1 **Halving premature death and improving quality of life at all ages**

2

3 Ole F Norheim*, Angela Y Chang, Sarah Bolongaita, Mariana Barraza-Lloréns, Ayodamope

4 Fawole, Lia Tadesse Gebremedhin, Eduardo González-Pier, Prabhat Jha, Emily Johnson,

5 Omar Karlsson, Mizan Kiros, Sarah Lewington, Wenhui Mao, Osondu Ogbuoji, Muhammad

6 Pate, Jennifer Sargent, Xuyang Tang, David Watkins, Gavin Yamey, Dean T Jamison**,

7 Richard Peto**.

8

9

10 * Correspondence to: Prof Ole F Norheim, Bergen Centre for Ethics and Priority Setting,

11 Department of Global Public Health and Primary Care, University of Bergen, Overlege

12 Danielsen's Hus, Årstadveien 19, 5020 Bergen, Norway. Ole.norheim@uib.no

13 ** Denotes last (senior) authors

14

15

16

17

18 **Authors' highest degrees and affiliations (full professors are denoted as Prof):**

19

20 Prof Ole F Norheim: PhD., Bergen Centre for Ethics and Priority Setting, Department of
21 Global Public Health and Primary Care, University of Bergen, Bergen, Norway

22

23 Angela Y Chang: ScD., Danish Centre for Health Economics, University of Southern Denmark,
24 Odense, Denmark

25

26 Sarah Bolongaita: SM, University of Bergen, Bergen, Norway

27

28 Mariana Barraza-Lloréns: MSc., Founding Partner, Blutitude, Mexico City, Mexico.

29

30 Ayodamope Fawole: MS., Duke Global Health Institute, Duke University, Durham, NC, USA

31

32 Lia Tadesse Gebremedhin: MD., Harvard Ministerial Leadership Program, Division of Policy
33 Translation and Leadership Development, Harvard T.H. Chan School of Public Health,
34 Harvard University, Boston, MA, USA

35

36 Eduardo Gonzalez-Pier: PhD., Palladium Group, Washington, DC, USA

37

38 Prof Prabhat Jha: DPhil., Center for Global Health Research, Dalla Lana School of Public
39 Health, University of Toronto, Toronto, Canada
40
41 Emily K Johnson: MSc., Department of Public Health, Danish Institute for Advanced Study,
42 University of Southern Denmark, Odense, Denmark
43
44 Omar Karlsson: PhD., Duke Global Health Institute, Duke University, Durham, NC, USA
45
46 Mizan Kiros: PhD., Bergen Centre for Ethics and Priority Setting, Department of Global Public
47 Health and Primary Care, University of Bergen, Bergen, Norway
48
49 Prof Sarah Lewington: DPhil, Nuffield Department of Population Health, Oxford University,
50 Oxford, UK and Health Data Research UK Oxford, University of Oxford, Oxford, UK
51
52 Wenhui Mao: PhD., Duke Global Health Institute, Duke University, Durham, NC, USA
53
54 Osondu Ogbuoji: ScD., Duke Global Health Institute, Duke University, Durham, NC, USA
55
56 Muhammad Pate: MD., Minister of Health and Social Welfare, Ministry of Health, Abuja,
57 Nigeria
58
59 Jennifer Sargent: PhD., Bergen Centre for Ethics and Priority Setting, Department of Global
60 Public Health and Primary Care, University of Bergen, Bergen Norway
61
62 Xuyang Tang: PhD, Center for Global Health Research, Dalla Lana School of Public Health,
63 University of Toronto, Toronto, Canada
64
65 David Watkins: MD, Department of Global Health, University of Washington, Seattle, WA,
66 USA
67
68 Prof Gavin Yamey: MD, Duke Global Health Institute, Duke University, Durham, NC, USA
69
70 Prof Dean T Jamison: PhD., Department of Epidemiology & Biostatistics, University of
71 California, San Francisco USA
72
73 Prof Richard Peto: FRS, Nuffield Department of Population Health, University of Oxford,
74 Oxford, UK
75
76
77
78

Abstract

Background: Reducing premature death (death before 70 years) is a global health challenge, with stark disparities across countries. We report global mortality trends at the country-level over the past half century and explore whether halving premature death by 2050 compared to pre-pandemic levels is feasible. We also explore the rates of improvement for the 30 most populous countries and for 10 global regions.

Methods: All analyses were conducted using data from the UN World Population Prospects 2024. The probability of premature death (PPD) is defined as the probability that a child born in the indicated year would die before age 70 if the prevailing age-specific death rates were to continue unchanged. We use 2019 as our baseline year.

Results: Considerable improvements in PPD have occurred over the past half century, but disparities across regions, countries, and sex in levels and trends of PPD remain. Among all countries, 34 halved their PPD over three decades between 1970 and 2019. Among the 30 most populous countries, seven countries, with varying levels of baseline PPD and income, halved their PPD in the past half century. Seven of the most populous countries have an implied rate of improvement towards 2050 that, if sustained, could lead to a halving of PPD.

