

Chapter 5

Annual Rates of Decline in Child, Maternal, Tuberculosis, and Noncommunicable Disease Mortality across 109 Low- and Middle-Income Countries from 1990 to 2015

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INTRODUCTION

A country's performance in health is typically defined by how much better or worse it performs with respect to a particular outcome (for example, life expectancy) compared with what would be expected in light of certain contextual attributes (for example, income and education) (Jamison and Sandbu 2001). In *Good Health at Low Cost*, Halstead, Walsh, and Warren (1985) used a case study approach to assess country performance in levels of mortality, examining why three countries and one Indian state had low levels of mortality despite scant resources. Later analyses also quantified performance with respect to levels of mortality and fertility (Wang and others 1999).

The number of deaths is affected strongly by long-standing country-level determinants. Essentially, a country that starts with a low level of mortality is likely to continue to have lower mortality, whereas a country that begins with a high level of mortality might improve substantially but still have comparatively high mortality. Examining alterations in the number of deaths or annual rate of change in mortality is useful for understanding

how a country's health performance might relate to adjustments in policy. Most published work on country performance is based on estimates of mortality levels, but some studies investigate rates of change (Bhutta and others 2010; Croghan, Beatty, and Ron 2006; Kassebaum and others 2014; Lozano and others 2011; Muennig and Glied 2010; Munshi, Yamey, and Verguet 2016; Verguet and Jamison 2013a, 2013b, 2014; Wang and others 2014). To the extent that rates of change respond to the introduction of health policies (for example, a new immunization program), rates of decline in mortality offer a dependent variable with which to understand the effect on performance of social and system determinants. Nevertheless, the measure—like any one-dimensional metric—still has weaknesses. Notably, large declines from high levels of mortality may still leave an unacceptably large number of deaths. Therefore, rates of change complement rather than replace the important information conveyed by estimates of mortality levels.

The need to measure progress in health was especially apparent when assessing whether countries were on track

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to achieve the Millennium Development Goals (Bhutta and others 2010; Kassebaum and others 2014; Lozano and others 2011; Wang and others 2014). Measuring progress is also crucial to determining whether countries can achieve the next set of post-2015 Sustainable Development Goals (SDGs) that were adopted by United Nations (UN) member states in 2015. The SDGs include health goals with an associated set of targets; the *Lancet* Commission on Investing in Health proposed a target of achieving a “grand convergence in global health” by 2035, defined as reducing infectious, maternal, and child deaths to universally low levels, similar to today’s rates in the best-performing middle-income countries, such as Chile and Turkey (Jamison and others 2013). Other targets were proposed by the Global Investment Framework for Women’s and Children’s Health (Stenberg and others 2014), the United Nations Children’s Fund (UNICEF 2013), the Sustainable Development Solutions Network (SDSN 2013), and the High-Level Panel on the post-2015 development agenda (Norheim and others 2015; Peto, Lopez, and Norheim 2014; UN 2013). All of these proposals were debated before adoption of the SDGs by all UN member states.

Studying historical rates of change (rates of decline) in mortality across countries over recent decades can be helpful for testing the feasibility of these different proposals and the SDGs, which include ambitious targets for child, maternal, tuberculosis, human immunodeficiency virus/acquired immune deficiency syndrome (HIV/AIDS), and noncommunicable disease (NCD) mortality that would require high rates of decline from 2015 to 2030. Such targets for mortality can be tested for their feasibility by looking at whether high rates of decline in mortality have ever been achieved by any low- or middle-income country (LMIC) and whether similar declines could be achieved in 2016–30.

Assessing a country’s health performance with respect to changes in rates of decline in mortality is, therefore, valuable for studying the effects of policy and for testing the feasibility of proposed post-2015 health goals. This chapter updates a previous study (Verguet and others 2014) that examined changes in the annual rate of decline of key mortality indicators for 109 LMICs by expanding the period to cover 1990–2015. In addition, we examine annual rates of decline in NCD mortality (the probability of dying between ages 50 and 69 years from NCDs in the presence of other causes) over 1993–2013.

METHODS

Verguet and others (2014) analyzed the rates of decline for under-five, maternal, tuberculosis, and HIV/AIDS-related mortality. The analysis in this chapter is restricted to four indicators—under-five mortality rates (5q0),

maternal mortality ratios, tuberculosis mortality rates, and NCD mortality rates in persons between ages 50 and 69 years. These indicators feature prominently in SDG 3, and updated data became available since the last analysis. We assessed the annual rates of decline in the chosen mortality indicators for 109 LMICs, as defined in the World Bank income classifications for 2014, with populations greater than 1 million people (Zeileis 2015). We used the 2013 World Bank income group classification to ensure that all of the countries in the original paper were covered. Annex 5B presents the countries and regional groupings included in the analysis.

We estimated rates of decline in under-five mortality rates (number of children who die after birth and before age five years per 1,000 live births), maternal mortality ratios (number of pregnant women who die per 100,000 live births), tuberculosis mortality ratios (number of deaths from tuberculosis per 100,000 population per year), and NCD mortality rates (probability of dying between ages 50 and 69 years from an NCD in the presence of other causes). Depending on the availability of data, we used a 1990–2015 time series for under-five mortality rates (UNICEF and others 2015), a 1990–2015 time series for maternal mortality ratios (WHO 2016b), a 1990–2014 time series for tuberculosis mortality rates (WHO 2016a), and a 1993–2013 time series for NCD mortality rates from UN-DESA (2015) life tables and IHME (2015) cause-of-death data. We used several time anchor points for every indicator: 1990, 1995, 2000, 2005, 2010, and 2015 for under-five mortality rates and maternal mortality ratios; 1990, 1995, 2000, 2005, 2010, and 2014 for tuberculosis mortality rates; and 1993, 1998, 2003, 2008, and 2013 for NCD mortality rates. Thus, our calculations differ from annualized rates of reduction computed using different time frames. We calculated 95 percent uncertainty intervals around the estimates and used R software for all analyses.

We calculated the average annual rates of decline from levels of the first three indicators for every five-year interval from 1990 to 2015 and the average annual rates of decline in NCD mortality rates for every five-year interval from 1993 to 2013 (equations 5.1 to 5.4). In total, we have five estimates for the annual rate of decline in under-five mortality rates, maternal mortality ratios, and tuberculosis mortality rates, and for estimates for the annual rate of decline in NCD mortality rates for every country included in the study: 1990–94, 1995–99, 2000–04, 2005–09, and 2010–15 (six-year interval) for under-five mortality rates and maternal mortality ratios; 1990–94, 1995–99, 2000–04, 2005–09, and 2010–14 for tuberculosis mortality rates; and 1993–98, 1998–2003, 2003–08, and 2008–13 (mid-year estimate) for NCD mortality rates.

