

BMJ Open Disease and demography: a systems-dynamic cohort-component population model to assess the implications of disease-specific mortality targets

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ABSTRACT

Introduction The 2015 Sustainable Development Goals include the objective of reducing premature mortality from major non-communicable diseases (NCDs) by one-third by 2030. Accomplishing this objective has demographic implications with relevance for countries' health systems and costs. However, evidence on the system-wide implications of NCD targets is limited.

Methods We developed a cohort-component model to estimate demographic change based on user-defined disease-specific mortality trajectories. The model accounts for ageing over 101 annual age cohorts, disaggregated by sex and projects changes in the size and structure of the population. We applied this model to the context of Bangladesh, using the model to simulate demographic outlooks for Bangladesh for 2015–2030 using three mortality scenarios. The 'status quo' scenario entails that the disease-specific mortality profile observed in 2015 applies throughout 2015–2030. The 'trend' scenario adopts age-specific, sex-specific and disease-specific mortality rate trajectories projected by WHO for the region. The 'target' scenario entails a one-third reduction in the mortality rates of cardiovascular disease, cancer, diabetes and chronic respiratory diseases between age 30 and 70 by 2030.

Results The status quo, trend and target scenarios projected 178.9, 179.7 and 180.2 million population in 2030, respectively. The cumulative number of deaths during 2015–2030 was estimated at 17.4, 16.2 and 15.6 million for each scenario, respectively. During 2015–2030, the target scenario would avert a cumulative 1.73 million and 584 000 all-cause deaths compared with the status quo and trend scenarios, respectively. Male life expectancy was estimated to increase from 71.10 to 73.47 years in the trend scenario and to 74.38 years in the target scenario; female life expectancy was estimated to increase from 73.68 to 75.34 years and 76.39 years in the trend and target scenarios, respectively.

Conclusion The model describes the demographic implications of NCD prevention and control targets, *estimating the potential increase in life expectancy associated with achieving key NCD reduction targets*. The results can be used to inform future health system needs and to support planning for increased healthcare coverage in countries.

Strengths and limitations of this study

- The model provides an understanding of how changes in disease-specific mortality may contribute to the demographic outlook of countries by simulating demographic evolution paths corresponding to pre-specified mortality rate outlooks.
- The model tracks population outcomes at a highly disaggregated level and can produce consistent and comparable cross-country estimates for a set of demographic indicators.
- The model uses established principles about the dynamics of the population process and can be flexibly adapted to the intended disaggregation schemes of population cohorts and disease categories.
- The cohort-component method does not explicitly incorporate socio-economic determinants of population change.
- The model outcomes are based on conditional calculations producing outlooks for a set of demographic indicators under a particular set of reasonable assumptions.

INTRODUCTION

Changes in population size and demographic composition have broad economic and social implications. Informed decisions regarding population-level policies and interventions hinge on robust population projections that delineate the dynamic interplay of demographic processes such as fertility, mortality and migration. Generating counts for population cohorts of interest determines investment in sectors like health, education, infrastructure and others.^{1 2}

We present a cohort-component population projection model to assess demographic changes associated with changes in the distribution of causes of death. Current population projections reflect a variety of assumptions about fertility, mortality and migration.^{3–6} For instance, the UN produces eight variants of population projections, five of which are based on different trajectories of fertility,

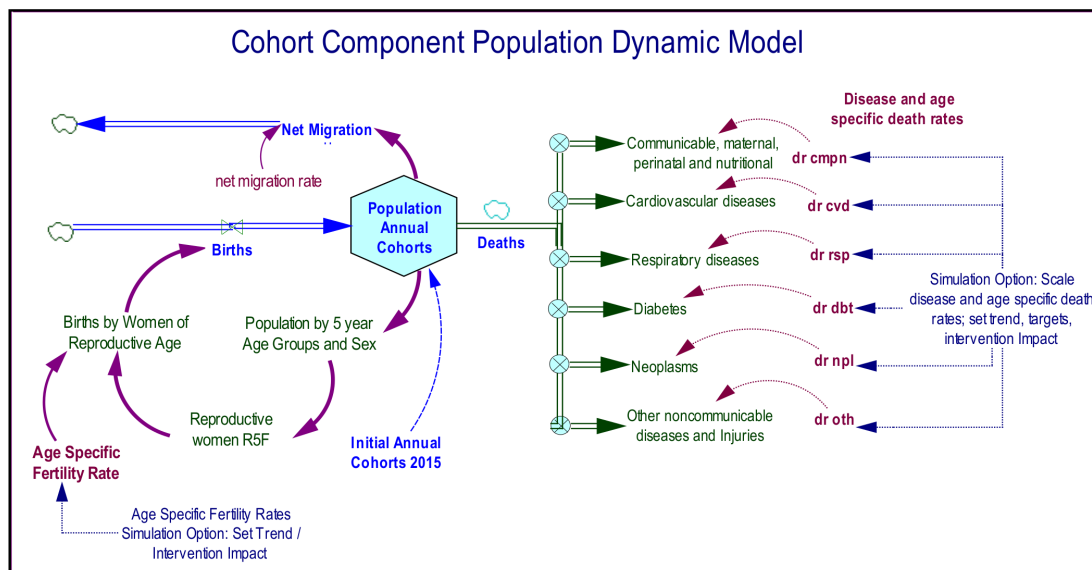


Figure 1 Overview of the cohort-component population model: stock, flows and simulation options. Note: The model is developed using the Vensim DSS (V.8) simulation platform. cmpn, communicable, maternal, perinatal and nutritional conditions; cvd, cardiovascular diseases; dbt, diabetes mellitus; dr, death rate; npl, neoplasms; oth, other non-communicable diseases and injuries; rsp, respiratory disease.

while mortality assumptions are determined by probabilistic trends of life expectancy at birth, and international migration is assumed either constant or zero.³ The existing population projection models typically emphasise the role of fertility but do not provide an understanding of how changes in disease-specific mortality rates may contribute to the demographic outlook of countries.

Preventable deaths and disability caused by communicable diseases, maternal, perinatal and nutritional conditions (CMPN), non-communicable diseases (NCDs) and injuries constitute core concerns across nations. Among these, cardiovascular diseases (CVDs) are in the lead, accounting for 15.2 million deaths of all 56.9 million deaths worldwide in 2016.⁷ Given the rising significance of NCDs in global health, the 2030 Sustainable Development Goals (SDGs) aim to reduce premature mortality from the four major NCDs (CVDs, diabetes, cancer and respiratory diseases) by one-third by 2030, relative to 2015 level.⁸ With the adoption of the WHO Global NCD Action Plan by the World Health Assembly in 2013, the WHO Member States agreed on a time-bound voluntary target of attaining a 25% relative reduction in overall mortality from the four leading NCDs by 2025.⁹ In a similar vein, the WHO 2013 Global Program of Work (GPW 2013) set the target of 20% relative reduction in the premature mortality (age 30–70 years) from these NCDs between 2019 and 2023.¹⁰ These objectives occur in the context of many budgetary and planning constraints that affect low-income and middle-income countries (LMICs). Further, variations in the incidence and prevalence of diseases across sex and age cohorts require policymakers to formulate targeted interventions and policies. Understanding the evolution of different age-cohorts resulting from shifts in disease-specific mortality over time can

inform the resource needs for national scale-up of interventions to attain SDG health targets.

The dynamic population projection model in this study simulates a range of demographic evolution paths corresponding to pre-specified disease-specific mortality outlooks. The results provide demographic information needed to plan for services to meet future demands of different segments of the population. Although the model in this study is applied to Bangladesh, it is replicable across different countries and can serve as a tool for planners to simulate user-defined scenarios corresponding to assumed fertility, mortality, and international migration trajectories.

Over the last several decades, Bangladesh has made substantial progress in disease prevention and control of childhood communicable diseases, but NCDs have emerged as the primary cause of death and disability in the country.^{11 12} In response, the Government of Bangladesh has formulated an NCD action plan to reduce NCDs and associated risk factors through a multisectoral coordinated approach.¹³ Bangladesh NCD prevention and control targets are consistent with the 2030 SDGs and with the WHO South-East Asia regional NCD 2025 objectives of reducing by 25% premature mortality from CVDs, diabetes, respiratory diseases and cancer.^{13 14} Attainment of these targets entails population-level prevention and treatment initiatives. A first step in planning for such initiatives is information on the demographic outcomes associated with accomplishing the health objectives of these initiatives.¹⁵ To this end, the present study models the demographic outlook for Bangladesh from 2015 to 2030 under the assumption of attaining the 2030 SDG target of reducing premature mortality (age 30–70 years) from four major NCDs by one-third. More specifically,

we produce the demographic outlook for Bangladesh corresponding to a one-third reduction (ie, ~30%) in the unconditional probability of dying between the exact ages of 30 and 70 years from any of CVDs, cancer, diabetes, or chronic respiratory diseases.

METHODS AND DATA

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

The systems-dynamic cohort-component population model

We develop a cohort-component population projection model that tracks each sex-specific and age-specific cohort of people throughout its lifetime, subject to assumed age-specific and sex-specific mortality, fertility and migration rates.^{6 16} The model represents a 'systems' structure defined by the stocks and flows and the connections between them.^{17–20} In this model, the population in each year is the stock variable, while births, deaths and international migration represent the flows. The model starts with defining the initial-year population, disaggregated by sex and age-cohorts, followed by defining the fertility, mortality and migration attributes of each cohort throughout the projected horizon. In other words, the model in this study resembles an ageing chain where, after birth, each birth cohort progresses from childhood (first stock) to old age (last stock) unless the individual dies and leaves the system.

Figure 1 presents an overview of the model structure using a stock-and-flow diagram. The population's dynamic path begins with the initial population stock observed in 2015 for Bangladesh, disaggregated by sex and age. In each subsequent year, changes in the annual population stock occur through adding births, subtracting deaths and through net international migration (emigration minus immigration) as expressed in Equation 1.

Population dynamics: $P_{s,A,t+1} = P_{s,A,t} + B_{s,t} - D_{s,A,t} + NM_{s,A,t}$ (1)

$P_{s,A,t}$ is population by sex ($s = \{f, m\}$), 101 annual age cohorts ($A = \{0, 1, 2, \dots, 100\}$) at year $t = \{0, 1, 2, \dots, T\}$ (ie, over 2015–2030). $B_{s,t}$ is the number of annual births, determined by applying exogenously set age-specific fertility rates to the cohorts of reproductive-age women (age 15–49).

Births during year: $B_{s,t} = P_{s,A=0,t} \cdot \varnothing_s B_{A=0,t}$ (2)

Total births: $B_t = \sum_{f,A^*=15}^{49} B_{A^*,t}$ (3)

Births by age of mother: $B_{A^*,t} = \alpha_{A^*,t} P_{f,A^*,t}$ (4)

Where \varnothing_s is the probability of sex ($s = \{f, m\}$) at birth; $\alpha_{A^*,t}$ represents age-specific fertility rate for women of reproductive age of 15–49 years (ie, $A^* = \{15, 16, \dots, 49\} \in (f, A)$).

In each year, people in each age cohort leave the system due to deaths ($D_{s,A,t}$) and net international migration ($NM_{s,A,t}$). The causes of deaths are aggregated into six major types of disease categories: CMPN; neoplasms; diabetes; CVDs; respiratory diseases; other NCDs and injuries.

Mortality by sex, age, causes of death: $D_{s,A,d,t} = \delta_{s,A,d,t} P_{s,A,t}$ (5)

Where, $\delta_{s,A,d,t}$ represents sex-specific, age-specific and disease-specific death rates over time; d represents the number of deaths from six types of diseases; $d = \{cmprn, npl, dbt, cvd, rsp, othNCDs\}$, *cmprn*: communicable, maternal, perinatal, nutritional (WHO Global Health Estimates (GHE) codes I.A., I.B., I.C., I.D., I.E.); *npl*: neoplasms (II.A., II.B.); *dbt*: diabetes (II.C.); *cvd*: cardiovascular diseases (II.H.); *rsp*: respiratory diseases (code II.I.); *othNCDs*: other non-communicable diseases and injuries (II.D., II.E., II.F., II.J., II.K., II.L., II.M., II.N., II.O., II.P., III.A., II.B.). Sex, age-group and disease-specific deaths rates determine the number of deaths each year. The online supplemental table S1 maps these broad categories with the disaggregated WHO GHE causes of death codes.²¹

Net international migration by sex, age and over time is defined as:

$$NM_{s,A,t} = P_{s,A,t} * \gamma_{s,A,t} \quad (6)$$

where $\gamma_{s,A,t}$ is sex and age-specific net international migration rate over the years. Depending on country contexts, sex and age-specific net migration rates determine the number of people removed from (or added to) the population due to migration to (or from) other countries.

The model allows the option of simulating different scenarios by setting sex-specific and age-specific fertility rates; sex-specific, age-specific and disease-specific death rates; and net-migration rates, for each year over the analytical time-horizon (2015–2030). For instance, scenarios of different mortality trends could reflect status-quo (ie, constant death rates over time), trajectories based on historical trends, trajectories based on the predicted impact of disease prevention interventions or reductions in risk factor exposures informed by the literature, or user-defined mortality outlooks based on national plans. We introduce a set of forcing functions ($I_{s,A,t}$) with a default or status quo value of 1 but allow scaling-up (scaling-down) functions (over time) corresponding to trend, targets and/or any other implementation sequences:

Death rates scale up/down over time: $\delta_{s,A,d,t} * I_{s,A,d,t}^{\delta}$ (7)

Fertility rates scale up/down over time: $\alpha_{A^*,t} * I_{s=f,A^*,t}^{\alpha}$ (8)

Net international migration rate scale up/down over time: $\gamma_{s,A,t} * I_{s,A,t}^{\gamma}$ (9)

The model allows user to set scale factors for different years by sex and age-groups. For instance, while $I_{s,A,d,t}^{\delta} = 1$ for each year during 2015–2030 in the status quo death rate scenario, $I_{s,A,d,t=2015}^{\delta} = 1$ and $I_{s,A,d,t=2030}^{\delta} = 0.67$ entail 33% reduction in the death rates from the 2015 level; scale factors for the interim years (ie, 2016–2029) may include linear interpolated values, or concave/convex path or user-defined values corresponding to interim national targets.