Interpretation: Halving premature death by 2050 is feasible, although substantial investments, particularly in adult health, are needed to sustain or accelerate the rate of improvement for high- and medium-performing countries. Particular attention must be paid to countries with very low or worsening rate of improvement in PPD. By reducing premature mortality, more people will live longer and more healthy lives. Yet, as people live longer, the absolute number of years lived with chronic disease will increase and investments in services reducing chronic disease morbidity are needed.

3

Background

For most people in the world, it would be a reasonable expectation to live to age 70 and a realistic indicator of progress in the future would be probability of premature death (death before 70 years). Historically, under-five mortality (probability of death before 5 years) has been a widely used and well understood indicator of progress in global health. As child mortality and fertility declines, and a demographic shift to older aged populations occurs, non-communicable diseases (NCDs) have become more prominent in most countries.[1] Thus, it is compelling to extend attention to the age range up to 70 years. We chose age 70 as the cut-off value for two reasons. First, because life expectancy at birth for the world is now around 70. Saving lives at ages below life expectancy will increase both life expectancy and life span equality.[2] Second, because the upper age limit for the Sustainable Development Goal NCD mortality target 3.4 is 70 years. If halving premature death in all countries could be achieved, the absolute gap in probability of premature death between low- and high-income countries would be reduced.

A 2014 review of national mortality trends to help quantify the United Nations Sustainable Development Goal for health[3,4] concluded that a 40% reduction in premature death could be achieved by 2030, or soon afterward, "at least in areas free of war, other major effects of political disruption, or a major new epidemic".[4] A decade later, the world has been through a major pandemic and continues to experience political disruption, nationalism, inflation, climate change, and violent conflict in Africa, the Middle East, Europe and elsewhere.[5] Against this background, we used the latest available mortality estimates to explore levels and trends and ask if the substantial gains in health improvement and reductions in premature death observed historically, before the COVID-19 pandemic, can be sustained.

We aimed to document mortality trends in the past half century and explore whether halving premature death by 2050 compared to pre-pandemic levels (2019) is feasible for each country in the world. To assess feasibility, we explored whether one or more countries historically have achieved a halving of premature death in about three decades or less. In addition, we estimated which countries had the necessary recent rate of change in PPD that, if continued, would lead to a halving of PPD over the next three decades. We also explored the rate of improvement for the 30 most populous countries (in our baseline year 2019) and

144   the 10 global regions as defined by the third Lancet Commission on Investing in Health

145   (CIH3). For selected countries, we provide an in-depth discussion of past trends and

146   prospects for the future. These countries were chosen to reflect both good and less well

147   performing populous countries

148

149   **Methods**

150

151   **Levels in probability of premature death**

152   We define premature death as death before age 70. The probability of premature death

153   (PPD) is defined as the probability that a child born in the indicated year would die before

154   age 70 if the age–specific death rates prevailing at the year of birth were to continue

155   unchanged ($_{70}q_0$).

156

157   We use PPD as an indicator to measure trends in health improvement since 1970 – i.e.,

158   during the last half century. All analyses on PPD were conducted using life tables from the

159   UN World Population Prospects 2024 (WPP 2024).[6] For each sex, country, and year,

160   probability of death was calculated from these life tables with one-year age-specific

161   mortality rates as:

162

163    $$_n q_x = \frac{l_x - l_{x+n}}{l_x}$$

164

165   where l_x and l_{x+n} are the number of people starting in the cohort at age x and at age x+n.

166   For example, PPD ($_{70}q_0$) is the number of people dying before age 70 over the starting

167   population at age 0, or:

168

169    $$PPD = {}_{70}q_0 = \frac{l_0 - l_{70}}{l_0}$$

170

171   where $_{70}q_0$ is the probability of dying between age 0 and exact age 70, l_0 is the number of

172   people alive at age 0 (100,000 in standard life tables), and l_{70} is the number of people alive

173   at exact age 70 (i.e., those that did not die before their 70th birthday). For this paper, we use

174   annual "rate of improvement" to indicate the decline in PPD. A faster rate of improvement

175   is desired. A few countries have a worsening or increasing rate of change, which is indicated

176   with a + sign in all tables. We also calculated the probabilities of dying between ages 0-14

177   ($_{15}q_0$), 15-49 ($_{35}q_{15}$), and 50-69 ($_{20}q_{50}$) using the same equation. For example, for the age

178   group 50-69, $_{20}q_{50}$ is the probability of death between age 50 and exact age 70, conditional

179   on survival to exact age 50.

