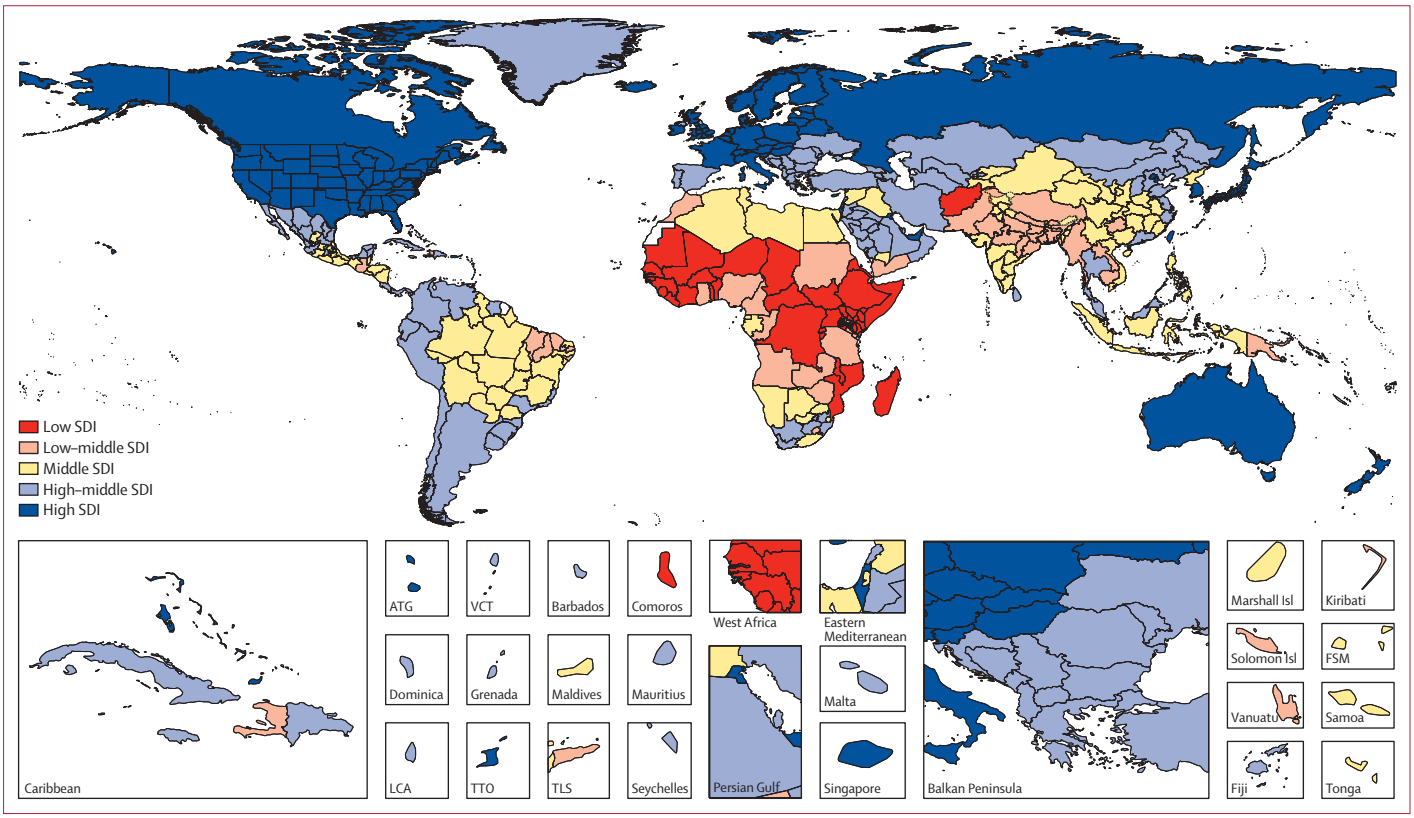

Figure 9: **SDI quintiles by GBD subnational level 1 geography, 2015**
SDI is calculated for each geography as a function of lag-dependent income per capita, average educational attainment in the population older than age 15 years, and the total fertility rate. SDI units are interpretable; a zero represents the lowest level of income per capita and educational attainment and highest total fertility rate observed during 1980–2015, whereas a one represents the highest income per capita and educational attainment and lowest total fertility rate observed in the same period. Cutoffs on the SDI scale for the quintiles have been selected on the basis of examination of the entire distribution of geographies 1980–2015. GBD=Global Burden of Disease. SDI=Socio-demographic Index. ATG=Antigua and Barbuda. VCT=Saint Vincent and the Grenadines. LCA=Saint Lucia. TTO=Trinidad and Tobago. TLS=Timor-Leste. FSM=Federated States of Micronesia.

Uncertainty analysis

To account for uncertainties that arise from sample sizes of data, adjustments to sources of all-cause mortality, model specifications in spatiotemporal Gaussian process regression and model life table systems, and cause-specific model specifications and estimation, we have estimated uncertainty intervals in key steps of the all-cause mortality and cause-specific mortality estimation processes. We have produced 1000 draws of all mortality metrics, including under-5 mortality rate, adult mortality rate, age-specific mortality rate and envelope, and cause-specific mortality rates and death numbers for each location by sex for all years covered by each analytical step from the posterior distribution in the estimation process. This allowed the quantification and propagation of uncertainty into the final quantities of interest. Because of computational time limitations, we have not propagated uncertainty in covariates used in cause of death models, nor have we been able to propagate uncertainty in garbage code redistribution algorithms into the final results. Our tests on the estimation of under-5 mortality rates show that the incorporation of uncertainty for included first stage model covariates such as crude death rate due to HIV/AIDS does not have a significant impact on the final estimates (data not shown).

Role of the funding source

The funder of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to the data in the study and had final responsibility for the decision to submit for publication.