The model generates population counts for 202 annual age-sex cohorts consisting of age 0–100+ years for men and women, respectively. Data on fertility, mortality and net-migration rates were only available by age-group and

were assigned to corresponding annual cohorts within each age-group. We used two age-groups depending on data availability, separately for men and women: (1) six broad age-groups: age 0–4, age 4–14, age 15–29, age 30–49, age 50–69, age 70 and above; (2) 5 year age-groups: age 0–4, age 5–9, age 10–14, age 15–19, age 20–24, age 25–29, age 30–34, age 35–39, age 40–44, age 45–49, age 50–54, age 55–59, age 60–64, age 65 and above.

Demographic indicators

The model produces several key demographic indicators, including population counts and age structure; total, child and old-age dependency ratios; the number of births; crude birth rate; total fertility; net reproduction rate; the rate of natural population increase; the number of deaths by diseases; infant and child mortality rates; crude death rate; life expectancy at birth and at each age; the probabilities of dying between age 30 and 70; and total years of lives lost by diseases. The online supplemental table S2 provides brief definitions of the indicators.²²

BANGLADESH CASE STUDY: DEMOGRAPHIC IMPLICATIONS OF SDG NCD MORTALITY TARGETS

Baseline data

To initiate the population dynamics, we needed base year population, age-specific fertility rates, age-specific death rates and age-specific net migration rates. We used the 2015 annual cohort (age 0–100) population data from the UN population projection (medium variant); age-specific fertility rates reported by the Bangladesh Bureau of Statistics; age-specific total death rates are obtained from the UN life tables for Bangladesh for the year 2015, and age-specific net migration rates from Bangladesh Bureau of Statistics.^{3 23–25} The UN estimate of the ratio of sex at birth for Bangladesh is 1.05 for their entire analytical horizon; we used the same for this model.²⁵ The UN life table for Bangladesh assumes a 100% mortality rate for ages 85 and above.^{25 26} Our model assumed that all people in the last age cohort (100+ years) leave the system (ie, die) with a 100% mortality rate, with interpolated death rates for ages 85–99. The total net migration rate reported in the UN population projection is –2.3/1000 population; our model assumed the same statistic when applying age-specific net migration rates to the baseline (2015) population.^{22 25} We used WHO GHE disease burden (mortality) data by cause, age and sex⁷ to decompose the total death rates by six broad categories of diseases, so that, $\delta_{s,A,d,t=2015} = \frac{GHE\ Death_{S,A,d,t=2015}}{\sum_{d=1}^6 GHE\ Deaths_{S,A,d,t=2015}}$ (10)

$$d = \{c\text{mpn}, n\text{pl}, dbt, cvd, rsp, othNCDs\}$$

$$\sum_{d=1}^6 \delta_{s,A,d,t} = \delta_{s,A,t}$$

Where equation 10 is used to decompose the baseline (year=2015) sex-specific and age-specific death rates into six diseases specific rates and $GHE\ Death_{S,A,d,t=2015}$ represent

the number of deaths by diseases obtained from WHO GHE mortality data for the year 2015. $\delta_{s,A,t}$ (ie, sex-specific and age-specific death rates at year t) is the sum of death rates from six broad categories of diseases (d). The online supplemental table S3 reports the 2015 baseline data used in the model, including the death rates by six broad disease categories.

Scenarios

We compared three demographic outlooks for Bangladesh: status quo, trend and target. The three scenarios differ in terms of their assumed mortality trajectories, keeping fertility and net migration trajectories the same across scenarios. The UN population projection uses five fertility variants: low, medium, high, constant-fertility and instant-replacement-fertility. For instance, for Bangladesh, during 2015–2020 the total fertility rates are assumed to be 2.2, 2.05 and 1.68 for the high, medium and low variants, respectively. For the 2025–2030 period the total fertility rates are assumed to be 2.26, 1.82 and 1.42 for the high, medium and low variants, respectively.^{3 23} We use the 2015 age-specific fertility rates reported by the Bangladesh Bureau of Statistics (BBS), setting the total fertility rate at 2.10. Then, using the UN probabilistic projections for age-specific fertility rates for the 2025–2030 period, we scaled down the respective 2015 age-specific fertility rates to arrive at a total fertility rate of 1.82 by 2030. For the interim years, the model uses interpolated linear trends. We used the 2015 sex-specific and age-specific net migration rates obtained from BBS, which remains constant during the 2015–2030 period.^{23 24}

The study uses three variants of mortality trajectories. The ‘status quo’ scenario entails that the 2015 disease-specific mortality rates remain constant for the analysis horizon, so that $I_{s,A,t}^{\delta} = 1$ for the 2015–2030 period. The ‘trend’ scenario adopts sex, age-group and disease-specific mortality rate trajectories based on the latest WHO GHE regional mortality projections for 2016–2030 for Southern Asia, consisting of Bangladesh and other neighbouring countries.^{27 28} We estimated the death rates by sex, age-groups and six broad disease categories for 2016 and 2030 from the number of deaths and total population obtained from WHO GHE study; and then produced a matrix of scale factors such that:

$$I_{s,A,d,t=2030}^{\delta} = \frac{\delta_{S,A,d,t=2030}^{GHE}}{\delta_{S,A,d,t=2016}^{GHE}}$$

Where $I_{s,A,t=2030}^{\delta}$ are sex-specific, age-specific, and disease-specific scale factors for the death rates in 2030 relative to 2015 levels. The interim years use interpolated scale factors and corresponding mortality rate values. For instance, the WHO GHE estimate projects that by 2030, the death rates of infectious, maternal, perinatal and nutritional conditions would reduce by 21% for women aged 70 and above and 48% for men

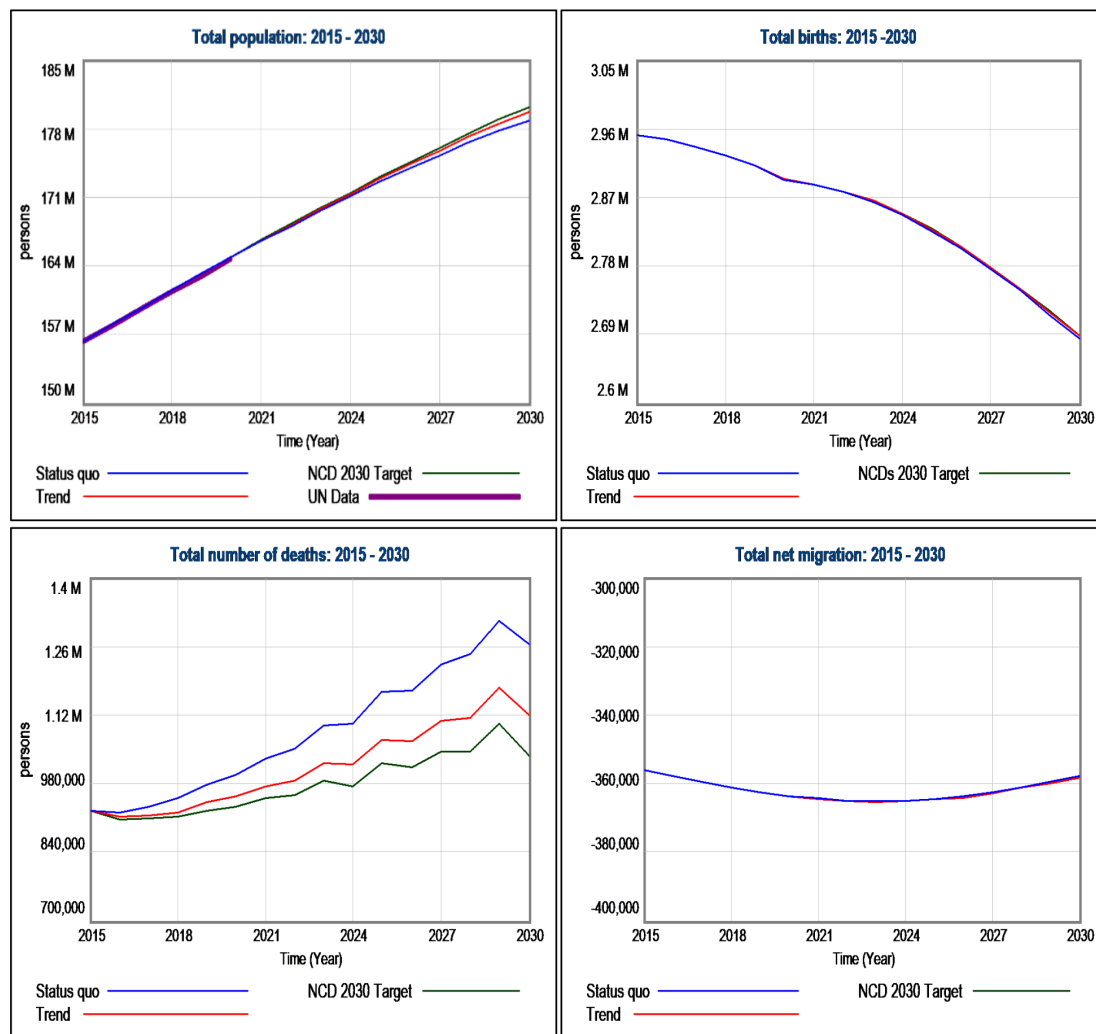


Figure 2 Population outlook for Bangladesh: 2015–2030. Calculations derived from the model. M, million; NCD, non-communicable disease.

aged 15–29 years. Accordingly, we set the death rate trajectories for the corresponding cohorts to reflect 21% and 48% reductions in 2030 from 2015, respectively. Similarly, depending on sex and age-groups, the reductions of death rates range from 3.4% to 22.9% for CVDs; 9.3% to 22.9% for respiratory diseases; and 3.9% to 14.1% for other NCDs and injuries. The trend projections for neoplasms ranges from 9.3% to 22.9% increases in the death rates by 2030. The changes in diabetes death rates ranges from a reduction of 20.7% to an increase of 3.4%. The online supplemental table S4 reports all sex, age-group and disease-specific scale factors ($I_{s,A,d,t}^{\delta}$) for the trend scenario.

The third scenario is the ‘target’ scenario, which entails relative reductions in the mortality rates that result in approximately one-third reduction (ie, ~30%) in the unconditional probability of dying between the ages of 30 and 70 years from any one of CVDs, cancer, diabetes or chronic respiratory diseases between 2015 and 2030. For the other two disease categories (ie, CMPN; and other NCDs and injuries) we use the same mortality rate trajectories as in the ‘trend’ scenario.

The mortality rate trajectory for the four major NCDs follows the trend scenario until 2020 for all age groups, and then declines by 33% during 2015–2030 for ages 30–69 to arrive at the probability of premature deaths representing about one-third reduction relative to 2015 level; that is, $I_{s,A=30to69,d=cvd,resp,dbt,npl,t=2030}^{\delta} = 0.67$ for 2030 and the interim years use interpolated values. The online supplemental table S4 reports the $I_{s,A,d,t}^{\delta}$ values under the target scenarios; the scale factors for 2020 are same in the trend and target scenarios but set at 0.67 for ages 30–69 for 2030 and four NCDs in the target scenario. In achieving the SDG NCD mortality target at the aggregate level, the death rate trajectories can be non-linear and can differ by sex, age and/or disease categories. While the model allows incorporating variants of implementation paths, for the sake of simplicity, in this study we assumed linear interpolated scale factors for the analytical horizon.

This cohort-component systems dynamic population model has been developed using Vensim DSS for Windows V.8.0.4 (Double Precision ×64) (<https://vensim.com/vensim-software/>).

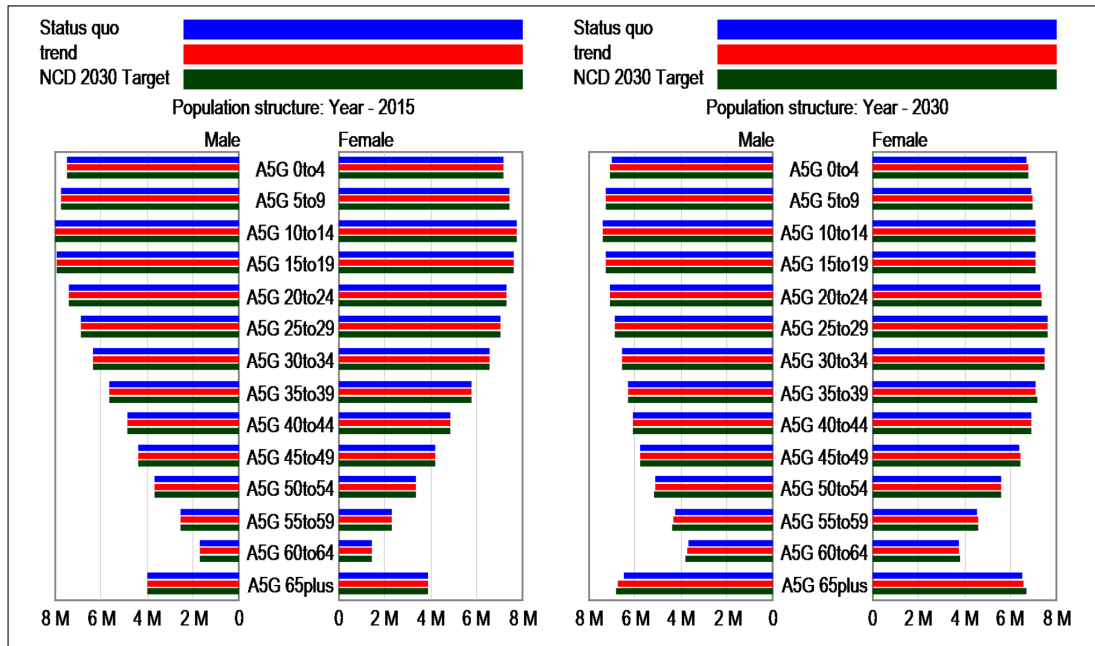


Figure 3 Projected population age structure in Bangladesh: 2015 and 2030. Calculations derived from the model. M, million, NCD, non-communicable disease.

