3	73·8
Portugal	83·8	76·4	75·9	77·0	77·6	72·1	71·6	72·6	80·8	74·3	73·9	74·7
Romania	79·0	70·5	69·9	71·1	71·5	65·6	64·9	66·2	75·2	68·2	67·8	68·7
Russia	76·5	67·5	66·9	68·0	65·3	57·2	56·6	57·8	71·0	62·4	62·0	62·8
Rwanda	68·1	42·6	37·2	46·5	64·1	40·7	35·6	44·2	66·0	41·6	37·7	44·6
Senegal	67·3	23·2	19·5	26·1	64·4	23·0	19·4	25·7	65·6	22·9	20·4	25·1
Serbia	78·8	74·3	74·0	74·6	73·5	70·2	69·9	70·5	76·2	72·2	72·0	72·4
Slovakia	80·9	76·9	76·5	77·4	73·9	71·8	71·5	72·2	77·5	74·4	74·1	74·7
Slovenia	83·8	78·4	77·9	78·8	77·9	74·7	74·4	75·1	80·9	76·6	76·3	76·9
South Africa	64·0	38·1	37·1	39·0	58·6	38·2	37·1	39·1	61·3	38·0	37·2	38·7
Spain	85·2	76·9	76·4	77·3	79·8	73·4	73·1	73·8	82·6	75·2	74·9	75·5
Sri Lanka	81·2	73·8	71·7	75·6	74·1	67·6	64·8	70·2	77·6	70·7	68·9	72·3
Sweden	83·9	77·1	76·5	77·6	80·2	75·9	75·4	76·4	82·1	76·6	76·2	77·0
Switzerland	85·1	78·3	77·7	78·8	80·6	77·5	77·0	77·9	82·9	77·9	77·6	78·3
Tajikistan	74·8	40·5	39·1	41·9	70·1	38·5	37·2	39·8	72·3	39·4	38·5	40·4
Tanzania	66·1	52·2	45·1	57·3	63·1	50·3	43·8	54·6	64·3	51·1	45·9	55·0
Timor Leste	73·0	50·8	48·4	53·0	72·0	49·9	47·6	52·3	72·4	50·3	48·4	52·1
Togo	64·9	12·6	11·5	13·7	58·8	13·1	11·7	14·5	61·7	12·8	11·8	13·7
Tunisia	80·7	57·5	55·9	58·9	74·7	53·7	51·7	55·5	77·6	55·5	54·2	56·7
Uganda	64·8	50·8	44·3	56·2	58·9	46·4	40·2	52·1	61·5	48·3	43·7	53·0
UK	82·8	77·6	77·2	78·0	79·0	75·2	74·8	75·5	80·9	76·4	76·2	76·7
USA	81·5	68·6	68·4	68·8	76·7	66·9	66·7	67·0	79·1	67·7	67·6	67·8
Uruguay	80·5	73·4	73·0	73·8	72·9	66·7	66·2	67·1	76·7	70·1	69·7	70·4
Zambia	60·2	30·3	27·2	33·4	54·3	28·2	25·1	31·6	56·9	29·1	26·9	31·4

Estimate refers to the mean, and lower and upper refer to bounds for the 95% uncertainty interval.

Table 3: **Poverty-free life expectancy (years) at birth based on national poverty lines and life expectancy at birth using Global Burden of Disease 2015 life tables**

circumstances are shown in figure 6. If all countries were to reduce population mortality rates to those of Japan, the greatest overall gains in PFLE would be in countries that fall in the middle of the range because countries with the lowest life expectancies will be adding years of life with relatively high prevalence of poverty. If countries had the same levels of poverty as in the USA, substantial gains would appear predominantly

