

The burden of disease and cause of mortality in Ethiopia, 2000–2016: findings from the Global Burden of Disease Study and Global Health Estimates

Obciążenie chorobami i przyczyny śmiertelności w Etiopii w latach 2000–2016 – wyniki badania Global Burden of Disease Study i globalnej statystyki zdrowotnej WHO

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Słowa kluczowe: przyczyny zgonów, śmiertelność, obciążenie chorobami, wskaźnik DALY.

Abstract

Introduction: Measuring the burden of disease and identifying the cause of mortality are very important to improve the health care system and to understand the key challenges of population health and monitoring progress achieved by the intervention programs.

Aim of the research: To systematically analyze the existing evidence to bring a solution.

Material and methods: The research used data from the Global Burden of Disease study (GBD 2016) and Global Health Estimates (GHE) 2016, which originally collected the information through vital registration, verbal autopsy, surveys, reports, published scientific articles, and modelling.

Results: In 2016, an estimated 700108.8 (95% CI: 588955.7–831398.4) deaths were recorded in Ethiopia, with an overall crude death rate (CDR) of 683.7/100,000 and an age-standardized death rate (ASDR) of 1048.3/100,000 population. Both declined, by 53.7% and 42.3% respectively, from the 2000 estimate. Group I causes (communicable, maternal, neonatal, and nutritional – CMNN), group II causes (non-communicable diseases – NCD), and group III causes (injuries) contributed to 37%, 53%, and 11.7% of ASDR, respectively. The ASDR due to group I, group II, and group III causes declined by 61.8%, 12.5%, and 36%, respectively. Ischemic heart disease, lower respiratory infections, diarrheal diseases, stroke, and tuberculosis were the top five causes of ASDR. Disability-adjusted life years lost (DALYs) due to all causes among all ages declined by 34.8% between 2000 and 2016. Of the 46,507,400 DALYs in 2016, group I, group II, and group III causes accounted for 54%, 34%, and 11.7% of national DALYs, respectively. DALYs due to group I causes declined by more than 52%, while DALYs due to group 2 causes increased by 31.5%.

Conclusions: Even though morbidity and mortality ascribed to communicable diseases declined remarkably, the burden of NCD is still higher and some of the existing communicable diseases caused higher mortality and DALYs.

Streszczenie

Wprowadzenie: Ocena obciążenia chorobami i identyfikacja przyczyn śmiertelności mają bardzo istotne znaczenie dla poprawy działania systemu opieki zdrowotnej, zrozumienia kluczowych wyzwań związanych ze zdrowiem populacyjnym oraz monitorowania postępów osiągniętych dzięki programom interwencyjnym.

Cel pracy: Analiza dostępnych dowodów pod kątem wypracowania rozwiązań.

Materiał i metody: W pracy wykorzystano dane z badania *Global Burden of Disease* (GBD 2016) i globalnej statystyki zdrowotnej WHO (*Global Health Estimates* – GHE 2016) gromadzone na podstawie obowiązkowego zgłaszania, autopsji słownej, ankiet, raportów, opublikowanych artykułów naukowych i modelowania.

Wyniki: W 2016 roku w Etiopii odnotowano 700 108,8 (95% CI: 588 955,7–831 398,4) zgonów. Surowy współczynnik umieralności (*crude death rate* – CDR) wyniósł 683,7/100 000, a standaryzowany według wieku (ASDR) osiągnął poziom 1 048,3/100 000. Wartości obu współczynników były niższe o odpowiednio 53,7% i 42,3% w stosunku do danych z 2000 roku. Przyczyny zaliczane do grupy I (schorzenia zakaźne, choroby matek i noworodków oraz przyczyny żywieniowe – CMNN), grupy II (choroby niezakaźne – NCD) i grupy III (urazy) stanowiły odpowiednio 37%, 53% i 11,7% ASDR. Wartość ASDR ze względu na przyczyny zmniejszyła się o odpowiednio 61,8%, 12,5% i 36%. Do pięciu głównych przyczyn ASDR należą: choroba niedokrwienna serca, zakażenia dolnych dróg oddechowych, choroby przebiegające z biegunką, udar

i gruźlica. Wskaźnik lat życia skorygowanych niesprawnością (*disability-adjusted life year* – DALY) ze wszystkich przyczyn we wszystkich grupach wiekowych w latach 2000–2016 zmniejszył o 34,8%. Przyczyny sklasyfikowane w grupie I, II i III stanowiły odpowiednio 54%, 34%, i 11,7% zarejestrowanych w kraju 46 507 400 DALY. Wskaźnik DALY z przyczyn zaliczanych do grupy I obniżył się o ponad 52%, a z przyczyn z grupy II wzrósł o 31,5%.