RESULTS

Population outlooks

The status quo, trend and target scenarios project 178.9, 179.7 and 180.2 million population in 2030, respectively. **Figure 2** shows the projections for total population along with the three main flow variables in the model, that is, total births, total deaths and total net international migration. Given that all fertility and migration assumptions are the same across all three scenarios, differences in the projected population numbers between scenarios reflect differences in the death rate trajectories. The assumption of a steady decline in total fertility from 2.10 in 2015 to 1.82 in 2030 leads to a declining trajectory for the annual number of births from 2.95 million in 2015 to around 2.69 million in 2030. The assumed constant age-specific net migration rate kept the total number of people migrating abroad between 356 000 and 365 000 each year. However, the annual number of deaths is much higher in the status quo scenario compared with the

trend and target scenarios. The model projects 1.26, 1.12 and 1.04 million deaths in 2030 in the status quo, trend and target scenario, respectively. The cumulative number of deaths during 2015–2030 are 17.37, 16.22 and 15.64 million in the status quo, trend and the target scenario, entailing 1.73 million and 584 000 deaths averted in the target scenario compared with the status quo and trend scenarios, respectively.

Figure 3 shows the inverted age-sex pyramid illustrating the distribution of various age groups in Bangladesh in 2015 (left panel) and 2030 (right panel). The population is distributed along the horizontal axis, with men shown on the left and women on the right. The male and female populations are broken down into 5-year age groups represented as horizontal bars along the vertical axis, with the youngest age groups (age 0–4) at the top and the oldest at the bottom (age 65 and above). The shape of the population pyramid gradually evolves during 2015–2030 based on fertility, mortality and international migration

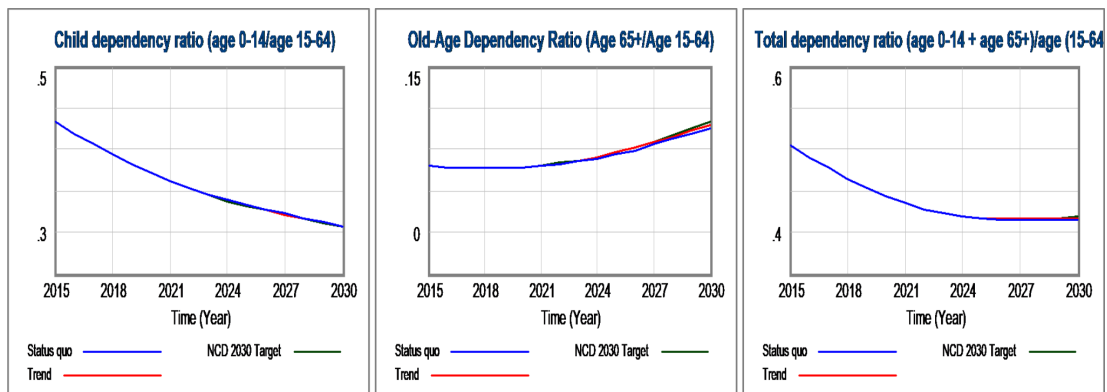


Figure 4 Child, old-age and total dependency ratios. Calculations derived from the model. NCD, non-communicable disease.

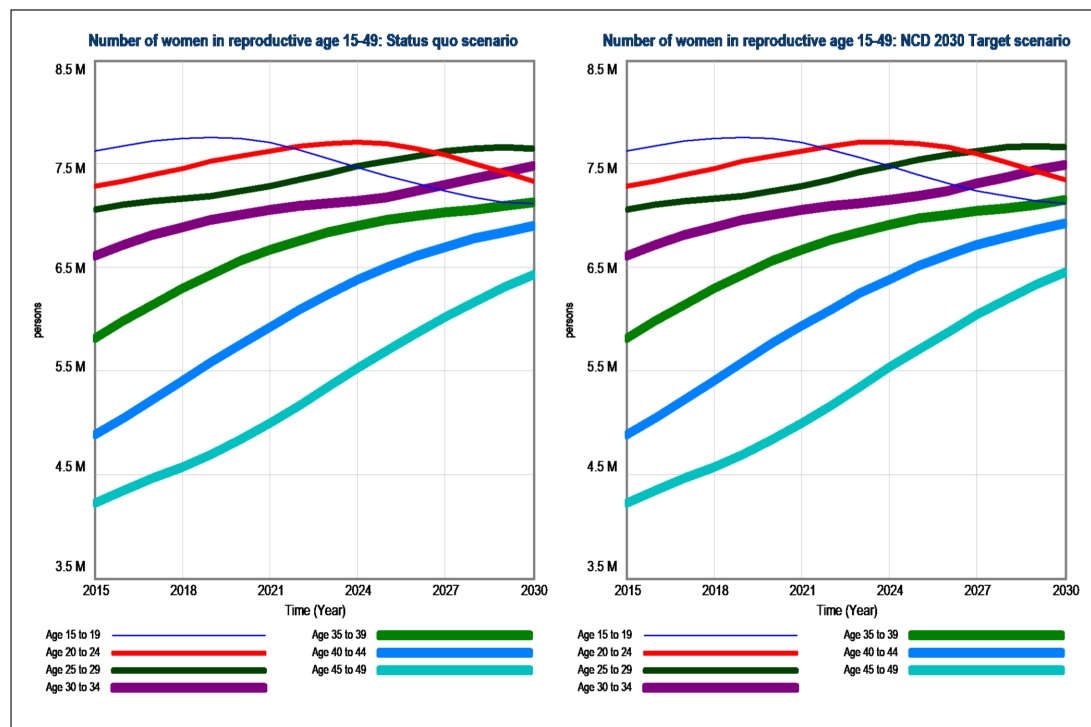


Figure 5 Number of women in reproductive age (15–49 years). Calculations derived from the model. M, million; NCD, non-communicable disease.

trends. The apparent cone-shaped population pyramid in 2015 appears more symmetric in 2030, consistent with population ageing over the analytical horizon.

The evolving population structure is also reflected in figure 4. The rapid reductions in infant and child mortality accompanied by decreasing fertility led to a continuous reduction in the child dependency ratio (ie, ratio of population age 0–14 and age 15–64) (0.45 in 2015 vs 0.35 in 2030 trend scenario). On the other hand, as the annual cohorts progress through the analytical period, the old-age dependency ratio (ie, ratio of population age 65 and above and age 15–64), after remaining relatively flat during 2015–2020, starts to rise beyond 2020 (0.078 in 2015; 0.077 in 2020; and ~0.10 in 2030 for the three scenarios). The total dependency ratio (ie, ratio of population age 0–14 and age 65 and above, and age 15–64) registers a relatively quick decline from 0.52 in 2015 to 0.45 in 2025 and remains at 0.45 until 2030.

The annual number of births is determined by the age-specific fertility rates and the number of women of reproductive age 15–49 years. The trajectory of the number of women in reproductive age is affected by the number of deaths and international migration for the corresponding cohorts. In figure 5, for the trend and target scenarios, it is evident that the number of women aged 15–19 begins to decline after 2021, and the number of women aged 20–24 declines after 2024. The number of women in all other older age groups increases during 2015–2030, with older cohorts showing larger growth.

Figure 6 presents the projected mortality trajectories by disease categories. The number of deaths from all

disease categories increases except for the CMPN category in the status quo scenario. In the status quo scenario, population decreases moderately for younger cohorts (ie, age <25) and increases more for the older cohorts age 25 and above during 2015–2030 period, leading to net increase in the total population. Consequently, the assumed constant death rates for the CMPN in the status quo scenario results in net increase in total deaths from CMPN. On the other hand, the continuous decline in death rates and a near-flat population trend with a slight decrease in numbers of children and adolescents lead to a reduction in deaths from CMPN in the trend and target scenarios. In all scenarios, NCD deaths rise with the rising population; however, the number of deaths is much smaller in the target scenario. The share of CMPN in total deaths declines from 26% in 2015 to 23%, 17.6%, and 19.1% in 2030 under the status quo, trend and target scenario, respectively. On the other hand, the contribution of the four major NCDs (CVD, respiratory diseases, diabetes and neoplasms) in total deaths increases from 54.9% in 2015 to 58.9%, 63.4% and 60.2% in 2030 under the status quo, trend and target scenarios, respectively.

Table 1 shows the number of deaths under the three mortality scenarios and the number of deaths averted under the target scenario compared with the status quo and trend. Of the four major NCDs, CVD is the major killer, followed by neoplasm, respiratory diseases and diabetes. In 2025, the model projects 375 000, 357 000 and 334 000 deaths from CVD under status quo, trend and target, respectively, which entails 23 000 and 41 000 CVD deaths averted under the target scenario compared

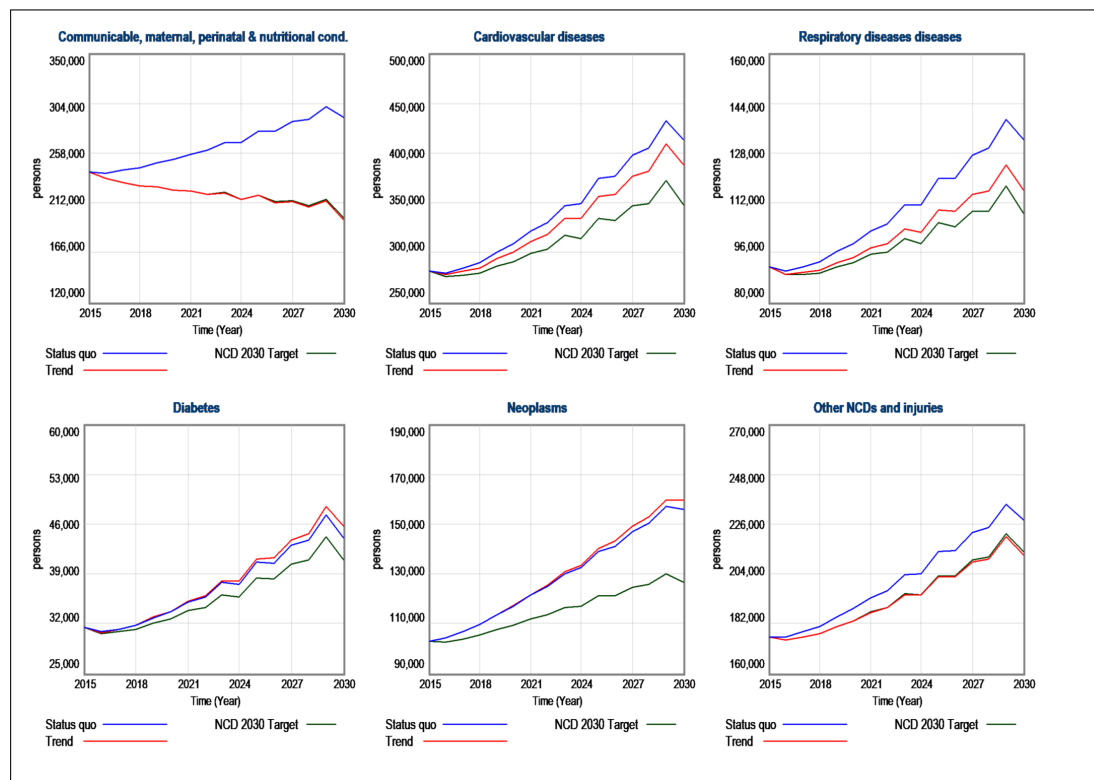


Figure 6 Mortality by diseases. Calculations derived from the model. NCD, non-communicable disease.

with trend and status quo scenarios. Over 2015–2030, the target scenario would avert a cumulative 485 000 (285 000 men and 199 000 women) CVD deaths and 282 000 CVD deaths (162 000 men and 120 000 women) compared with the status quo and trend scenario, respectively. Under the target scenario, the cumulative (2015–2030) number of deaths averted from the four major NCDs is projected to be about 897 000 (500 000 men and 396 000 women) and 596 000 (291 000 men and 305 000 women), compared with the status quo and trend scenarios, respectively.

The online supplemental table S5 shows the projections of years of lives lost (YLL) in the three scenarios, and YLL averted in the target scenario compared with status quo and trend. Compared with the status quo mortality trajectories, the attainment of NCD targets would avert a cumulative (2015–2030) 14.9 million YLL (ie, 7.74, 2.2, 0.49 and 4.49 million YLL averted from CVD, respiratory diseases, diabetes and neoplasm, respectively). Compared with the trend mortality trajectories, the attainment of NCD targets would avert a cumulative (2015–2030) 12.16 million YLL (ie, 5.30, 0.92, 0.64 and 5.30 million YLL averted from CVD, respiratory diseases, diabetes and neoplasm, respectively).