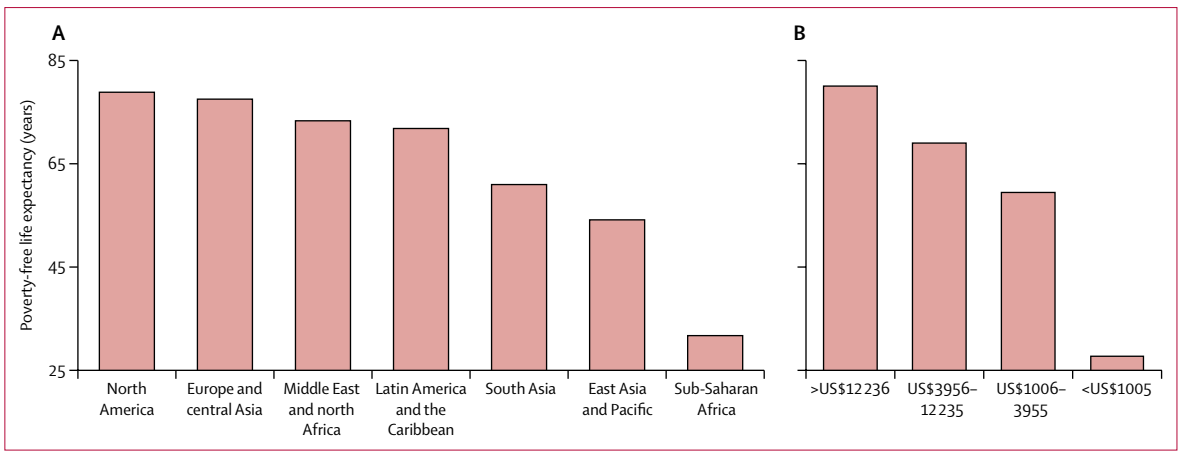

Figure 4: **Mean poverty-free life expectancy at birth by region (A) and country income group (B)**
Country income groups are defined in terms of ranges for the gross domestic product per capita.

