Forecasting Health outcomes to Envision Health strategies in Ethiopia

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Abstract

Background: Universal health coverage is the main goal of the health sector in the coming decade for Ethiopia in the country's transition to a middle-income state. We used the Global Burden of Disease 2017-2040 forecasting study to support Ethiopia's envisioning strategies with baseline and targets.

Methods: The research utilized 2017 forecasts from the Global Burden of Disease, focusing on Ethiopia. The forecasts included 250 causes and causes of death, spanning from 2017 to 2040. The study examined various parameters, including life expectancy, death rates, and premature mortality rates. It employed broader and detailed categories from the Global Burden of Disease, accompanied by 95% uncertainty intervals.

Results: In Ethiopians, life expectancy is expected to increase from 66 years (64-68.5) in 2017 to 73.8 years (70.3-77.3) in 2040. In 2040, the all-cause age-standardized death rate will be 854 per 100,000. Projected age-standardized death rates from 2017 to 2040 due to non-communicable diseases and injuries showed a smaller reduction of 26% and 23%, respectively, while communicable, maternal, neonatal, and nutritional disorders decreased by 53%. In 2040, cardiovascular and neoplasms are projected to cause age-standardized death rates of 224.7 and 137.8 per 100,000, respectively. The age-standardized premature mortality percentage contribution of communicable, maternal, neonatal, and nutritional disorders altogether declined from 62.4% in 1990, 45% in 2018, and 34% in 2040, whereas non-communicable diseases contribution increased from 25.2% in 1990, 46% in 2019 and 54% in 2040.

Conclusions: This major life expectancy gain is expected to be attributed to further reductions in major communicable, maternal, neonatal, and nutritional causes of death. Ethiopia is more likely to achieve the success of lower middle-income countries in terms of life expectancy. However less likely to achieve the success of upper middle-income countries by 2040. Non-communicable disease and injuries are expected to be leading causes from 2017 through 2040 that need more emphasis on the country's envisioning plans and strategies. This finding could help to strengthen the health care system, devise prevention and control strategies, and implement Best Buy interventions for NCDs and Injuries while addressing the unfinished agenda of communicable diseases and others. Providing subnational forecasting results could also be helpful in understanding projected progress and disparities between regional states to devise relevant strategies and interventions. There is also a need to improve quality data availability and accessibility to produce reliable decision-making results. [*Ethiop. J. Health Dev.* 2023;37 (SI-2)]

Keywords: Forecasting, health outcomes, envisioning strategy, Ethiopia

Background

In Ethiopia, Universal Health Coverage (UHC) is the health sector's main goal, and the health policy focuses on promoting, preventing, and controlling diseases and injuries (1). Over the last three decades, the country has successfully reduced deaths from major infectious diseases and nutritional conditions, maternal and child mortalities, and improved life expectancy (2). The population projections by the Central Statistical Agency (CSA) from 2007 to 2037 have shown trends of declining fertility, increasing population, increasing life expectancy, and high urbanization (3). Ethiopia has finalized the first health sector transformation plan, which covered the period from 2015 to 2020, and currently implementing the second phase of the Health Sector Transformation Plan (HSTP), which extends from 2021- 2025. The HSTP has emphasized the PHC system to achieve Universal Health Coverage (UHC) through minimizing equity gap and resource scarcity and addressing issues on sustainable financing (4). The UHC is assumed to guarantee access to essential services while protecting against financial risk (5–7). However, the lack of regular evidence on demographic and epidemiologic conditions and social determinants of health that show past trends and future projections has challenged monitoring progress and predicting gains and resource needs. Projections are important to inform HSTP strategies, SDG indicators, and targets to advance UHC in Ethiopia (8,9). Understanding future disease burden and the nature of the epidemiologic transitions with its major drivers and determinates is equally important for prioritizing priorities, resource mobilization and high-impact interventions to achieve UHC targets. Thus, this paper used Global Burden of Disease (GBD) forecasting results to support Ethiopia's HSTP with baseline scenario and calibration targets for intervention that intends to guide the overall investment direction of the country in health.

Methods

This paper is part of the GBD 2017 forecasting study, which utilized the methods previously described in (10). In summary, the study utilized GBD 2016 data to model and forecast 250 causes and cause of death groups, organized according to the GBD hierarchical cause structure, from 2017 to 2040. The study developed a three-component model for cause-specific mortality: the first component accounted for changes in

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behavioral, metabolic, and environmental risks, as well as selected interventions quantified in GBD; the second component accounted for the socio-demographic index (SDI), which combines income per person, educational attainment, total fertility rate under 25 years, and time; and the third component used an autoregressive integrated moving average (ARIMA) model to capture the unexplained component that is correlated over time (10).

The data sources include surveys, surveillance, case notifications, facility reports, sibling history, verbal autopsy, and police records to estimate mortality and causes of death. The study reported Life Expectancy (LE) compared with countries considered the benchmark in Ethiopia's envisioning strategy (9), death and premature mortality rates using GBD broader and detail categories with 95% Uncertainty Intervals (UI). Years of life lost (YLLs) are calculated as a measure of premature mortality by summing up the remaining life expectancy for people dying in each age group.

Ethics approval and consent to participate

The study follows GBD protocol publicly available online (https://www.healthdata.org/gbd/about/protocol) and complies with the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) recommendations. GATHER defines best practices for documenting studies that synthesize evidence from multiple sources to describe past and current population health and its determinants quantitatively. These practices include documenting and sharing data inputs, analyses , methods, and results. Documenting the input data on which estimates are based and the methods by which estimates are derived is essential for the accurate interpretation and use of results (11).

Results

Life expectancy: In Ethiopia, the average life expectancy will increase from 66.0 (64.0-68.5) years in 2017 to 73.8 (70.3-77.3) years in 2040. Average life expectancy for males increases from 65.4 (62.3-68.4 years) in 2017 to 72.2 (68.1-76.3) years in 2040 and for females from 67.2 (64.3-69.9) years in 2017 to 75.5 (71.6-79) years in 2040 (Figure 1).

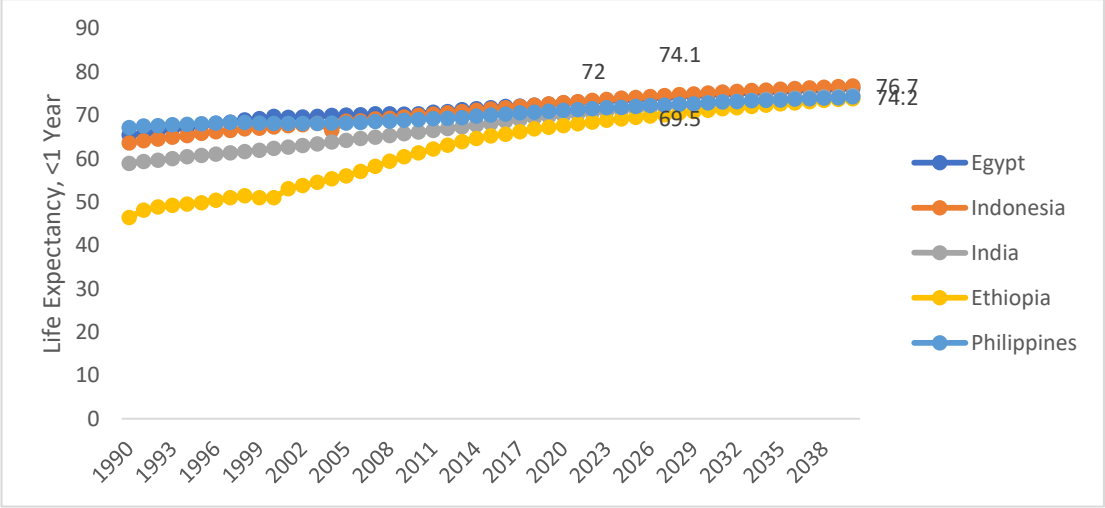

Figure 1: **Life Expectancy of Ethiopia compared with lower middle-income countries identified for benchmarking for envisioning strategies, 1990-2040**

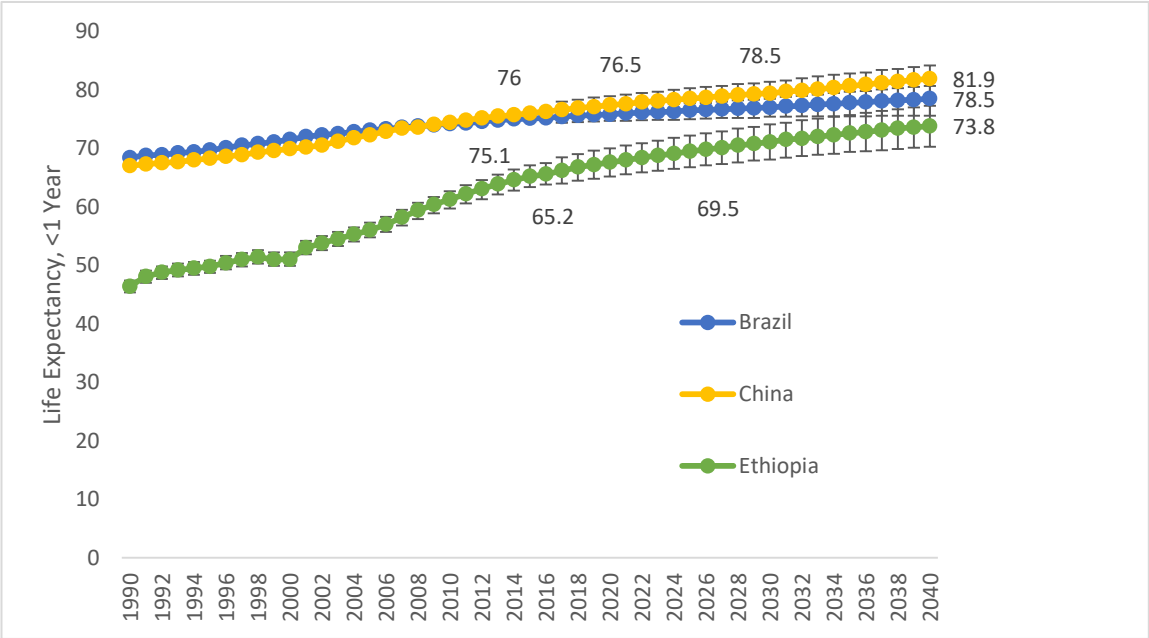

Figure 2: **Life Expectancy of Ethiopia compared with upper middle income identified benchmark countries for Envisioning, 1990-2040**