180

181   **Trends in the probability of premature death**

182   To explore whether halving the probability of premature death by 2050 is feasible, we

183   looked at variations in the rates of change in previous decades for the world's major regions

184   and countries. We then assessed which countries, through improved and targeted health

185   policies, could or could not realistically achieve a halving of premature death. To calculate a

186   50% reduction in premature death, we chose the year 2019 as our baseline. Levels in PPD

187   for the period 2020-23 were substantially affected by the COVID-19 pandemic and are

188   therefore inappropriate as baseline years for assessing progress. To determine feasibility of

189   what CIH3 calls "50 by 50", a 50% reduction in the probability of premature death by 2050,

190   we estimated changes in the probability of premature death from the last half century, and

191   calculated the average annual rate of improvement in PPD (AARI) with the following

192   equation:

193    $$AARI = \left(\frac{q_t}{q_{t+1}}\right)^{\frac{1}{t}} - 1$$

194

195   where q_t is the probability of premature death at time t and q_{t+n} is the probability after a

196   further n years. The rate of improvement needed to reach a 50% reduction was estimated

197   by setting the probability in year 2050 (q_{2050}) at half the level of the probability in 2019

198   (q_{2019}). The required rate of improvement to reach a halving of PPD in 31 years (i.e., by

199   2050 from a 2019 baseline) is the same for all regions and countries: 2.2%. We also

200   calculated the rate of improvement for each age group listed above.

201

202   The required rate of improvement depends only on the level of PPD in our baseline year and

203   the set target and does not depend upon past rate of improvement. We then compared the

204   observed rate of improvement over the last decade (2010-2019) with the required rate of

205   improvement over the next three decades. Based on the annual rate of improvement in the

206   period 2010-19, we pragmatically grouped countries into three categories: high (>2.2%),

207   medium (2.2% - 1.0%), and low rate (<1.0%) of PPD change. The method for decomposition

208   of changes in PPD by age is provided in the appendix.

209

210   **Regions**

211   Since we explore historical health trends in the past half century and discuss feasibility of

212   continued or improved rate of improvement for the next 30 years, World Bank regional

213   classifications of countries by income are not appropriate. For example, more than 30

214   countries have transitioned from low-income status, defined by the World Bank

215   classification, to middle-income status since 2001.[7] In addition, the income classification cut-

216   offs have changed. We therefore follow CIH3 and classify countries in geographical regions

217   with somewhat similar characteristics in terms of disease burden and economic

218   development (appendix, Figure A1). The world's three most populous countries (India,

219   China, and the United States [US]) are separated out as "regions" since they would

220   dominate all trends if included in other regions. The North Atlantic region includes Western

221   Europe and Canada.

222

223   The funders played no role in the design, data collection and analysis, decision to publish, or

224   preparation of the manuscript.

225

226   **Results**

227

228   **Improvements in PPD**

229   There have been major improvements in PPD over the last half century but there are also

230   disparities across regions, countries, and sex in levels of and trends in PPD. In 2019, before

231   the COVID-19 pandemic, PPD ranged from 52% in sub-Saharan Africa to 15% in the North

232   Atlantic (Table 1). Sub-Saharan Africa, Central Asia, and India had levels of PPD above the

233   world average (31%) (Figure 1).

234

235   Central and Eastern Europe had little improvement, and even saw an increase in PPD,

236   between 1970 and 2005 but had the greatest improvement from 2010-19 (2.2%). All the

237 other regions had substantial improvements in PPD from 1970-2019, and five regions had

238 equal or higher rates of improvement than the world average (1.4%; Table 1). China had a

239 strong observed rate of improvement (1.9%), India around average (1.3%), whereas the US

240 was the only region to observe a (small) worsening trend over the past decade (+0.1%).

241

242 Levels of and trends in PPD also varied within regions. Figure 2 shows trends in overall PPD

243 for the 30 most populous countries in the world, and for age-groups of 0-14, 15-49, and 50-

244 69 years.

245

246 For all age groups, substantial improvements in PPD were observed, with variations across

247 countries. All countries saw improved PPD at ages 0-14 years (with a few blips for Nigeria,

248 Kenya and Russia), at 15-49 years except Kenya and South Africa due to HIV/AIDS (with blips

249 for several other countries due to war and political turmoil), at 50-69 years except Kenya

250 and consequently all countries at ages 0-69 years. Large increases in PPD are seen for some

251 subgroups in countries substantially affected by HIV/AIDS (southern and eastern Africa

252 around 1990), alcohol overconsumption (Russia around 2000), or war and famine

253 (Bangladesh around 1971 and Ethiopia 1980s). These trends are examined in detail for

254 selected countries in the Discussion section.

255

256 **Prospects towards 2050**

257 From 2010 to 2019, the global annual rate of improvement in PPD was 1.3% for both sexes

258 combined (Table 1). Of the 30 most populous countries, seven had a rate of improvement

259 equal to or better than 2.2% (the required rate to achieve "50 by 50") from 2010-2019

260 (Table 2). If sustained, continuing this trend would lead to a halving or more. Conversely,

261 nine out of 30 countries had a rate of improvement worse than 1.0%, meaning the implied

262 improvement would be less than one-third.

263

264 Among all countries in the world, those with minimal decline or increasing PPD are highly

265 unlikely to achieve a halving of PPD by 2050. Some of these countries – Libya, Yemen, Syrian

266 Arab Republic, Jamaica, Mexico, and Venezuela – are marked by war, violent political

267 conflict, or political disruption, while others (USA, Costa Rica, Cuba) are harder to explain

268 (appendix Table A1)." (appendix Table A1).