Equations (5.1)–(5.4) are used to perform the estimates:

$$R(t) = \frac{L_{t+1} - L_t}{L_t}, \quad (5.1)$$

$$R(p) = \frac{1}{n} \sum_{t=1}^n R(t), \quad (5.2)$$

$$RCR(p) = \frac{R_{p+1} - R_p}{R_p}, \quad (5.3)$$

$$RCR(p)_t = \frac{1}{n} \sum_{p=1}^n \frac{R_{p+1} - R_p}{R_p}, \quad (5.4)$$

where $R(t)$ is the annual rate of decline; L represents levels of under-five mortality rates, maternal mortality ratios, tuberculosis mortality rates, and NCD mortality rates; $R(p)$ is the average $R(t)$ for each period; $RCR(p)$ is the rate of change in the rate of decline (acceleration or deceleration) from one period to the next; $RCR(p)_t$ is the period average of annual rate of change (acceleration or deceleration) in the rate of decline; t represents time intervals; and n represents the number of time intervals in a period.

We calculated the annual rate of change in the decline (either an acceleration or a deceleration) for every transition from one five-year period to the next between 1990 and 2015 (equations 5.3 and 5.4). In total, we have four values for the rate of change in decline for each country using equation 5.3 for the first three mortality indicators, three values using equation 5.3 for NCD mortality rates, and five values using equation 5.4 for under-five and maternal mortality ratios. For acceleration between periods in equation 5.3, we use the rates of decline from two consecutive five-year periods (for example, 1995–99 and 2000–05) to estimate the rate of change in decline for the transition between those two periods. For simplicity, we present results obtained using equations 5.1, 5.2, and 5.4.

For every mortality indicator, we estimated the year by which the *Lancet* Commission on Investing in Health target (Jamison and others 2013) and SDG target (UN 2016) would be achieved (figures 5.1–5.4). We obtained estimates for every country’s aspirational best-performer rate of decline (90th percentile for all countries) and every region’s aspirational rate of decline (90th percentile for each region).

Figure 5.1 Year by Which the Global Targets for Under-Five Mortality Rates Will Be Reached at Aspirational Rates of Decline, Disaggregated by Geographic Region, 2015–50

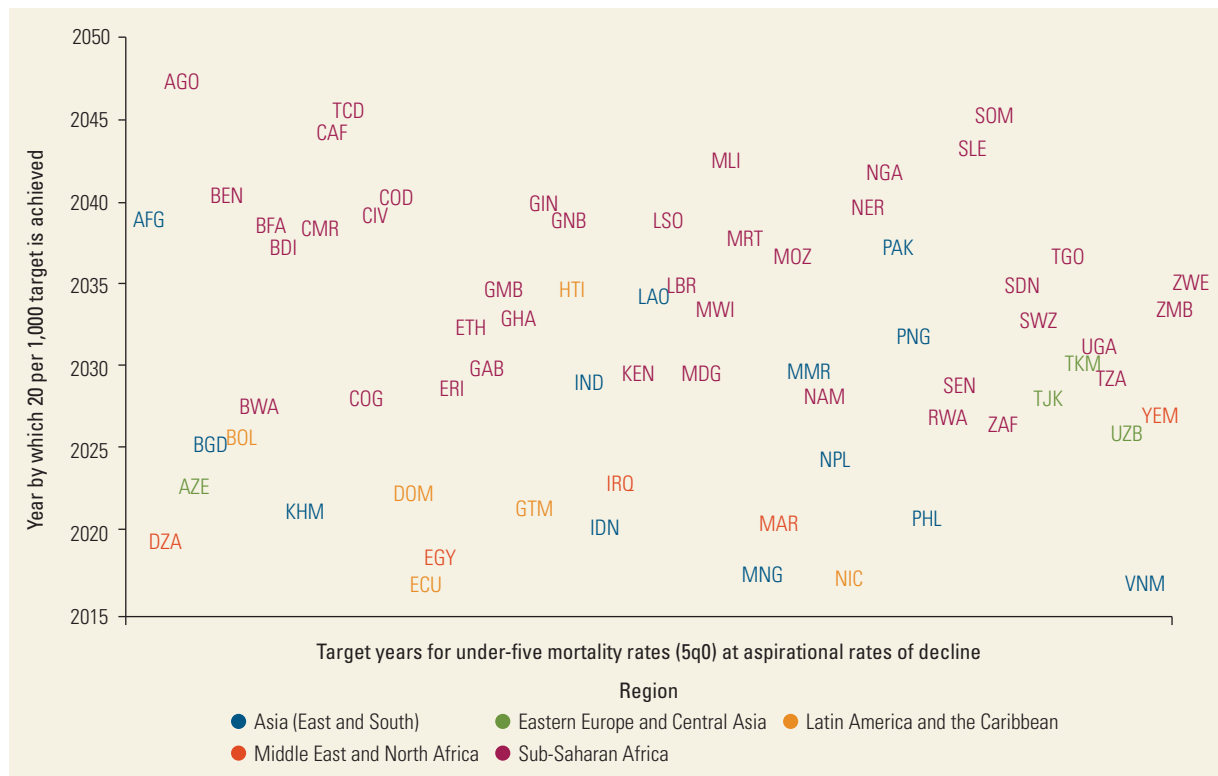


Figure 5.2 Year by Which the Global Targets for Maternal Mortality Ratios Will Be Reached at Aspirational Rates of Decline, Disaggregated by Geographic Region, 2015–50