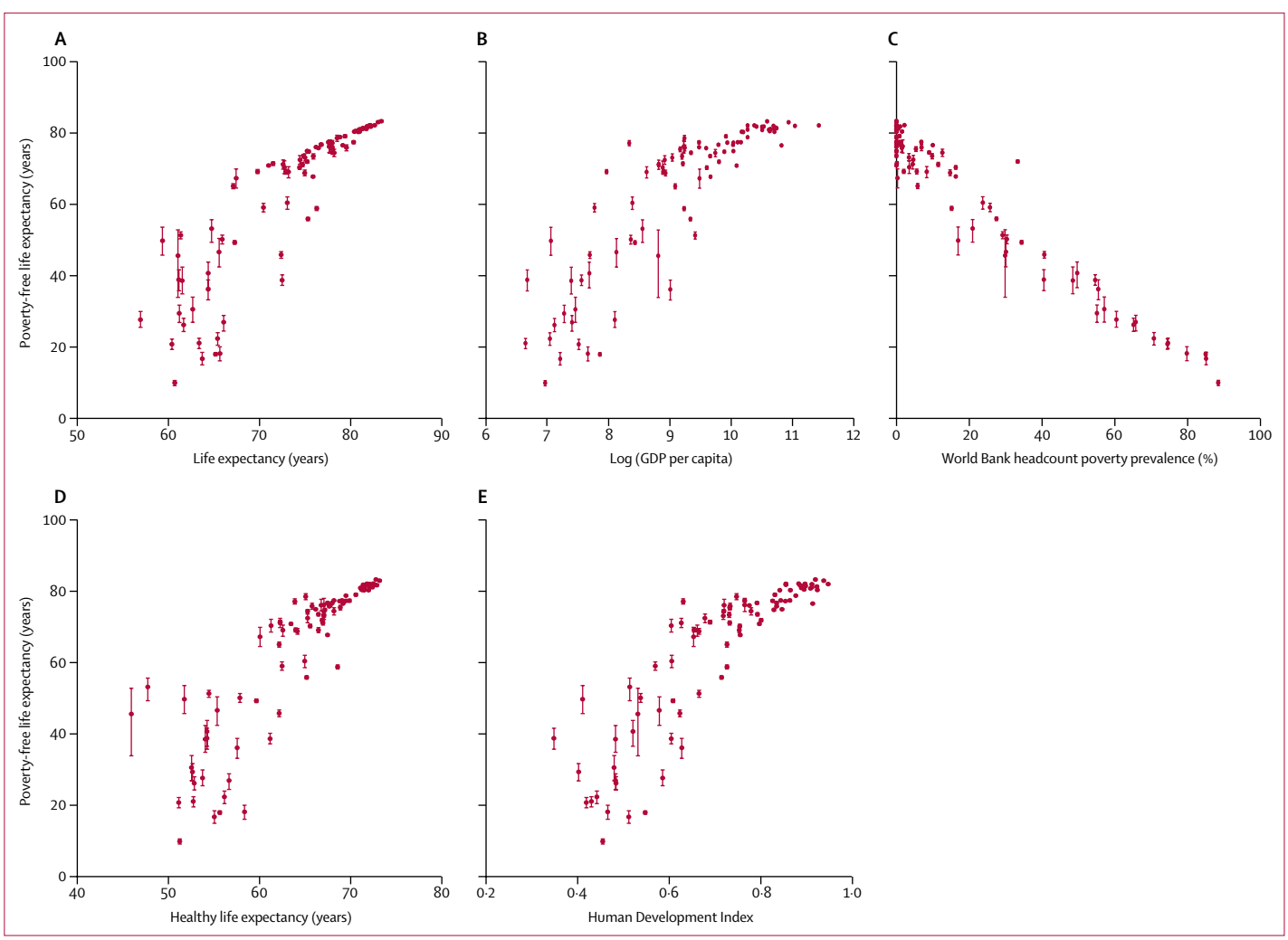

Figure 5: **Relationship between poverty-free life expectancy using World Bank poverty lines and other summary measures of health and development**
Error bars indicate 95% uncertainty intervals for each poverty-free life expectancy estimate. GDP=gross domestic product.

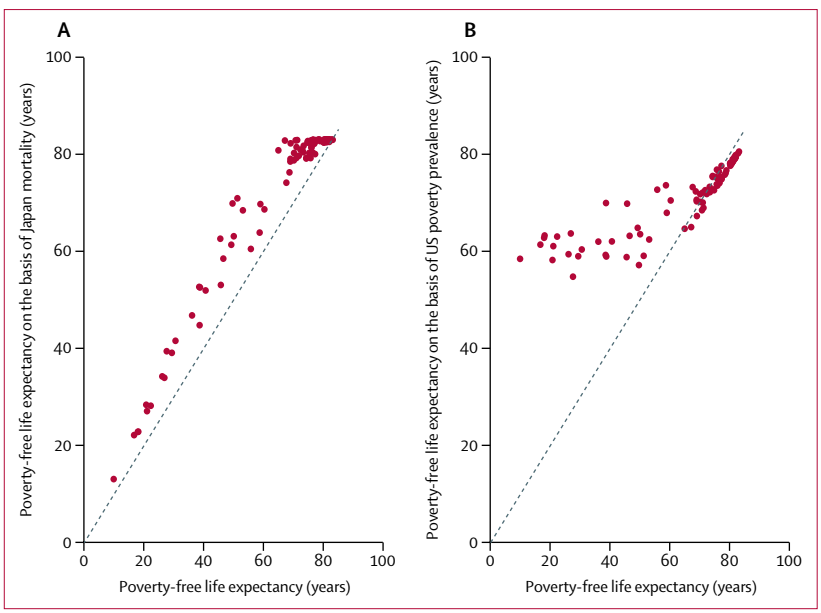

Figure 6: **Counterfactual analysis of poverty-free life expectancy based on mortality rates in Japan (A) or poverty prevalence in the USA (B)**

in countries that fall in the lower range of current PFLE estimates.

Discussion

We used household economic surveys and life tables to develop a measure of population wellbeing that combines fundamental aspects of economic wellbeing and health. This measure is analogous and complementary to healthy life expectancy and resembles other metrics in the broader category of health expectancies.[91] To develop this measure, we used definitions of poverty consistent with the World Bank development indicators and approaches similar to those used to estimate healthy life expectancy. The average poverty-free life expectancy across the 90 countries included in this study was 66·0 years for females and 61·6 years for males, which equates to a 20% deduction from the average life expectancy at birth. Stratifying by sex and comparing results between countries, we found that poverty-free life expectancy was 10·0–80·8 years for males and 9·8–85·7 years for females. In many African countries, poverty-free life expectancy was less than half as great as the overall life expectancy. Results based on national poverty lines showed similar broad patterns but magnified losses to poverty in wealthy countries because of their higher thresholds for national poverty.

An important finding from this study is that more life-years are lost to poverty by females than by males. In developed countries, this difference is mostly driven by the fact that females have a longer life expectancy than males and therefore have more years available to live in poverty. In developing countries, however, the prevalence of poverty is higher in females than in males, in sufficient magnitude to overturn a survivorship advantage for females. Age-specific and sex-specific poverty prevalence data by country income group show that poverty is more prevalent for women than for men during young and middle adulthood, with the gap narrowing at the end of life. The sex-specific results are in line with evidence suggesting that risk of poverty is higher in lone mothers and elderly women than in male counterparts.[96] This finding underscores the need for policies that provide support for female-headed households and elderly women. Comparing poverty-free life expectancy with other indicators used in benchmarking progress in development, we found that PFLE was highly correlated with other measures of development but that rankings based on PFLE varied substantially from those based on the other measures. This result suggests that the new measure conveys additional information that is not reflected in existing measures. An advantage of PFLE over other measures of economic wellbeing is that it can provide within-country measures of economic wellbeing, unlike GDP per capita or the World Bank headcount poverty prevalence, which represent the macro conditions of the country. Furthermore, PFLE allows the link between health and economic policies to be operationalised, consistent with the spirit of the SDG agenda. A further advantage is that the estimate of PFLE is constructed from data that are readily available in most countries or will become increasingly available in the coming years, given the current World Bank objective of expanding the measurement of economic wellbeing in the poorest countries.[97] Finally, the possibility to disaggregate this measure at subnational levels would allow countries to monitor their progress in health and economic dimensions with little additional data collection efforts.