269

Seven populous countries halved PPD over three decades in the last half century

271 We also looked historically at whether any country had achieved a halving of PPD in three

272 decades or less. Among the 30 most populous countries, seven countries halved their PPD

273 over 31 years or less in the past half century (the required and fastest time to achieve

274 halving between 2019 and 2050 is given in parentheses): Bangladesh (1991-2022), Iran

275 (1983-2006), China (1970-2001), Viet Nam (1972-1995), Republic of Korea (1992-2011), Italy

276 (1983-2012), and Japan (1970-2001). When looking at countries beyond the most populous,

277 we find that among all countries in the world, 34 countries in total halved their PPD

278 (appendix Table A2) over 31 years or less between 1970 and 2019. These historical

279 experiences from diverse countries show that halving PPD over three decades is feasible.

280 Halving occurred in countries starting with both high initial levels of PPD (e.g., Viet Nam,

281 Algeria) and low initial levels (e.g., Italy, Norway), and across all income levels.

282

283 There is no statistically significant correlation between initial levels of PPD and rates of

284 improvement in the period 2010 to 2019 (appendix Figure A3). For example, the Republic of

285 Korea had the highest rate of improvement but with low initial PPD, while Ethiopia also had

286 high rate of improvement but from a much higher level of initial PPD (Table 2).

287

PPD trends by sex

289 In all countries, females had lower PPD than males in 2019. Global rate of improvements in

290 PPD by sex were generally higher for females than for males. In the period 2010-19, the

291 global rate in PPD fell by 1.5% annually for females and 1.1% for males (appendix Table A3).

292 In the most populous countries, rates were highest for females in 21 out of 30 countries

293 (Figure 3) (for all disaggregated results by sex, see appendix Table A3). Yet, the pattern is

294 not uniform. For example, the gap in PPD between females and males narrowed in the US

295 between 1970 and 2010, while in Thailand, the gap increased between 1985 and 2019

296 (appendix Figure A4).

297

Decomposition of changes in PPD by age group

299 For the world, changes in PPD since 1970 have largely been driven by improvements at ages

300 50-69 years (appendix Figure A5). In the period 2010-19, about 50% of the improvements in

9

301   PPD were due to this age group, followed by the age groups 0-14 years and 15-49 years

302   (about 23%). In the North Atlantic, the proportion contributing to the fall in PPD has been

303   about 70% from ages 50-69 since the 1970s, and even in sub-Saharan Africa, this age group

304   contributed the most (40%) to changes in PPD in the 2010s. This contribution is largely

305   because most deaths increasingly occur in older age groups.

306

307   **Discussion**

308   Substantial improvements in premature mortality in the past half century have been

309   achieved, but there are also disparities across regions, countries, and sexes in levels and

310   trends. Nevertheless, we find that 34 diverse countries halved their PPD in three decades or

311   less and seven of the 30 most populous countries have an implied rate of improvement

312   towards 2050 that, if sustained, could lead to a halving of PPD. The absolute gap between

313   countries with high and low levels of PPD would also be reduced.

314

315   One striking finding is the higher rate of improvement in PPD for females over males in most

316   countries. The reasons for this disparity warrant further scrutiny. Disparities in PPD within

317   countries across geographical regions, income, and level of education should also be

318   studied.

319

320   **In-depth discussion of selected countries**

321   China has achieved good progress in population health over the last half-century, reducing

322   its PPD from 61% in 1970 to 21% in 2019. There have been substantial reductions in the

323   probabilities of dying between ages 0-14, 15-49, and 50-69 years during this period. The rate

324   of improvement in PPD has consistently remained at about 2% or more, with the most

325   considerable progress occurring at 2.6% in the 1970s, followed by 2.3% in the 2000s. China's

326   initial achievement in reducing premature death is largely due to its success in reducing

327   maternal and infant mortality.[8] Rapid economic growth, poverty alleviation efforts, and

328   universal education programs have also contributed to health advancements. Improving

329   access to care and enhancing financial protection and population health were also

330   important—these were achieved through (i) the government's commitment to universal

331   access to basic health care; (ii) increasing public funding for health from 1% to over 3% of

332   gross domestic product to fund a universal health insurance program; and (iii)

333   implementation of free national essential public health programs (including HIV/AIDS and

334   tuberculosis).[9] Rural health insurance rolled out from 2003-08 may have saved about one

335   million lives per year at its peak.[10] Yet, inequality in quality of care by geographical and

336   socioeconomic status presents another challenge.[11,12]

337

338   Ethiopia made substantive progress in reducing the PPD between 1991 and 2019, and since

339   2000, its rate of improvement has been among the fastest in sub-Saharan Africa.[13] The

340   largest contributions to PPD decline are from reductions in maternal and child health

341   conditions and communicable diseases such as HIV/AIDS, tuberculosis, and malaria.[14] These

342   can be attributed to reforms within and outside the health sector, including a pro-poor

343   health policy emphasizing rural communities and primary health care that resulted in the

344   decentralization of health service delivery, community empowerment, and better access to

345   primary health care. Between 1990 and 2019, GDP per capita increased from US$110 to

346   US$840[15], the proportion of people living in poverty was halved from 48 to 24%[16], literacy

347   doubled from 27 to 52%[17], access to basic drinking water tripled from 13 to 38%[18],[18]; and

348   total fertility rate fell from 7.2 to 4.3 children per woman.[19] The country also enjoyed peace

349   and security between 2000 to 2020. The ongoing civil conflicts in Ethiopia since 2021 and

350   the global crisis have hindered economic growth and could have long-term population

351   health impacts on the country.