Crude death rates and percentage changes : Crude death rates for broad groups of causes and the crude all-cause mortality rate are presented in Table 1. In 2017, Communicable, Maternal, Neonatal, and Nutritional Diseases (CMNND) accounted for 47.9% (95% UI 43.2–53.4), non-communicable diseases (NCDs) accounted for 43.6% (95% UI:38.6–47.9) and injuries accounted for 8.5% (95% UI:7.4–9.8) of the total 686,800 deaths. In 2040, forecasted deaths due to NCDs account for 60.8% (95% UI:53.3–66.7), CMNND causes account for 28.1% (95% UI 22.2–36.0), and injuries account for 11.0% (95% UI:9.17%–13.2) of 784,400 deaths.

Table 1: **Crude Death Rates (CDR) per 100,000 for both sex and all age groups in 1990, 2007, 2017,2040**

Cause of death	1990		2005			2017			2040		
	Number (Thousands)	CDR	Number (Thousands)	CDR	CDR % change 1990-2005	Number (Thousands)	CDR	CDR % change (2005-17)	Number (Thousands)	CDR	CDR % change (2017-2040)
All cause	842 (805.5-880.5)	1805.7 (1727.3-1888.1)	821.8 (774.3-873.4)	1098.3 (1034.8-1167.2)	-39%	686.8 (596.2-784.4)	650.3 (564.8-743.9)	41%	784.4 (649.2-936)	457.9 (374-563.2)	-30%
CMNN diseases	548 (517.8-579.7)	1175.2 (1110.4-1243.1)	535.4 (500.5-572.7)	715.5 (668.9-765.4)	-2%	329.2 (273.4-397.7)	311.7 (258.8-376.2)	-56%	221.9 (155.7-309.5)	129.6 (89.1-184.3)	-58%
HIV/AIDS and tuberculosis	99.2 (70.1-115.4)	212.6 (150.4-247.6)	149.4 (132.6-165.9)	199.7 (177.2-221.8)	-6%	63.4 (51.1-77.7)	60.1 (48.3-73.4)	-70%	45.1 (28.9-68)	26.3 (16.8-40.1)	-56%
Diarrhea, lower respiratory, and other common infectious diseases	297.4 (260.3-339.6)	635.8 (558.1-728.3)	224.7 (200.7-254.1)	300.3 (268.3-339.6)	-52.9%	157.3 (110.1-216)	149.0 (104.0-205.0)	-50%	135.7 (75.2-216.4)	79.3 (43.2-127.2)	-47%
Neglected tropical diseases and malaria	19.5 (12.9-27.9)	41.9 (27.7-59.8)	23.9 (17.4-31.6)	31.9 (23.3-42.2)	-23.8%	4.2 (3-5.8)	4.0 (3-6)	-88%	2.4 (1.7-3.4)	1.4 (1.0-2.0)	-65%
Maternal disorders	16.5 (13.6-19.6)	35.4 (29.2-42.0)	18.3 (14.7-22.2)	24.5 (19.7-29.6)	-30%	11.8 (8.2-16.1)	11.1 (7.8-15.3)	-55%	5.7 (3.4-8.9)	3.3 (2.0-5.3)	-70%
Neonatal disorders	71 (62.4-79.4)	152.3 (133.7-170.3)	72.7 (63.7-83.1)	97.2 (85.1-11.1)	-36.2%	61.2 (47.6-79.3)	57.9 (45.0-75)	-40%	19.5 (13.4-28.7)	11.4 (7.8-16.5)	-80%
Nutritional deficiencies	28.4 (17-44.1)	60.8 (36.4-94.5)	30.1 (22-38.9)	40.2 (29.4-52.0)	-33.9%	18.7 (14.7-23.3)	17.7 (13.9-22.0)	-56%	8.9 (7.1-10.9)	5.2 (4.2-6.5)	-71%
Other communicable, maternal, neonatal, and nutritional diseases	16.1 (9.9-25.9)	34.5 (21.2-55.5)	16.3 (10.9-22.7)	21.8 (14.6-30.4)	-37%	12.6 (8-19.6)	12.0 (7.6-18.6)	-45%	4.7 (3.6-6.3)	2.8 (2.1-3.7)	-77%
Non-communicable diseases	198.3 (180.4-216.5)	425.3(386.9-464.3)	235.4 (213.9-258.1)	314.7 (285.9-344.9)	-26%	299 (254.2-348)	283.1 (240.4-330)	-10%	476.2 (398.7-559.6)	277.9 (228.4-333.6)	-2%
Neoplasms	35.9 (30.7-43.5)	77(65.9-93.4)	46.3 (37.6-55.5)	61.9 (50.3-74.2)	-19.6%	66.7 (53.4-80.3)	63.1(50.3-75.8)	2%	131.6 (105.4-158.5)	76.8(60-93.7)	22%
Cardiovascular diseases	87.3 (77.6-97.1)	187.3(166.5-208.2)	103.6 (93.3-115)	138.4 (124.6-153.7)	-26.1%	125.3 (98.5-154)	118.6(93.1-145.8)	-14%	173 (126.8-220.5)	101(74.1-130.8)	-15%
Chronic respiratory diseases	13.4(11.5-15.3)	28.8(24.7-32.8)	14.4(12.6-	19.3	-33.0%	17	16.1(11.5-	-16%	18.1	10.6(7.2-	-35%

			16.3)	(16.9-21.7)		(12.2-26)	24.7)		(12.4-29.3)	17.2)	
Cirrhosis	12.1(9.9-14.2)	25.9(21.3-30.4)	14.3(12.5-16.2)	19.1 (16.8-21.6)	-26.0%	18.1 (15.1-21.5)	17.2(14.3-20.4)	-10%	30.2 (24.5-37.3)	17.7(13.9-22)	3%
Digestive diseases	16.8(13-19.8)	36(27.9-42.5)	18.1(15.9-20.4)	24.3 (21.2-27.3)	-32.7%	20.9 (17.6-24.4)	19.8(16.6-23.1)	-18%	27.8 (23.5-32.3)	16.2(13.5-19.2)	-18%
Neurological disorders	5.4(4.3-6.4)	11.5(9.3-13.7)	8.1(6.9-9.5)	10.8 (9.3-12.7)	-6.5%	12.5 (10.3-15.4)	11.9(9.8-14.6)	10%	27.8 (22.7-33.7)	16.2(13.2-19.7)	37%
Mental and substance use disorders	1(0.7-1.5)	2.1(1.5-3.3)	1.2(1-1.5)	1.6(1.4-2)	-22.8%	1.8 (1.4-2.3)	1.7(1.3-2.2)	5%	3.5 (2.8-4.5)	2.1(1.6-2.7)	21%
Diabetes, urogenital, blood, and endocrine diseases	19.1(16.9-21.3)	40.9(36.3-45.6)	22.8(20.4-25.2)	30.5 (27.3-33.7)	-25.5%	29.4 (22.9-39.7)	27.8(21.7-37.6)	-9%	54.4 (35.6-87.7)	31.7(20.6-52.1)	14%
Musculoskeletal disorders	0.3(0.2-0.5)	0.7(0.5-1)	0.4(0.3-0.6)	0.6 (0.4-0.8)	-25.3%	0.6 (0.4-0.8)	0.5(0.4-0.8)	-2%	1.3 (0.8-1.9)	0.7(0.5-1.1)	37%
Other non-communicable diseases	7(2.1-12.9)	15 (4.6-27.7)	6.1(2.8-9.5)	8.2 (3.8-12.6)	-45.4%	6.8 (3.7-9.5)	6.4(3.5-9)	-22%	8.5 (5.7-12.3)	4.9(3.3-7.2)	-23%
Injuries	95.6 (86.7-105.1)	205.1(185.9-225.4)	51.0 (45.9-57.3)	68.2 (61.4-76.6)	-66.8%	58.6 (48.7-68.7)	55.4 (46.1-65)	-19%	86.3 (69.3-105.7)	50.3 (39.6-63.4)	-9%
Transport injuries	11.9(10.1-13.8)	25.5 (21.6-29.5)	12.6 (11.1-14.3)	16.9 (14.8-19.2)	-33.8%	15 (12.2-18.1)	14.2 (11.6-17.2)	-16%	29.3 (21.5-39.9)	17.1 (12.5-23.5)	21%
Unintentional injuries	24(18.9-29.6)	51.4 (40.6-63.5)	25 (22.3-27.9)	33.4 (29.8-37.2)	-35.0%	26.4 (22.6-30.1)	25 (21.4-28.5)	-25%	31 (26.6-36)	18.1(15.3-21.3)	-28%
Self-harm and interpersonal violence	9.8(6.8-14.9)	21 (14.5-32)	12.8 (10.7-17.2)	17.1 (14.3-23)	-18.5%	17 (12.5-23.2)	16.1 (11.8-21.9)	-6%	25.8 (18.2-36.9)	15 (10.6-21.4)	-6%
Forces of nature, war, and legal intervention	50(46.1-54.1)	107.3 (98.9-115.9)	0.6 (0.4-0.9)	0.8 (0.5-1.1)	-99.2%	0.2 (0-2.5)	0.2 (-2.4)	-72%	0.2 (0-0.9)	0.1 (0-0.5)	-56%

In 2017, 311.7 deaths per 100,000 were due to CMNND disease ,283.1 deaths per 100,000 were due to NCDs, and 55.5 deaths per 100,000 were due to injuries. In 2040, non-communicable diseases were projected to account for 277.9 deaths per 100,000, CMNND accounted for 129.6 deaths per 100,000, and injuries accounted for 50.4 deaths per 100,000.