Results

Global life expectancy and mortality

Global life expectancy at birth increased by 10·2 years, rising from 61·7 years (95% uncertainty interval [UI] 61·4–61·9) in 1980 to 71·8 years (71·5–72·2) in 2015 (table 4), equating to an average gain of 0·29 years per year. By 2015, male life expectancy had risen by 9·4 years, increasing from 59·6 years (59·3–60·0) in 1980 to 69·0 years (68·6–69·4), whereas female life expectancy improved by 11·1 years, climbing from 63·7 years (63·3–64·1) to 74·8 years (74·4–75·2). On average, an additional 0·27 and 0·32 years of life were gained per

	Life expectancy at birth (years)		Life expectancy at age 50 (years)		Age-standardised death rate (per 100 000)		Age-standardised YLL rate (per 100)		Total deaths (millions)		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Both sexes
1980	59·6 (59·3–60·0)	63·7 (63·3–64·1)	23·1 (22·9–23·2)	26·4 (26·2–26·7)	1536·1 (1513·0–1558·5)	1194·6 (1172·4–1217·9)	49·8 (49·0–50·5)	40·8 (40·1–41·6)	23·5 (23·2–23·9)	21·6 (21·2–22·0)	45·2 (44·6–45·7)
1981	59·9 (59·6–60·2)	64·1 (63·7–64·4)	23·1 (22·9–23·3)	26·5 (26·3–26·8)	1525·0 (1502·7–1547·1)	1177·5 (1155·9–1199·6)	49·1 (48·4–49·8)	40·0 (39·3–40·7)	23·7 (23·4–24·1)	21·7 (21·3–22·1)	45·5 (44·9–46·0)
1982	60·3 (59·9–60·6)	64·5 (64·1–64·9)	23·2 (23·0–23·4)	26·7 (26·5–26·9)	1499·7 (1478·4–1521·2)	1155·8 (1134·3–1177·4)	48·1 (47·4–48·7)	39·1 (38·4–39·7)	23·8 (23·5–24·1)	21·7 (21·3–22·1)	45·5 (45·0–46·1)
1983	60·5 (60·1–60·9)	64·7 (64·3–65·2)	23·3 (23·1–23·5)	26·7 (26·5–26·9)	1486·1 (1463·7–1507·7)	1146·6 (1125·7–1167·7)	47·4 (46·7–48·2)	38·5 (37·8–39·2)	24·0 (23·6–24·4)	22·0 (21·6–22·4)	46·0 (45·5–46·6)
1984	60·8 (60·4–61·2)	65·1 (64·6–65·5)	23·4 (23·2–23·5)	26·8 (26·6–27·0)	1472·0 (1451·3–1493·7)	1132·5 (1112·4–1153·3)	46·7 (46·0–47·5)	37·7 (37·0–38·4)	24·2 (23·9–24·6)	22·1 (21·8–22·5)	46·4 (45·8–47·0)
1985	61·2 (60·9–61·6)	65·5 (65·1–65·9)	23·4 (23·3–23·6)	26·9 (26·7–27·1)	1453·9 (1434·0–1474·9)	1116·4 (1097·3–1135·7)	45·6 (45·0–46·3)	36·8 (36·2–37·4)	24·3 (24·0–24·7)	22·2 (21·9–22·6)	46·6 (46·0–47·1)
1986	61·7 (61·3–62·0)	66·0 (65·6–66·4)	23·6 (23·4–23·8)	27·1 (26·9–27·3)	1428·4 (1409·1–1450·0)	1091·5 (1073·4–1111·2)	44·5 (43·9–45·2)	35·7 (35·2–36·3)	24·3 (24·0–24·7)	22·1 (21·8–22·5)	46·5 (45·9–47·0)
1987	62·0 (61·6–62·3)	66·3 (65·9–66·7)	23·7 (23·5–23·9)	27·2 (27·0–27·4)	1411·7 (1392·5–1432·2)	1077·6 (1059·9–1097·0)	43·8 (43·2–44·4)	35·0 (34·5–35·6)	24·5 (24·1–24·8)	22·3 (21·9–22·6)	46·7 (46·2–47·3)
1988	62·1 (61·7–62·4)	66·5 (66·2–66·9)	23·7 (23·5–23·8)	27·2 (27·0–27·4)	1409·9 (1389·3–1430·2)	1068·2 (1051·0–1087·0)	43·5 (42·8–44·1)	34·5 (34·0–35·0)	24·9 (24·5–25·2)	22·5 (22·1–22·9)	47·3 (46·8–47·9)
1989	62·4 (62·0–62·7)	66·9 (66·5–67·2)	23·6 (23·5–23·8)	27·3 (27·1–27·5)	1401·9 (1380·9–1422·3)	1055·5 (1039·0–1073·2)	42·8 (42·2–43·4)	33·8 (33·3–34·3)	25·1 (24·7–25·4)	22·6 (22·3–23·0)	47·7 (47·2–48·2)
1990	62·5 (62·2–62·8)	67·1 (66·7–67·4)	23·7 (23·5–23·9)	27·4 (27·2–27·6)	1381·1 (1359·0–1401·6)	1035·1 (1019·1–1052·0)	42·4 (41·8–43·0)	33·2 (32·8–33·7)	25·3 (24·9–25·7)	22·6 (22·3–23·0)	47·9 (47·4–48·5)
1991	62·6 (62·3–62·9)	67·3 (66·9–67·6)	23·8 (23·6–24·0)	27·5 (27·3–27·7)	1371·9 (1349·3–1393·1)	1025·1 (1010·2–1041·2)	42·1 (41·4–42·7)	32·8 (32·4–33·3)	25·6 (25·2–26·0)	22·7 (22·4–23·1)	48·3 (47·8–48·8)