352

353   From 1970 to 2019, Nigeria experienced a 13% decrease in PPD, with most progress

354   occurring between 1970 and 1975 and between 2000 and 2019. The rate of improvement

355   was 1.2% per year in the 1970s, but this was followed by a reversal in the 1980s and 1990s,

356   when PPD increased by 0.1% per year for two decades, erasing the gains from the 1970s. In

357   the 2000s, PPD started to decline again, but at a slow rate of 0.6% per year. Currently,

358   Nigeria's PPD (62.5%) is one of the highest in sub-Saharan Africa and is largely driven by the

359   unfinished infectious disease agenda, worsening socioeconomic inequality, and the growing

360   incidence of NCDs such as diabetes, hypertension, and cancers. Emerging challenges also

361   include rising rates of poverty and conflict-related decreased access to healthcare.[20]

362

363   From 1970 until 2000, Mexico showed steady progress, with rate of improvement in PPD

364   averaging between 1.2 and 2.0% per decade. However, gains stalled in the past two

365   decades, and PPD has remained at around 30% since around 2003 (data not shown). A

366   narrow set of three conditions — ischaemic heart disease, diabetes, and injuries resulting

367   from interpersonal violence — accounted for the largest share of premature deaths,

368   offsetting health gains in infectious diseases and explaining the poor performance.

369   Increased mortality from ischaemic heart disease and diabetes has mainly affected the 50-

370   69 age group, while interpersonal violence is concentrated in ages 15-49 years.[21-24]

371   Undertreated or untreated diabetes in adult Mexicans is the major challenge.[25] At 75% in

372   2022, the combined prevalence of obesity and overweight among the adult population in

373   Mexico is one of the highest in the world.[23] An underfunded and fragmented primary health

374   care system has been unable to contain the rising prevalence of hypertension,

375   dyslipidaemia, and high blood sugar levels over the past decades. On the other hand, the

376   underlying determinants of deaths associated with violence remain a complex multifactorial

377   agenda perceived to be beyond the traditional scope of health policy intervention.

378

379   Adults in the US are experiencing higher PPD, and poorer health compared to their

380   counterparts in other high-income nations. While its peer nations continue to make strides

381   in improving adult survival, the US has witnessed a stark stagnation in such progress,

382   particularly since the 1970s.[26] PPD declined by an average of 2.0% annually in the 1970s, but

383   subsequent decades saw this rate of decline halved, or even dissipated in the 2010s (Figure

384   4). The stagnation disproportionately affects younger Americans. Deaths before age 50

385   constitute a significant portion of the disparity in life expectancy between sexes in the US

386   and overall compared to other high-income nations.[26] The trend is most pronounced

387   among Non-Hispanic White Americans, whose deaths comprise about two-thirds of all

388   deaths in the US since 1990 and who have seen slight improvement in reducing mortality

389   since 1990. By contrast, mortality trends among Hispanic Americans have improved, driven

390   partly by immigration.[27] Among Black Americans, notable strides in reducing premature

391   mortality have been seen.[28] Among Non-Hispanic White Americans, stagnation has occurred

392   in those who have attained high-school education or less: those attending college continue

393   to show overall decline in PPD.[29] The COVID-19 pandemic amplified these marked

394   educational differences.[30] The phenomenon has been termed "diseases of despair," and

395 causes include increases in opioid-related deaths, cirrhosis, and suicides.[31] However, the

396 narrative is clearly incomplete, as rising mortality rates extend to vascular disease, chronic

397 lung disease, injuries, and homicides. Analysis indicates that tobacco-related causes

398 contributed to nearly half of the excess deaths among lower-educated Non-Hispanic White

399 Americans from 1990 to 2019, a finding consistent with international comparisons.[32] Since

400 2010, the combined contribution of smoking, opioids, cirrhosis, suicide, and other external

401 injuries has been approximately two-thirds of all excess deaths among Non-Hispanic White

402 Americans.[33]

403

404 **Looking forward**

405 Countries with a rate of improvement in PPD better than 2.2% between 2010 and 2019 do

406 not only include those with high PPD or high child mortality, but also include higher-income

407 countries with low PPD and predominantly NCD-related mortality. Indeed, changes in PPD

408 since 1970 for the world have largely been driven by improvements in ages 50-69 years. In

409 2010-19, about 50% of the improvements in PPD were attributable to this age group. If

410 countries with a medium rate of improvement (between 2.2% and 1.0%) can achieve the

411 same rate of improvement as their better-performing regional neighbours through

412 benchmarking, halving premature death by 2050 is feasible but requires sustained and

413 substantial investments.