Table 2 reports the projections for life expectancy, infant mortality, under-five mortality and probability of premature deaths (ie, between age 30–70) from NCDs. Male life expectancy at birth increases from 71.10 in 2015 to 73.47 and 74.38 years in 2030 under the trend and target scenario, respectively. Female life expectancy at birth increases from 73.68 years in 2015 to 75.34 and 76.39 in 2030 in the trend and target scenarios. Fulfilment

of SDG NCD mortality targets entail 2.63 and 1.96 year increases in life expectancy at age 30 for male and female population, respectively (ie, life expectancies at 30 in the target scenario: 43.79 years in 2015 vs 46.42 years in 2030 for men; and 46.36 years in 2015 vs 48.32 years in 2030 for women). The projections show declining trends for infant and child mortality in both trend and target scenarios. Since the drivers of infant and child mortality are primarily CMPN diseases, the magnitudes of reduction are similar in the trend and target scenarios. Large reductions in the probabilities of premature deaths (ie, between age 30–70) are projected in both scenarios, and the reduction is much larger in the target scenario. The probability of death for men between age 30–70 from any of four major NCDs decreases from 219 per 1000 people in 2015 to 198 and 153 per 1000 people in 2030 in the trend and target scenarios, respectively. The probability of premature death for women from four major NCDs decreases from 199 per 1000 people in 2015 to 186 and 138 per 1000 people in 2030 in the trend and target scenarios, respectively. For the target scenario, these entail an overall 30% reduction in the probability of premature deaths from four major NCDs.

DISCUSSION

The cohort-component model in this study projects the demographic outlook of a population using a systems-dynamic process determined by inter-relationships between population determinants, including those affected by policy actions.^{2 17 29} The strengths of this

Table 1 Number of deaths and deaths averted from four major NCDs

| | Deaths and deaths averted in 2025 | | | Deaths and deaths averted in 2030 | | | Cumulative number of deaths and deaths averted: 2015–2030 | | |
|--|-----------------------------------|---------|---------|-----------------------------------|---------|---------|---|-----------|-----------|
| | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| Cardiovascular diseases | | | | | | | | | |
| Number of deaths | | | | | | | | | |
| Status quo | 189 239 | 185 322 | 374 561 | 212 078 | 201 626 | 413 704 | 2 790 691 | 2 701 365 | 5 492 056 |
| Trend | 178 532 | 178 423 | 356 955 | 197 107 | 191 310 | 388 417 | 2 667 253 | 2 621 899 | 5 289 152 |
| NCD target | 165 118 | 168 569 | 333 687 | 174 039 | 173 421 | 347 460 | 2 505 477 | 2 502 029 | 5 007 506 |
| Deaths averted in NCD target scenario | | | | | | | | | |
| Compared with status quo | 24 121 | 16 753 | 40 874 | 38 039 | 28 205 | 66 244 | 285 214 | 199 336 | 484 550 |
| Compared with trend | 13 414 | 9854 | 23 268 | 23 068 | 17 889 | 40 957 | 161 776 | 119 870 | 281 646 |
| Respiratory diseases | | | | | | | | | |
| Number of deaths | | | | | | | | | |
| Status quo | 67 761 | 52 218 | 119 980 | 75 691 | 56 609 | 132 300 | 998 798 | 761 490 | 1 760 288 |
| Trend | 60 586 | 49 204 | 109 789 | 64 545 | 51 640 | 116 185 | 914 259 | 725 901 | 1 640 160 |
| NCD target | 58 953 | 46 487 | 105 439 | 61 818 | 46 678 | 108 496 | 894 714 | 692 819 | 1 587 533 |
| Deaths averted in NCD target scenario | | | | | | | | | |
| Compared with status quo | 8809 | 5732 | 14 540 | 13 873 | 9931 | 23 804 | 104 084 | 68 670 | 172 755 |
| Compared with trend | 1633 | 2717 | 4350 | 2727 | 4962 | 7689 | 19 545 | 33 082 | 52 627 |
| Diabetes | | | | | | | | | |
| Number of deaths | | | | | | | | | |
| Status quo | 16 036 | 24 649 | 40 685 | 17 809 | 26 248 | 44 056 | 236 911 | 360 091 | 597 002 |
| Trend | 15 686 | 25 412 | 41 097 | 17 613 | 28 072 | 45 685 | 233 429 | 370 221 | 603 650 |
| NCD target | 14 858 | 23 602 | 38 460 | 16 199 | 24 798 | 40 997 | 223 476 | 348 223 | 571 698 |
| Deaths averted in NCD target scenario | | | | | | | | | |
| Compared with status quo | 1178 | 1047 | 2225 | 1610 | 1450 | 3060 | 13 436 | 11 868 | 25 303 |
| Compared with trend | 828 | 1809 | 2637 | 1414 | 3274 | 4689 | 9954 | 21 998 | 31 952 |
| Neoplasm | | | | | | | | | |
| Number of deaths | | | | | | | | | |
| Status quo | 75 367 | 63 763 | 139 129 | 83 959 | 72 006 | 155 965 | 1 116 473 | 937 279 | 2 053 752 |
| Trend | 75 386 | 64 846 | 140 232 | 85 322 | 74 376 | 159 698 | 1 119 111 | 951 193 | 2 070 304 |
| NCD target | 67 086 | 54 086 | 121 172 | 71 225 | 55 565 | 126 789 | 1 019 066 | 820 728 | 1 839 794 |
| Deaths averted in NCD target scenario | | | | | | | | | |
| Compared with status quo | 8281 | 9676 | 17 957 | 12 735 | 16 441 | 29 176 | 97 407 | 116 551 | 213 958 |
| Compared with trend | 8300 | 10 759 | 19 060 | 14 098 | 18 811 | 32 909 | 100 045 | 130 465 | 230 510 |

Calculations derived from the model.
NCD, non-communicable disease.

model are several. First, it is replicable as it uses established principles about the dynamics of the population process. Second, it can produce consistent and comparable cross-country estimates that are easy to update using country data across multiple countries. Third, it can provide focused estimates for target groups of interest because it tracks population outcomes at a highly disaggregated level. In the same vein, the model can be flexibly adapted to the intended disaggregation schemes (eg, more aggregate) of population cohorts and disease categories; Finally, the model outcomes can be potentially linked to other dynamic inputs related to health systems, education, the environment, housing and city

planning, infrastructure, energy and utility and alike.²⁹ The main contribution of the model used in this study is in estimating the expected demographic shifts associated with different disease-specific mortality trajectories. The resulting estimates inform the effects of proposed NCD control targets, linking the number of deaths averted by achieving these targets to demographic shifts in the population.²⁹

The model in this study has several limitations. The cohort-component method does not explicitly incorporate socio-economic determinants of population change. The evolution of fertility, mortality and migration over time are not endogenously determined; the respective

**Table 2** Life expectancy, infant mortality rate, under-five mortality, probability of dying age 0–70

| | 2015 | 2020 | 2025 | 2030 | 2015 | 2020 | 2025 | 2030 |
|---|-------|-------|-------|-------|--------|-------|-------|-------|
| | Male | | | | Female | | | |
| Life expectancy at birth | | | | | | | | |
| Status quo | 71.10 | 71.10 | 71.10 | 71.10 | 73.68 | 73.68 | 73.68 | 73.68 |
| Trend | 71.10 | 71.86 | 72.65 | 73.47 | 73.68 | 74.23 | 74.78 | 75.34 |
| NCD target | 71.10 | 72.14 | 73.23 | 74.38 | 73.68 | 74.56 | 75.46 | 76.39 |
| Life expectancy at age 30 | | | | | | | | |
| Status quo | 43.79 | 43.79 | 43.79 | 43.79 | 46.36 | 46.36 | 46.36 | 46.36 |
| Trend | 43.79 | 44.33 | 44.89 | 45.48 | 46.36 | 46.65 | 46.95 | 47.25 |
| NCD target | 43.79 | 44.62 | 45.49 | 46.42 | 46.36 | 47 | 47.65 | 48.32 |
| Life expectancy at age 65 | | | | | | | | |
| Status quo | 14.56 | 14.56 | 14.56 | 14.56 | 15.87 | 15.87 | 15.87 | 15.87 |
| Trend | 14.56 | 14.87 | 15.20 | 15.55 | 15.87 | 16.02 | 16.18 | 16.34 |
| NCD target | 14.56 | 14.95 | 15.36 | 15.79 | 15.87 | 16.12 | 16.37 | 16.63 |
| Infant mortality rate | | | | | | | | |
| Status quo | 31.24 | 31.24 | 31.24 | 31.24 | 27.79 | 27.79 | 27.79 | 27.79 |
| Trend | 31.24 | 27.88 | 24.52 | 21.14 | 27.79 | 24.79 | 21.78 | 18.77 |
| NCD target | 31.24 | 27.88 | 24.52 | 21.14 | 27.79 | 24.79 | 21.78 | 18.77 |
| Under-five mortality rate | | | | | | | | |
| Status quo | 38.16 | 38.16 | 38.16 | 38.16 | 34.54 | 34.54 | 34.54 | 34.54 |
| Trend | 38.16 | 34.05 | 29.92 | 25.79 | 34.54 | 30.81 | 27.06 | 23.31 |
| NCD target | 38.16 | 34.05 | 29.92 | 25.79 | 34.54 | 30.81 | 27.06 | 23.31 |
| Probability of dying between age 30–70 from any of CVDs, respiratory diseases, diabetes and cancer (per 1000 people) | | | | | | | | |
| Status quo | 219 | 219 | 219 | 219 | 199.3 | 199.3 | 199.3 | 199.3 |
| Trend | 219 | 211.9 | 204.8 | 197.6 | 199.3 | 194.9 | 190.4 | 186 |
| NCD target | 219 | 197.5 | 175.3 | 152.6 | 199.3 | 179.5 | 159.2 | 138.3 |
| Probability of dying between age 30–70 from CVDs (per 1000 people) | | | | | | | | |
| Status quo | 130.7 | 130.7 | 130.7 | 130.7 | 110.6 | 110.6 | 110.6 | 110.6 |
| Trend | 130.7 | 126.2 | 121.8 | 117.3 | 110.6 | 106.6 | 102.5 | 98.5 |
| NCD target | 130.7 | 117.2 | 103.5 | 89.6 | 110.6 | 99.1 | 87.4 | 75.5 |
| Probability of dying between age 30–70 from respiratory diseases (per 1000 people) | | | | | | | | |
| Status quo | 36.9 | 36.9 | 36.9 | 36.9 | 31.1 | 31.1 | 31.1 | 31.1 |
| Trend | 36.9 | 34.3 | 31.7 | 29.1 | 31.1 | 30 | 28.9 | 27.8 |
| NCD target | 36.9 | 32.9 | 28.9 | 24.9 | 31.1 | 27.7 | 24.3 | 20.9 |
| Probability of dying between age 30–70 from diabetes (per 1000 people) | | | | | | | | |
| Status quo | 7.8 | 7.8 | 7.8 | 7.8 | 12 | 12 | 12 | 12 |
| Trend | 7.8 | 7.6 | 7.4 | 7.2 | 12 | 12.1 | 12.2 | 12.4 |
| NCD target | 7.8 | 7 | 6.1 | 5.3 | 12 | 10.7 | 9.3 | 8 |
| Probability of dying between age 30–70 from neoplasms (per 1000 people) | | | | | | | | |
| Status quo | 59.7 | 59.7 | 59.7 | 59.7 | 59.5 | 59.5 | 59.5 | 59.5 |
| Trend | 59.7 | 58.8 | 57.9 | 57 | 59.5 | 59.6 | 59.6 | 59.6 |
| NCD target | 59.7 | 53.3 | 46.9 | 40.4 | 59.5 | 53.2 | 46.8 | 40.3 |

Calculations derived from the model.

CVD, cardiovascular disease; NCD, non-communicable disease.

trajectories are set exogenously using informed assumptions. To that effect, the model outcomes are projections based on a set of assumptions about trajectories of mortality, fertility and migration. The objective is

not to make a perfect prediction of the future, but to assess comparative differences in population trajectories resulting from different health policy scenarios, keeping other input assumptions constant. Therefore, the model

outcomes should not be interpreted as a perfect forecast but are based on conditional calculations showing what the future population would be if a particular set of reasonable assumptions were to hold true. Using similar assumptions but different approach, a global study by Cao *et al* quantified the potential gains in average expected life-years lived between 30 years and 70 years of age worldwide should the SDG target of a one-third reduction in premature mortality from the four major NCDs be achieved, as well as the maximum gains if all premature mortalities from these diseases were eliminated.³⁰ While the model in our paper captures differences in mortality scenarios, it does not capture the extent of disabilities averted from attaining the targets. Also, the scenarios do not consider the mortality implications of the recent COVID-19 pandemic in Bangladesh.