1992	62·8 (62·5–63·1)	67·5 (67·2–67·8)	23·8 (23·7–24·0)	27·6 (27·4–27·7)	1363·9 (1342·2–1384·4)	1016·1 (1001·2–1032·0)	41·6 (41·0–42·2)	32·3 (31·9–32·8)	25·8 (25·4–26·2)	22·9 (22·5–23·2)	48·7 (48·2–49·2)
1993	62·8 (62·5–63·1)	67·6 (67·3–67·9)	23·8 (23·6–24·0)	27·5 (27·3–27·7)	1367·1 (1347·1–1386·3)	1016·0 (1001·6–1031·0)	41·5 (40·9–42·1)	32·0 (31·6–32·5)	26·3 (25·9–26·6)	23·2 (22·8–23·5)	49·4 (48·9–49·9)
1994	62·6 (62·2–63·0)	67·7 (67·4–68·0)	23·8 (23·6–24·0)	27·6 (27·4–27·7)	1375·7 (1353·5–1399·0)	1014·1 (999·2–1029·5)	42·0 (41·2–43·0)	31·9 (31·5–32·4)	27·0 (26·5–27·5)	23·5 (23·2–23·8)	50·5 (49·9–51·2)
1995	63·1 (62·8–63·4)	68·0 (67·7–68·3)	23·9 (23·8–24·1)	27·7 (27·5–27·8)	1351·0 (1333·4–1368·4)	1000·7 (987·4–1014·9)	40·9 (40·4–41·4)	31·3 (30·9–31·7)	26·8 (26·5–27·2)	23·5 (23·2–23·9)	50·4 (49·9–50·9)
1996	63·4 (63·1–63·6)	68·3 (68·0–68·5)	24·1 (24·0–24·3)	27·9 (27·7–28·0)	1330·2 (1314·1–1347·0)	986·6 (974·0–999·9)	40·2 (39·7–40·7)	30·8 (30·5–31·2)	26·9 (26·6–27·2)	23·6 (23·3–23·9)	50·4 (50·0–50·9)
1997	63·7 (63·4–63·9)	68·5 (68·3–68·8)	24·3 (24·2–24·4)	28·0 (27·9–28·1)	1312·0 (1296·7–1327·7)	975·1 (962·9–986·9)	39·6 (39·1–40·0)	30·4 (30·0–30·7)	27·0 (26·6–27·3)	23·6 (23·3–23·9)	50·6 (50·1–51·1)
1998	63·9 (63·6–64·1)	68·8 (68·5–69·0)	24·4 (24·3–24·5)	28·1 (28·0–28·2)	1301·7 (1286·8–1316·9)	966·6 (954·7–978·8)	39·1 (38·7–39·5)	29·9 (29·6–30·3)	27·2 (26·8–27·5)	23·8 (23·5–24·1)	50·9 (50·5–51·4)
1999	64·0 (63·7–64·2)	68·9 (68·7–69·1)	24·4 (24·3–24·6)	28·1 (28·0–28·3)	1297·1 (1282·1–1312·1)	963·9 (952·1–976·1)	38·8 (38·4–39·2)	29·6 (29·3–30·0)	27·6 (27·2–27·9)	24·1 (23·8–24·4)	51·6 (51·2–52·1)
2000	64·2 (64·0–64·4)	69·1 (68·9–69·4)	24·5 (24·4–24·6)	28·2 (28·1–28·3)	1284·9 (1270·1–1299·5)	954·8 (943·4–966·3)	38·3 (37·9–38·7)	29·2 (28·8–29·6)	27·9 (27·5–28·2)	24·3 (24·0–24·6)	52·1 (51·7–52·6)
2001	64·4 (64·2–64·7)	69·4 (69·1–69·6)	24·6 (24·5–24·7)	28·3 (28·2–28·4)	1272·5 (1258·1–1286·7)	944·1 (932·9–955·5)	37·7 (37·3–38·1)	28·7 (28·4–29·1)	28·1 (27·8–28·4)	24·5 (24·2–24·8)	52·6 (52·1–53·1)
2002	64·6 (64·4–64·9)	69·6 (69·4–69·8)	24·6 (24·5–24·8)	28·4 (28·2–28·5)	1265·8 (1251·2–1280·3)	933·4 (923·0–944·4)	37·2 (36·8–37·7)	28·2 (27·9–28·6)	28·5 (28·2–28·9)	24·7 (24·4–25·0)	53·2 (52·7–53·7)
2003	65·0 (64·8–65·2)	70·0 (69·7–70·2)	24·8 (24·7–24·9)	28·5 (28·4–28·7)	1240·0 (1225·5–1254·6)	915·4 (905·3–925·9)	36·4 (36·0–36·8)	27·5 (27·2–27·9)	28·6 (28·2–28·9)	24·7 (24·4–25·0)	53·3 (52·9–53·8)
2004	65·3 (65·1–65·5)	70·3 (70·1–70·5)	25·0 (24·8–25·1)	28·7 (28·6–28·9)	1216·5 (1202·2–1231·6)	895·9 (885·5–906·9)	35·8 (35·3–36·2)	26·9 (26·6–27·3)	28·7 (28·4–29·1)	24·7 (24·4–25·0)	53·5 (53·0–54·0)
2005	65·7 (65·5–65·9)	70·7 (70·5–71·0)	25·1 (25·0–25·3)	28·9 (28·8–29·0)	1195·0 (1180·9–1209·1)	878·1 (868·3–888·2)	34·9 (34·5–35·3)	26·1 (25·8–26·4)	28·9 (28·5–29·2)	24·8 (24·5–25·1)	53·6 (53·1–54·1)
2006	66·2 (65·9–66·4)	71·2 (71·0–71·5)	25·4 (25·3–25·5)	29·2 (29·1–29·3)	1163·8 (1150·2–1176·9)	852·4 (842·9–862·3)	33·8 (33·4–34·2)	25·2 (24·9–25·5)	28·7 (28·4–29·1)	24·6 (24·3–24·8)	53·3 (52·8–53·7)
2007	66·6 (66·3–66·8)	71·7 (71·5–72·0)	25·6 (25·4–25·7)	29·4 (29·3–29·5)	1141·3 (1127·7–1154·8)	830·4 (820·5–840·6)	33·0 (32·6–33·4)	24·4 (24·1–24·7)	28·8 (28·4–29·2)	24·5 (24·2–24·8)	53·3 (52·8–53·7)