All-cause deaths declined by 30%, from 650.3 deaths per 100,000 in 2017 to 457.9 deaths per 100,000 in 2040. A potential transition from a high CMNNDs burden to high NCDs burden occurred from 2017 to 2040. Mortality due to CMNND causes showed a significant decline of 58.4%, while NCDs decreased by only 1.8% and injuries by 9% between 2017 and 2040.

In 2017, diarrheal diseases, lower respiratory infections, and other common infectious diseases collectively caused 149.0 (95% UI; 104.0-205.0) deaths per 100,000 people. HIV/AIDs and tuberculosis collectively caused 60.1 (95% UI; (48.3-73.4) deaths per 100,000 people. Neonatal disorders caused 57.9 (95% UI; 45.0-75) deaths per 100,000 people (Table 1). Cardiovascular diseases and neoplasms caused 118.6 (95% UI; 93.1-145.8), 63.1(95% UI; 50.3-75.8) per 100,000 people, respectively, and diabetes caused 27.8 (95% UI; 21.7-37.6) per 100,000 people. Transport injury, unintentional injuries, self-harm, and interpersonal violence causes 29.3 (95% UI; 21.5-39.9), 31 (95% UI; 26.6-36) and 25.8 (95% UI; 18.2-36.9) deaths per 100,000 people respectively. Between 2017 and 2040, diarrheal diseases, lower respiratory infections, and other common infectious disease causes collectively declined by 47%, HIV/AIDS and tuberculosis collectively declined by 56%, neonatal disorder causes decreased by 80%, while cardiovascular disease fell only by15%, unintentional injuries by 28% and self-harm and interpersonal violence decreased by 6%. In contrast, mortality due to neoplasm and diabetes is projected to increase by 22% and 14%, respectively, and transport injury increased by 21% between 2017 and 2040.

Age-standardized death rates and the Epidemiologic transition: The CMNNDs the leading causes of age-standardized death rates since 1990, whereas non-communicable diseases becaome leading causes of age-standardized death ratesdeaths from 2007 through 2040 (Table 2). Figure 3 shows the epidemiologic transition from CMNNDs to NCDs and the burden of injuries in terms of age-standardized death rates for both sexes and all age groups. Overall, total mortality and age-standardized death rates for each broad group of causes decreased between 2017 and 2040. In 2040, the all-cause age-standardized death rate was 854 (95% UI; 635.3-1168.7) per 100,000 people, of which NCDs caused 567.1 (95% UI; 429.4-753.3) and CMNNDs caused 211.2 (95% UI; 132.8-331.9) deaths per 100,000 people. The age-standardized death rate due to NCDs and injuries decreased by 26% and 23% between 2017 and 2040, whereas CMNNDs decreased by 53% (Table 2).

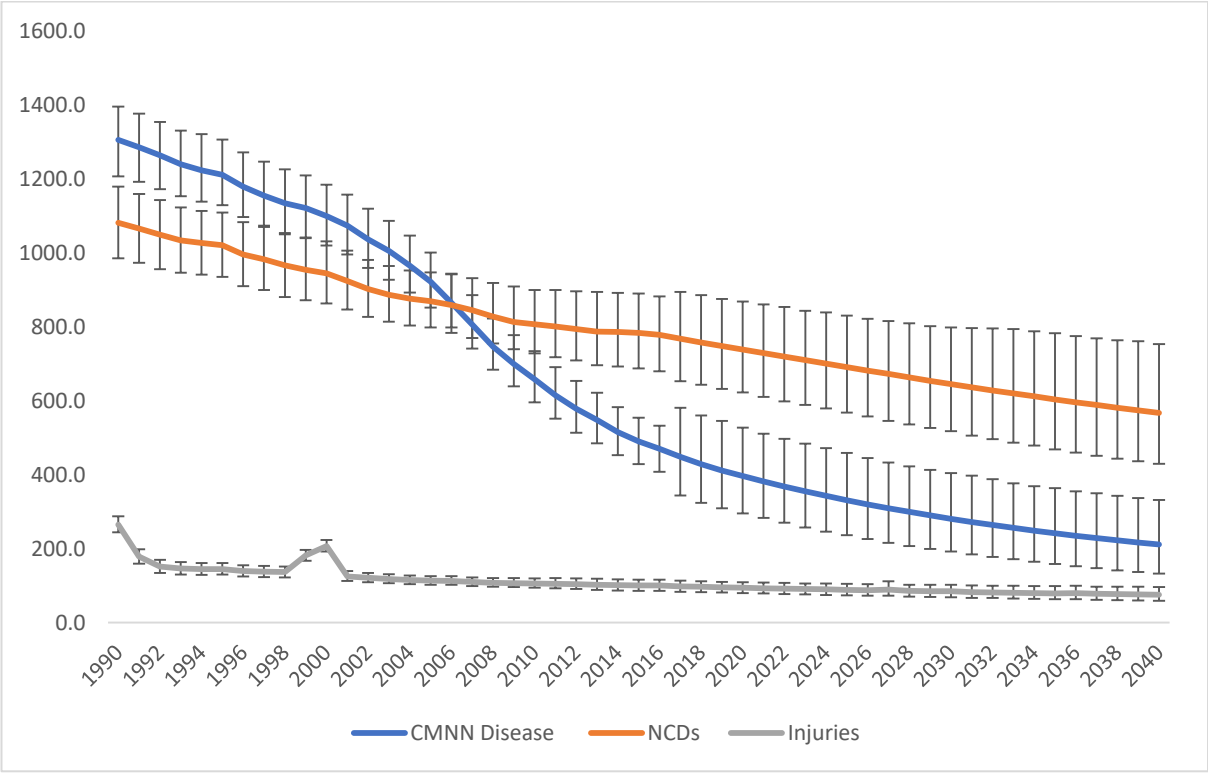

Figure 3: **Trends of age-standardized death rate per 100,000 by major causes for both sex and all age groups in Ethiopia, 1990-2040**

Note: CMNN Disease; communicable, maternal, neonatal and nutritional diseases; NCDs; non-communicable disease

Diarrheal diseases, lower respiratory infections, and other common infectious diseases caused 144.5 (95% UI; 72.4-253.2) age-standardized deaths per 100,000 people in 2040. The combined age-standardized death rate for HIV/AIDs and tuberculosis was 35.2 (95% UI:22.2-53.5) deaths per 100,000 people (Table 2). Cardiovascular and neoplasm caused 224.7 (95% UI: 149.2-328.4) and 137.8 (95% UI: 103.2-177.1) age-standardized deaths per 100,000 people, respectively. Transport and unintentional injuries caused 22.5 (95% UI: 16.3-30.8) and 34 (95% UI: 27.3-42.5) age-standardized deaths deaths per 100,000 people, respectively.