The model generates the evolution of annual cohorts and population structure during 2015–2030 using demographic indicators for Bangladesh that are consistent with those offered by international agencies.^{3–5} For instance, while the model replicates the baseline (2015) demographic indicators as reported in UN population projections, the population shares in 2030 for the 0–14, 15–64 and 65 and above years old age-groups in the UN medium variant projections versus the model trend projections compare as follow: 22.9 versus 23.8; 69.7 versus 68.8; and 7.4 versus 7.4, respectively. This model captures dynamic population outflows based on deaths from disaggregated disease categories, allowing comparison between disease-specific mortality scenarios. We estimated that by attaining NCD targets in compliance with SDG 2030 goals, people in Bangladesh will live longer by more than 3 years on average (3.28 and 2.71 years for men and women, respectively). Over the 15-year analysis period, a cumulative 1.73 million all-cause deaths (99 600 men and 73 600 women) and 584 000 all-cause deaths (284 000 men and 300 000 women) would be averted in the NCD target scenario compared with the status quo and trend scenarios, respectively. In the target scenario, the cumulative number of deaths averted from the four major NCDs are projected to be 896 000 (500 000 men and 396 000 women) and 597 000 (291 000 men and 305 000 women), compared with the status quo and trend scenarios, respectively. These estimates inform the potential benefits as well as trade-offs in health and demographic outcomes associated with accomplishing current NCD targets.

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Supplementary Table S1: Mapping of disease categories

| Broad groups | WHO GHE Code | GHE Cause name* |
|--|--|--|
| Communicable, maternal, perinatal and nutritional conditions | I.A. Infectious and parasitic diseases | (1-12): Tuberculosis; STDs excluding HIV; HIV/AIDS; Diarrhoeal diseases; Childhood-cluster diseases; Meningitis; Encephalitis; Hepatitis; Parasitic and vector diseases; Intestinal nematode infections; Leprosy; Other infectious diseases |
| | I.B. Respiratory Infectious | (1-3): Lower respiratory infections; Upper respiratory infections; Otitis media |
| | I.C. Maternal conditions | |
| | I.D. Neonatal conditions | (1-4): Preterm birth complications; Birth asphyxia and birth trauma; Neonatal sepsis and infections; Other neonatal conditions |
| | I.E. Nutritional deficiencies | (1-5): Protein-energy malnutrition; Iodine deficiency; Vitamin A deficiency; Iron-deficiency anaemia; Other nutritional deficiencies |
| Neoplasms | II.A. Malignant neoplasms | (1-24): Mouth and oropharynx cancers; Oesophagus cancer; Stomach cancer; Colon and rectum cancers; Liver cancer; Pancreas cancer; Trachea, bronchus, lung cancers; Melanoma and other skin cancers; Breast cancer; Cervix uteri cancer; Corpus uteri cancer; Ovary cancer; Prostate cancer; Testicular cancer; Kidney cancer; Bladder cancer; Brain and nervous system cancers; Gallbladder and biliary tract cancer; Larynx cancer; Thyroid cancer; Mesothelioma; Lymphomas, multiple myeloma; Leukaemia; Other malignant neoplasms |
| | II.B. Other neoplasms | |
| Diabetes | II.C. Diabetes mellitus | |
| Cardiovascular diseases | II. H. Cardiovascular diseases | (1-6): Rheumatic heart disease; Hypertensive heart disease; Ischaemic heart disease; Stroke; Cardiomyopathy, myocarditis, endocarditis; Other circulatory diseases |
| Respiratory diseases | II.I. Respiratory diseases | (1-3): Chronic obstructive pulmonary disease; Asthma; Other respiratory diseases |
| Other NCDs and Injuries | II.D. Endocrine, blood, immune disorders | (1-4): Thalassaemias; Sickle cell disorders and trait; Other haemoglobinopathies and haemolytic anaemias; Other endocrine, blood and immune disorders |
| | II.E. Mental and substance use disorders | (1-11): Depressive disorders; Bipolar disorder; Schizophrenia; Alcohol use disorders; Drug use disorders; Anxiety disorders; Eating disorders; Autism and Asperger syndrome; Childhood behavioural disorders; Idiopathic intellectual disability; Other mental and behavioural disorders |
| | II.F. Neurological conditions | (1-7): Alzheimer disease and other dementias; Parkinson disease; Epilepsy; Multiple sclerosis; Migraine; Non-migraine headache; Other neurological conditions |
| | II. J. Digestive diseases | (1-9): Peptic ulcer disease; Cirrhosis of the liver; Appendicitis; Gastritis and duodenitis; Paralytic ileus and intestinal obstruction; Inflammatory bowel disease; Gallbladder and biliary diseases; Pancreatitis; Other digestive diseases |
| | II.K. Genitourinary diseases | (1-6): Kidney diseases; Benign prostatic hyperplasia; Urolithiasis; Other urinary diseases; Infertility; Gynecological diseases |
| | II.L. Skin diseases | |
| | II.M. Musculoskeletal diseases | (1-5): Rheumatoid arthritis; Osteoarthritis; Gout; Back and neck pain; Other musculoskeletal disorders |
| | II.N. Congenital anomalies | (1-6): Neural tube defects; Cleft lip and cleft palate; Down syndrome; Congenital heart anomalies; Other chromosomal anomalies; Other congenital anomalies |
| | II.O: Oral conditions | |
| | II.P. Sudden infant death syndrome | |
| | III.A. Unintentional injuries | (1-8): Road injury; Poisonings; Falls; Fire, heat and hot substances; Drowning Exposure to mechanical forces; Natural disasters; Other unintentional injuries |
| | III.B. Intentional injuries | (1-3): Self-harm; Interpersonal violence; Collective violence and legal intervention |

Note: * See Annex Table A in: World Health Organization. (2018). WHO methods and data sources for global burden of disease estimates 2000-2016. *Global Health Estimates Technical Paper WHO/HIS/IER/GHE/2018.4*, WHO, Geneva.

Supplementary Table S2: Demographic Indicators

| Indicators | Description |
|---|---|
| Annual population | Annual population by sex and annual cohorts (age 0 – 100+), by age-groups |
| Annual population age structure | Population and share of total population by five-year age groups – by sex; Five-year age-groups: age 0 – 4, age 5 – 9, age 10 – 14, age 15 – 19, age 20 – 24, age 25 – 29, age 30 – 34, age 35 – 39, age 40 – 44, age 45 – 49, age 50 – 54, age 55 – 59, age 60 – 64, age 65 and above. |
| Total, child, and old-age dependency ratios | (i) Total Dependency Ratio ((Age 0-14 + Age 65+) / Age 15-64); (ii) Total Dependency Ratio ((Age 0-19 + Age 65+) / Age 20-64); (iii) Child Dependency Ratio (Age 0-14 / Age 15-64); (iv) Child Dependency Ratio (Age 0-19 / Age 20-64); (v) Old-Age Dependency Ratio (Age 65+ / Age 15-64); (vi) Old-Age Dependency Ratio (Age 65+ / Age 20-64) |
| Number of births | Annual number of births by sex |
| Crude birth rate | Average annual number of births per 1,000 population. |
| Age-specific fertility rate | Number of births to women in a particular age group, divided by the number of women in that age group. The age groups used are: 15-19, 20-24, ..., 45-49. |
| Total fertility | The average number of live births a cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as live births per woman. |
| Net reproduction rate | The average number of daughters a cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates and the mortality rates of a given period. It is expressed as number of daughters per woman. |
| Rate of natural population increase | The difference between the number of live births and the number of deaths occurring in a year, divided by the population of that year, multiplied by a factor (usually 1,000). It is equal to the difference between the crude birth rate and the crude death rate. |
| Crude death rate | Average annual number of deaths per 1,000 population. |
| Number of deaths | Total annual number of deaths, by sex and annual cohorts. |
| Death rate or mortality rate | A measure of the number of deaths (in general, or due to a specific cause) in a population, scaled to the size of that population, per unit of time (e.g. the number of deaths per one thousand people per year). |
| Deaths by diseases | Total annual number of deaths; by sex and annual cohorts; by six broad disease categories: communicable, maternal, perinatal and nutritional conditions; neoplasms; diabetes; cardiovascular diseases; respiratory diseases; other noncommunicable diseases and injuries. |
| Infant mortality rate | Probability of dying between birth and exact age 1; expressed as average annual deaths per 1,000 births. |
| Under-five mortality rate | Probability of dying between birth and age 5; expressed as average annual deaths per 1,000 births. |
| Probabilities of dying between age 30 to 70 from major NCDs | Per 1000 of 30-year-old-people who would die before their 70th birthday from any of cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that s/he would experience current mortality rates at every age and s/he would not die from any other cause of death. |
| Life expectancy at birth | The average number of years that a newborn could expect to live if he or she were to pass through life exposed to the sex- and age-specific death rates prevailing at the time of his or her birth, for a specific year, in a given country. |
| Life expectancy at age 'x' years | The average number of years that a person of 'x' years of age could expect to live if exposed to the sex- and age-specific death rates prevailing at the time of his/her X_{th} birthday |
| Crude net migration rate: | The ratio of net migration during the year to the average population in that year. The value is expressed per 1 000 inhabitants. |
| Total net migration | Number of migrants, that is, the number of immigrants minus the number of emigrants. |
| Years of lives lost | The years of potential life lost due to premature deaths calculated by summing up number of deaths at each age multiplied by life expectancy at the age at which death occurs |

Source: United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision.

Supplementary Table S3: Baseline data for 2015

| Age | Fertility rate | | Death rate: Total | | Death rate: CMPN | | Death rate: CVD | | Death rate: DBT | | Death rate: RSP | | Death rate: NPL | | Death rate: OTH | | Net migration rate | |
|---------------|----------------|---------|-------------------|--------|------------------|--------|-----------------|--------|-----------------|-------|-----------------|--------|-----------------|-------|-----------------|--------|--------------------|-------|
| | Per 1000 women | | Per 1000 people | | | | | | | | | | | | | | | |
| | Data | Calib.* | M** | F** | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| < 1 years | | | 31.74 | 28.18 | 24.92 | 22.13 | 0.12 | 0.11 | 0.01 | 0.01 | 0.06 | 0.10 | 0.31 | 0.33 | 6.34 | 5.50 | 0.00 | 0.00 |
| 1 – 4 years | | | 1.73 | 1.69 | 1.36 | 1.33 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 0.35 | 0.33 | 0.00 | 0.00 |
| 5 - 9 years | | | 0.55 | 0.66 | 0.20 | 0.35 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 0.30 | 0.25 | 0.29 | 0.16 |
| 10 – 14 years | | | 0.53 | 0.52 | 0.20 | 0.27 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 | 0.29 | 0.20 | 0.83 | 0.20 |
| 15 - 19 years | 75 | 77 | 0.83 | 0.86 | 0.16 | 0.30 | 0.07 | 0.08 | 0.00 | 0.01 | 0.01 | 0.03 | 0.05 | 0.06 | 0.53 | 0.38 | -6.17 | -0.24 |
| 20 – 24 years | 137 | 140 | 0.94 | 0.88 | 0.18 | 0.31 | 0.08 | 0.08 | 0.00 | 0.01 | 0.02 | 0.03 | 0.06 | 0.06 | 0.61 | 0.39 | -16.49 | -0.54 |
| 25 – 29 years | 105 | 105 | 1.06 | 1.06 | 0.20 | 0.37 | 0.09 | 0.10 | 0.00 | 0.01 | 0.02 | 0.04 | 0.07 | 0.08 | 0.68 | 0.47 | -11.70 | -0.19 |
| 30 - 34 years | 56 | 56 | 1.33 | 1.30 | 0.31 | 0.25 | 0.34 | 0.28 | 0.02 | 0.03 | 0.05 | 0.06 | 0.21 | 0.41 | 0.41 | 0.26 | -7.46 | -0.19 |
| 35 - 39 years | 25 | 25 | 1.79 | 1.65 | 0.41 | 0.32 | 0.45 | 0.36 | 0.02 | 0.04 | 0.06 | 0.08 | 0.28 | 0.52 | 0.56 | 0.33 | -6.12 | 0.01 |
| 40 - 44 years | 9 | 9 | 2.81 | 2.09 | 0.65 | 0.41 | 0.71 | 0.45 | 0.03 | 0.05 | 0.10 | 0.10 | 0.44 | 0.66 | 0.88 | 0.41 | -3.63 | 0.16 |
| 45 - 49 years | 3 | 3 | 4.53 | 2.76 | 1.04 | 0.54 | 1.15 | 0.60 | 0.05 | 0.07 | 0.16 | 0.13 | 0.72 | 0.88 | 1.41 | 0.54 | -1.74 | 0.16 |
| 50 – 54 years | | | 8.33 | 5.01 | 1.58 | 0.51 | 2.84 | 1.55 | 0.12 | 0.16 | 0.56 | 0.37 | 1.61 | 1.71 | 1.60 | 0.72 | -0.34 | 0.14 |
| 55 – 59 years | | | 11.39 | 8.29 | 2.17 | 0.84 | 3.89 | 2.56 | 0.17 | 0.26 | 0.77 | 0.62 | 2.21 | 2.83 | 2.19 | 1.19 | -0.13 | 0.12 |
| 60 – 64 years | | | 22.99 | 16.37 | 4.13 | 1.54 | 8.92 | 7.55 | 0.55 | 0.77 | 2.79 | 2.12 | 3.28 | 2.26 | 3.32 | 2.13 | -0.04 | 0.07 |
| 65 – 69 years | | | 27.91 | 24.38 | 5.01 | 2.30 | 10.83 | 11.25 | 0.67 | 1.14 | 3.38 | 3.15 | 3.98 | 3.37 | 4.03 | 3.17 | 0.21 | 0.06 |
| 70 – 74 years | | | 56.59 | 45.38 | 12.57 | 7.03 | 18.84 | 20.16 | 2.22 | 3.09 | 8.94 | 5.87 | 5.80 | 2.27 | 8.22 | 6.96 | 0.21 | 0.06 |
| 75 – 79 years | | | 60.00 | 46.35 | 13.33 | 7.18 | 19.97 | 20.59 | 2.36 | 3.16 | 9.48 | 6.00 | 6.14 | 2.31 | 8.72 | 7.11 | 0.21 | 0.06 |
| 80 – 84 years | | | 90.37 | 71.99 | 20.07 | 11.16 | 30.08 | 31.98 | 3.55 | 4.90 | 14.28 | 9.32 | 9.25 | 3.59 | 13.13 | 11.04 | 0.21 | 0.06 |
| 85 year | | | 151.53 | 125.05 | 33.66 | 19.38 | 50.44 | 55.55 | 5.95 | 8.52 | 23.94 | 16.18 | 15.52 | 6.24 | 22.02 | 19.17 | 0.21 | 0.06 |
| 90 year | | | 434.35 | 416.70 | 96.49 | 64.59 | 144.59 | 185.11 | 17.05 | 28.38 | 68.63 | 53.92 | 44.48 | 20.81 | 63.12 | 63.89 | 0.21 | 0.06 |
| 95 year | | | 717.18 | 708.35 | 159.31 | 109.79 | 238.73 | 314.67 | 28.16 | 48.25 | 113.32 | 91.67 | 73.45 | 35.37 | 104.22 | 108.60 | 0.21 | 0.06 |
| 100 and above | | | 1000 | 1000 | 222.1 | 155.00 | 332.88 | 444.24 | 39.26 | 68.12 | 158.00 | 129.41 | 102.41 | 49.93 | 145.31 | 153.32 | 0.21 | 0.06 |

Note: * 2015 age-group specific fertility data obtained from the Bangladesh Bureau of Statistics produced total fertility rate of 2.05; the data has been calibrated up to produce a total fertility rate of 2.10 for 2015. ** M: Male; F: Female. The numbers are rounded to two decimal points.