(Table 4 continues on next page)

	Life expectancy at birth (years)		Life expectancy at age 50 (years)		Age-standardised death rate (per 100 000)		Age-standardised YLL rate (per 100)		Total deaths (millions)		
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Both sexes
(Continued from previous page)											
2008	66·8 (66·6–67·1)	72·1 (71·9–72·4)	25·7 (25·6–25·8)	29·6 (29·5–29·7)	1127·2 (1112·9–1140·8)	814·0 (803·9–823·4)	32·5 (32·0–32·9)	23·7 (23·4–24·1)	29·1 (28·7–29·5)	24·5 (24·2–24·8)	53·6 (53·1–54·1)
2009	67·3 (67·0–67·6)	72·6 (72·4–72·9)	25·9 (25·7–26·0)	29·9 (29·7–30·0)	1103·4 (1090·0–1116·6)	791·7 (782·3–801·5)	31·5 (31·1–31·9)	22·9 (22·6–23·2)	29·1 (28·7–29·5)	24·4 (24·1–24·7)	53·5 (52·9–54·0)
2010	67·5 (67·2–67·8)	72·9 (72·6–73·2)	26·0 (25·8–26·1)	30·0 (29·9–30·2)	1091·6 (1077·2–1105·6)	777·8 (767·4–788·0)	31·0 (30·6–31·5)	22·4 (22·0–22·7)	29·5 (29·1–29·9)	24·5 (24·2–24·8)	54·0 (53·4–54·6)
2011	68·0 (67·7–68·3)	73·4 (73·1–73·8)	26·2 (26·0–26·3)	30·3 (30·1–30·4)	1068·1 (1053·8–1083·1)	756·1 (745·4–767·2)	30·1 (29·7–30·5)	21·5 (21·2–21·9)	29·5 (29·0–29·9)	24·4 (24·0–24·7)	53·8 (53·3–54·4)
2012	68·3 (68·0–68·6)	73·9 (73·5–74·2)	26·3 (26·1–26·5)	30·5 (30·3–30·6)	1051·9 (1037·1–1067·9)	739·9 (728·9–751·9)	29·4 (29·0–29·9)	20·8 (20·5–21·2)	29·7 (29·2–30·2)	24·4 (24·0–24·8)	54·1 (53·5–54·7)
2013	68·6 (68·2–68·9)	74·2 (73·9–74·6)	26·4 (26·2–26·6)	30·6 (30·4–30·8)	1037·9 (1021·4–1055·4)	725·8 (714·1–738·9)	28·8 (28·3–29·3)	20·2 (19·9–20·6)	30·0 (29·5–30·5)	24·5 (24·1–25·0)	54·5 (53·8–55·1)
2014	68·8 (68·4–69·1)	74·5 (74·1–74·9)	26·5 (26·3–26·6)	30·7 (30·5–30·9)	1029·7 (1012·5–1048·3)	715·8 (703·8–729·6)	28·4 (27·9–28·9)	19·8 (19·4–20·2)	30·4 (29·9–31·0)	24·8 (24·3–25·2)	55·2 (54·4–55·9)
2015	69·0 (68·6–69·4)	74·8 (74·4–75·2)	26·6 (26·4–26·8)	30·9 (30·7–31·1)	1018·6 (1000·4–1037·1)	703·4 (691·0–717·8)	27·9 (27·4–28·5)	19·3 (18·9–19·7)	30·9 (30·3–31·5)	24·9 (24·5–25·5)	55·8 (55·0–56·6)

Data in parentheses are 95% uncertainty intervals. Age-standardised rates are standardised using the GBD world population standard. YLLs=years of life lost. GBD=Global Burden of Disease.

Table 4: **Global life expectancy at birth and at age 50, age-standardised death rates, age-standardised YLL rate, and total deaths, by sex, 1980–2015**

year for males and females, respectively, since 1980. Global gains in life expectancy were generally gradual but steady, although catastrophic events, including the Rwandan genocide and North Korean famines, and escalating mortality due to HIV/AIDS, had worldwide effects on longevity. Slower gains were achieved for life expectancy at 50 years, or the average number of additional years of life 50 year olds can anticipate at a given point in time. On average, 50-year-old females saw an increase of 4·5 additional years of life since 1980, and 50-year-old males experienced an increase of 3·5 years. Annual estimates of life expectancy, by sex and geography are shown in the results appendix (pp 36–47).

Global mortality trends showed a 16·4% (95% UI 14·3–18·5) increase in total deaths between 1990 and 2015, whereas age-standardised rates of mortality fell by 28·5% (27·3–29·8) during this time. The trend was similar from 2005 to 2015, with total deaths increasing by 4·1% (2·6–5·6) and age-standardised death rates decreasing by 17·0% (15·8–18·1). In 2015, 55·8 million deaths (55·0 million to 56·6 million) occurred worldwide, an increase of 7·9 million deaths since 1990 and 2·2 million deaths since 2005 (table 4). From 1990 to 2015, total deaths rose by 21·9% (19·1–24·8) for males and 10·3% (7·6–13·1) for females, whereas age-standardised death rates fell by 26·2% (24·5–27·9) for males and 32·1% (30·4–33·8) for females. In 2015, 30·9 million (30·3 million to 31·5 million) males and 24·9 million (24·5 million to 25·5 million) females died, representing an increase of 5·6 million male deaths and 2·3 million female deaths since 1990. Differences in total deaths by sex widened over time, with increasingly more males dying than females; this gap grew from 2·7 million in 1990 to 4·1 million in 2005 and 6·0 million in 2015.

Age-standardised rates of YLLs per 100 population, a measure of premature mortality, fell 34·1% (95% UI 32·5–35·6) for males and 42·1% (40·6–43·5) for females between 1990 and 2015. Notably, the pace of decline in YLL rates was faster from 2005 to 2015 (19·9%, 95% UI 18·3–21·5 for males and 26·3%, 24·6–27·9 for females) than from 1990 to 2005 (17·7%, 16·2–19·2 for males and 21·4%, 20·0–22·7 for females).