Table 2: **Age-standardized death rates (ASDR) per 100,000 for both sexes and all age groups with level one and two categories, 1990, 2005, 2017, 2040**

Causes of death	1990	2005	% change, 1990-2005	2017	% change, 2005-2017	2040	% change, 2017-2040
All cause	2651.7 (2516.1-2785.4)	1904.9 (1794.3-2028.7)	-28%	1315.1 (1130-1535.3)	-31%	854 (635.3-1168.7)	-35%
CMNN diseases	1305.5 (1206.9-1395.8)	921.9 (852.2-1001.1)	-29%	448.8 (343.9-581.1)	-51%	211.2 (132.8-331.9)	-53%
HIV/AIDS and Tuberculosis	416.4 (285.7-496.8)	351 (316.1-382.7)	-16%	112.4 (89.7-138.4)	-68%	35.2 (22.2-53.5)	-69%
Diarrhea, lower respiratory, and other common infectious diseases	633.5 (551-753.3)	388 (331.1-468.8)	-39%	249.3 (152.3-376.1)	-36%	144.5 (72.4-253.2)	-42%
Neglected tropical diseases and malaria	47.1 (35.7-60.1)	34.7 (27.2-44)	-26%	5.5 (4.1-7.6)	-84%	1.9 (1.3-2.7)	-65%
Maternal disorders	43.4 (35.4-52.2)	30.5 (24.3-37.4)	-30%	12.8 (8.9-17.8)	-58%	3.1 (1.8-4.9)	-76%
Neonatal disorders	69.5 (61.1-77.8)	50.9 (44.6-58.1)	-27%	28.5 (22.6-36.1)	-44%	12.3 (8.5-17.5)	-57%
Nutritional deficiencies	68.7 (50.9-88.6)	48.4 (41.4-56.6)	-30%	29 (24.7-33.2)	-40%	10.2 (7.8-13.5)	-65%
Other communicable, maternal, neonatal, and nutritional diseases	26.9 (19.8-37.4)	18.5 (14.4-23.4)	-31%	11.3 (8.6-15.1)	-39%	4.1 (3.1-5.4)	-64%
Non-communicable diseases	1081.1 (985-1179.1)	869.4 (798.7-947.2)	-20%	768.2 (652.8-894.3)	-12%	567.1 (429.4-753.3)	-26%
Neoplasms	176.5 (152.4-212.1)	150.5 (122.7-179.2)	-15%	149.9 (120.4-179.5)	0%	137.8 (103.2-177.1)	-8%
Cardiovascular diseases	535.7 (480.6-597.3)	426.2 (385.1-471.7)	-20%	355.2 (281.4-439)	-17%	224.7 (149.2-328.4)	-37%
Chronic respiratory diseases	77.2 (66.6-87.9)	55.8 (48.9-62.6)	-28%	46.2 (33-72.8)	-17%	22.3 (13.8-39.1)	-52%
Cirrhosis	55 (46.2-64)	44 (38.6-49.8)	-20%	38.8 (32.5-45.9)	-12%	29.4 (22.6-38.1)	-24%
Digestive diseases	81.9 (64.1-97.4)	60.3 (53-67.5)	-26%	48.9 (41.1-57.2)	-19%	30.8 (24-39.5)	-37%
Neurological disorders	44.4 (36.7-53.7)	42.7 (36-51.1)	-4%	45.4 (36.9-55.8)	6%	45 (33.7-59.3)	-1%
Mental and substance use disorders	4.5 (3.2-6.5)	3.7 (3.1-4.6)	-18%	3.6 (2.9-4.6)	-2%	3.2 (2.4-4.2)	-11%
Diabetes, urogenital, blood, and endocrine diseases	92.9 (83.3-102.7)	76.6 (68.4-84.4)	-18%	71.3 (55.9-96.3)	-7%	63.7 (38.1-101.6)	-11%

Musculoskeletal disorders	1.5 (1-2)	1.2 (0.8-1.7)	-23%	1.1 (0.7-1.7)	-4%	1.2 (0.8-1.9)	8%
Other non-communicable diseases	11.5 (5.3-18.4)	8.5 (5-12)	-26%	7.8 (5.1-11)	-8%	8.9 (5.7-13.8)	14%
Injuries	265.1 (244.2-288.1)	113.6 (102.8-126.1)	-57%	98.1 (83.2-113.5)	-14%	75.7 (59.2-96.4)	-23%
Transport injuries	37.7 (32.8-42.8)	26.1 (23.1-29.4)	-31%	22.9 (18.7-27.5)	-12%	22.5 (16.3-30.8)	-2%
Unintentional injuries	84.4 (74-94.6)	59.4 (53.7-65.4)	-30%	50.7 (44-58)	-15%	34 (27.3-42.5)	-33%
Self-harm and interpersonal violence	31.9 (22.7-46)	27.1 (23.1-34.5)	-15%	24.3 (18.7-32.1)	-10%	19.1 (13.6-27)	-21%
Forces of nature, war, and legal intervention	111.1 (102.4-120.1)	1 (0.7-1.3)	-99%	0.2 (-2.4)	-74%	0.1 (-0.6)	-58%

Between 2017 and 2040, the age-standardized death rate due to diarrheal diseases, lower respiratory infections, and other common infectious diseases declined by 42%; the rest of CMNND level two categories of causes of death declined by more than 57%. During the same period, the age-standardized death rates from cardiovascular diseases and neoplasms reduced by 37% and 8%, respectively. Age-standardized death rates due to unintentional injuries also declined by 33% and due to transport injuries by 2% (Table 2).

The top 20 leading causes of death were projected to account for 72% of the total age-standardized deaths in 2040, of which twelve were non-communicable diseases. The top five leading causes of death in 2040 were; ischemic heart disease accounted for 96 (95% UI:47.3-167.6), lower respiratory infections 71.1 (95% UI:42.6-110.4), diarrheal diseases 57.5 (95% UI:12.1-148.1), stroke 56.8 (95% UI:34.6-95) and diabetes 39.9 (95% UI:23-69.8) per 100,000 people (Table 2).

The transition in disease burden in the age-standardized death rate per 100,000 people for the top 30 leading causes of death between 2017 and 2040 is shown in Figure 5. Significantly larger reductions were observed in diarrheal disease (50%), tuberculosis (76%), Meningitis (52%), protein-energy malnutrition (69%), lower respiratory infection (28%) and HIV/AIDs (35%). The non-communicable diseases ranked in the top 10 leading categories showed a reduction: ischemic heart disease by 39%, stroke by 46%, and diabetes by 3%, whereas prostate cancer increased by 18%.

Rank,1990	Disorder,1990	YLL per 100,000	Rank,2017	Disorder, 2017	YLL per 100,000	1990 - 2017, YLLs % change	Rank,2040	Disorder, 2040	YLLs per 100,000	2017- 2040, YLLs % change
1	Tuberculosis	393.8(265.1-472.7)	1	Ischemic heart disease	393.8(265.1-472.7)	-27%	1	Ischemic heart disease	96(47.3-167.6)	-39%
2	Ischemic heart disease	216.5(187.9-249.2)	2	Diarrheal diseases	393.8(265.1-472.7)	-45%	2	Lower respiratory infections	71.1(42.6-110.4)	-28%
3	Diarrheal diseases	207(127.8-320.6)	3	Stroke	393.8(265.1-472.7)	-45%	3	Diarrheal diseases	57.5(12.1-148.1)	-50%
4	Lower respiratory infections	203.9(165.1-239.8)	4	Lower respiratory infections	393.8(265.1-472.7)	-52%	4	Stroke	56.8(34.6-95)	-46%
5	Stroke	191.9(158.6-223.1)	5	Tuberculosis	393.8(265.1-472.7)	-76%	5	Diabetes mellitus	39.9(23-69.8)	-3%
6	Conflict and war	110.9(102-119.9)	6	Other cardiovascular	393.8(265.1-472.7)	-24%	6	Alzheimer's disease	39(28.4-52.7)	0%
7	Other cardiovascular	61.3(40.4-95.4)	7	Diabetes mellitus	393.8(265.1-472.7)	-19%	7	Other cardiovascular	38.1(25-54.2)	-18%
8	Protein-energy malnutrition	55.3(37.1-75.4)	8	Alzheimer's disease	393.8(265.1-472.7)	8%	8	Prostate cancer	24.6(9.4-36.1)	18%
9	COPD	53.7(39.7-64.4)	9	COPD	393.8(265.1-472.7)	-36%	9	Tuberculosis	22.5(13.1-37.7)	-76%
10	Diabetes mellitus	50.8(43.9-57.5)	10	Hypertensive heart disease	393.8(265.1-472.7)	-30%	10	Road injuries	21.8(15.8-29.8)	-2%
11	Meningitis	45.5(33.3-59.9)	11	Protein-energy malnutrition	393.8(265.1-472.7)	-58%	11	Hypertensive heart disease	20(9-42.1)	-29%
12	Hypertensive heart disease	40.4(24.5-55.6)	12	Falls	393.8(265.1-472.7)	-23%	12	Falls	18.6(14.8-23.5)	-18%
13	Road injuries	36.6(31.7-41.5)	13	Road injuries	393.8(265.1-472.7)	-39%	13	COPD	17.5(10.1-33.8)	-49%
14	Alzheimer's disease	36(29.2-44.9)	14	Meningitis	393.8(265.1-472.7)	-52%	14	Colon and rectum cancer	16.3(11.2-23.3)	18%
15	Cervical cancer	31.6(18.4-67.1)	15	Prostate cancer	393.8(265.1-472.7)	15%	15	Chronic kidney disease	15.3(7.9-30.4)	-12%
16	Falls	29.5(24.3-34.1)	16	Cervical cancer	393.8(265.1-472.7)	-37%	16	HIV/AIDS	12.7(5.4-22.2)	-35%
17	Peptic ulcer disease	27(18-34.5)	17	HIV/AIDS	393.8(265.1-472.7)	-14%	17	Ileus and intestinal obstruction	12.3(8.7-16.7)	-24%
18	Tetanus	26.6(10.3-59.4)	18	Chronic kidney disease	393.8(265.1-472.7)	-22%	18	Cervical cancer	12(7-20.1)	-40%
19	Malaria	24.9(16.3-37)	19	Ileus and intestinal obstructic	393.8(265.1-472.7)	-21%	19	Self-harm	11.4(8-16.7)	-10%
20	HIV/AIDS	22.6(12.7-39.3)	20	Cirrhosis due to hepatitis B	393.8(265.1-472.7)	-30%	20	Other neoplasms	10.9(8.4-14)	-2%
21	Chronic kidney disease	22.3(19.3-25.7)	21	Colon and rectum cancer	393.8(265.1-472.7)	-10%	21	Cirrhosis due to hepatitis B	10.8(7.8-14.4)	-23%
22	Neonatal preterm birth	21.9(16.4-28.2)	22	Self-harm	393.8(265.1-472.7)	-30%	22	Meningitis	10.5(7.1-15.9)	-52%
23	Asthma	21.9(12.9-32.5)	23	Peptic ulcer disease	393.8(265.1-472.7)	-56%	23	Liver cancer	9.4(6.5-13.1)	-8%
24	Neonatal encephalopathy	21.1(14.9-28.6)	24	Interpersonal violence	393.8(265.1-472.7)	-16%	24	Breast cancer	8.7(6-11.9)	-4%
25	Ileus and intestinal obstruction	20.4(14.8-26.5)	25	Other neoplasms	393.8(265.1-472.7)	-5%	25	Skin diseases	7.9(5-12.7)	38%
26	Cirrhosis, due to hepatitis B	19.9(15.8-24.9)	26	Asthma	393.8(265.1-472.7)	-52%	26	Interpersonal violence	7.7(5-12.4)	-34%
27	Prostate cancer	18.2(7.3-29.1)	27	Cirrhosis due to alcohol use	393.8(265.1-472.7)	-26%	27	Cirrhosis due to alcohol use	7.5(5.6-10)	-26%
28	Self-harm	18(13.3-21.8)	28	Liver cancer	393.8(265.1-472.7)	4%	28	Tracheal, bronchus, and lung ca	7.2(4.5-10.7)	-5%
29	Stomach cancer	15.4(12.9-18)	29	Neonatal encephalopathy	393.8(265.1-472.7)	-54%	29	Cirrhosis due to hepatitis C	7.1(4.9-9.9)	-23%
30	Colon and rectum cancer	15.3(12.2-18.5)	30	Cirrhosis due to hepatitis C	393.8(265.1-472.7)	-32%	30	Protein-energy malnutrition	7.1(5-9.7)	-69%
			33	Stomach cancer	4.7(3.5-6.4)	-41%	33	Stomach cancer	4.7(3.5-6.4)	-41%
			36	Neonatal preterm birth	393.8(265.1-472.7)	-71%	35	Peptic ulcer disease	4.4(2.5-6.6)	-63%
			73	Tetanus	393.8(265.1-472.7)	-92%	40	Neonatal encephalopathy due	3.8(2.1-6.4)	-61%
			95	Malaria	393.8(265.1-472.7)	-95%	42	Asthma	3.7(2.1-6.2)	-66%
			120	Conflict and war	393.8(265.1-472.7)	-100%	45	Neonatal preterm birth	3.2(2-4.6)	-51%
							110	Tetanus	0.3(0.1-0.4)	-87%