Wnioski: Chociaż zachorowalność i śmiertelność związane z chorobami zakaźnymi znacznie się zmniejszyły, obciążenie chorobami niezakaźnymi jest nadal wysokie, a niektóre z chorób zakaźnych występujących w objętej badaniem populacji wiążą się z wyższymi wartościami wskaźnika śmiertelności i DALY.

Introduction

Although measuring the burden of disease and identifying the cause of mortality are very important to improve health care systems and monitor progress achieved by the intervention programs [1, 2], their utilization was poor until the Global Burden of Disease (GBD) study. The study was launched in 1991 by the World Bank and the World Health Organization [3–5]. The GBD study is conducted periodically for all countries around the globe. It measures the burden of diseases and injuries, and the risk factors that cause them broken down by age, sex, and region, and it is used as an important input to health decision-making, planning processes, assessing development, guiding resource allocation, and is used to monitor progress towards Sustainable Development Goals (SDGs) [1, 4].

Globally the burden of disease, which is measured by years lived with disability (YLD), years of life lost (YLL) and disability-adjusted life years (DALYs) [4], has been continuously shifted at different rates as a result of demographic expansion and epidemiologic transitions. These transitions shaped the epidemiology and burden of communicable and non-communicable diseases, maternal and child health problems, nutritional problems, and different types of injuries. Generally in the last two decades deaths due to infectious and nutritional causes as well as maternal and child conditions have declined, whereas deaths from non-communicable diseases (NCDs) have risen globally and in most countries including the developing ones [4–7].

As reported from previous GBD studies, globally, the number of deaths increased from 47.47 million in 1990, to 54.86 million in 2013, partly from population growth and infectious diseases [6–9]. DALYs slightly decreased from 2497 million to 2482 million between 1990 and 2010, and to 2464 million in 2015 [6–8]. Ischemic heart disease and stroke were the two leading causes of DALYs in 2015 [7]. These epidemiological shifts from communicable disease to non-communicable diseases have also been reported in developing countries including Africa.

Also, the high burden of communicable disease and maternal conditions such as lower respiratory tract infections, diarrhea, malaria, complications of preterm birth, and neonatal encephalopathy was the leading cause of death in children in low-income countries in 1990 and remained major contributors of DALYs in 2010. In addition, the leading communicable diseases (tuberculosis and HIV/AIDS) and dis-

abling conditions (low back pain and major depressive disorder) were among the top 15 causes of DALYs. Road-traffic injuries also caused higher DALYs [6].

Ethiopia, as one of the low-income countries, is facing a high burden of disease. Previous reports indicated that the major health problems of the country remained largely preventable communicable diseases, reproductive health problems, and nutritional disorders. However, the demographic, nutritional, and epidemiological transitions and intervention programs may have shifted the burden of these diseases [10, 11]. As a result of health care improvement child mortality was reduced from 166/1000 live births to 67/1000 live births and, maternal mortality from 871/100,000 to 412/100,000 live births between 2000 and 2016 [11]. However, in 2015, communicable, maternal, and nutrition-related diseases were the leading causes of premature mortality, whereas non-communicable diseases were the leading causes of age-standardized mortality [7, 11].

Although major signs of progress have been made to improve the health status of the population, Ethiopia's population still faces a high rate of morbidity and mortality and the health status remains relatively poor. However, the causes of such higher mortality and DALYs were not well understood.

Aim of the research

Therefore, this study aimed to measure the burden of disease and identify the cause of mortality in Ethiopia between 2000 and 2016 by using evidence from Global Burden of Disease Study 2016 (<https://vizhub.healthdata.org/gbd-compare/>) and Global Health Estimates 2016 (<https://vizhub.healthdata.org/gbd-compare/>), which will contribute to improving the health status of the population.

Material and methods

Study design and source of data

The main data sources for this work are the World Health Organization Global Health Estimate database (<https://vizhub.healthdata.org/gbd-compare/>) and the Institute for Health Metrics and Evaluation (IHME) (Global Burden of Disease study 2016) database (<http://vizhub.healthdata.org/gbd-compare/>). The WHO in collaboration with UN partner agencies (such as UNICEF, UNAIDS, UNFPA, and the UN Population Division), UN multi-agency expert groups and academic net-

works collect and compile global health statistics and estimates causes of death. WHO has drawn data on the GBD 2016 analyses for selected causes for member states without the determination of comprehensive death registration data. It estimates population characteristics (demography), all-cause, and specific causes of death, through vital registration (VR) data, Global Burden of Disease 2016 (GBD 2016) study estimates, and scientific estimations. The majority of the data sources were validated by the agency.