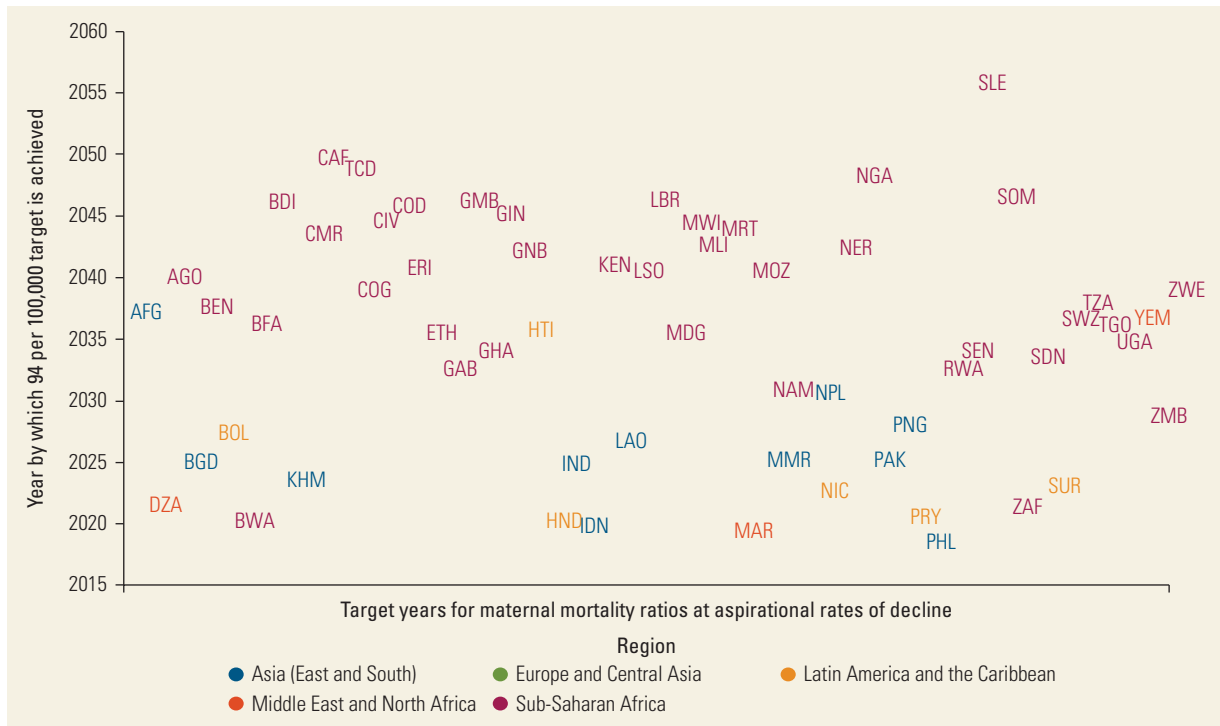


Figure 5.3 Year by Which the Global Targets for Tuberculosis Mortality Rates Will Be Reached at Aspirational Rates of Decline, Disaggregated by Geographic Region, 2015–50

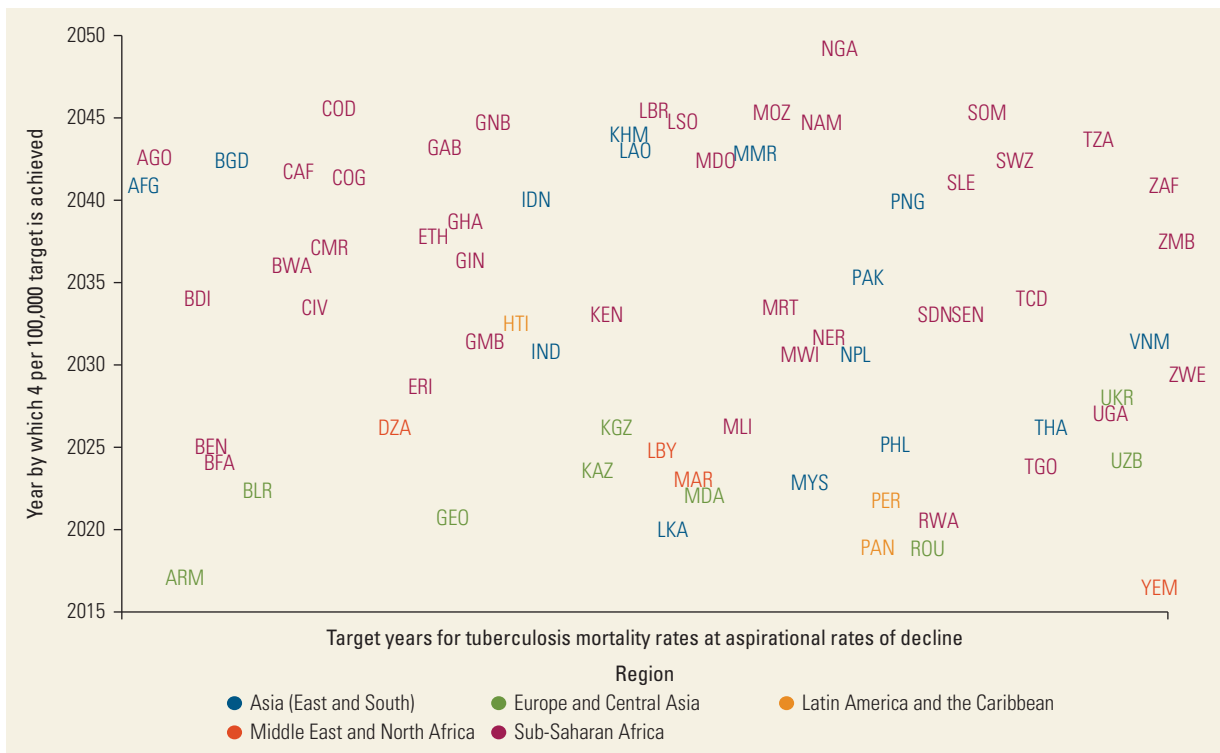
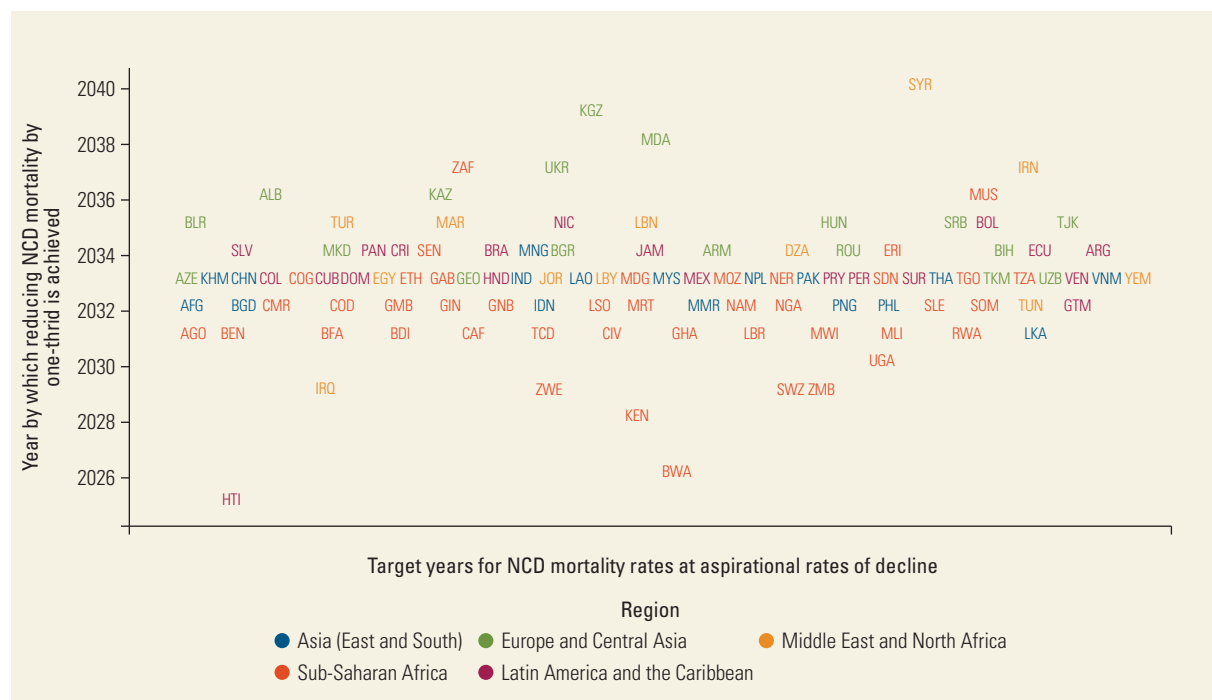


Figure 5.4 Year by Which the Global Targets for NCD Mortality Rates Will Be Reached at Aspirational Rates of Decline, Disaggregated by Geographic Region, 2015–40



Note: NCD = noncommunicable disease.