CMNN disease
Non-communicable diseases
Injuries

Figure 5: **Ranks of age-standardized death rate per 100,000 people for both sexes and all age groups in 1990, 2017, and 2040 in Ethiopia**

Crude YLL rates and percentage changes

In 2040, the all-cause crude YLL rate was 14223.2 per 100,000 people (95% UI: 11000.3-18499.7) of which CMNNDs caused 28.1% (5524.9 per 100,000 people (95% UI: 3754-7866.6), NCDs caused 60.8% (6725.8 (95% UI: 5231.6-8461.8) per 100,000 people, injuries caused 11% (1972.5 per 100,000 people (95% UI: 1479.2-2568.1) (Table 3). The crude YLL per 100,000 people showed a 70% reduction with CMNNDs, 12% for NCDs, and 23% in injuries. All CMNNDs level two causes showed a 55 to 85% reduction in crude YLL rates. Cardiovascular disease and diabetes causes declined by 21% and 5%, respectively, while neoplasm increased by 12%, mental and substance use disorder by 17%, and neurological disorders increased by 2% between 2017 and 2040. Unintentional injuries declined by 47%; however, transport injuries increased by 11% in the same period.

Table 3: **Crude YLL rates per 100,000 people for both sexes and all age groups with level one and two categories, from 1990,2005,2017,2040**

Cause of YLLs	1990 Number (Million)	Crude YLL rate	2005 Number (Million)	Crude YLL rate	% change 1990-2005	2017 Number (Million)	Crude YLL rate	% change (2005-17)	2040 Number (Million)	Crude YLL rate	% change (2017-40)
All cause	48.8 (46.5-51.2)	104575.3 (99689.9-109690.9)	43.3 (40.8-46.2)	57910.9 (54526.4-61720.1)	-45%	30.1 (26.3-34.3)	28458.5 (24858.5-32476.8)	-51%	24.4 (19.1-30.7)	14223.2 (11000.3-18499.7)	-50%
CMNN diseases	37 (34.8-39.3)	79357 (74571.4-84341.2)	33.9 (31.6-36.5)	45296.8 (42246.1-48748.7)	-43%	19.3 (16.4-22.8)	18282.5 (15500.4-21576.4)	-60%	9.5 (6.6-13.3)	5524.9 (3754-7866.6)	-70%
HIV/AIDS and tuberculosis	4(2.8-4.6)	8477.1 (5998.7-9928.7)	6.8 (5.9-7.6)	9051.9 (7892.6-10207.4)	7%	2.6(2.1-3.2)	2480.9 (1983.2-3053.9)	-73%	1.9 (1.2-2.9)	1108.4 (673.5-1695.1)	-55%
Diarrhea, lower respiratory, and other common infectious diseases	21.5(18.5-24.6)	46117.7 (39677.8-52709.9)	14.9 (13.2-16.9)	19857.7 (17658.7-22536.2)	-57%	8.5(6.4-10.8)	8062.5 (6068.3-10294.2)	-59%	4.9 (2.7-8)	2889.7 (1559.9-4748.7)	-64%
Neglected tropical diseases and malaria	1.3(0.8-2)	2768.1 (1656.7-4262.5)	1.6 (1.1-2.2)	2169.8 (1473.6-2981)	-22%	0.2(0.2-0.3)	220.3 (153.5-317.1)	-90%	0.1 (0.1-0.2)	59.8 (39.7-90.8)	-73%
Maternal disorders	0.9(0.7-1.1)	1902.8 (1582.8-2252.6)	1 (0.8-1.2)	1338.3 (1080.4-1623.6)	-30%	0.6(0.4-0.9)	605.2 (422.6-829.7)	-55%	0.3 (0.2-0.5)	172.9 (103.8-275.3)	-71%
Neonatal disorders	6.1(5.4-6.9)	13180.1 (11575.7-14740.8)	6.3 (5.5-7.2)	8409.7 (7367.5-9613.8)	-36%	5.3(4.1-6.9)	5013.6 (3897-6492.4)	-40%	1.7 (1.2-2.5)	982.3 (675.7-1426.4)	-80%
Nutritional deficiencies	2(1-3.3)	4268.5 (2233.1-7081.9)	2.1 (1.4-2.8)	2806.4 (1880.7-3798.3)	-34%	1.1(0.8-1.5)	1034.9 (727.6-1390)	-63%	0.3 (0.2-0.4)	181.1 (122.8-261.2)	-83%
Other communicable, maternal, neonatal, and nutritional diseases	1.2(0.7-2.1)	2642.7 (1512.7-4454.8)	1.2 (0.8-1.8)	1662.9 (1058.2-2397.4)	-37%	0.9(0.5-1.5)	865 (491.6-1420.8)	-48%	0.2 (0.1-0.3)	130.8 (86-200)	-85%
Non-communicable diseases	6.2 (5.5-7)	13321.7 (11731.3-15010.4)	6.8 (6.1-7.6)	9126.5 (8162.3-10104.6)	-31%	8.1 (6.8-9.4)	7628.5 (6430.4-8884.3)	-16%	11.5 (9.1-14.4)	6725.8 (5231.6-8461.8)	-12%
Neoplasms	1.1(1-1.4)	2439 (2069.2-3058.9)	1.4 (1.2-1.7)	1933.3 (1559.7-2289.1)	-21%	2(1.6-2.4)	1912.4 (1515.8-2319.7)	-1%	3.7 (2.9-4.6)	2146.4 (1609.5-2724.3)	12%
Cardiovascular diseases	2.2(2-2.5)	4742.1 (4210.3-5273.3)	2.4 (2.2-2.7)	3230.4 (2897.9-3579.4)	-32%	2.7(2.1-3.4)	2586.3 (2030.5-	-20%	3.5 (2.5-4.6)	2043.3 (1416.3-2803.8)	-21%