The PFLE measure also has methodological advantages. First, we combined two reliable and repeatable data sources. Life tables are updated regularly and released publicly by WHO, IHME, and other institutions. Household economic surveys in many developing and developed countries are regularly undertaken and would allow age-specific and sex-specific poverty prevalence to be estimated on an annual basis. Although we used a convenient sample, we identified more than 30 additional household surveys that are regularly collected but that unfortunately are not made publicly available or are only available for a substantial fee. As the World Bank pursues the collection of regular household and income surveys in the poorest countries, there should also be an important push for open data that will further contribute to the achievement of the SDG goals.

The method proposed here would be suitable for monitoring at the international, national, or subnational level. A distinction between international and national benchmarking that is highlighted in our analysis concerns the appropriate definition of the poverty line, which is a normative choice that should align with a

particular evaluation purpose. The World Bank poverty line provides an internationally comparable benchmark that is used to measure progress in the SDGs and therefore allows for standardised comparisons between countries. By contrast, national poverty lines reflect local criteria that might be suitable for tracking progress within a country (eg, across subnational units). The construct of PFLE can be adapted from the binary formulation of poverty presented here to include other measures such as the poverty gap or severity, which would lead to more nuanced values of poverty-free or poverty-adjusted life expectancy, analogous to the variety of different measures within the category of health expectancies.

The PFLE construct follows a non-welfarist measurement tradition,[98,99] with inspiration from Sen's capabilities approach to measuring wellbeing.[100] Being alive and out of poverty can be thought of as fundamentally contributing to a person's capability of living a full life, and is a measure of opportunities rather than happiness. A more comprehensive capabilities approach would be to measure life expectancy in years that are both poverty-free and disability-free; however, this approach would need comprehensive data on joint distribution of disability and poverty by age, which are not available for most countries.

Another contribution of this measure is making explicit the link between income and health. This is in line with the increasing amount of evidence that suggests that income affects health and that health affects income at the aggregate and individual levels.[101–103] Consequently, the PFLE measure becomes relevant for policy makers to identify, implement, and evaluate policies that would address low PFLE with either health or other social policies. Because of the bidirectional relationship between income and health, policies are likely to have complementary effects on PFLE.

A final advantage of PFLE is that, although it adjusts quality of life for economic wellbeing, the unit of account is life-years, which is more pertinent to global health. An important goal of our approach is to provide an alternative to the common practice of converting life-years to money values, and to instead think of adjusted life-years as the fundamental measure of wellbeing. The utility of this measure goes beyond global monitoring, and it could be used as additional information in priority-setting exercises. It also operationalises the SDG targets of financial risk protection and healthier lives in a single measure.

Our study also has limitations. Estimates of PFLE depend on the data quality of the two key inputs, which are derived from mortality estimation in life tables and poverty prevalence estimates from analysis of household economic surveys. The estimation of age-specific mortality rates relies on indirect estimation, extrapolation, and modelling in settings without reliable vital or sample registration systems.[104] Income and expenditure data from surveys are subject to their own sources of uncertainty and potential bias such as recall bias and various types of measurement error.[105] Although we account for quantified uncertainty in life tables that results from the GBD mortality estimation procedures and for sampling uncertainty in poverty estimates using bootstrap methods for survey analysis, there are undoubtedly sources of non-sampling error that will be incompletely and imperfectly captured in these estimation approaches, and any limitations in the underlying data inputs will propagate through into the derived estimates of PFLE.