RESULTS

Tables 5.1–5.4 show the rates of decline in mortality indicators and highlight the best and worst performers (top-five and bottom-five rates of decline). For under-five mortality and NCD mortality rates, the distribution of rates of decline among the 109 LMICs is narrow (annex 5C) and becomes narrower in the most recent 10-year period (2005–15 and 2003–13, respectively), while the distribution of rates of decline in maternal mortality ratios and tuberculosis mortality rates starts out wide and becomes more narrow in recent periods; notably, several countries had very high or very low rates of decline in maternal mortality ratios. For under-five mortality rate, in 2010–15, the mean rate of decline was 3.5 percent per year; the aspirational rate was 6.5 percent per year, with some variation across regions (3.9 percent for South-East Asia, 4.2 percent for Sub-Saharan Africa, 3.8 percent for Middle East and North Africa, 4.8 percent for Europe and Central Asia, and 3.5 percent for Latin America and the Caribbean). The top two performers between 2010 and 2015 were Haiti and the former Yugoslav Republic of Macedonia, with rates of 14.8 and 11.1 percent per year,

respectively (table 5.1). Between 1990 and 2004, countries with the worst performance for under-five mortality rate had zero or negative rates of decline (that is, mortality remained the same or increased) and, with the exception of Sri Lanka, were largely in Southern Africa. Some countries (for example, FYR Macedonia, Peru, and Serbia in 1990–99; Cambodia and Rwanda in 2001–15) maintained very high rates of decline in under-five mortality rates, above 6.0 percent per year.

For maternal mortality ratio, in 2010–15, the mean rate of decline was 2.7 percent per year; the aspirational rate was 6.6 percent per year, with some variation across regions (4.3 percent for South-East Asia, 2.7 percent for Sub-Saharan Africa, 1.6 percent for North Africa and the Middle East, 2.1 percent for Eastern Europe and Central Asia, and 1.9 percent for Latin America and the Caribbean). The top performers in 2010–15 were Kazakhstan, the Lao People’s Democratic Republic, and Ethiopia, with rates of 10.0, 7.6, and 7.6 percent per year, respectively (table 5.2). In all periods assessed, the five worst performers had negative rates of decline, while the five top performers had high rates, greater than 7.0 percent per year.

Table 5.1 Top-Five and Bottom-Five Country Performers in Rate of Decline for Under-Five Mortality Rate (5q0), 1990–2015

1990–94		1995–99		2000–04		2005–09		2010–15		
Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	
<i>Best performers</i>										
1	Macedonia, FYR	7.6	Bosnia and Herzegovina	9.5	Rwanda	9.6	Rwanda	10.3	Haiti	14.8
2	Serbia	7.0	Serbia	8.5	Cambodia	9.6	Congo, Rep.	8.7	Macedonia, FYR	11.1
3	Peru	6.3	Macedonia, FYR	8.2	Moldova	8.8	Belarus	8.3	Rwanda	8.2
3	Hungary	6.3	Peru	7.7	China	8.2	China	8.1	Kazakhstan	8.2
4	Turkey	5.8	Brazil	7.1	Belarus	8.0	Cambodia	8.0	Cambodia	7.8
<i>Worst performers</i>										
1	Rwanda	–14.4	Swaziland	–5.8	Sri Lanka	–6.5	Haiti	–29.4	Brazil	0.2
2	Swaziland	–5.4	South Africa	–3.9	Lesotho	–1.1	Costa Rica	0.4	Costa Rica	1.0
3	Botswana	–5.2	Botswana	–3.5	Swaziland	–0.3	Malaysia	0.5	Algeria	1.4
4	Zimbabwe	–4.7	Lesotho	–3.4	Somalia	0.0	Mauritius	0.6	Moldova	1.7
5	Moldova	–2.9	Congo, Rep.	–2.5	South Africa	0.0	Myanmar	1.5	Dominican Republic	1.8

Table 5.2 Top-Five and Bottom-Five Country Performers in Rate of Decline for Maternal Mortality Ratios, 1990–2015

1990–94		1995–99		2000–04		2005–09		2010–15		
Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	
<i>Best performers</i>										
1	South Africa	10.4	Dominican Republic	15.2	Belarus	13.0	Belarus	16.8	Kazakhstan	10.0
2	Thailand	9.9	Tajikistan	11.9	Rwanda	11.0	Turkey	16.5	Lao PDR	7.6
3	Uzbekistan	9.7	Azerbaijan	10.8	Mongolia	10.1	Kazakhstan	13.9	Ethiopia	7.6
4	Honduras	9.4	Iran, Islamic Rep.	8.7	Lebanon	8.3	Botswana	9.3	Afghanistan	7.5
5	Romania	9.1	Ukraine	7.9	Libya	8.3	Cambodia	8.5	Brazil	7.3
<i>Worst performers</i>										
1	Suriname	–7.1	Suriname	–7.9	South Africa	–5.8	Dominican Republic	–8.9	Dominican Republic	–12.5
2	Azerbaijan	–6.8	South Africa	–6.5	Uzbekistan	–4.2	Mauritius	–8.7	Syrian Arab Republic	–6.5
3	Moldova	–5.5	Zimbabwe	–5.6	Kyrgyz Republic	–3.2	South Africa	–6.5	Hungary	–1.8
4	Tajikistan	–4.8	Botswana	–5.6	Lesotho	–2.8	Panama	–3.2	Libya	–1.8
5	Nicaragua	–4.3	Lesotho	–4.4	Honduras	–2.5	Georgia	–1.6	Serbia	–1.6

Table 5.3 Top-Five and Bottom-Five Country Performers in Rate of Decline for Tuberculosis Mortality Rates, 1990–2014

1990–94		1995–99		2000–04		2005–09		2010–14		
Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	
<i>Best performers</i>										
1	Zimbabwe	16.5	Syrian Arab Republic	14.0	Azerbaijan	12.7	Azerbaijan	34.4	Azerbaijan	24.1
2	Mauritius	15.3	Morocco	13.6	Mongolia	11.6	Tajikistan	16.4	Turkmenistan	22.8
3	Kenya	14.2	Lebanon	13.2	Georgia	11.1	Turkmenistan	15.2	Philippines	20.9
4	Lesotho	13.2	Cuba	11.6	Ecuador	11.0	Honduras	13.7	Egypt, Arab Rep.	18.1
5	Libya	12.9	Mongolia	11.5	Turkey	11.0	Kazakhstan	13.5	Syrian Arab Republic	16.7
<i>Worst performers</i>										
1	Cameroon	–23.8	Mauritius	–19.3	Suriname	–26.2	Lebanon	–16.4	Albania	–17.7
2	Kazakhstan	–20.7	Lesotho	–15.3	Mauritius	–19.7	Suriname	–16.0	Libya	–15.9
3	Burundi	–19.3	Albania	–14.1	Jamaica	–10.8	Cuba	–8.8	Mauritius	–11.1
4	Azerbaijan	–16.6	Tajikistan	–11.9	Lebanon	–8.7	Libya	–8.6	Lebanon	–9.8
5	Moldova	–16.2	Thailand	–11.1	Congo, Rep.	–7.6	Georgia	–7.9	Kenya	–8.9