Evolution of global and super-region life expectancy, probabilities of death, and SDI

The differences between observed life expectancy and mortality rates and those expected on the basis of SDI show the complex interactions between gains in SDI and improved health over time. Figure 10 summarises the trends in observed and expected life expectancy or mortality at the global level and for each GBD super-region from 1980 to 2015. Some regions have higher than expected levels, whereas others have lower levels than expected.

By 2015, global life expectancy had increased faster than expected based on changes in SDI for both sexes, equating to an increase of an additional 3·06 years for males and 2·78 years for females (figure 10A); however, before 2005, gains in life expectancy were lower than expected, particularly for females. Observed life expectancy consistently exceeded expected levels over time in southeast and east Asia and Oceania; Latin America and the Caribbean; and north Africa and the Middle East. Furthermore, for the latter two super-regions, gains for male life expectancy improved following the 1980s and 1990s, when observed levels of longevity were closer to expected life expectancy based

on SDI. By contrast, observed life expectancy was generally lower than expected based on SDI in high-income countries and central Europe, eastern Europe, and central Asia. For high-income countries, however, observed male life expectancy converged with expected levels around 2005, whereas the gap between observed and expected life expectancy based on SDI widened for females in this super-region. In south Asia, where average SDI more than doubled between 1980 and 2015, observed male life expectancy consistently met or slightly exceeded expected levels, whereas female life expectancy gradually moved closer to expected levels based on SDI. Amid its escalating HIV/AIDS epidemic, sub-Saharan Africa recorded widening gaps between observed and expected life expectancies for both sexes between 1988 and 1999. From 2001 to 2015, during which the region's average SDI rose by 31%, observed life expectancy quickly increased, particularly among females, nearing expected levels.

Overall, global and regional trends for observed under-5 mortality steadily moved closer to expected levels, based on rising SDI, and in some super-regions, such as Latin America, the Caribbean, and north Africa and the Middle East, observed rates of under-5 mortality became lower than expected (figure 10B). Substantial progress occurred in sub-Saharan Africa, with the gap between observed and expected 5q0 decreasing from 0·055 in 1980 to 0·006 in 2015. Observed under-5 mortality was consistently lower than expected, given rising SDI, in southeast Asia, east Asia, and Oceania, whereas the opposite was seen for central and eastern Europe and central Asia, with observed under-5 mortality exceeding expected levels from 1980 to 2015. With the exception of south Asia, super-region under-5 mortality trends did not substantially differ by sex. Observed levels of male under-5 mortality in south Asia gradually neared expected rates of under-5 mortality over time, whereas female under-5 mortality remained above expected levels between 1980 and 2000; by 2015, however, this gap had narrowed considerably.

Regional trends for observed and expected 35q15, which represents the probability of dying between the ages of 15 and 50 years, were much more variable than life expectancy at birth or 5q0 (figure 10C). The 35q15 age band corresponds to the reproductive period; for the analysis of changes in mortality with SDI, we include results for these age groups because of their very strong association with mortality from HIV/AIDS during the reproductive age period. Except for three super-regions (high income; sub-Saharan Africa; and central Europe, eastern Europe, and central Asia), observed levels of 35q15 remained lower than would be expected based on SDI between 1980 and 2015. However, relative trends, in terms of proximity to expected levels of 35q15 over time and by sex, shifted considerably. Although observed rates of female 35q15 were lower than expected from 1980 to 2015 in three super-regions (Latin America and the Caribbean; north Africa and the Middle East; and southeast and east Asia and Oceania), each super-region registered improvements in 35q15 over time and moved closer to expected levels by 2015. In sub-Saharan Africa, observed 35q15 for both sexes increased to well above expected levels between 1988 and 2000, a trend largely attributable to HIV/AIDS. By 2004, however, gains in SDI quickened in sub-Saharan Africa, and observed 35q15 began to fall closer to expected levels at a similar pace. Central and eastern Europe and central Asia experienced the most divergent patterns for 35q15 by sex. For males in this super-region, observed 35q15 remained far above expected levels of mortality based on SDI from 1980 to 2015, but observed 35q15 climbed between 1986 and 1994. This rapid rise in observed male mortality between the ages of 15 and 50 years, relative to SDI, occurred in tandem with the collapse of the Soviet Union and the widespread economic hardships that followed. The gap between observed and expected male 35q15 began to gradually narrow during the late 1990s, corresponding with rises in SDI; nonetheless, gains stalled by 1999. For females in central and eastern Europe and central Asia, observed 35q15 closely followed expected levels from 1980 to 1990, after which observed mortality jumped and remained higher than expected 35q15, based on SDI, through to 2015.

Results were similarly heterogeneous for observed and expected trends for 20q50, or the probability of dying between the ages 50 and 70 years, particularly by sex and rising SDI (figure 10D). First, based on gains in SDI alone, expected levels of 20q50 differed substantially by sex. For males, expected reductions for 20q50 were quite gradual relative to improvements in SDI, until the 80th percentile, after which expected 20q50 steeply fell. For females, expected 20q50 followed a fairly linear trend with rising SDI. Two regions—Latin America and the Caribbean and north Africa and the Middle East—experienced observed levels of 20q50 that were lower than expected from 1980 to 2015 for both sexes; however, for females in north Africa and the Middle East, observed 20q50 shifted closer to expected levels of mortality after 1999. After largely following expected rates of 20q50 from 1989 to 1998, southeast and east Asia and Oceania saw observed male 20q50 drop below expected levels. Observed female 20q50 generally remained lower than expected for this super-region, although observed levels approached expected rates from 2000 to 2003 before declining again. Although south Asia recorded large gains in SDI over time, from an average of the 25th percentile in 1980 to the 54th in 2015, observed rates of 20q50 remained higher than expected for both sexes over time. Aside from a jump in observed 20q50 rates between 1995 and 2007, in sub-Saharan Africa, observed 20q50 for both sexes mainly followed the expected rates given rising SDI. Similar to the results for 35q15, observed levels of male and female 20q50 in central and eastern Europe and central Asia followed a dissonant pattern over time. For males, although observed 20q50