The interpretation of PFLE merits some discussion because it is based on a prevalence measure of poverty and the relatively simple Sullivan's approach to partitioning life-years within each age group into those lived with or without poverty. If poverty were distributed at birth and persisted for the entire lifespan of all those affected, it would be incorrect to conceptualise PFLE as the average number of years a person could expect to live free from poverty because a fraction of the population would live their entire lives free from poverty and the remainder would live their entire lives in poverty. A key question that bears on the interpretation, therefore, is the extent to which individuals can move into and out of poverty over time. Although poverty is often concentrated in a small subset of the population, those individuals who are referred to as chronically poor have been estimated to represent half of this group.[106] Existing evidence suggests that although this group lives in poverty for a longer period of time, it does not represent a permanent life status. For example, in one study[106] the average duration of poverty in a set of low-income developing countries was 5–33 months. This finding is reflected on a macro scale in observations of poverty prevalences decreasing in people of working ages. The notion of poverty dynamics is consistent with evidence suggesting that poverty is strongly related to changes in family structure, changes in the head of household earnings, and social policies.[107–109] One caveat for this interpretation is that the extent to which poverty is concentrated in a subset of the population can vary greatly between countries. In some developing countries, more than 80% of the population will be poor at some point in their lifetime. Consequently, although simplifying the interpretation of PFLE as the average expected years lived above the poverty line is convenient, this interpretation will be less apt in settings where the risk of poverty is highly concentrated and more persistent, as opposed to broadly dispersed and dynamic. Further stratification of the measure by population subgroups will be useful in this respect, as would future refinements of PFLE to account more explicitly for the distribution of poverty.

A related point is that the PFLE measure described here does not account directly for correlations between income and survival at different age groups. Mortality varies by income, and these inequalities have been

increasing in recent decades.[110–113] One way to integrate this dependence into the estimation of PFLE would be to use a multistate life table approach, as opposed to Sullivan's method. Such an approach requires both estimates of the transition rates into and out of poverty, as opposed to cross-sectional prevalence measures, as well as differential mortality estimates for those living above or below the poverty line. It will be worthwhile to assemble available data for such calculations and to undertake a comparison of the results. However, this approach will be limited by the reduced number of locations that could supply the requisite data inputs, so it will support a less comprehensive global view given the present state of evidence.

A further limitation is that although we measured household poverty, it might have a differential effect on individuals within the same household, as shown in several studies.[114] Further work could move from household-based to individual-based measurement of poverty, although the latter might increase the data requirements and complicate the objective of estimating a simple measure from routinely available data. Additionally, although our measure makes explicit the link between poverty and health, we acknowledge that it does not account for the aggregated effects of poverty on those individuals living below or above the poverty line. Addressing these consequences will necessitate further causal evidence of the effect of poverty on health at the population level.

Finally, a characteristic of the PFLE metric is that policies that reduce mortality in populations living below the poverty line will not add to overall PFLE in the way that reducing mortality in populations living above the poverty line will. This limitation is shared by analogous summary health measures such as healthy life expectancy, wherein individuals in poor health contribute less to these summary measures than individuals in good health do. In a binary measure such as PFLE (as in binary summary health measures such as disability-free life expectancy or dementia-free life expectancy), the disparity between contributions from different population groups is most pronounced because those below the threshold contribute nothing. An alternative would be to use a polytomous or continuous scale to differentiate levels of economic wellbeing. The disadvantage of such an approach is that estimation of the measure would be more complex and require further normative assumptions about the weighting function that maps from different income levels to partial credit for survivorship, which is a challenge that other health measures have encountered.

As the world seeks to achieve the SDGs by 2030, it is necessary to develop monitoring tools that encourage the development of policies that address different dimensions of development. A limitation of using narrow measures that focus on a single dimension is that they can encourage governments to focus on narrow policies and disregard other policies that might have broader ramifications across sectors. We propose a population wellbeing measure, similar in spirit to summary measures of population health such as healthy life expectancy, that combines age-specific and sex-specific economic wellbeing and survival. This measure is consistent with the linked global agendas of improving health and eliminating poverty. As such, PFLE brings focus to health and wellbeing of populations in a way that encourages policy makers to consider broad benefits of decisions, policies, and reforms. Responding to frequent calls for better monitoring (encompassing both enhanced collection of reliable data and the development of appropriate measures linked to agreed goals and targets), we suggest that the new measure of PFLE can help establish accountability for policies that aim to end poverty and promote wellbeing at all ages.

Contributors

CR-H led the collection of data, analysis, and writing of the first draft of the manuscript and contributed to study design and data interpretation. DC contributed to study design, analysis, data interpretation, and revision of the manuscript. JAS conceived the study and contributed to study design, data acquisition, analysis, interpretation, and writing and revision of the manuscript.

Declaration of interests

We declare no competing interests.

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