Table 5.4 Top-Five and Bottom-Five Performers in Rate of Decline for Noncommunicable Disease Mortality Rates, 1993–2013

1993–98		1998–2003		2003–08		2008–13		1993–13		
Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	Country	Rate of decline per year (%)	
<i>Best performers</i>										
1	Rwanda	10.3	Botswana	7.1	Haiti	8.0	Syrian Arab Republic	4.5	Rwanda	3.6
2	Malawi	4.9	Zimbabwe	6.0	Lebanon	3.6	Kyrgyz Republic	4.0	Malawi	2.5
3	Eritrea	4.4	Sri Lanka	4.6	South Africa	3.4	Moldova	3.7	South Africa	2.5
4	Uganda	3.3	Albania	4.1	Lesotho	3.0	Iran, Islamic Rep.	3.3	Syrian Arab Republic	2.3
5	Burundi	3.2	Kenya	3.6	Mongolia	2.7	South Africa	3.2	Algeria	2.2
<i>Worst performers</i>										
1	Kazakhstan	-3.8	Liberia	-3.8	Eritrea	-3.0	Haiti	-7.3	Burkina Faso	-0.7
2	Belarus	-2.9	Guinea	-1.7	Zambia	-1.2	Botswana	-5.1	Guinea	-0.6
3	Sri Lanka	-2.6	Bosnia and Herzegovina	-1.3	Central African Republic	-1.2	Kenya	-3.1	Côte d'Ivoire	-0.6
4	Kyrgyz Republic	-2.6	Burkina Faso	-0.7	Albania	-1.1	Zambia	-2.7	Ghana	-0.4
5	Lesotho	-2.0	Senegal	-0.6	Burkina Faso	-1.1	Zimbabwe	-2.5	Central African Republic	-0.3

In contrast to under-five and maternal mortality ratios, rates of decline for tuberculosis mortality rates were distributed more widely and showed little change over time (annex 5C). During 2010–14, the mean rate of decline was 3.5 percent per year; the aspirational rate was 6.5 percent per year, with substantial variation across regions (4.6 percent for South-East Asia, 1.0 percent for Sub-Saharan Africa, 3.7 percent for North Africa and the Middle East, 6.9 percent for Eastern Europe and Central Asia, and 5.0 percent for Latin America and the Caribbean). The top performers in 2010–14 were Azerbaijan, Turkmenistan, and the Philippines, with rates of 24.1, 22.8, and 20.9 percent per year, respectively (table 5.3). In all periods assessed, the worst performers had high negative rates, with more than half of them having rates of less than –15 percent per year. In the last three periods Azerbaijan ranked as the best performer, with rates above 10 percent (12.7 percent in 2000–04, 34.4 percent in 2005–09, and 24.1 percent in 2010–14).

For NCD mortality rates, the distribution of rates of decline varied greatly across World Bank income groups (annex 5C). From 1993 to 2013, the mean rate of decline was 0.51 percent per year for low-income countries and 0.48 percent per year for lower-middle-income countries. For upper-middle-income and high-income countries, the mean rate of decline over 20 years was much higher, at 1.43 and 1.71 percent per year, respectively. Low- and lower-middle-income countries are off-track to achieve the SDG target of reducing premature mortality from NCDs by one-third by 2030 (UN 2016). LMICs exhibit wide distribution in the rates of decline, with NCD mortality rates rising in some countries. Over the periods assessed, the worst performers were Burkina Faso and Guinea, with mean rates of decline per year of –0.7 and –0.6 percent, respectively, and the best performers were Rwanda (3.6 percent), Malawi (2.5 percent), and South Africa (2.5 percent), with mean annual rates of decline of more than 2 percent (table 5.4).

Based on the change in the rate of decline, it is possible to identify rapid transitions in performance over time (annex 5D, tables 5D.1 to 5D.3). For under-five mortality rates, most countries had small rates of acceleration or deceleration (0 percent \pm 3 percent) for all periods; when the estimates were larger, they were not significant, with uncertainty intervals spanning zero. Likewise, for tuberculosis mortality rates, the point estimates were small, ranging from 2 percent per year to –3.4 percent per year. However, unlike for under-five mortality rates, many of the point estimates for rates of change in tuberculosis mortality rates were significant. For maternal mortality ratio, although many of the point estimates were large, none was found to be significant.

A country's performance with respect to the rate of change in mortality differs greatly from its performance with respect to death rate. Examining rates of decline versus number of deaths for under-five and maternal mortality from 1990 to 2015, we found little correlation between the two indicators (annex 5D, figure 5D.1). Our findings show that high rates of decline in mortality can be achieved even at low levels of mortality.

For under-five mortality rates, 36 of 109 countries (33 percent) have already achieved the interim 2030 target of 20 deaths per 1,000 live births and 73 have not. At current rates of mortality decline, none of these 73 countries will achieve the target between 2030 and 2050. With an aspirational best-performer rate of decline (at the 90th percentile), 38 (35 percent) of the 73 countries will achieve the target by 2030 and the remaining 35 countries (32 percent) will achieve it over 2030–50 (figure 5.1). With regional aspirational rates, 37 of the 73 countries (34 percent) will achieve the target by 2030, and the remaining 36 countries (33 percent) will achieve it between 2030 and 2050 (annex 5E).

For maternal mortality ratios, 46 of 109 countries (42 percent) have already achieved the interim 2030 target of 94 deaths per 100,000 live births and 63 have not. At current rates, none of these 63 countries will achieve the target by 2050. At the aspirational rate, 21 countries (19 percent) will achieve the target by 2030, 41 countries (38 percent) will achieve it between 2030 and 2050, and one country (Sierra Leone) will achieve it after 2050 (figure 5.2). At regional aspirational rates, 21 (19 percent) of these 63 countries will achieve the target by 2030, 28 countries (26 percent) will achieve it between 2030 and 2050, and 14 countries (13 percent) will achieve the target after 2050 (annex 5E).

For tuberculosis mortality rates, 36 (33 percent) of 108 countries have already achieved the *Lancet* Commission's target of 4 deaths per 100,000 population per year and 72 have not. At current rates, none of these 72 countries will achieve the target by 2050. At the aspirational rate, 27 countries (25 percent) will achieve the target by 2030, and the remaining 45 countries (42 percent) will achieve it between 2030 and 2050 (figure 5.3). At regional aspirational rates, 25 countries (23 percent) will achieve the target by 2030, 46 countries (43 percent) will achieve it between 2030 and 2050, and the remaining country (Nigeria) will achieve it in 2054 (annex 5E).