In Global Health Estimates, the disease burden and cause of mortality for the case of Ethiopia were measured using the Global Burden of Disease study 2016 approach through surveys and model estimates. This study used Global Health Estimates as a source of information for population structure and total mortality and then estimated for disability-adjusted life years. The data from 1990 to 2016 for GBD and from 2000 to 2016 for GHE are archived in IME and World Health Organization databases, which are freely available for research purposes. Ethiopia is the second-most populous country in Africa after Nigeria, with a population estimated at 102 million in 2016, of which 83.86% live in rural areas [12].

Operational definitions

Disability: is used broadly in disease burden analyses to refer to departures from good or ideal health in any of the important domains of health.

Disability-adjusted life year (DALY): is a summary measure that combines time lost through premature death and time lived in states of less than optimal health, loosely referred to as “disability”.

Statistical analysis

The GBD study and GHE approaches to estimate all-cause mortality and cause-specific mortality rates by age, sex, and year have been described elsewhere [1–4]. Causes of death by age, sex, and year for all causes were measured mainly using the cause of death ensemble modeling (CODEm) [13]. The model tests a wide range of models, such as mixed-effects linear models and spatiotemporal Gaussian process regression (ST-GPR) models, and constructs an ensemble model based on the performance of the different models.

DALY was measured by summing years of life lost (YLL) due to premature mortality and years lived with disability (YLD), a measure of non-fatal health loss, in a single metric. YLL was estimated using standard GBD methods whereby each death is multiplied by the normative standard life expectancy at each age. YLD was estimated using sequelae prevalence and disability weights derived from population-based surveys. For most sequelae, the GBD 2016 study used a Bayesian meta-regression method, DisMod-MR 2.1, designed to address key limitations in descriptive

epidemiological data, including missing data, inconsistency, and large methodological variation between data sources [1–4].

Results

There were an estimated 700108.8 (95% CI: 588955.7–831398.4) deaths due to all causes and among all age and gender groups in 2018, with a 28.7% decline from the year 2000 record of 981955.9 (95% CI: 867049.4–1107745.6) deaths. The estimated number of deaths due to tuberculosis by the year 2018 was 25475.9 (95% CI: 15352.4–38120.6) while it was 70460.3 (95% CI: 41102.5–107591.5) by the year 2020 with a 63.8% change between them. In the years 2000 and 2018, the estimated number of deaths due to HIV/AIDS was 74692.2 (95% CI: 54289.0–99454.5) and 20313.9 (95% CI: 13327.3–30196.9) with a 72.8% change between them (Table 1).

The estimated number of deaths due to the overall non-communicable disease in the year 2016 was 274998.8 (95% CI: 211290.2–362882.1) with a change of 38% since the year 2000. There were 5184.9 (95% CI: 3547.7–7332.7) estimated deaths in the year 2000 and 7653.6 (95% CI: 4961.7–11508.1) in the year 2016 due to breast cancer with a 47.6% change. In considering the estimated number of deaths due to diabetes mellitus, there were 8058.9 (4956.3–12447.5) and 13027.9 (95% CI: 7589.9–21245.6) in the years 2000 and 2016, respectively, a 61.7% change. Similarly, there were 3136.4 (95% CI: 2065.4–4601.8) in the year 2000 and 3342.2 (95% CI: 2040.4–5311.5) in the year 2016 due to epilepsy, which is a 6.6% change (Table 2).

There was a 25.7% increase in the estimated number of deaths due to overall respiratory diseases between the years 2000 and 2016. The estimated number of deaths due to chronic obstructive pulmonary diseases (COPD) in the year 2016 was 10347.0 (95% CI: 6609.1–15775.4) while it was 7323.6 (95% CI: 4958.6–10463.3) in the year 2000, which is a 41.3% change. Similarly, it was 1364.8 (95% CI: 792.3–2234.9) and 1206.1 (95% CI: 641.7–2144.5) due to appendicitis in the same periods, respectively, an 11.6% reduction. The overall estimated number of deaths due to injuries was 92782.3 (95% CI: 72070.7–118943.0) in the year 2000 while it was 81849.7 (95% CI: 59603.8–114268.5) in the year 2016, which is an 11.8% reduction. There was a 73% increase in deaths due to skin diseases between the year 2000 and 2016, which was 1421.4 (95% CI: 604.3–2940.4) and 2458.6 (95% CI: 1015.6–5156.5) respectively (Table 3).