Supplementary Table S4: The scale factors ($I_{s,A,d,t}^{\delta}$) for the 'trend' and 'NCD target' mortality rate trajectories

| Age | Scenario | Male | | | Female | | | Male | | | Female | | |
|-----------|----------|--|-------|-------|--------|-------|-------|-------------------------|-------|-------|--------|-------|-------|
| | | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 |
| | | Infectious, Maternal, Perinatal, Nutritional | | | | | | Cardiovascular Disease | | | | | |
| Age 0-4 | Trend | 1.000 | 0.869 | 0.608 | 1.000 | 0.867 | 0.602 | 1.000 | 0.955 | 0.866 | 1.000 | 0.931 | 0.794 |
| | Target | 1.000 | 0.869 | 0.608 | 1.000 | 0.867 | 0.602 | 1.000 | 0.955 | 0.866 | 1.000 | 0.931 | 0.794 |
| Age 5-14 | Trend | 1.000 | 0.849 | 0.547 | 1.000 | 0.848 | 0.544 | 1.000 | 0.972 | 0.915 | 1.000 | 0.961 | 0.882 |
| | Target | 1.000 | 0.849 | 0.547 | 1.000 | 0.848 | 0.544 | 1.000 | 0.972 | 0.915 | 1.000 | 0.961 | 0.882 |
| Age 15-29 | Trend | 1.000 | 0.842 | 0.526 | 1.000 | 0.850 | 0.549 | 1.000 | 0.924 | 0.771 | 1.000 | 0.929 | 0.788 |
| | Target | 1.000 | 0.842 | 0.526 | 1.000 | 0.850 | 0.549 | 1.000 | 0.924 | 0.771 | 1.000 | 0.929 | 0.788 |
| Age 30-49 | Trend | 1.000 | 0.842 | 0.525 | 1.000 | 0.848 | 0.544 | 1.000 | 0.948 | 0.845 | 1.000 | 0.940 | 0.821 |
| | Target | 1.000 | 0.842 | 0.525 | 1.000 | 0.848 | 0.544 | 1.000 | 0.948 | 0.670 | 1.000 | 0.940 | 0.670 |
| Age 50-69 | Trend | 1.000 | 0.871 | 0.612 | 1.000 | 0.889 | 0.666 | 1.000 | 0.965 | 0.895 | 1.000 | 0.963 | 0.889 |
| | Target | 1.000 | 0.871 | 0.612 | 1.000 | 0.889 | 0.666 | 1.000 | 0.965 | 0.670 | 1.000 | 0.963 | 0.670 |
| Age 70+ | Trend | 1.000 | 0.923 | 0.769 | 1.000 | 0.931 | 0.792 | 1.000 | 0.963 | 0.888 | 1.000 | 0.989 | 0.966 |
| | Target | 1.000 | 0.923 | 0.769 | 1.000 | 0.931 | 0.792 | 1.000 | 0.963 | 0.888 | 1.000 | 0.989 | 0.966 |
| | | Respiratory Disease | | | | | | Neoplasm | | | | | |
| Age 0-4 | Trend | 1.000 | 0.947 | 0.842 | 1.000 | 0.915 | 0.746 | 1.000 | 1.040 | 1.119 | 1.000 | 1.036 | 1.107 |
| | Target | 1.000 | 0.947 | 0.842 | 1.000 | 0.915 | 0.746 | 1.000 | 1.040 | 1.119 | 1.000 | 1.036 | 1.107 |
| Age 5-14 | Trend | 1.000 | 0.954 | 0.863 | 1.000 | 0.932 | 0.797 | 1.000 | 0.987 | 0.960 | 1.000 | 0.992 | 0.975 |
| | Target | 1.000 | 0.954 | 0.863 | 1.000 | 0.932 | 0.797 | 1.000 | 0.987 | 0.960 | 1.000 | 0.992 | 0.975 |
| Age 15-29 | Trend | 1.000 | 0.912 | 0.737 | 1.000 | 0.918 | 0.755 | 1.000 | 0.989 | 0.967 | 1.000 | 0.987 | 0.960 |
| | Target | 1.000 | 0.912 | 0.737 | 1.000 | 0.918 | 0.755 | 1.000 | 0.989 | 0.967 | 1.000 | 0.987 | 0.960 |
| Age 30-49 | Trend | 1.000 | 0.910 | 0.731 | 1.000 | 0.945 | 0.836 | 1.000 | 0.983 | 0.950 | 1.000 | 1.005 | 1.014 |
| | Target | 1.000 | 0.910 | 0.670 | 1.000 | 0.945 | 0.670 | 1.000 | 0.983 | 0.670 | 1.000 | 1.005 | 0.670 |
| Age 50-69 | Trend | 1.000 | 0.929 | 0.788 | 1.000 | 0.966 | 0.897 | 1.000 | 0.984 | 0.953 | 1.000 | 0.999 | 0.998 |
| | Target | 1.000 | 0.929 | 0.670 | 1.000 | 0.966 | 0.670 | 1.000 | 0.984 | 0.670 | 1.000 | 0.999 | 0.670 |
| Age 70+ | Trend | 1.000 | 0.940 | 0.820 | 1.000 | 0.969 | 0.907 | 1.000 | 1.004 | 1.012 | 1.000 | 1.029 | 1.086 |
| | Target | 1.000 | 0.940 | 0.820 | 1.000 | 0.969 | 0.907 | 1.000 | 1.004 | 1.012 | 1.000 | 1.029 | 1.086 |
| | | Diabetes | | | | | | Other NCDs and Injuries | | | | | |
| Age 0-4 | Trend | 1.000 | 0.981 | 0.942 | 1.000 | 0.988 | 0.964 | 1.000 | 0.967 | 0.902 | 1.000 | 0.975 | 0.925 |
| | Target | 1.000 | 0.981 | 0.942 | 1.000 | 0.988 | 0.964 | 1.000 | 0.967 | 0.902 | 1.000 | 0.975 | 0.925 |
| Age 5-14 | Trend | 1.000 | 0.982 | 0.947 | 1.000 | 0.966 | 0.898 | 1.000 | 0.971 | 0.914 | 1.000 | 0.974 | 0.923 |
| | Target | 1.000 | 0.982 | 0.947 | 1.000 | 0.966 | 0.898 | 1.000 | 0.971 | 0.914 | 1.000 | 0.974 | 0.923 |
| Age 15-29 | Trend | 1.000 | 0.931 | 0.793 | 1.000 | 0.953 | 0.860 | 1.000 | 0.963 | 0.888 | 1.000 | 0.942 | 0.827 |
| | Target | 1.000 | 0.931 | 0.793 | 1.000 | 0.953 | 0.860 | 1.000 | 0.963 | 0.888 | 1.000 | 0.942 | 0.827 |
| Age 30-49 | Trend | 1.000 | 0.961 | 0.883 | 1.000 | 1.010 | 1.030 | 1.000 | 0.953 | 0.859 | 1.000 | 0.953 | 0.859 |
| | Target | 1.000 | 0.961 | 0.670 | 1.000 | 1.010 | 0.670 | 1.000 | 0.953 | 0.859 | 1.000 | 0.953 | 0.859 |
| Age 50-69 | Trend | 1.000 | 0.975 | 0.925 | 1.000 | 1.011 | 1.034 | 1.000 | 0.963 | 0.890 | 1.000 | 0.970 | 0.911 |
| | Target | 1.000 | 0.975 | 0.670 | 1.000 | 1.011 | 0.670 | 1.000 | 0.963 | 0.890 | 1.000 | 0.970 | 0.911 |
| Age 70+ | Trend | 1.000 | 0.979 | 0.936 | 1.000 | 1.010 | 1.031 | 1.000 | 0.975 | 0.926 | 1.000 | 0.987 | 0.961 |
| | Target | 1.000 | 0.979 | 0.936 | 1.000 | 1.010 | 1.031 | 1.000 | 0.975 | 0.926 | 1.000 | 0.987 | 0.961 |

Note: The 'trend' scenario adopts sex, age-group and disease-specific mortality rate trajectories based on the latest WHO GHE regional mortality projections 2016-2030 for 'Southern Asia' consisting of Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. (WHO 2020, Mathers 2006)22,23 The scale factors in both the trend and the NCD 2030 target scenarios are same until 2020 for all age groups and disease categories. For the period 2021-2030, the scale factors used in the NCD target scenarios differ from the trend scenario for the age groups 30-49 and 50-69 for cardiovascular diseases, neoplasm, diabetes, and respiratory disease.

Supplementary Table S5: Years of lives lost (YLL) and YLL averted

| | YLL and YLL averted in 2025 | | | YLL and YLL averted in 2030 | | | Cumulative number of YLL and YLL averted: 2015 - 2030 | | |
|---|-----------------------------|---------|---------|-----------------------------|---------|---------|---|----------|------------|
| | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| Cardiovascular Diseases | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 2628410 | 2395870 | 5024280 | 2996780 | 2853440 | 5850220 | 39431070 | 35694730 | 75,125,800 |
| <i>Trend</i> | 2538880 | 2280630 | 4819510 | 2866200 | 2661530 | 5527730 | 38364420 | 34307980 | 72,672,400 |
| <i>NCD target</i> | 2289050 | 2094930 | 4383980 | 2428830 | 2320920 | 4749750 | 35338430 | 32042630 | 67,381,060 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 339360 | 300940 | 640300 | 567950 | 532520 | 1100470 | 4092640 | 3652100 | 7,744,740 |
| <i>Compared to trend</i> | 249830 | 185700 | 435530 | 437370 | 340610 | 777980 | 3025990 | 2265350 | 5,291,340 |
| Respiratory Diseases | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 749096 | 664638 | 1413734 | 873661 | 789733 | 1663394 | 11252806 | 9933068 | 21,185,874 |
| <i>Trend</i> | 683002 | 625524 | 1308526 | 762576 | 723793 | 1486369 | 10449656 | 9458391 | 19,908,047 |
| <i>NCD target</i> | 657731 | 575196 | 1232927 | 718066 | 630902 | 1348968 | 10143973 | 8843957 | 18,987,930 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 91365 | 89442 | 180807 | 155595 | 158831 | 314426 | 1108833 | 1089111 | 2,197,944 |
| <i>Compared to trend</i> | 25271 | 50328 | 75599 | 44510 | 92891 | 137401 | 305683 | 614434 | 920,117 |
| Diabetes | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 175112 | 286897 | 462009 | 203287 | 341275 | 544562 | 2642602 | 4303544 | 6,946,146 |
| <i>Trend</i> | 175277 | 298383 | 473660 | 205832 | 364177 | 570009 | 2647001 | 4447344 | 7,094,345 |
| <i>NCD target</i> | 159998 | 260900 | 420898 | 179167 | 296554 | 475721 | 2462325 | 3991308 | 6,453,633 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 15114 | 25997 | 41111 | 24120 | 44721 | 68841 | 180277 | 312236 | 492,513 |
| <i>Compared to trend</i> | 15279 | 37483 | 52762 | 26665 | 67623 | 94288 | 184676 | 456036 | 640,712 |
| Neoplasm | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 1280430 | 1492110 | 2772540 | 1422430 | 1682870 | 3105300 | 19346850 | 22311220 | 41,658,070 |
| <i>Trend</i> | 1308030 | 1529450 | 2837480 | 1479230 | 1750120 | 3229350 | 19693330 | 22768490 | 42,461,820 |
| <i>NCD target</i> | 1136680 | 1263360 | 2400040 | 1185180 | 1288140 | 2473320 | 17621820 | 19542930 | 37,164,750 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 143750 | 228750 | 372500 | 237250 | 394730 | 631980 | 1725030 | 2768290 | 4,493,320 |
| <i>Compared to trend</i> | 171350 | 266090 | 437440 | 294050 | 461980 | 756030 | 2071510 | 3225560 | 5,297,070 |

Note: Calculations derived from the model.