For NCD mortality rates between age 50 and 69, we estimated the 2016 (January) NCD mortality level as the starting point to achieve the SDG target of one-third lower NCD mortality in 2030. At current rates, 30 countries have increasing rates of NCD mortality; only 6 countries will achieve the target by 2030, and 27 countries will

achieve it by 2050. At the aspirational rate, all countries will achieve the target by 2040 (figure 5.4). At regional aspirational rates, 30 countries (28 percent) will achieve the target by 2030, and 24 countries (22 percent) will achieve it between 2030 and 2050 (Annex 5C, figure 5C.4). Countries in South-East Asia and Sub-Saharan Africa have much lower rates of decline.

DISCUSSION

We studied the historical rates of decline in rates of under-five, maternal, tuberculosis, and NCD mortality for 109 LMICs. Annex 5A of this chapter provides a graphical overview of our findings by country income group. We also identified countries with the best and worst performance and regions in which performance had changed rapidly, either improving or deteriorating.

Analysis of rates of change in health is useful because rapid alterations in rates of decline—whether accelerations or decelerations—can point to a potential effect of policy changes and provide a mechanism for understanding what constitutes good policy. We noted almost no correlation between number of deaths and rate of decline in mortality indicators (annex 5D, figure 5D.1), which suggests that rates of change augment the information conveyed by mortality estimates but cannot replace the examination of number of deaths, particularly with regard to capturing the underlying intensity of country-level mortality.

As in our original analysis (Verguet and others 2014), this update reveals some interesting patterns. Rates of decline in child mortality indicate the severe effect of the HIV/AIDS epidemic in Southern Africa. In this region, large increases were recorded in child mortality over 1995–99, but the number of deaths fell rapidly beginning in 2000, reaching a peak rate of decline of 6.3 percent per year in 2005–09. This is probably linked to the rollout of antiretroviral therapy for the prevention of mother-to-child transmission of HIV/AIDS (UNAIDS 2013; WHO 2011). Likewise, rates of decline in maternal and tuberculosis mortality rates deteriorated during 1990–99 in many Central Asian countries after the collapse of the Soviet Union in 1991, and rates of decline in under-five mortality rates dropped abruptly in Rwanda during 1990–99, probably because of the genocide in 1994. Low rates of decline in NCD mortality rates between ages 50 and 69 years for low- and lower-middle-income countries over the 20 years between 1993 and 2013 suggest lack of effective health interventions (screening, prevention, treatment) and rising risk factors (smoking, alcohol consumption, high-calorie processed food).

A few countries have sustained high rates of decline—for example, under-five mortality rates in Turkey from 1990 to 2015, maternal mortality ratios in Cambodia from 1990 to 2015, and NCD mortality rates in Rwanda from 1993 to 2003. Did unusual circumstances or specific policies account for these changes in mortality? Indeed, subsequent assessments could control for contextual determinants (for example, income) and exceptional events (for example, natural disasters, political instability) and try to identify the contributions of specific policies implemented. For instance, Turkey's high rates of decline in under-five mortality rates coincide with substantial economic growth, political stability, and the introduction of the Health Transformation Program, which rapidly expanded access to health care services (Atun and others 2013). Cambodia's progress in maternal mortality can probably be attributed to socioeconomic improvements, better primary education, and specific policies leading to increases in skilled birth attendance (Liljestrand and Sambath 2012).

We used the rates of decline in mortality to test the feasibility of achieving SDGs, with a particular focus on the 2030 targets proposed by the *Lancet* Commission on Investing in Health. Because post-2015 goals present ambitious targets for levels of mortality, meeting them will require high (aspirational) rates of mortality decline from 2015 to 2030. Hence, we used historical rates of decline—including best-performer aspirational rates—to identify how many countries will achieve these ambitious targets if they achieve similar rates of decline over 2015–30. If all LMICs are able to achieve aspirational best-performer rates of decline in mortality, some countries will meet the targets for under-five, maternal, and tuberculosis mortality by 2030, but the majority will reach their targets by 2050. However, meeting the SDG target of reducing premature mortality from NCDs by one-third by 2030 requires a 2.7 percent annual rate of decline. Only Lebanon and South Africa had average annual rates of decline greater than 2.7 percent during most of the 15 years between 1998 and 2013, and a few countries maintained rates greater than 2 percent in the same period, including Algeria, the Islamic Republic of Iran, Malawi, Rwanda, and the Syrian Arab Republic. The majority of LMICs will not reach the NCD target by 2030.

Similar methods have been used to assess the feasibility of other post-2015 targets. Norheim and others (2015) have suggested setting (in addition to specific subtargets for under-five mortality) an overarching goal of reducing premature (under age 70) deaths by 40 percent in 2030 from what they were in 2010.

Our analysis has three key limitations. First, for some countries with poor data, the mortality estimates were predicted largely from past trends. Many countries, particularly those with high mortality, do not have strong

registration systems for vital statistics, so mortality estimates are not always reliable. In view of the large number of countries and distinct mortality indicators analyzed, some findings might also be attributable to poor quality of data. We used mortality estimates from the UN, UNICEF, World Health Organization (WHO), and Institute for Health Metrics and Evaluation to draw general lessons, but our findings could be strengthened further by incorporating additional sources of data (IHME 2015; Jamison, Murphy, and Sandbu 2016; Kassebaum and others 2014; Liu and others 2012; Lozano and others 2013; Murray and others 2014; UN-DESA 2015; Wang and others 2014).

Second, in contrast to our original analysis, where we used five-year intervals, we used annual estimates for this update. Although this may improve the accuracy of the estimates, it may also produce too much noise and mask changes or reveal only small changes that may not be relevant for policy. Despite this noise, annual outcomes could isolate inflection points that capture times when countries make performance transitions and help identify seasonal variations or cyclical patterns that longer intervals (for example, every five years) might not flag.

The final limitation is that other modeling techniques could be used to forecast rates of decline in mortality and to ascertain whether countries would achieve targets by 2030. For instance, specific explanatory variables related to declines in mortality could be used, and regression models could be fitted to mortality time series to make future predictions. However, it is the purpose of our analyses to provide specific performance indicators to be explained, rather than explanations. As such, they provide a starting point. Further research focusing on individual countries can elucidate the reasons for these differences in the rates of change.

ANNEXES

This chapter has one accompanying print annex:

- Annex 5A: Cross-Country Variation in Rates of Decline for Mortality Indicators, 1998–2013

The online annexes to this chapter are as follows. They are available at <http://www.dcp-3.org/DCP>.

- Annex 5B: Countries and Regional Groupings in the Analysis

- Annex 5C: Distribution of Country-Level Rates of Decline in Mortality Indicators, by Period
- Annex 5D: Rate of Change in Decline for Mortality Indicators
- Annex 5E: Reaching Global Targets for Mortality Indicators under Regional Best-Performer Rates of Decline.