In 2016, the overall crude death rate was estimated to be 683.7/100,000 and the age-standardized death rate (ASDR) was 1048.3/100,000 population. Both declined by 53.7% and 42.3% respectively from the year 2000 estimate. Similarly, in 2016, group I causes (communicable, maternal, perinatal, and nutritional conditions – CMNN) were responsible for 49% of

Table 1. Number and cause of CMNN deaths for both sexes and all age groups for the period from 2000 to 2016

Cause of death	Number of deaths in 2000			Number of deaths in 2016			% change
	Value	95% LL	95% UL	Value	95% LL	95% UL	
All causes	981955.9	867049.4	1107745.6	700108.8	588955.7	831398.4	-28.7
CMNN diseases	689873.7	572049.6	825646.4	343260.3	266145.2	448530.8	-50.2
Infectious and parasitic diseases	405415.8	307381.3	516867.5	168659.4	118868.1	233555.5	-58.4
STDs excluding HIV	6974.9	3134.5	13761.6	6527.3	2797.1	13286.8	-6.4
Diarrheal diseases	107342.9	70792.1	154000.3	59523.3	36404.2	92418.6	-44.5
Childhood-cluster diseases	67076.4	32333.7	124227.0	16187.4	7158.7	32088.6	-75.9
Meningitis	39540.0	25420.8	58293.9	18381.3	10832.7	29634.3	-53.5
Hepatitis	3169.4	1894.4	5040.3	2932.6	1619.7	5036.5	-7.5
Parasitic and vector diseases	23792.6	15087.9	35591.3	12473.2	7254.2	20375.7	-47.6
Other infectious diseases	7154.6	4382.4	11097.0	5524.1	3121.0	9283.1	-22.8
Respiratory infections	117162.7	77435.8	167696.2	66695.5	40935.9	103176.8	-43.1
Lower respiratory infections	116769.5	77169.6	167148.4	66543.9	40840.0	102949.6	-43.0
Maternal conditions	28591.4	18557.3	41727.2	13102.5	7809.5	20885.1	-54.2
Neonatal conditions	112573.1	82718.1	148236.6	75546.3	51923.2	107300.6	-32.9
Preterm birth complications	40396.3	25991.4	59507.9	27586.8	16476.9	43880.9	-31.7
Birth asphyxia and trauma	47756.5	22792.2	89267.0	27941.7	12588.3	54512.2	-41.5
Neonatal sepsis and infections	19553.9	9089.7	37439.2	16447.7	7284.9	32563.0	-15.9
Other neonatal conditions	4866.3	2160.4	9703.7	3570.1	1495.8	7402.6	-26.6
Nutritional deficiencies	26130.6	16612.1	38985.6	19256.6	11365.0	31000.4	-26.3
Protein-energy malnutrition	23761.3	11103.7	45278.5	17059.9	7560.7	33756.8	-28.2
Other nutritional deficiencies	2186.0	943.7	4464.1	1970.5	807.0	4161.0	-9.9

CMNN – communicable, maternal, neonatal, and nutritional problems, STD – sexually transmitted diseases, UL – upper limit, LL – lower limit.

the crude deaths and 37% of ASDR, whereas non-communicable diseases were responsible for 39.3% of the crude deaths and 53% of ASDR, and injuries were responsible for 11.7% of the crude deaths and 10% of ASDR. Mortality (ASDR) due to group I (CMNN), group II (NCD), and group III (injuries) declined by 61.8%, 12.5%, and 36%, respectively, between 2000 and 2016. However, the number of deaths due to non-communicable diseases increased by 38% during the same period (Table 4).

Among the level 2 causes/diseases, infectious and parasitic diseases caused the highest number of deaths: 168659.4 (95% CI: 118868.1–233555.5) by the year 2016. Also, cardiovascular diseases, neonatal conditions, respiratory infections, unintentional injuries, and malignant neoplasms caused 109499.7, 75546.3, 66695.5, 66403.9, and 50913.5 deaths, respectively. Of the level 3 diseases/causes, lower respiratory infections caused the highest number of death, 66543.9 (95% CI: 40840–102949.6) in the same year; while diarrheal diseases, ischemic heart disease, stroke, road injury, and birth asphyxia and trauma caused

59523.3, 47711.6, 32859.5, 29386.4 and 27941.7 deaths respectively (Table 1).