414

415 Historically, countries that made the most progress in reducing PPD did so by implementing

416 a limited set of interventions that addressed a relatively small number of diseases, injuries,

417 and risk factors. For example, about one third of the gains in life expectancy in low-income

418 countries between 2002 and 2019 were attributable to mortality reductions from treatment

419 of HIV/ AIDS, tuberculosis, and malaria.[34] In sub-Saharan Africa the overall decline in

420 mortality has been substantial in the age group 0-14, and these deaths are easily

421 preventable through cost-effective interventions. At the other end of the spectrum, nearly

422 half of the reduction in cardiovascular mortality in the US between 1980 and 2000 was

423 attributable to reductions in tobacco use, high systolic blood pressure, and high

424 cholesterol.[35] Secondary prevention of cardiovascular disease, i.e., giving effective

425 medicines to those who have experienced an event can substantially reduce mortality.[36] In

426 some cases, the mortality reductions can be massive and rapid. For example, following a

427   1995 ban on organophosphate pesticides, suicide mortality in Sri Lanka declined by about

428   50% in the following decade.[37] A prioritized approach to health conditions and interventions

429   could allow countries with fewer resources to achieve considerable reductions in mortality

430   at a reasonable cost.[5,38-40]

431

432   Lastly, some of the most populous countries are unlikely to achieve "50 by 50" based on

433   recent trends – even if most other countries could do so. These countries include Mexico,

434   Viet Nam, Nigeria, and the US. Among all countries, the number of countries from Latin

435   America and Caribbean in this category is of particular concern.

436

437   **Quality of life at all ages**

438   While reducing the probability of premature death is a worthy goal for global health, people

439   also care about living healthy lives. Prevalence of morbidity, the number of people living

440   with chronic disease, the number of years they live in such conditions, and health-related

441   quality of life at all ages are therefore of substantial interest. By reducing premature

442   mortality, most people will live longer and healthier lives (for a more detailed discussion of

443   the relationship between PPD, life expectancy and healthy life expectancy (HALE), see

444   Appendix, page 2-3). As shown by Salomon and others, in countries where life expectancy

445   has increased, the total number of years lived in good health (HALE) has also increased.[41,42]

446   Yet, as people live longer, the number of years lived with chronic disease will increase. This

447   trend, combined with an ageing of the population, will lead to higher demand for long term

448   health services. Investments in services reducing chronic disease morbidity are therefore

449   needed.

450

451   **Limitations of our study**

452   For our analysis, we relied on estimates from the UN WPP 2024, which are widely used and

453   generally considered reliable. For about half of the countries, mortality rates were derived

454   by UN WPP from vital registration systems. However, for the other half, model life tables

455   were generated from censuses, survey data, and other input parameters.[43] There is

456   substantial uncertainty surrounding data on risks of dying in countries lacking

457   comprehensive death registration systems and especially for adult deaths. Levels of and

458   trends in mortality should therefore be interpreted with caution. WPP 2024 does not

459 provide uncertainty intervals for their estimates, so we could not produce the

460 corresponding ranges.

461

462 Our study aimed to look at the feasibility of halving the probability of premature death by

463 2050, not the absolute number of premature deaths. The crude death rate is projected to

464 increase towards 2050 due to demographic change with many countries moving towards

465 inverted population pyramids.[43] Halving the absolute number of premature deaths will

466 therefore be more difficult. Our justification for exploring halving PPD is that the probability

467 of premature death is amenable to policies and health investments, while changes in

468 population size and age distribution of populations are not.[44] PPD is therefore a policy-

469 relevant outcome and easier to communicate to decision-makers and citizens than many

470 other indicators.

471

472 Decomposing the relative contribution of leading causes of death to the rate of reduction of

473 PPD can further help identifying the most effective policies and interventions. We did not do

474 so in this study; this is discussed more extensively in Jamison & Summers et al.[5]

475

476 **Conclusion**

477 In this study we find that "50 by 50" is a feasible global goal that would substantially

478 improve the chance of living a long and healthy life everywhere, with the caveat that this is

479 in areas free of war, other major effects of political disruption, natural disasters, or a major

480 new epidemic which cannot be reliably predicted or their effects quantified. Substantial

481 investments in health are needed to sustain or accelerate the rate of improvement for high

482 and medium performing countries. For low-performing countries, "50 by 50" may remain an

483 aspiration goal. Historical evidence indicates that a limited set of interventions that address

484 a relatively small number of diseases, injuries, and risk factors can substantially boost

485 progress on reducing PPD. Yet, as people live longer, the absolute number of years lived

486 with chronic disease will increase and so will demand for services reducing chronic

487 morbidity.

488

489

490   *

497   Authors' contributions: The first draft of this report was written by Ole F. Norheim, Angela Y.
498   Chang and Sarah Bolongaita, with contributions from all the authors. Data analysis and
499   creation of graphs and tables were conducted by Ole F. Norheim, Angela Y. Chang, Sarah
500   Bolongaita, Prabhat Jha, Dean Jamison and Richard Peto. In-depth country descriptions
501   were written by Wenhui Mao and Winnie Yip (China); Mizan Kiros and Lia Tadesse
502   (Ethiopia); Osondu Ogbuoji and Muhammad Pate (Nigeria); Mariana Barraza-Lloréns and
503   Eduardo González Pier (Mexico); and Prabhat Jha and Xuyang Tang (USA). All authors
504   contributed fully to the overall article structure, writing and editing of subsequent drafts,
505   and the conclusions. The corresponding author had full access to all data in the study and
506   had the final responsibility for the decision to submit for publication.