							3227.7)				
Chronic respiratory diseases	0.4(0.3-0.4)	817 (679.6-964.1)	0.4 (0.3-0.4)	515.1 (446.5-585.2)	-37%	0.4(0.3-0.6)	381 (279.1-560.9)	-26%	0.4 (0.3-0.6)	230.9 (152.2-370.8)	-39%
Cirrhosis	0.4(0.3-0.5)	872.8 (710.9-1032.3)	0.5 (0.4-0.5)	624.9 (541.9-709.4)	-28%	0.6(0.5-0.7)	543.2 (442.4-651.3)	-13%	0.9 (0.7-1.2)	534.8 (402.4-687.5)	-2%
Digestive diseases	0.6(0.5-0.8)	1311.5 (998-1670.3)	0.6 (0.5-0.7)	829.5 (713.2-954.6)	-37%	0.7(0.5-0.8)	615.9 (510.4-725.7)	-26%	0.8 (0.6-0.9)	440.5 (341-557.1)	-28%
Neurological disorders	0.2(0.1-0.2)	354.4 (254.5-448.1)	0.2 (0.2-0.2)	280.6 (242.8-322.5)	-21%	0.3(0.2-0.3)	261.1 (214.4-314.1)	-7%	0.5 (0.4-0.6)	265.6 (215.6-325.3)	2%
Mental and substance use disorders	0(0-0.1)	74.9(50.6-117.9)	0(0-0.1)	58 (47.1-73.5)	-23%	0.1(0-0.1)	61.2 (45.7-79.6)	6%	0.1 (0.1-0.2)	71.4 (51.4-96.6)	17%
Diabetes, urogenital, blood, and endocrine diseases	0.7(0.6-0.8)	1500.2 (1265.5-1750.7)	0.8 (0.7-0.9)	1033.7 (921.7-1162.9)	-31%	0.9(0.7-1.2)	819 (637.3-1109.4)	-21%	1.3 (0.8-2.3)	779.2 (474.7-1372)	-5%
Musculoskeletal disorders	0(0-0)	29.2 (17.4-42.2)	0(0-0)	22 (14.7-30.4)	-25%	0(0-0)	20.6 (13.9-29.1)	-6%	0 (0-0.1)	25.3 (16.5-37.5)	23%
Other non-communicable diseases	0.6(0.1-1.1)	1180.5 (295.4-2254.9)	0.4 (0.2-0.7)	599 (242.2-978.9)	-49%	0.5(0.2-0.7)	427.7 (203.4-647.7)	-29%	0.3 (0.2-0.5)	188.4 (113.3-269.2)	-56%
Injuries	5.5 (5-6.2)	11896.7 (10625.3-13277.3)	2.6 (2.3-3)	3487.6 (3074.1-3967.4)	-71%	2.7 (2.2-3.2)	2547.5 (2088.9-3036.9)	-27%	3.4 (2.5-4.3)	1972.5 (1479.2-2568.1)	-23%
Transport injuries	0.6(0.5-0.7)	1305 (1060.3-1575.2)	0.6 (0.6-0.7)	861.2 (737.8-987.4)	-34%	0.7(0.6-0.9)	661.3 (531.1-807.7)	-23%	1.3 (0.9-1.8)	735.6 (519.8-1026)	11%
Unintentional injuries	1.3(0.9-1.7)	2770.6 (1955.6-3731.5)	1.3 (1.1-1.5)	1749.2 (1482.6-2034.2)	-37%	1.2(1-1.4)	1102.7 (923-1277.5)	-37%	1 (0.8-1.3)	582.7 (452.8-736.8)	-47%
Self-harm and interpersonal violence	0.5(0.3-0.8)	1015.7 (684.4-1628)	0.6 (0.5-0.9)	826.8 (679-1157.8)	-19%	0.8(0.6-1.2)	769.2 (555.9-1092.7)	-7%	1.1 (0.8-1.6)	648.6 (431.5-974.7)	-16%
Forces of nature, war, and legal intervention	3.2(2.9-3.4)	6805.5 (6273.9-7353.4)	0(0-0.1)	50.5 (30.5-72.6)	-99%	0(0-0.2)	14.2 (-149.8)	-72%	0(0-0)	5.6 (-27.8)	-60%

Age-standardized YLL rates and disease burden transitions

In 2040, the all-cause age-standardized YLL rate was 19023.2 (95% UI: 14223.8-25077.7), of which CMNNDs caused 6496.1 per 100,000 people (95% UI: 4322.6-9529.3), NCDs caused 10332.3 per 100,000 (95% UI: 7695-13683) and Injuries caused 2194.7 per 100,000 people (95% UI: 1647.3-2836.8) (Table 4). The age-standardize YLL percentage contribution of CMNNDs declined from 62.4% in 1990 to 45% in 2018 and 34% in 2040, whereas NCDs contribution increased from 25.2% in 1990, 46% in 2019 and 54% in 2040 (Figure 4). The NCDs were the leading causes of age-standardized YLL rates between 2019 and 2040, as indicated in Figure 6. The top 20 leading causes accounted for 64% of the total age-standardized YLL rate in 2040 (Figure 5). In 2040, 10 of the 20 leading causes were non-communicable diseases. The top five leading causes were lower respiratory infections, Ischemic heart disease, diarrheal diseases, stroke, and road injuries causing 1665.6(95% UI: 921.9-2634.2), 1493.6(95% UI: 788-2482.6), 1211.5(95% UI: 334.3-2912.7), 951.3(95% UI: 560.8-1650.6), and 742.9 (95% UI: 525-1032.7) per 100,000 people, respectively.

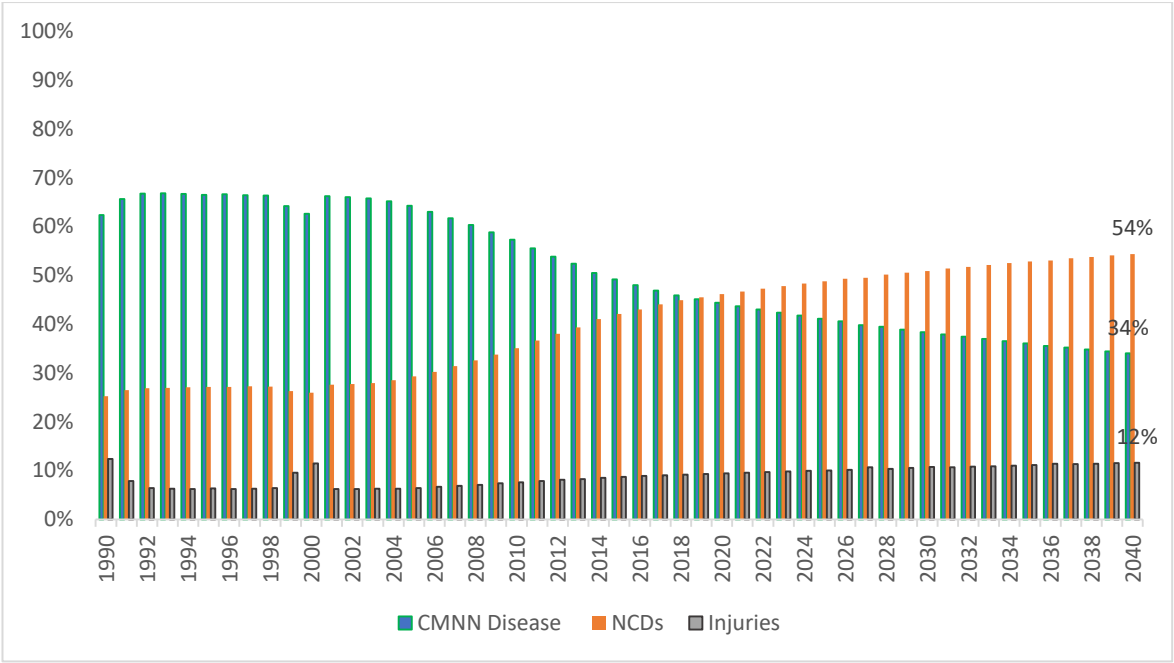

Figure 4: **Percentage contribution to total age-standardized YLL rates per 100,000 by years for major causes for both sexes and all age groups in Ethiopia, 1990-2040**

Note: Note: CMNN Disease; communicable, maternal, neonatal and nutritional diseases; NCDs; non-communicable disease

Rank,1990	Disorder,1990	YLL per 100,000
1	Tuberculosis	11286.1(7774.1-13281.6)
2	Lower respiratory infection	7916.3(5844.2-10025.3)
3	Diarrheal diseases	6775.1(4511.8-9924.5)
4	Conflict and war	6024.2(5537.9-6509.4)
5	Ischemic heart disease	4065.3(3524.1-4702.2)
6	Stroke	3700.8(3087.5-4325.2)
7	Protein-energy malnutritio	2611.5(1504.1-4130.7)
8	Meningitis	2191.9(1501.4-3085.9)
9	Neonatal preterm birth	1894.9(1423.4-2443.5)
10	Neonatal encephalopathy	1823.6(1291.6-2476.4)
11	Road injuries	1384.9(1175.8-1588.7)
12	Malaria	1311.2(759.5-2076.4)
13	Tetanus	1270.9(543.3-2807.6)
14	Neonatal sepsis	1139.2(713.5-1671.6)
15	Other cardiovascular	1103.1(713.4-1672.6)
16	HIV/AIDS	1055.2(595.5-1817.8)
17	Diabetes mellitus	1048.1(913.1-1196.2)
18	COPD	963.3(709-1170.8)
19	STIs	936.9(493.7-1581.8)
20	Cervical cancer	904.2(511.1-1911.8)
21	Other neonatal	899.3(539.3-1359)
22	Whooping cough	882(72.7-2747)
23	Hypertensive heart diseas	709.9(378.1-995.7)
24	Interpersonal violence	669.3(405.2-1310.1)
25	Peptic ulcer disease	606.2(401.7-788.2)
26	Falls	582.9(451.4-704)
27	Self-harm	574.3(420.7-698.3)
28	Indirect maternal deaths	569(349.2-832.9)
29	Asthma	555.4(335-780.7)
30	Ileus and obstruction	549.1(383.7-723.8)