The number of deaths due to Alzheimer’s disease and dementias, ovary cancer, road injury, lymphomas and myeloma, ischemic heart disease, other circulatory diseases, other malignant neoplasms, cardiomyopathy and myocarditis, and hypertensive heart diseases increased by more than 50% between 2000 and 2016. By contrast, the number of deaths due to childhood-cluster diseases, HIV/AIDS, tuberculosis, and meningitis declined by more than 50%, which indicates the epidemiological transition from communicable to non-communicable and degenerative chronic diseases (Tables 2 and 3).

The major cause of ASDR was ischemic heart disease, with a death rate of 112.4/100,000 population in 2016. In decreasing order: lower respiratory infections (86.9/100,000), diarrheal diseases (86.5/100,000), stroke (74.9/100,000), tuberculosis (43.1/100,000), other circulatory diseases (38.7/100,000), road injury (36.8/100,000), cirrhosis of the liver (30.9/100,000), HIV/AIDS (27.7/100,000) and COPD (24.6/100,000) ranked at the

Table 2. Number and cause (non-communicable, endocrine, cardiovascular, mental disorder) of deaths for both sexes and all age groups for the period from 2000 to 2016

Cause of death	Number of deaths in 2000			Number of deaths in 2016			% change
	Value	95% LL	95% UL	Value	95% LL	95% UL	
Non-communicable diseases	199299.9	158916.3	248625.1	274998.8	211290.2	362882.1	38.0
Malignant neoplasms	34534.5	25677.2	46261.7	50913.5	36092.1	73018.8	47.4
Colon and rectum cancers	2370.5	1538.3	3525.7	3475.1	2116.5	5533.4	46.6
Cervix uteri cancer	4427.3	3014.5	6290.7	5013.5	3197.1	7655.4	13.2
Ovary cancer	1200.2	779.2	1784.4	2511.2	1554.6	3940.3	109.2
Lymphomas, myeloma	1897.3	1220.6	2844.6	3098.6	1877.3	4957.1	63.3
Leukemia	2317.4	1502.7	3449.4	3473.7	2115.3	5531.9	49.9
Other malignant neoplasms	6937.3	4684.3	9937.3	10916.3	6985.9	16614.0	57.4
Other neoplasms	1119.1	645.1	1845.0	2537.3	1391.3	4386.9	126.7
Endocrine, blood, immune dis.	4775.1	2888.9	7500.9	4144.7	2316.2	7038.5	-13.2
Other hemolytic problems	1838.7	789.2	3773.0	1655.2	673.3	3514.0	-10.0
Mental and substance use disorders	1249.6	752.0	2015.7	1926.9	1058.5	3431.3	54.2
Alcohol use disorders	957.4	602.6	1464.7	1309.1	764.7	2162.1	36.7
Neurological conditions	7281.4	4928.1	10406.8	12700.2	8177.1	19218.8	74.4
Alzheimer disease, dementias	3615.3	2167.6	5731.4	8316.4	4769.8	13772.9	130.0
Cardiovascular diseases	76252.4	58615.4	98787.6	109499.7	80701.5	150979.3	43.6
Rheumatic heart disease	2018.5	1301.7	3019.7	1449.6	845.7	2396.2	-28.2
Hypertensive heart disease	5106.9	3097.0	8002.7	7754.3	4436.5	12872.8	51.8
Ischemic heart disease	30060.2	21287.7	41090.7	47711.6	32277.9	68837.1	58.7
Stroke	26536.2	18716.1	36420.1	32859.5	21936.9	48029.7	23.8
Cardiomyopathy, myocarditis,	1919.4	1236.3	2874.6	2957.8	1790.3	4736.0	54.1
Other circulatory diseases	10611.3	7271.7	14983.7	16767.0	10915.1	25109.7	58.0

UL – upper limit, LL – lower limit.

top of the 40 causes of ASDR. Tuberculosis, which was the leading cause of ASDR with 191.1 deaths/100,000 population in 2000, ranked fifth in 2016.

Similarly, diarrheal diseases and HIV/AIDS were the second and third leading causes of ASDR in 2000; in 2016 they ranked to third and ninth respectively (Table 5).