507

508   Ethics committee approval: Not required.

509

References

1. Bukhman G, Mocumbi AO, Atun R, et al. The Lancet NCDI Poverty Commission: bridging a gap in universal health coverage for the poorest billion. *Lancet* 2020; **396**(10256): 991-1044.

2. Aburto JM, Villavicencio F, Basellini U, Kjaergaard S, Vaupel JW. Dynamics of life expectancy and life span equality. *Proc Natl Acad Sci U S A* 2020; **117**(10): 5250-9.

3. Peto R, Lopez AD, Norheim OF. Halving premature death. *Science* 2014; **345**(6202): 1272.

4. Norheim OF, Jha P, Admasu K, et al. Avoiding 40% of the premature deaths in each country, 2010-30: review of national mortality trends to help quantify the UN sustainable development goal for health. *Lancet* 2015; **385**(9964): 239-52.

5. Jamison D, Summers LH, Chang AY, et al. Global health 2050: the path to halving premature death by mid-century. *Lancet* 2024 (in press).

6. United Nations Population Division. World Population Prospects. 2024. https://population.un.org/wpp/Download/Standard/Population/ (accessed July 11, 2024).

7. Steinbach R. Growth in Low-Income Countries: Evolution, Prospects, and Policies. Policy Research Working Paper 8949. . Washington DC: World Bank Group, 2019.

8. Qiao J, Wang Y, Li X, et al. A Lancet Commission on 70 years of women's reproductive, maternal, newborn, child, and adolescent health in China. *Lancet* 2021; **397**(10293): 2497-536.

9. Yip W, Fu H, Chen AT, et al. 10 years of health-care reform in China: progress and gaps in Universal Health Coverage. *Lancet* 2019; **394**(10204): 1192-204.

10. Gruber J, Lin M, J. Y. The largest insurance expansion in history: saving one million lives per year in china: NBER, 2023.

11. Yip W, Fu H, Jian W, et al. Universal health coverage in China part 1: progress and gaps. *Lancet Public Health* 2023; **8**(12): e1025-e34.

12. Yip W, Fu H, Jian W, et al. Universal health coverage in China part 2: addressing challenges and recommendations. *Lancet Public Health* 2023; **8**(12): e1035-e42.

13. Mekonnen W, Mariam DH, Meh C, et al. Child, maternal, and adult mortality in rural Ethiopia in 2019: a cross-sectional mortality survey using electronic verbal autopsies. *EClinicalMedicine* 2024; **71**: 102573.

14. Assefa Y, Damme WV, Williams OD, Hill PS. Successes and challenges of the millennium development goals in Ethiopia: lessons for the sustainable development goals. *BMJ Glob Health* 2017; **2**(2): e000318.

15. The World Bank. GDP per capita (current US$) - Ethiopia. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?locations=ET (accessed March 21st 2024).

16. Federal Democratic Republic of Ethiopia National Planning Commission. Ethiopia's progress towards erradicating poverty: an interim report on 2015/16 poverty analysis study. 2017.

17. The World Bank. Literacy rate, adult total (% of people ages 15 and above) - Ethiopia. https://data.worldbank.org/indicator/SE.ADT.LITR.ZS?locations=ET (accessed March 21st 2024).

18. WHO and UNICEF JMP. WASH Data-Ethiopia https://washdata.org/data/household#!/table?geo0=country&geo1=ETH (accessed March 21st 2024).

19. The World Bank. Fertility rate, total (births per woman) - Ethiopia. https://data.worldbank.org/indicator/SP.DYN.TFRT.IN?locations=ET (accessed March 21st 2024).