Rank,2017	Disorder, 2017	YLL per 100,000	1990 - 2017, DALYs % change
1	Diarrheal diseases	2914.2(1254.1-5543.9)	-57%
2	Lower respiratory infection	2651(1789.9-3545.9)	-67%
3	Ischemic heart disease	2590.6(1729.9-3531.8)	-36%
4	Tuberculosis	2516(1872.9-3233.5)	-78%
5	Stroke	1858.3(1297.6-2621.3)	-50%
6	HIV/AIDS	924.7(670.8-1201.6)	-12%
7	Neonatal encephalopathy	831.8(548.7-1224.6)	-54%
8	Meningitis	831.1(611.6-1149.4)	-62%
9	Diabetes mellitus	770.8(538.1-1198.1)	-26%
10	Other cardiovascular	766.3(557.6-1034.6)	-31%
11	Protein-energy malnutritio	762.4(579.9-965.8)	-71%
12	Road injuries	751(610.5-916.4)	-46%
13	Neonatal sepsis	574.8(332.5-897.1)	-50%
14	Neonatal preterm birth	556.7(372.3-788.1)	-71%
15	COPD	552.5(344.8-977.4)	-43%
16	Cervical cancer	540.4(321.3-873.9)	-40%
17	Interpersonal violence	528.2(362.5-840.2)	-21%
18	Other neonatal	444.5(201.4-740.8)	-51%
19	Hypertensive heart disease	434.9(231.1-754.3)	-39%
20	Whooping cough	426.7(43.6-1146.8)	-52%
21	Ileus and obstruction	386.6(305.3-492.1)	-30%
22	Self-harm	385.5(295.5-495.5)	-33%
23	Other neoplasms	379.9(294.1-480.1)	-8%
24	Falls	364.7(306.3-424.4)	-37%
25	Alzheimer's disease	352.2(277.2-450.6)	7%
26	STIs	346.4(162.3-610.2)	-63%
27	Cirrhosis	345.1(269.8-434.2)	-35%
28	Chronic kidney disease	339.8(241.4-527.4)	-34%
29	Prostate cancer	331.4(118.3-489)	10%
30	Liver cancer	251(184.5-318)	2%
33	Asthma	236.9(165.7-362.6)	-57%
36	Peptic ulcer disease	222.9(144.5-302.1)	-63%
43	Indirect maternal deaths	148.9(84.6-240.3)	-74%
58	Tetanus	97.8(57.1-143)	-92%
79	Malaria	57.3(36.6-82.6)	-96%
116	Conflict and war	10.6(-125.3)	-100%

Rank,2040	Disorder, 2040	YLLs per 100,000	YLLs % change
1	Lower respiratory infecti	1665.6(921.9-2634.2)	-37%
2	Ischemic heart disease	1493.6(788-2482.6)	-42%
3	Diarrheal diseases	1211.5(334.3-2912.7)	-58%
4	Stroke	951.3(560.8-1650.6)	-49%
5	Road injuries	742.9(525-1032.7)	-1%
6	Diabetes mellitus	714.6(371.6-1410)	-7%
7	HIV/AIDS	607.2(272.1-1033.8)	-34%
8	Other cardiovascular	577.2(386.8-826.4)	-25%
9	Tuberculosis	572.4(318.2-958.1)	-77%
10	Prostate cancer	383(146.2-575.7)	16%
11	Meningitis	376(246-570.5)	-55%
12	Other neoplasms	358.4(264-474)	-6%
13	Self-harm	341.2(231.3-511.1)	-11%
14	Interpersonal violence	337.3(211.2-570.9)	-36%
15	Alzheimer's disease	334.6(242.3-457.6)	-5%
16	Neonatal encephalopati	326.7(179.2-551.7)	-61%
17	Cervical cancer	317.4(183.5-536.9)	-41%
18	Hypertensive heart dise	285.4(127.6-567)	-34%
19	COPD	281.3(157.1-533.7)	-49%
20	Neonatal sepsis	279.3(150.5-470.7)	-51%
21	Neonatal preterm birth	274.9(176.2-401.1)	-51%
22	Chronic kidney disease	270.4(145.3-535.9)	-20%
23	Falls	268.4(210.6-341.2)	-26%
24	Ileus and obstruction	267.7(195.5-354.1)	-31%
25	Whooping cough	264.3(29-740)	-38%
26	Cirrhosis	262.6(189.4-355.4)	-24%
27	Colon and rectum cancer	261.6(176.3-374.6)	11%
28	Liver cancer	222.3(148.2-318)	-11%
29	Breast cancer	214.6(143.8-306.6)	-10%
30	Non-Hodgkin lymphoma	193.7(113-277.3)	-9%
33	Protein-energy malnutrit	174.1(114.4-257.3)	-77%
34	Other neonatal disorder	165.3(66.7-304.2)	-63%
58	STIs	54.6(23.5-108.6)	-84%
47	Asthma	76.2(45.4-127.1)	-68%
46	Peptic ulcer disease	77.1(45.6-113.9)	-65%
78	Indirect maternal deaths	30.7(15.8-53.7)	-79%

CMNN disease
Non-communicable diseases
Injuries

Figure 6: **Ranks of causes of age-standardized YLL rate per 100,000 people for both sexes and all age groups between 1990, 2017, and 2040 in Ethiopia.**

Table 4: **Age-standardized YLL rates per 100,000 people for both sex and all age groups with level one and two categories from 1990, 2005, 2017, and 2040**

Causes of death	1990	2005	% change, 1990-2005	2017	% change, 2005-2017	2040	% change, 2017-2040
All cause	92334.6 (88207.3-96677.3)	59659.7 (56036-63533.7)	-35%	33443.3 (28752.8-38547.1)	-44%	19023.2 (14223.8-25077.7)	-43%
CMNN diseases	57604.4 (54444.5-60913.5)	38363.7 (35807.4-41112.7)	-33%	15694.1 (12971.8-19010.9)	-59%	6496.1 (4322.6-9529.3)	-59%
HIV/AIDS and Tuberculosis	12341.4 (8776.9-14357.7)	12420.5 (10962.5-13808)	1%	3440.7 (2729.4-4247.3)	-72%	1179.6 (735.5-1794)	-66%
Diarrhea, lower respiratory, and other common infectious diseases	30345.1 (26426.2-34819.7)	15208.6 (13547.9-17215.8)	-50%	7455 (5158.3-10372.6)	-51%	3649.7 (1924.3-6131.5)	-51%
Neglected tropical diseases and malaria	2126.7 (1452-2952.5)	1656 (1222.6-2178.9)	-22%	214.6 (155.3-296.8)	-87%	65.1 (44.1-95.2)	-70%
Maternal disorders	2262.2 (1863.5-2685.6)	1587 (1276.4-1928.8)	-30%	666.2 (462.5-918.3)	-58%	158.5 (94.3-253.1)	-76%
Neonatal disorders	6015.1 (5288.5-6735)	4402.8 (3859.8-5033.6)	-27%	2465.7 (1955.9-3125.4)	-44%	1061.2 (735.9-1512)	-57%
Nutritional deficiencies	2945.8 (1817.2-4554.2)	2020.3 (1495.1-2604.8)	-31%	878.6 (689.7-1092)	-57%	232.9 (162.1-322)	-73%
Other communicable, maternal, neonatal, and nutritional diseases	1568.1 (1005.2-2460.9)	1068.5 (735.4-1471.7)	-32%	573.2 (371.6-863.5)	-46%	149 (100.1-223.4)	-74%
Non-communicable diseases	23300 (21193.1-25505.4)	17480 (15813.2-19246.1)	-25%	14740.1 (12442.2-17286)	-16%	10332.3 (7695-13683)	-30%
Neoplasms	4402.7 (3755.8-5385.6)	3623.3 (2949.1-4350.6)	-18%	3510 (2799.3-4250.7)	-3%	3036.8 (2283.5-3931.2)	-13%
Cardiovascular diseases	10163.7 (9028.7-11317.1)	7529.3 (6748.8-8363.6)	-26%	5968.5 (4646-7424.1)	-21%	3540.9 (2335.4-5030.8)	-41%
Chronic respiratory diseases	1560.2 (1340.1-1770.2)	1050.2 (914.6-1187.2)	-33%	818.4 (582.6-1239.4)	-22%	381.8 (239.9-639.8)	-53%
Cirrhosis	1496.7 (1229.9-1758.8)	1143.5 (997.3-1295.7)	-24%	975.5 (803.8-1164.6)	-15%	721.2 (545.8-939.8)	-26%
Digestive diseases	1998.9 (1548.8-2336.1)	1369 (1197.7-1543.8)	-32%	1051.2 (874-1236.6)	-23%	621.7 (474.9-798.2)	-41%
Neurological disorders	629.7 (508.8-748.4)	547.7 (475-637.8)	-13%	536.7 (438.5-654)	-2%	484.2 (368.8-633.8)	-10%
Mental and substance use disorders	126.3 (86.4-196.2)	102 (83.7-129.1)	-19%	100 (76.1-129.6)	-2%	86.3 (62.6-116.4)	-14%
Diabetes, urogenital, blood, and endocrine diseases	2227.4 (1984.1-2472.6)	1684.3 (1507-1861.8)	-24%	1449.4 (1118.7-2005.2)	-14%	1191.2 (694.3-2009.9)	-18%