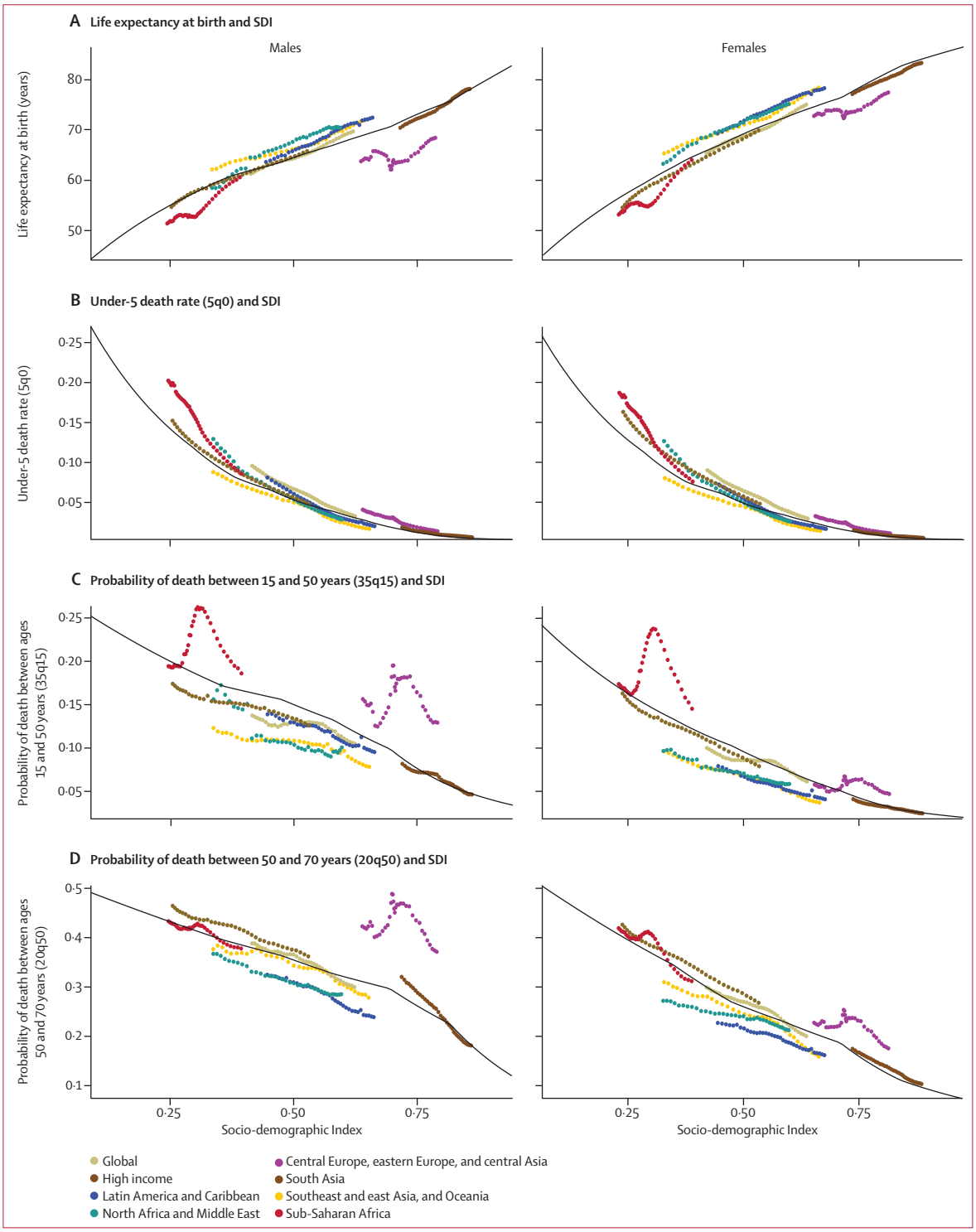

Figure 10: **Co-evolution of life expectancy and probabilities of death with SDI globally and for GBD super-regions, 1980 to 2015**
(A) Life expectancy at birth and SDI; (B) under-5 death rate (5q0) and SDI; (C) probability of death between 15 and 50 years of age (35q15) and SDI; and (D) probability of death between 50 and 70 years of age (20q50) and SDI. Coloured lines show global and super-region values. Each point in a line represents 1 year, starting at 1980 and ending at 2015. In all super-regions, SDI has increased year on year so progress in SDI is associated with later years for a given super-region. Black lines show trajectories expected for each geography on the basis of SDI alone. GBD=Global Burden of Disease. SDI=Socio-demographic Index. 5q0=probability of death from birth to age 5 years. 35q15=probability of death from age 15 years to 50 years. 20q50=probability of death from age 50 years to 70 years.

surpassed expected rates between 1980 and 2015, observed 20q50 escalated from 1986 to 1994, rapidly increasing the gap between observed and expected rates of mortality for several years. The difference between observed and expected 20q50 widened for females in central and eastern Europe and central Asia during this time, albeit with a much smaller magnitude of change. Notably, observed levels of male 20q50 consistently exceeded expected rates for high-income countries between 1980 and 1997 before converging. Conversely, observed 20q50 for females in high-income countries remained higher than expected from 1980 to 2015.

Global causes of death

Table 5 shows the global estimates of total deaths and age-standardised death rates by cause for 2005 and 2015, as well as the percentage change in mortality from 2005 to 2015. Annual mortality estimates from 1990 to 2015 and more detailed age–sex results can be viewed online.