Supplementary Table S1: Mapping of disease categories

| Broad groups | WHO GHE Code | GHE Cause name* |
|--|--|--|
| Communicable, maternal, perinatal and nutritional conditions | I.A. Infectious and parasitic diseases | (1-12): Tuberculosis; STDs excluding HIV; HIV/AIDS; Diarrhoeal diseases; Childhood-cluster diseases; Meningitis; Encephalitis; Hepatitis; Parasitic and vector diseases; Intestinal nematode infections; Leprosy; Other infectious diseases |
| | I.B. Respiratory Infectious | (1-3): Lower respiratory infections; Upper respiratory infections; Otitis media |
| | I.C. Maternal conditions | |
| | I.D. Neonatal conditions | (1-4): Preterm birth complications; Birth asphyxia and birth trauma; Neonatal sepsis and infections; Other neonatal conditions |
| | I.E. Nutritional deficiencies | (1-5): Protein-energy malnutrition; Iodine deficiency; Vitamin A deficiency; Iron-deficiency anaemia; Other nutritional deficiencies |
| Neoplasms | II.A. Malignant neoplasms | (1-24): Mouth and oropharynx cancers; Oesophagus cancer; Stomach cancer; Colon and rectum cancers; Liver cancer; Pancreas cancer; Trachea, bronchus, lung cancers; Melanoma and other skin cancers; Breast cancer; Cervix uteri cancer; Corpus uteri cancer; Ovary cancer; Prostate cancer; Testicular cancer; Kidney cancer; Bladder cancer; Brain and nervous system cancers; Gallbladder and biliary tract cancer; Larynx cancer; Thyroid cancer; Mesothelioma; Lymphomas, multiple myeloma; Leukaemia; Other malignant neoplasms |
| | II.B. Other neoplasms | |
| Diabetes | II.C. Diabetes mellitus | |
| Cardiovascular diseases | II. H. Cardiovascular diseases | (1-6): Rheumatic heart disease; Hypertensive heart disease; Ischaemic heart disease; Stroke; Cardiomyopathy, myocarditis, endocarditis; Other circulatory diseases |
| Respiratory diseases | II.I. Respiratory diseases | (1-3): Chronic obstructive pulmonary disease; Asthma; Other respiratory diseases |
| Other NCDs and Injuries | II.D. Endocrine, blood, immune disorders | (1-4): Thalassaemias; Sickle cell disorders and trait; Other haemoglobinopathies and haemolytic anaemias; Other endocrine, blood and immune disorders |
| | II.E. Mental and substance use disorders | (1-11): Depressive disorders; Bipolar disorder; Schizophrenia; Alcohol use disorders; Drug use disorders; Anxiety disorders; Eating disorders; Autism and Asperger syndrome; Childhood behavioural disorders; Idiopathic intellectual disability; Other mental and behavioural disorders |
| | II.F. Neurological conditions | (1-7): Alzheimer disease and other dementias; Parkinson disease; Epilepsy; Multiple sclerosis; Migraine; Non-migraine headache; Other neurological conditions |
| | II. J. Digestive diseases | (1-9): Peptic ulcer disease; Cirrhosis of the liver; Appendicitis; Gastritis and duodenitis; Paralytic ileus and intestinal obstruction; Inflammatory bowel disease; Gallbladder and biliary diseases; Pancreatitis; Other digestive diseases |
| | II.K. Genitourinary diseases | (1-6): Kidney diseases; Benign prostatic hyperplasia; Urolithiasis; Other urinary diseases; Infertility; Gynecological diseases |
| | II.L. Skin diseases | |
| | II.M. Musculoskeletal diseases | (1-5): Rheumatoid arthritis; Osteoarthritis; Gout; Back and neck pain; Other musculoskeletal disorders |
| | II.N. Congenital anomalies | (1-6): Neural tube defects; Cleft lip and cleft palate; Down syndrome; Congenital heart anomalies; Other chromosomal anomalies; Other congenital anomalies |
| | II.O: Oral conditions | |
| | II.P. Sudden infant death syndrome | |
| | III.A. Unintentional injuries | (1-8): Road injury; Poisonings; Falls; Fire, heat and hot substances; Drowning Exposure to mechanical forces; Natural disasters; Other unintentional injuries |
| | III.B. Intentional injuries | (1-3): Self-harm; Interpersonal violence; Collective violence and legal intervention |

Note: * See Annex Table A in: World Health Organization. (2018). WHO methods and data sources for global burden of disease estimates 2000-2016. *Global Health Estimates Technical Paper WHO/HIS/IER/GHE/2018.4*, WHO, Geneva.

Supplementary Table S2: Demographic Indicators

| Indicators | Description |
|---|---|
| Annual population | Annual population by sex and annual cohorts (age 0 – 100+), by age-groups |
| Annual population age structure | Population and share of total population by five-year age groups – by sex; Five-year age-groups: age 0 – 4, age 5 – 9, age 10 – 14, age 15 – 19, age 20 – 24, age 25 – 29, age 30 – 34, age 35 – 39, age 40 – 44, age 45 – 49, age 50 – 54, age 55 – 59, age 60 – 64, age 65 and above. |
| Total, child, and old-age dependency ratios | (i) Total Dependency Ratio ((Age 0-14 + Age 65+) / Age 15-64); (ii) Total Dependency Ratio ((Age 0-19 + Age 65+) / Age 20-64); (iii) Child Dependency Ratio (Age 0-14 / Age 15-64); (iv) Child Dependency Ratio (Age 0-19 / Age 20-64); (v) Old-Age Dependency Ratio (Age 65+ / Age 15-64); (vi) Old-Age Dependency Ratio (Age 65+ / Age 20-64) |
| Number of births | Annual number of births by sex |
| Crude birth rate | Average annual number of births per 1,000 population. |
| Age-specific fertility rate | Number of births to women in a particular age group, divided by the number of women in that age group. The age groups used are: 15-19, 20-24, ..., 45-49. |
| Total fertility | The average number of live births a cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates of a given period and if they were not subject to mortality. It is expressed as live births per woman. |
| Net reproduction rate | The average number of daughters a cohort of women would have at the end of their reproductive period if they were subject during their whole lives to the fertility rates and the mortality rates of a given period. It is expressed as number of daughters per woman. |
| Rate of natural population increase | The difference between the number of live births and the number of deaths occurring in a year, divided by the population of that year, multiplied by a factor (usually 1,000). It is equal to the difference between the crude birth rate and the crude death rate. |
| Crude death rate | Average annual number of deaths per 1,000 population. |
| Number of deaths | Total annual number of deaths, by sex and annual cohorts. |
| Death rate or mortality rate | A measure of the number of deaths (in general, or due to a specific cause) in a population, scaled to the size of that population, per unit of time (e.g. the number of deaths per one thousand people per year). |
| Deaths by diseases | Total annual number of deaths; by sex and annual cohorts; by six broad disease categories: communicable, maternal, perinatal and nutritional conditions; neoplasms; diabetes; cardiovascular diseases; respiratory diseases; other noncommunicable diseases and injuries. |
| Infant mortality rate | Probability of dying between birth and exact age 1; expressed as average annual deaths per 1,000 births. |
| Under-five mortality rate | Probability of dying between birth and age 5; expressed as average annual deaths per 1,000 births. |
| Probabilities of dying between age 30 to 70 from major NCDs | Per 1000 of 30-year-old-people who would die before their 70th birthday from any of cardiovascular disease, cancer, diabetes, or chronic respiratory disease, assuming that s/he would experience current mortality rates at every age and s/he would not die from any other cause of death. |
| Life expectancy at birth | The average number of years that a newborn could expect to live if he or she were to pass through life exposed to the sex- and age-specific death rates prevailing at the time of his or her birth, for a specific year, in a given country. |
| Life expectancy at age 'x' years | The average number of years that a person of 'x' years of age could expect to live if exposed to the sex- and age-specific death rates prevailing at the time of his/her X_{th} birthday |
| Crude net migration rate: | The ratio of net migration during the year to the average population in that year. The value is expressed per 1 000 inhabitants. |
| Total net migration | Number of migrants, that is, the number of immigrants minus the number of emigrants. |
| Years of lives lost | The years of potential life lost due to premature deaths calculated by summing up number of deaths at each age multiplied by life expectancy at the age at which death occurs |

Source: United Nations, Department of Economic and Social Affairs, Population Division (2013). World Population Prospects: The 2012 Revision.

Supplementary Table S3: Baseline data for 2015

| Age | Fertility rate | | Death rate: Total | | Death rate: CMPN | | Death rate: CVD | | Death rate: DBT | | Death rate: RSP | | Death rate: NPL | | Death rate: OTH | | Net migration rate | |
|---------------|----------------|---------|-------------------|--------|------------------|--------|-----------------|--------|-----------------|-------|-----------------|--------|-----------------|-------|-----------------|--------|--------------------|-------|
| | Per 1000 women | | Per 1000 people | | | | | | | | | | | | | | | |
| | Data | Calib.* | M** | F** | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| < 1 years | | | 31.74 | 28.18 | 24.92 | 22.13 | 0.12 | 0.11 | 0.01 | 0.01 | 0.06 | 0.10 | 0.31 | 0.33 | 6.34 | 5.50 | 0.00 | 0.00 |
| 1 – 4 years | | | 1.73 | 1.69 | 1.36 | 1.33 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.02 | 0.02 | 0.35 | 0.33 | 0.00 | 0.00 |
| 5 - 9 years | | | 0.55 | 0.66 | 0.20 | 0.35 | 0.01 | 0.02 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.03 | 0.30 | 0.25 | 0.29 | 0.16 |
| 10 – 14 years | | | 0.53 | 0.52 | 0.20 | 0.27 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 | 0.01 | 0.03 | 0.02 | 0.29 | 0.20 | 0.83 | 0.20 |
| 15 - 19 years | 75 | 77 | 0.83 | 0.86 | 0.16 | 0.30 | 0.07 | 0.08 | 0.00 | 0.01 | 0.01 | 0.03 | 0.05 | 0.06 | 0.53 | 0.38 | -6.17 | -0.24 |
| 20 – 24 years | 137 | 140 | 0.94 | 0.88 | 0.18 | 0.31 | 0.08 | 0.08 | 0.00 | 0.01 | 0.02 | 0.03 | 0.06 | 0.06 | 0.61 | 0.39 | -16.49 | -0.54 |
| 25 – 29 years | 105 | 105 | 1.06 | 1.06 | 0.20 | 0.37 | 0.09 | 0.10 | 0.00 | 0.01 | 0.02 | 0.04 | 0.07 | 0.08 | 0.68 | 0.47 | -11.70 | -0.19 |
| 30 - 34 years | 56 | 56 | 1.33 | 1.30 | 0.31 | 0.25 | 0.34 | 0.28 | 0.02 | 0.03 | 0.05 | 0.06 | 0.21 | 0.41 | 0.41 | 0.26 | -7.46 | -0.19 |
| 35 - 39 years | 25 | 25 | 1.79 | 1.65 | 0.41 | 0.32 | 0.45 | 0.36 | 0.02 | 0.04 | 0.06 | 0.08 | 0.28 | 0.52 | 0.56 | 0.33 | -6.12 | 0.01 |
| 40 - 44 years | 9 | 9 | 2.81 | 2.09 | 0.65 | 0.41 | 0.71 | 0.45 | 0.03 | 0.05 | 0.10 | 0.10 | 0.44 | 0.66 | 0.88 | 0.41 | -3.63 | 0.16 |
| 45 - 49 years | 3 | 3 | 4.53 | 2.76 | 1.04 | 0.54 | 1.15 | 0.60 | 0.05 | 0.07 | 0.16 | 0.13 | 0.72 | 0.88 | 1.41 | 0.54 | -1.74 | 0.16 |
| 50 – 54 years | | | 8.33 | 5.01 | 1.58 | 0.51 | 2.84 | 1.55 | 0.12 | 0.16 | 0.56 | 0.37 | 1.61 | 1.71 | 1.60 | 0.72 | -0.34 | 0.14 |
| 55 – 59 years | | | 11.39 | 8.29 | 2.17 | 0.84 | 3.89 | 2.56 | 0.17 | 0.26 | 0.77 | 0.62 | 2.21 | 2.83 | 2.19 | 1.19 | -0.13 | 0.12 |
| 60 – 64 years | | | 22.99 | 16.37 | 4.13 | 1.54 | 8.92 | 7.55 | 0.55 | 0.77 | 2.79 | 2.12 | 3.28 | 2.26 | 3.32 | 2.13 | -0.04 | 0.07 |
| 65 – 69 years | | | 27.91 | 24.38 | 5.01 | 2.30 | 10.83 | 11.25 | 0.67 | 1.14 | 3.38 | 3.15 | 3.98 | 3.37 | 4.03 | 3.17 | 0.21 | 0.06 |
| 70 – 74 years | | | 56.59 | 45.38 | 12.57 | 7.03 | 18.84 | 20.16 | 2.22 | 3.09 | 8.94 | 5.87 | 5.80 | 2.27 | 8.22 | 6.96 | 0.21 | 0.06 |
| 75 – 79 years | | | 60.00 | 46.35 | 13.33 | 7.18 | 19.97 | 20.59 | 2.36 | 3.16 | 9.48 | 6.00 | 6.14 | 2.31 | 8.72 | 7.11 | 0.21 | 0.06 |
| 80 – 84 years | | | 90.37 | 71.99 | 20.07 | 11.16 | 30.08 | 31.98 | 3.55 | 4.90 | 14.28 | 9.32 | 9.25 | 3.59 | 13.13 | 11.04 | 0.21 | 0.06 |
| 85 year | | | 151.53 | 125.05 | 33.66 | 19.38 | 50.44 | 55.55 | 5.95 | 8.52 | 23.94 | 16.18 | 15.52 | 6.24 | 22.02 | 19.17 | 0.21 | 0.06 |
| 90 year | | | 434.35 | 416.70 | 96.49 | 64.59 | 144.59 | 185.11 | 17.05 | 28.38 | 68.63 | 53.92 | 44.48 | 20.81 | 63.12 | 63.89 | 0.21 | 0.06 |
| 95 year | | | 717.18 | 708.35 | 159.31 | 109.79 | 238.73 | 314.67 | 28.16 | 48.25 | 113.32 | 91.67 | 73.45 | 35.37 | 104.22 | 108.60 | 0.21 | 0.06 |
| 100 and above | | | 1000 | 1000 | 222.1 | 155.00 | 332.88 | 444.24 | 39.26 | 68.12 | 158.00 | 129.41 | 102.41 | 49.93 | 145.31 | 153.32 | 0.21 | 0.06 |

Note: * 2015 age-group specific fertility data obtained from the Bangladesh Bureau of Statistics produced total fertility rate of 2.05; the data has been calibrated up to produce a total fertility rate of 2.10 for 2015. ** M: Male; F: Female. The numbers are rounded to two decimal points.