Musculoskeletal disorders	42.6 (26.3-59.2)	32 (20.8-43.9)	-25%	29.7 (19.8-43.1)	-7%	30.4 (19.5-46.4)	3%
Other non-communicable diseases	651.7 (210.1-1179.3)	398.8 (187.6-609.7)	-39%	300.8 (172-416.2)	-25%	237.9 (147.9-339.6)	-21%
Injuries	11430.2 (10419.9-12516)	3816 (3425.4-4311.4)	-67%	3009.1 (2476.5-3551.3)	-21%	2194.7 (1647.3-2836.8)	-27%
Transport injuries	1440.3 (1229.6-1649.4)	960.3 (839.9-1092.4)	-33%	783.9 (635.3-957)	-18%	773.4 (552.4-1072.9)	-1%
Unintentional injuries	2712.2 (2178.3-3274.4)	1787.4 (1598.9-1985.3)	-34%	1298.9 (1106.2-1491.5)	-27%	737.6 (575.2-931.3)	-43%
Self-harm and interpersonal violence	1243.6 (858.7-1898.5)	1023.3 (853.9-1371.2)	-18%	913.7 (672.5-1248.3)	-11%	678.6 (461.4-994.1)	-26%
Forces of nature, war, and legal intervention	6034.1 (5563.2-6520.5)	45 (27.4-64.4)	-99%	12.6 (0-127.5)	-72%	5.2 (0-26.3)	-59%

Discussions

GBD forecasting study used an innovative method for combining projections from multiple models to more completely capture the uncertainty about future trends in life expectancy (12). The key limitation of this study is the inability to account for completely unexpected events such as pandemics and conflict and changes in the social, technological, and health systems determinants of health. Moreover, limitations of the data have been indicated with wide uncertainty interval that challenges public health decisions.

Ethiopians' average life expectancy is expected to increase significantly, with females gaining more than males between 2017 and 2040. During this period, life expectancy at birth is expected to increase by 8 years between 2017 and 2040. This finding aligns with the increasing trend of life expectancy projection by the Central Statistical Agency from 2007 to 2037 (3). Mortality due to NCD and injuries is expected to show a smaller reduction than CMNNDs. NCDs continued to be the leading causes of the age-standardized death rate through 2040. Of the CMNNDs, age-standardized deaths due to diarrheal disease, tuberculosis, Meningitis, and protein-energy malnutrition were expected to decline by half or more.

In contrast, lower respiratory infections and HIV/AIDS showed aone-third or less decline from the rates during the projection period. During the same period, cardiovascular diseases declined by 37%, neoplasms by 8%, and diabetes by 3%. On the contrary, prostate cancer was expected to increase by 18%. In 2040, twenty leading causes account for 72% of the total age-standardized death rates of which six out of ten leading were non-communicable diseases. The five leading causes of age-standardized death rates are ischemic heart disease, lower respiratory infections, diarrheal disease, stroke, and diabetes. Regarding premature mortality, NCDs were expected to be the leading causes of age-standardized rates from 2017 through 2040. The percentage contribution of CMNNDs to the total premature deaths declined from 47% in 2017 to 34% in 2040. By contrast, the contribution of NCDs was expected to increase from 44% in 1990 and 54% in 2040. The top twenty leading causes accounted for two-thirds of the total age-standardized premature mortality in 2040. In 2040, 10 of the 20 leading causes of premature mortality are expected to be non-communicable diseases. The top five leading causes of premature mortality were lower respiratory infections, Ischemic heart disease, diarrheal diseases, stroke, and road injuries.

More gains in life expectancy could happen from a reduction in mortality due to NCDs and injuries by improving healthcare availability and accessibility to treat, prevent and control NCDs and injuries. Ethiopia's average life expectancy gain was expected to be higher than many lower middle-income countries (LMIC) and countries considered a benchmark in Ethiopia's envisioning strategy by 2040. The increment was one year in Philippines, 4 years in Egypt, 5 years in Indonesia, and 6 years in India, while it was 8 years in Ethiopia. During the same period, life expectancy was expected to increase by 3 years in Brazil and 6 years in China, considered as benchmarking upper middle-income countries (UMIC) for Ethiopia. In terms of years gain, Ethiopia was better than China or Brazil, but the baseline had affected UMIC, and gaining more years of life expectancy would be challenging for UMIC. The projection showed that Ethiopia was expected to be more likely to join LMIC in terms of life expectancy than to join UMIC by 2040.

The rate of unemployment and income inequalities is quite high in Ethiopia, which contributes significantly to health inequalities and access to quality health services. A lack of sustainable health care resources negatively impacts Ethiopia's life expectancy gains (13). The current move to use the universal health coverage (UHC) approach to guarantee access to essential health services for all and ensure financial risk protection through strengthening the primary health care system is commendable for Ethiopia (14). However, it is important to examine effective primary health care coverage to address non-communicable diseases and expand the role of health extension programs and community involvement. The country is implementing health insurance and health care financing, and there is a need to ensure financial risk protection, improve the contribution of domestic financing, and increase the overall health budget for the sustainability of the progress (15). Furthermore, it is important to address life expectancy inequalities across Ethiopia's different regional states and implement relevant strategies (3,11).

Ethiopia is expected to reduce neonatal mortality from 23 in 2017 to 14 deaths per 1,000 live births by the end of 2030. Neonatal mortality in Ethiopia is expected to be higher than in other lower-middle-income countries such as Philippines, Egypt, and Indonesia in the next 11 years. More success with neonatal mortality has been a longstanding challenge for Ethiopia in the MDG (16) and is expected to continue. Risk factors such as low birth weight and short gestation appear highly prevalent in this period. There is a need for global investment and more domestic financing to strengthen essential obstetric, neonatal care, and high-impact survival interventions to address leading causes of neonatal deaths including neonatal encephalopathy, neonatal sepsis, and neonatal preterm birth complications in Ethiopia (17).

The under-five mortality rate is expected to be high for Ethiopia (30 per 1000 live births) by 2030 compared with some LMICs such as Philippines (19 per 1000 live births), ,Indonesia (16 per 1000 live births), and some Upper Middle Income countries like Brazil (14 per 1000 live births) and China (7 per 1000 live births). In 2030, Ethiopia is more likely to achieve a under 5 mortality rate success of current LMICs' but less likely to achieve UMICs success such as Brazil and China (10). In terms of maternal mortality ratio, Ethiopia is expected to reduce to 140 per 100,000 live births by the end of 2030 an estimated 200 by 2017. Ethiopia is expected to be closer to India (129 per 100,000 live

births) and Indonesia (119 per 100,000 live births). However, the maternal mortality ratio in Ethiopia is higher than in the Philippines and Egypt and much higher than in Brazil and China, although Ethiopia is expected to show a faster decline. Access to quality health services and healthcare resources and strengthening high-impact interventions such as child survival and skilled delivery is essential. There is a need to accelerate maternal mortality and morbidity reduction, sustaining gains, and consolidating safe motherhood initiatives.

Ethiopia is expected to reduce malaria, tuberculosis, and HIV/AIDS cause-specific age-standardized death rates by 56% (1.25 to 0.55 deaths per 100,000), 76% (93 to 23 deaths per 100,000), 35% (19 to 13 deaths per 100,000) respectively from 2017 to 2040 (10). In 2040, Ethiopia could target malaria, tuberculosis, and HIV/AIDS ,causing specific age-standardized death rates in 2017 achievement of some LMICs, such as India, Philippines, and Indonesia, but higher than Egypt and much higher than UMICs, such as Brazil and China (10). Ethiopia needs to strengthen malaria elimination, and end tuberculosis and HIV/AIDS prevention and control programs to account for more success close to upper-middle-income countries by 2040.

In Ethiopia, progress has been made (4) to reduce population-based risk factors, including intervention the government has passed a bill restricting smoking in public places ,banning alcohol advertisements on billboards, and limiting the time when promotion is broadcasted on media (18). There is a need to empower the community to prevent non-communicable diseases and strengthen health service delivery with emphasis on primary health care units (PHCU) within Ethiopia's wider healthcare sector context. The findings of this study are comprehensive to inform national-level envisioning plans and strategies. The study has also highlighted the need to produce subnational forecasting results to understand disparities and progress and devise relevant strategies for regional states. There is a need to improve quality data availability and accessibility to produce reliable decision-making results.

Conclusions

Ethiopians' average life expectancy is expected to increase. This major gain in life expectancy is expected to be attributed to further reductions in under-five mortality and a decline in the burden of major communicable, maternal, and nutritional diseases. However, it will be negatively affected by pandemics, conflict, war, and emergencies, and more life expectancy gains could be expected, postponing death from non-communicable diseases and injuries. Ethiopia is more likely to achieve the success of lower middle income countries in terms of life expectancy, neonatal, child, and maternal mortality rates, and eradicating malaria, tuberculosis, and HIV/AIDS causes of mortality; however less likely to achieve success of UMICs by 2040. Non-communicable diseases and injuries are expected to show a smaller reduction and are expected to be leading causes of age-standardized death rate from 2017 through 2040 thatneeds more emphasis on strengthening the health care system, devising prevention and control strategies, and implementing Best Buy interventions while addressing the unfinished agenda of communicable diseases. Providing subnational forecasting results could also be helpful in understanding projected disparities and progress to devise relevant strategies for regional states. It is also important to improve quality data availability and accessibility to produce reliable results.

Competing interests

The authors declare that they have no competing interests.

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