For **online visualisation of the detailed results** see http://vizhub.healthdata.org/gbd-compare

Broadly, communicable, maternal, neonatal, and nutritional diseases, known as Group 1 causes for GBD, accounted for 20·2% (95% UI 19·7–20·7) of global deaths in 2015 (11·3 million, 95% UI 10·9 million to 11·6 million), NCDs caused 71·3% (70·9–72·0) of deaths (39·8 million, 39·2 million to 40·5 million), and injuries resulted in 8·5% (7·9–8·5) of deaths (4·7 million, 4·4 million to 4·9 million). Between 2005 and 2015, Group 1 causes saw significant reductions for both total deaths (decrease of 19·7% [17·8–21·6]) and age-standardised rates (decrease of 29·6% [27·9–31·3]). For NCDs, total deaths rose by 14·3% (12·6–16·0), an increase of 5·0 million deaths (4·4 million to 5·6 million) since 2005, but age-standardised rates decreased from 719·1 deaths (711·9–727·3) per 100 000 in 2005 to 624·7 deaths (615·8–634·5) per 100 000 in 2015 (decrease of 13·1%, 11·9–14·3). Injuries caused about 4·7 million deaths in both 2005 and 2015, but the age-standardised rates due to injuries significantly declined during this time, decreasing by 15·8% (12·4–18·7) from 78·6 deaths (73·5–80·8) per 100 000 in 2005 to 66·2 deaths (61·5–68·7) per 100 000 in 2015.

Communicable, maternal, neonatal, and nutritional diseases

Marked reductions in total deaths and age-standardised death rates were achieved for many of the world's most important communicable diseases. Total HIV/AIDS deaths fell 33·4% (95% UI 30·0–36·2), from 1·8 million (95% UI 1·7 million to 1·9 million) in 2005 to 1·2 million (1·1 million to 1·3 million) in 2015, and age-standardised death rates dropped even more rapidly (reduction of 42·1%, 39·1–44·6). Globally, HIV/AIDS mortality peaked in 2005, underscoring the continued expansion of ART and PMTCT. Malaria deaths decreased by 37·4% (27·8–47·0), falling to 730 500 (555 800–904 000) in 2015. Age-standardised death rates due to malaria fell slightly more rapidly (43·1%, 34·7–51·8) during this time; nonetheless, this rate of decline only partly represents the sustained gains against malaria, given that mortality peaked in 2003, claiming 1·2 million lives (1·0 million to 1·4 million) that year. Age-standardised death rates due to diarrhoeal diseases fell 32·2% (27·7–36·5) from 2005 to 2015, although total deaths fell more slowly (20·8%, 15·4–26·1) to 1·3 million deaths (1·2 million to 1·4 million). Other communicable diseases that had significant reductions in mortality included tetanus (decreased by 47·5% [95% UI 39·0–54·6], to 56 700 deaths [48 200–80 000]), measles (decreased by 75·0% [58·8–84·5], to 73 400 deaths [26 100–161 400]), and African trypanosomiasis (decreased by 75·3% [67·9–81·4], to 3510 deaths [1790–5660]).

Amid these gains, less pronounced progress occurred for several communicable diseases, and fatalities climbed rapidly for others, such as Ebola virus disease. Tuberculosis, which killed fewer people than HIV/AIDS in 2005 (1·3 million, 95% UI 1·2 million to 1·7 million), essentially matched HIV/AIDS's toll by 2015, causing 1·1 million deaths (0·91 million to 1·4 million). Deaths due to tuberculosis decreased by 17·4% (11·3–24·4) between 2005 and 2015; however, age-standardised tuberculosis death rates dropped by 33·8% (28·7–39·6). Total mortality due to lower respiratory infections remained fairly constant from 2005 to 2015 (between 2·8 million and 2·7 million deaths), although age-standardised death rates fell by 19·5% (16·9–22·3); a similar trend was observed for meningitis. Deaths due to hepatitis and age-standardised death rates decreased (deaths fell by 14·0% [10·0–17·9], to 106 000 [101 000–111 000], and death rates fell by 28·0% [24·7–31·1]), which was mainly driven by significant reductions in deaths due to acute hepatitis A (decrease of 34·0% [24·2–43·5], to 11 000 [7000–16 000]) since 2005. Mortality due to other types of hepatitis improved less rapidly. Dengue deaths increased by 48·7% (15·1–90·9), resulting in 18 400 deaths (11 800–22 700) in 2015, and Chagas disease, which largely affects populations in Latin America, claimed 8000 lives (7500–8600) that year. Deaths due to leishmaniasis increased, albeit not significantly, between 2005 and 2015, causing 24 200 deaths (17 100–32 500) in 2015. The peak of the west African Ebola virus disease outbreak occurred in 2014, causing 12 800 deaths (10 300–15 300) that year. In 2015, 5500 people (4400–6600) died from Ebola virus disease, mainly in Guinea, Liberia, and Sierra Leone.

Among the leading causes of global maternal mortality, most showed significant reductions in both total deaths and age-standardised death rates between 2005 and 2015. Deaths due to maternal haemorrhage decreased by 16·6% (95% UI 3·2–28·8), claiming 16 600 (3300–29 800) fewer lives in 2015, and deaths due to abortion, miscarriage, and ectopic pregnancies dropped by 23·1% (11·1–33·9), to 32 000 (25 000–40 000); age-standardised death rates fell by 25·0% (12·9–35·9) for maternal haemorrhage and by 30·7% (19·8–40·4) for abortion, miscarriage, and ectopic pregnancies. For neonatal disorders, total deaths fell by 18·5% (16·4–20·4) and age-standardised death rates fell

by 22·8% (–24·6 to –20·9) from 2005 to 2015, to 2·2 million (2·1 million to 2·2 million). Preterm birth complications caused 282 200 (215 000–353 500) fewer deaths in 2015 than in 2005 (reduction of 25·9%, 20·6–31·3) and age-standardised rates dropped by 29·8% (24·8–34·9). Total deaths and age-standardised death rates due to neonatal encephalopathy also decreased significantly during this time, albeit at a more moderate pace. Overall, these trends probably reflect a combination of decreasing fertility rates, improved maternal care, and safer delivery practices in many settings.