559 20.   Croke K, Ogbuoji O. Health reform in Nigeria: the politics of primary health care and
560 universal health coverage. *Health Policy Plan* 2024; **39**(1): 22-31.
561 21.   Gonzalez-Pier E, Barraza-Llorens M, Beyeler N, et al. Mexico's path towards the
562 Sustainable Development Goal for health: an assessment of the feasibility of reducing
563 premature mortality by 40% by 2030. *Lancet Glob Health* 2016; **4**(10): e714-25.
564 22.   Campos-Nonato I, Galván-Valencia O, Hernández-Barrera L, Oviedo-Solís C, S. B.
565 Prevalence of obesity and associated risk factors in Mexican adults: results of the Ensanut
566 2022. *Salud Publica Mexico* 2023; (65): S238-S47.
567 23.   Basto-Abreu A L-ON, Rojas-Martínez R, Aguilar-Salinas CA, Moreno-Banda GL,
568 Carnalla M, Rivera JA, Romero-Martínez M, Barquera S, Barrientos-Gutiérrez T. Prevalence
569 of prediabetes and diabetes in Mexico: Ensanut 2022. *Salud Publica Mexico* 2023; (65):
570 S163-S8.
571 24.   Campos-Nonato I, Oviedo-Solís C, Vargas-Meza J, et al. Prevalence, treatment and
572 control of hypertension in Mexican adults: results of the Ensanut 2022. *Salud Publica Mexico*
573 2023; (65): S169-S80.
574 25.   Alegre-Diaz J, Herrington W, Lopez-Cervantes M, et al. Diabetes and Cause-Specific
575 Mortality in Mexico City. *N Engl J Med* 2016; **375**(20): 1961-71.
576 26.   Institute of Medicine and National Research Council. U.S. Health in International
577 Perspective: Shorter Lives, Poorer Health. Washington (DC); 2013.
578 27.   Reynales-Shigematsu LM, Guerrero-Lopez CM, Hernandez Avila M, Irving H, Jha P.
579 Divergence and convergence in cause-specific premature adult mortality in Mexico and US
580 Mexican Hispanics from 1995 to 2015: analyses of 4.9 million individual deaths. *Int J
581 Epidemiol* 2018; **47**(1): 97-106.
582 28.   Chen Y, Freedman ND, Rodriquez EJ, et al. Trends in Premature Deaths Among
583 Adults in the United States and Latin America. *JAMA Netw Open* 2020; **3**(2): e1921085.
584 29.   Hummer RA, Hernandez EM. The Effect of Educational Attainment on Adult
585 Mortality in the United States. *Popul Bull* 2013; **68**(1): 1-16.
586 30.   Feldman JM, Bassett MT. Variation in COVID-19 Mortality in the US by Race and
587 Ethnicity and Educational Attainment. *JAMA Netw Open* 2021; **4**(11): e2135967.
588 31.   Case A, Deaton A. The Great Divide: Education, Despair, and Death. *Annu Rev
589 Econom* 2022; **14**: 1-21.
590 32.   Jha P, Peto R, Zatonski W, Boreham J, Jarvis MJ, Lopez AD. Social inequalities in
591 male mortality, and in male mortality from smoking: indirect estimation from national death
592 rates in England and Wales, Poland, and North America. *Lancet* 2006; **368**(9533): 367-70.
593 33.   Tang X, Cho E-R, Brown P, Warner K, Jha P. Smoking, opioid and other causes of
594 death by education level in the United States: National mortality statistics from 1989-2021. .
595 *NEJM Evidence 2024 in press* 2024.
596 34.   Haacker M. Contributions of declining mortality, overall and from HIV, TB and
597 malaria, to reduced health inequality and inequity across countries. *Health Policy Plan* 2023;
598 **38**(8): 939-48.
599 35.   Ford ES, Ajani UA, Croft JB, et al. Explaining the decrease in U.S. deaths from
600 coronary disease, 1980-2000. *N Engl J Med* 2007; **356**(23): 2388-98.
601 36.   Prabhakaran D, Anand S, Watkins D, et al. Cardiovascular, respiratory, and related
602 disorders: key messages from Disease Control Priorities, 3rd edition. *Lancet* 2018;
603 **391**(10126): 1224-36.
604 37.   Gunnell D, Fernando R, Hewagama M, Priyangika WD, Konradsen F, Eddleston M.
605 The impact of pesticide regulations on suicide in Sri Lanka. *Int J Epidemiol* 2007; **36**(6):
606 1235-42.

607   38.   NCD Countdown collaborators. NCD Countdown 2030: efficient pathways and
608   strategic investments to accelerate progress towards the Sustainable Development Goal target
609   3.4 in low-income and middle-income countries. *Lancet* 2022; **399**(10331): 1266-78.
610   39.   Jamison DT, Alwan A, Mock CN, et al. Universal health coverage and intersectoral
611   action for health: key messages from Disease Control Priorities, 3rd edition. *Lancet* 2018;
612   **391**(10125): 1108-20.
613   40.   Watkins DA, Qi J, Kawakatsu Y, Pickersgill SJ, Horton SE, Jamison DT. Resource
614   requirements for essential universal health coverage: a modelling study based on findings
615   from Disease Control Priorities, 3rd edition. *Lancet Glob Health* 2020; **8**(6): e829-e39.
616   41.   Salomon JA, Wang H, Freeman MK, et al. Healthy life expectancy for 187 countries,
617   1990-2010: a systematic analysis for the Global Burden Disease Study 2010. *Lancet* 2012;
618   **380**(9859): 2144-62.
619   42.   Diseases GBD, Injuries C. Global incidence, prevalence, years lived with disability
620   (YLDs), disability-adjusted life-years (DALYs), and healthy life expectancy (HALE) for 371
621   diseases and injuries in 204 countries and territories and 811 subnational locations, 1990-
622   2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet* 2024;
623   **403**(10440): 2133-61.
624   43.   United Nations Population Division. World Population Prospects 2024: Methodology
625   of the United Nations population estimates and projections (UN DESA/POP/2024/DC/NO.
626   10). New York: United Nations, 2024.
627   44.   World Bank. Unlocking the Power of Healthy Longevity: Demographic Change,
628   Noncommunicable Diseases, and Human Capital. Washington DC: World Bank, 2024.
629