NOTES

Large portions of this chapter have been reproduced from: Verguet, S., O. F. Norheim, Z. D. Olson, G. Yamey, and D. T. Jamison. 2014. “Annual Rates of Decline in Child, Maternal, HIV, and Tuberculosis Mortality across 109 Countries of Low and Middle Income from 1990 to 2013: An Assessment of the Feasibility of Post-2015 Goals.” *The Lancet Global Health* 2 (12): e698–709.

World Bank Income Classifications as of July 2014 are as follows, based on estimates of gross national income (GNI) per capita for 2013:

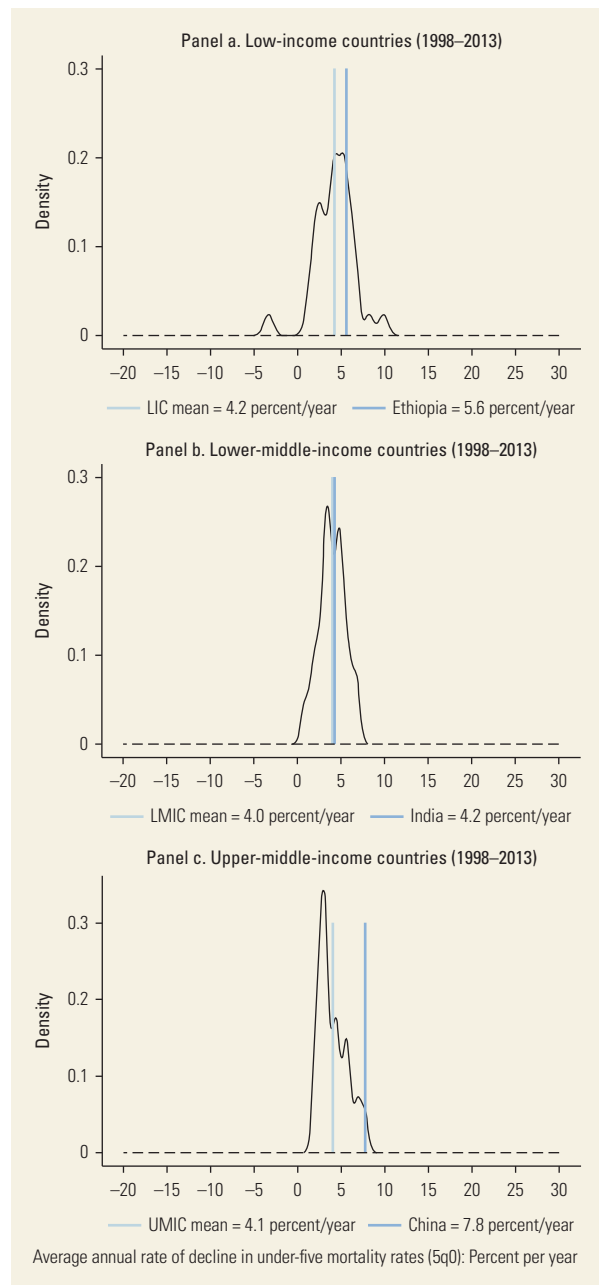
- Low-income countries (LICs) = US\$1,045 or less
- Middle-income countries (MICs) are subdivided:
 - (a) lower-middle-income = US\$1,046 to US\$4,125
 - (b) upper-middle-income (UMICs) = US\$4,126 to US\$12,745
- High-income countries (HICs) = US\$12,746 or more.

ANNEX 5A: CROSS-COUNTRY VARIATION IN RATES OF DECLINE FOR MORTALITY INDICATORS, 1998–2013

For under-five mortality rates, tuberculosis mortality rates, and maternal mortality ratios, we calculated the average annual rate of decline over a 15-year period (1998–2013). We also calculated separate average rates of decline for the World Bank’s low-income, lower-middle-income, and upper-middle-income countries. For NCD mortality, we calculated the mean rate of decline over the same 15-year period and average rates of change for all four World Bank income groups, including high income.

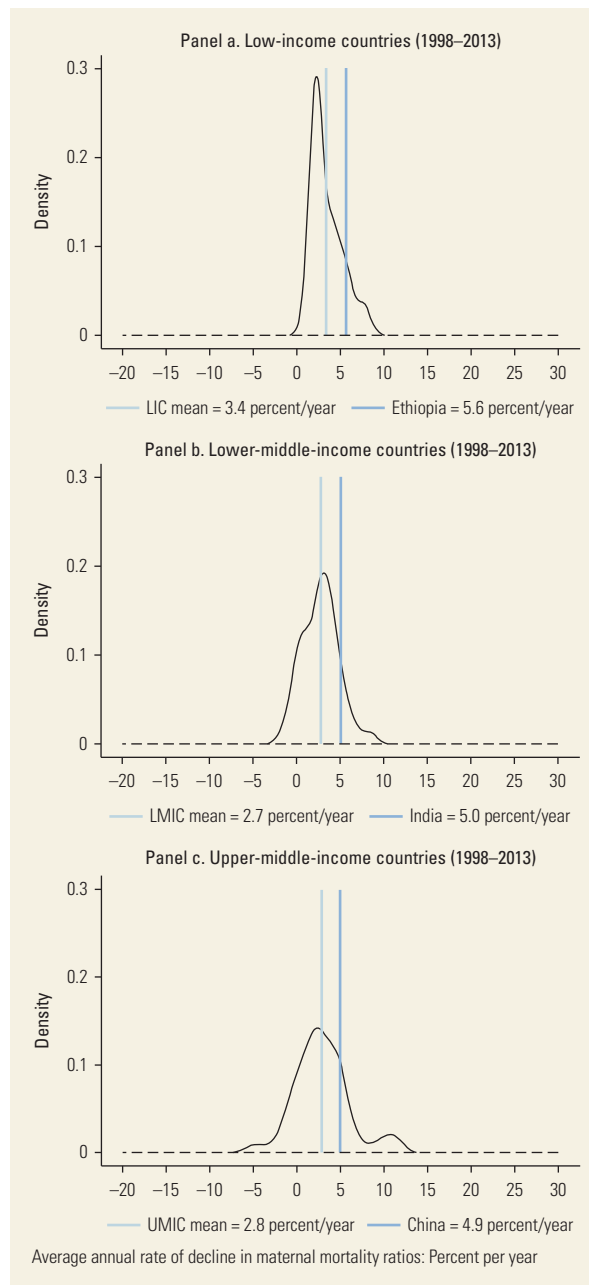
For each of the four mortality indicators, we graph the distribution of rates of decline separately for the three income groups (four income groups for NCDs). Each graph also displays the mean for its income group and the rate of decline for a populous country in the group (China, Ethiopia, India, United States).