Notably less progress occurred for nutritional deficiencies, which caused 405 700 deaths (95% UI 331 700–495 600) in 2015. In 2015, iron-deficiency anaemia led to 54 200 deaths (35 100–72 900) and protein-energy malnutrition caused 323 200 deaths (264 900–400 800); in combination, nutritional deficiencies accounted for 3·6% (2·7–4·1) of lives lost to Group 1 disorders. Age-standardised death rates significantly decreased for nutritional deficiencies (decreased by 24·3%, 14·3–32·9).

Non-communicable diseases

In 2015, the leading causes of NCD deaths were cardiovascular disease (17·9 million, 95% UI 17·6 million to 18·3 million), cancers (8·8 million, 8·6 million to 8·9 million), and chronic respiratory diseases (3·8 million, 3·7 million to 3·9 million). The global death toll due to cancers increased by 17·0% (95% UI 14·8–19·3) between 2005 and 2015, although age-standardised rates of death fell by 10·0% (8·3–11·6). Tracheal, bronchus, and lung cancer (total deaths 1·7 million, 1·7 million to 1·8 million) were the leading causes of cancer deaths, and also had the highest age-standardised death rate (26·6 deaths [25·9–27·4] per 100 000) among cancers in 2015. For several cancers, total deaths increased by 20% or more between 2005 and 2015, including tracheal, bronchus, and lung cancer (20·1% [16·7–24·0], to 1·7 million deaths [1·7 million to 1·8 million); colon and rectum cancer (23·2% [20·6–26·0], to 832 000 deaths [811 700–854 500]); malignant skin melanoma (27·2% [20·0–32·6], to 59 800 deaths [47 600–72 700]); pancreatic cancer (30·8% [28·3–33·6], to 411 600 deaths [403 600–420 700]); and prostate cancer (31·9% [28·2–35·4], to 365 900 deaths [303 500–459 600]). Breast and ovarian cancers, which largely, if not exclusively, affect females, caused significantly more deaths in 2015 than in 2005 (breast cancer increased by 21·3% [14·9–27·2], to 534 000 deaths [502 000–553 000]; ovarian cancer increased by 20·4% [16·5–24·4], to 161 000 deaths [157 000–167 000]); however, age-standardised death rates for both cancers significantly declined during this time (breast cancer decreased by 6·8% [2·5–11·5] and ovarian cancer decreased by 7·9% [4·9–10·8]). The largest reductions in death rates from 2005 to 2015 were recorded for oesophageal cancer, which fell by 26·8% (22·9–30·3) and Hodgkin's lymphoma, which fell by 23·9% (20·1–27·7). At the same time, significant increases occurred in age-standardised death rates due to non-melanoma skin cancer (increased by 7·6%, 3·4–11·1) and mesothelioma (increased by 7·8%, 3·6–11·6).

Global cardiovascular disease deaths rose by 12·5% (95% UI 10·6–14·4) between 2005 and 2015, whereas age-standardised rates of death due to cardiovascular disease fell 15·6% (14·2–16·9). These reductions were largely driven by declining mortality rates due to cerebrovascular disease (ie, stroke; decreased by 21·0%, 19·2–22·8) since 2005. Globally, deaths due to ischaemic heart disease increased by 16·6% (14·6–18·6) from 2005 to 2015 to 8·9 million deaths (8·8 million to 9·1 million), whereas age-standardised mortality rates for ischaemic heart disease decreased at a more moderate pace (fell by 12·8%, 11·4–14·2). Ischaemic heart disease and stroke accounted for 15·2 million deaths (15·0 million to 15·6 million) in 2015, equating to 85·1% (84·7–85·5) of all deaths due to cardiovascular disease that year. Among respiratory conditions, age-standardised death rates fell by 22·9% (20·0–25·4) for chronic obstructive pulmonary disease (COPD) and by 31·3% (19·4–38·9) for asthma; total deaths due to these causes did not significantly differ from 2005 to 2015. By contrast, for interstitial lung disease and pulmonary sarcoidosis, significant increases occurred in total deaths, which rose by 51·5% (37·9–60·5) to 121 800 deaths (94 100–135 200), and age-standardised rates, which rose by 14·1% (4·1–20·9) from 2005 to 2015.

Mortality patterns were similar for other leading NCD causes of death. Age-standardised mortality rates decreased for all subtypes of cirrhosis, yet total deaths increased to 1·3 million in 2015 (95% UI 1·2 million to 1·4 million). Total mortality also increased from 2005 to 2015 for diabetes, which rose by 32·1% (95% UI 27·7–36·3), to 1·5 million deaths (1·5 million to 1·6 million), and chronic kidney disease, which rose by 31·7% (27·7–35·6), to 1·2 million deaths (1·1 million to 1·3 million); by contrast, changes in age-standardised death rates due to diabetes and chronic kidney disease were not statistically significant. Chronic kidney disease due to diabetes mellitus caused significantly more deaths in 2015 than in 2005 (an increase of 39·5% [35·4–43·5], to 418 000 deaths [389 000–441 000]), and age-standardised death rates also rose 6·4% (3·3–9·3). Global deaths due to Alzheimer's disease and other dementias increased by 38·2% (36·2–40·1), to 1·9 million deaths (1·6 million to 2·2 million), which was largely driven by population ageing, given that age-standardised mortality decreased by 2·7% (1·7–3·7). Notably, both total deaths and age-standardised death rates due to alcohol use disorders significantly dropped from 2005 to 2015, falling by 12·6% (7·0–16·7), to 138 000 deaths (131 000–144 000), and 29·2% (24·7–32·4), respectively. However, drug use disorders claimed increasingly more lives, resulting in a rise of 31·8% (20·4–39·4; rising to 170 000 deaths, 152 000–179 000) since 2005. Deaths due to opioid use disorders accounted for 71·9% (69·5–73·3) of these drug-related deaths in 2015, increasing by 29·6% (18·2–37·2) to a total of 122 100 deaths (109 500–129 700) that year.