Supplementary Table S4: The scale factors ($I_{s,A,d,t}^{\delta}$) for the 'trend' and 'NCD target' mortality rate trajectories

| Age | Scenario | Male | | | Female | | | Male | | | Female | | |
|-----------|----------|--|-------|-------|--------|-------|-------|-------------------------|-------|-------|--------|-------|-------|
| | | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 | 2015 | 2020 | 2030 |
| | | Infectious, Maternal, Perinatal, Nutritional | | | | | | Cardiovascular Disease | | | | | |
| Age 0-4 | Trend | 1.000 | 0.869 | 0.608 | 1.000 | 0.867 | 0.602 | 1.000 | 0.955 | 0.866 | 1.000 | 0.931 | 0.794 |
| | Target | 1.000 | 0.869 | 0.608 | 1.000 | 0.867 | 0.602 | 1.000 | 0.955 | 0.866 | 1.000 | 0.931 | 0.794 |
| Age 5-14 | Trend | 1.000 | 0.849 | 0.547 | 1.000 | 0.848 | 0.544 | 1.000 | 0.972 | 0.915 | 1.000 | 0.961 | 0.882 |
| | Target | 1.000 | 0.849 | 0.547 | 1.000 | 0.848 | 0.544 | 1.000 | 0.972 | 0.915 | 1.000 | 0.961 | 0.882 |
| Age 15-29 | Trend | 1.000 | 0.842 | 0.526 | 1.000 | 0.850 | 0.549 | 1.000 | 0.924 | 0.771 | 1.000 | 0.929 | 0.788 |
| | Target | 1.000 | 0.842 | 0.526 | 1.000 | 0.850 | 0.549 | 1.000 | 0.924 | 0.771 | 1.000 | 0.929 | 0.788 |
| Age 30-49 | Trend | 1.000 | 0.842 | 0.525 | 1.000 | 0.848 | 0.544 | 1.000 | 0.948 | 0.845 | 1.000 | 0.940 | 0.821 |
| | Target | 1.000 | 0.842 | 0.525 | 1.000 | 0.848 | 0.544 | 1.000 | 0.948 | 0.670 | 1.000 | 0.940 | 0.670 |
| Age 50-69 | Trend | 1.000 | 0.871 | 0.612 | 1.000 | 0.889 | 0.666 | 1.000 | 0.965 | 0.895 | 1.000 | 0.963 | 0.889 |
| | Target | 1.000 | 0.871 | 0.612 | 1.000 | 0.889 | 0.666 | 1.000 | 0.965 | 0.670 | 1.000 | 0.963 | 0.670 |
| Age 70+ | Trend | 1.000 | 0.923 | 0.769 | 1.000 | 0.931 | 0.792 | 1.000 | 0.963 | 0.888 | 1.000 | 0.989 | 0.966 |
| | Target | 1.000 | 0.923 | 0.769 | 1.000 | 0.931 | 0.792 | 1.000 | 0.963 | 0.888 | 1.000 | 0.989 | 0.966 |
| | | Respiratory Disease | | | | | | Neoplasm | | | | | |
| Age 0-4 | Trend | 1.000 | 0.947 | 0.842 | 1.000 | 0.915 | 0.746 | 1.000 | 1.040 | 1.119 | 1.000 | 1.036 | 1.107 |
| | Target | 1.000 | 0.947 | 0.842 | 1.000 | 0.915 | 0.746 | 1.000 | 1.040 | 1.119 | 1.000 | 1.036 | 1.107 |
| Age 5-14 | Trend | 1.000 | 0.954 | 0.863 | 1.000 | 0.932 | 0.797 | 1.000 | 0.987 | 0.960 | 1.000 | 0.992 | 0.975 |
| | Target | 1.000 | 0.954 | 0.863 | 1.000 | 0.932 | 0.797 | 1.000 | 0.987 | 0.960 | 1.000 | 0.992 | 0.975 |
| Age 15-29 | Trend | 1.000 | 0.912 | 0.737 | 1.000 | 0.918 | 0.755 | 1.000 | 0.989 | 0.967 | 1.000 | 0.987 | 0.960 |
| | Target | 1.000 | 0.912 | 0.737 | 1.000 | 0.918 | 0.755 | 1.000 | 0.989 | 0.967 | 1.000 | 0.987 | 0.960 |
| Age 30-49 | Trend | 1.000 | 0.910 | 0.731 | 1.000 | 0.945 | 0.836 | 1.000 | 0.983 | 0.950 | 1.000 | 1.005 | 1.014 |
| | Target | 1.000 | 0.910 | 0.670 | 1.000 | 0.945 | 0.670 | 1.000 | 0.983 | 0.670 | 1.000 | 1.005 | 0.670 |
| Age 50-69 | Trend | 1.000 | 0.929 | 0.788 | 1.000 | 0.966 | 0.897 | 1.000 | 0.984 | 0.953 | 1.000 | 0.999 | 0.998 |
| | Target | 1.000 | 0.929 | 0.670 | 1.000 | 0.966 | 0.670 | 1.000 | 0.984 | 0.670 | 1.000 | 0.999 | 0.670 |
| Age 70+ | Trend | 1.000 | 0.940 | 0.820 | 1.000 | 0.969 | 0.907 | 1.000 | 1.004 | 1.012 | 1.000 | 1.029 | 1.086 |
| | Target | 1.000 | 0.940 | 0.820 | 1.000 | 0.969 | 0.907 | 1.000 | 1.004 | 1.012 | 1.000 | 1.029 | 1.086 |
| | | Diabetes | | | | | | Other NCDs and Injuries | | | | | |
| Age 0-4 | Trend | 1.000 | 0.981 | 0.942 | 1.000 | 0.988 | 0.964 | 1.000 | 0.967 | 0.902 | 1.000 | 0.975 | 0.925 |
| | Target | 1.000 | 0.981 | 0.942 | 1.000 | 0.988 | 0.964 | 1.000 | 0.967 | 0.902 | 1.000 | 0.975 | 0.925 |
| Age 5-14 | Trend | 1.000 | 0.982 | 0.947 | 1.000 | 0.966 | 0.898 | 1.000 | 0.971 | 0.914 | 1.000 | 0.974 | 0.923 |
| | Target | 1.000 | 0.982 | 0.947 | 1.000 | 0.966 | 0.898 | 1.000 | 0.971 | 0.914 | 1.000 | 0.974 | 0.923 |
| Age 15-29 | Trend | 1.000 | 0.931 | 0.793 | 1.000 | 0.953 | 0.860 | 1.000 | 0.963 | 0.888 | 1.000 | 0.942 | 0.827 |
| | Target | 1.000 | 0.931 | 0.793 | 1.000 | 0.953 | 0.860 | 1.000 | 0.963 | 0.888 | 1.000 | 0.942 | 0.827 |
| Age 30-49 | Trend | 1.000 | 0.961 | 0.883 | 1.000 | 1.010 | 1.030 | 1.000 | 0.953 | 0.859 | 1.000 | 0.953 | 0.859 |
| | Target | 1.000 | 0.961 | 0.670 | 1.000 | 1.010 | 0.670 | 1.000 | 0.953 | 0.859 | 1.000 | 0.953 | 0.859 |
| Age 50-69 | Trend | 1.000 | 0.975 | 0.925 | 1.000 | 1.011 | 1.034 | 1.000 | 0.963 | 0.890 | 1.000 | 0.970 | 0.911 |
| | Target | 1.000 | 0.975 | 0.670 | 1.000 | 1.011 | 0.670 | 1.000 | 0.963 | 0.890 | 1.000 | 0.970 | 0.911 |
| Age 70+ | Trend | 1.000 | 0.979 | 0.936 | 1.000 | 1.010 | 1.031 | 1.000 | 0.975 | 0.926 | 1.000 | 0.987 | 0.961 |
| | Target | 1.000 | 0.979 | 0.936 | 1.000 | 1.010 | 1.031 | 1.000 | 0.975 | 0.926 | 1.000 | 0.987 | 0.961 |

Note: The 'trend' scenario adopts sex, age-group and disease-specific mortality rate trajectories based on the latest WHO GHE regional mortality projections 2016-2030 for 'Southern Asia' consisting of Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, and Sri Lanka. (WHO 2020, Mathers 2006)22,23 The scale factors in both the trend and the NCD 2030 target scenarios are same until 2020 for all age groups and disease categories. For the period 2021-2030, the scale factors used in the NCD target scenarios differ from the trend scenario for the age groups 30-49 and 50-69 for cardiovascular diseases, neoplasm, diabetes, and respiratory disease.

Supplementary Table S5: Years of lives lost (YLL) and YLL averted

| | YLL and YLL averted in 2025 | | | YLL and YLL averted in 2030 | | | Cumulative number of YLL and YLL averted: 2015 - 2030 | | |
|---|-----------------------------|---------|---------|-----------------------------|---------|---------|---|----------|------------|
| | Male | Female | Total | Male | Female | Total | Male | Female | Total |
| Cardiovascular Diseases | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 2628410 | 2395870 | 5024280 | 2996780 | 2853440 | 5850220 | 39431070 | 35694730 | 75,125,800 |
| <i>Trend</i> | 2538880 | 2280630 | 4819510 | 2866200 | 2661530 | 5527730 | 38364420 | 34307980 | 72,672,400 |
| <i>NCD target</i> | 2289050 | 2094930 | 4383980 | 2428830 | 2320920 | 4749750 | 35338430 | 32042630 | 67,381,060 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 339360 | 300940 | 640300 | 567950 | 532520 | 1100470 | 4092640 | 3652100 | 7,744,740 |
| <i>Compared to trend</i> | 249830 | 185700 | 435530 | 437370 | 340610 | 777980 | 3025990 | 2265350 | 5,291,340 |
| Respiratory Diseases | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 749096 | 664638 | 1413734 | 873661 | 789733 | 1663394 | 11252806 | 9933068 | 21,185,874 |
| <i>Trend</i> | 683002 | 625524 | 1308526 | 762576 | 723793 | 1486369 | 10449656 | 9458391 | 19,908,047 |
| <i>NCD target</i> | 657731 | 575196 | 1232927 | 718066 | 630902 | 1348968 | 10143973 | 8843957 | 18,987,930 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 91365 | 89442 | 180807 | 155595 | 158831 | 314426 | 1108833 | 1089111 | 2,197,944 |
| <i>Compared to trend</i> | 25271 | 50328 | 75599 | 44510 | 92891 | 137401 | 305683 | 614434 | 920,117 |
| Diabetes | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 175112 | 286897 | 462009 | 203287 | 341275 | 544562 | 2642602 | 4303544 | 6,946,146 |
| <i>Trend</i> | 175277 | 298383 | 473660 | 205832 | 364177 | 570009 | 2647001 | 4447344 | 7,094,345 |
| <i>NCD target</i> | 159998 | 260900 | 420898 | 179167 | 296554 | 475721 | 2462325 | 3991308 | 6,453,633 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 15114 | 25997 | 41111 | 24120 | 44721 | 68841 | 180277 | 312236 | 492,513 |
| <i>Compared to trend</i> | 15279 | 37483 | 52762 | 26665 | 67623 | 94288 | 184676 | 456036 | 640,712 |
| Neoplasm | | | | | | | | | |
| Years of lives lost (YLL) | | | | | | | | | |
| <i>Status quo</i> | 1280430 | 1492110 | 2772540 | 1422430 | 1682870 | 3105300 | 19346850 | 22311220 | 41,658,070 |
| <i>Trend</i> | 1308030 | 1529450 | 2837480 | 1479230 | 1750120 | 3229350 | 19693330 | 22768490 | 42,461,820 |
| <i>NCD target</i> | 1136680 | 1263360 | 2400040 | 1185180 | 1288140 | 2473320 | 17621820 | 19542930 | 37,164,750 |
| YLL averted in NCD target scenario | | | | | | | | | |
| <i>Compared to status quo</i> | 143750 | 228750 | 372500 | 237250 | 394730 | 631980 | 1725030 | 2768290 | 4,493,320 |
| <i>Compared to trend</i> | 171350 | 266090 | 437440 | 294050 | 461980 | 756030 | 2071510 | 3225560 | 5,297,070 |

Note: Calculations derived from the model.