Annex Figure 5A.1 Cross-country variation in rates of decline of under-five mortality rates (5q0)



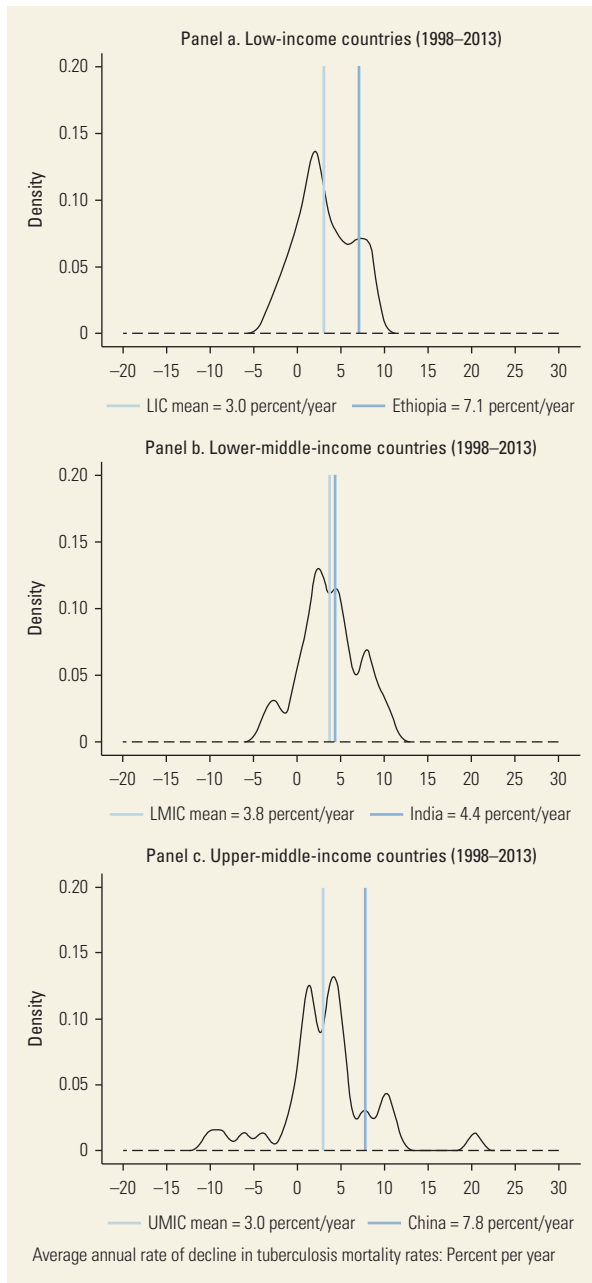
Note: LIC = low-income countries; LMIC = lower-middle-income countries; UMIC = upper-middle-income countries.

Annex Figure 5A.2 Cross-country variation in rates of decline of maternal mortality ratios



Note: LIC = low-income countries; LMIC = lower-middle-income countries; UMIC = upper-middle-income countries.

Annex Figure 5A.3 Cross-country variation in rates of decline of tuberculosis mortality rates



Note: LIC = low-income countries; LMIC = lower-middle-income countries; UMIC = upper-middle-income countries.

Annex Figure 5A.4 Cross-country variation in rates of decline in mortality rates age 50-69 from noncommunicable diseases

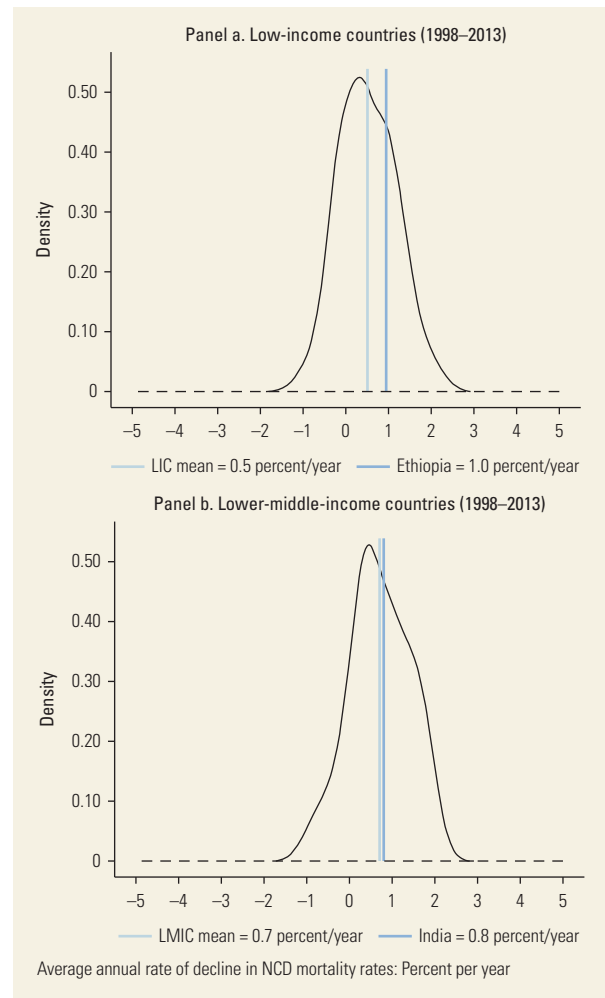
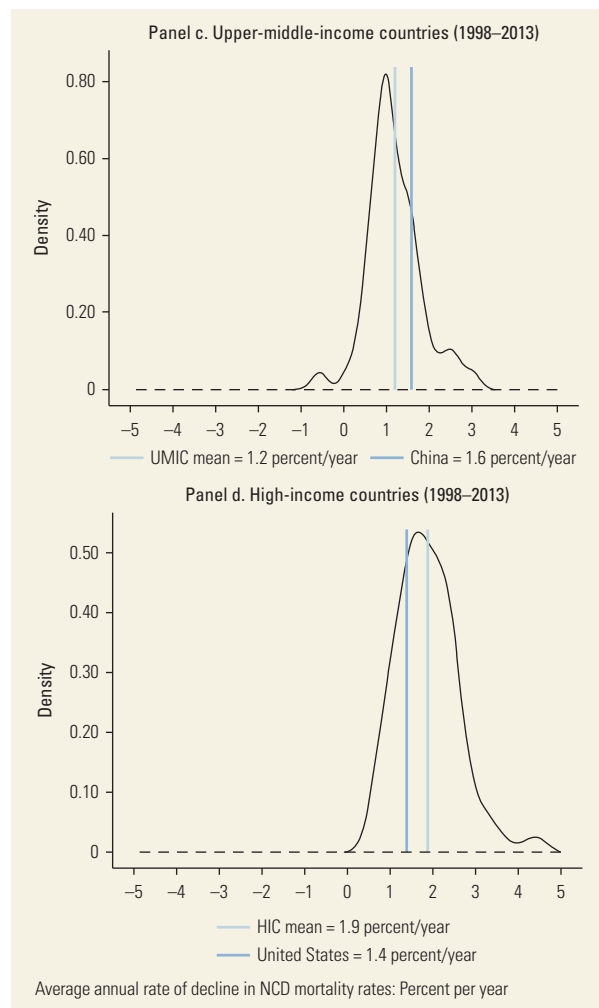


figure continues next page

Annex Figure 5A.4 (continued)



Note: HIC = high-income countries; LIC = low-income countries; LIMC = lower-middle-income countries; NCD = noncommunicable diseases; UMIC = upper-middle-income countries.

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