Disability-adjusted life years lost (DALY) due to all causes among all ages was 46,507,400 DALYs in 2016, with a 34.8% decline from the 2000 record of 71,354,000 DALYs. Group I causes accounted for 54% (25204100/46507400) of national DALYs, with NCDs leading to 34% (15849800/46507400) and injuries to 11.7% (5453500/46507400). After 2000, DALYs due to group I causes and many of the leading communicable causes substantially declined. DALYs due to infectious and parasitic diseases, respiratory infections, and maternal conditions declined by more than 50%, while neonatal conditions and nutritional deficiencies declined by 31% and 28.6% respectively (Table 6).

However, DALYs due to group II causes (NCD) increased by 31.5%. Especially, malignant neoplasms, other neoplasms, diabetes mellitus, mental and substance use disorders, neurological conditions, skin diseases, and musculoskeletal diseases increased by 45–109%. Lower respiratory infections, diarrheal diseases, birth asphyxia, and birth trauma, preterm birth complications, and road injury caused the highest DALYs lost in 2016.

Discussion

This study assessed the burden of disease and cause of mortality among all ages in Ethiopia from 2000 to 2016 using data from the Global Burden of Disease Study and Global Health Estimates 2016 reported in 2017. The burden of disease was measured in terms of mortality and DALY. It was found that the number of deaths, crude death rates, and the ASDR declined remarkably between 2000 and 2016. DALY due to all causes of all ages also declined, particularly

Table 3. Number and cause of deaths (respiratory, digestive, genitourinary, skin, congenital and injuries) for both sexes and all age groups for the period from 2000 to 2016

Cause of death	Number of deaths in 2000			Number of deaths in 2016			% change
	Value	95% LL	95% UL	Value	95% LL	95% UL	
Respiratory diseases	12300.6	8470.8	17286.0	15459.8	10032.7	23221.2	25.7
Asthma	4538.7	2740.8	7142.8	4484.8	2514.2	7593.1	-1.2
Digestive diseases	29438.5	20849.5	40238.0	36868.2	24736.9	53627.7	25.2
Peptic ulcer disease	4245.3	2558.3	6695.3	4198.9	2347.6	7127.4	-1.1
Cirrhosis of the liver	11958.2	7444.9	18237.6	16579.5	9745.3	26800.5	38.6
Paralytic ileus and IO	5755.1	3508.1	8971.4	7449.6	4262.5	12366.9	29.4
Other digestive diseases	3649.8	2196.4	5765.0	3656.5	2038.4	6224.4	0.2
Genitourinary diseases	6717.0	4112.3	10424.0	9329.6	5377.4	15376.7	38.9
Kidney diseases	4549.3	2748.8	7155.4	6426.2	3650.7	10741.6	41.3
Other urinary diseases	1917.6	1140.4	3065.9	2615.9	1455.3	4462.7	36.4
Congenital anomalies	14467.8	9046.6	21964.1	14442.6	8439.8	23481.2	-0.2
Neural tube defects	5514.5	2460.4	10948.8	3638.5	1526.6	7535.9	-34.0
Congenital heart anomalies	3130.6	1369.5	6321.9	3820.5	1604.7	7905.6	22.0
Other congenital anomalies	4968.8	2207.5	9901.3	5811.9	2479.1	11875.3	17.0
Unintentional injuries	54664.6	39420.7	73373.3	66403.9	45491.8	94625.3	21.5
Road injury	16264.9	12105.8	20901.9	29386.4	22148.0	37273.1	80.7
Poisonings	3374.3	1482.5	6789.4	2935.8	1222.2	6119.0	-13.0
Falls	6745.6	4554.9	9662.8	8509.5	5393.3	13068.5	26.1
Fire, heat and hot substances	5453.1	3651.1	7874.9	4403.7	2710.2	6946.9	-19.2
Drowning	8429.8	5741.1	11975.9	6538.0	4105.8	10127.1	-22.4
Exposure to mechanical forces	3266.4	2152.2	4789.9	3262.5	1988.1	5193.1	-0.1
Other unintentional injuries	11057.5	7590.7	15587.4	11368.0	7294.4	17258.6	2.8
Intentional injuries	38117.7	27273.1	51575.1	15445.7	10075.3	23090.7	-59.5
Self-harm	5335.3	3251.3	8320.0	7323.2	4203.1	12122.0	37.3
Interpersonal violence	7303.4	4491.9	11281.1	7977.5	4585.9	13183.9	9.2

COPD – chronic obstructive pulmonary diseases, UL – upper limit, LL – lower limit, IO – intestinal obstruction.

for communicable diseases. However, DALYs due to group II causes (NCD) increased.

In 2016, an estimated 700,108.8 (95% CI: 588955.7–831398.4) deaths occurred due to all causes in Ethiopia, with an overall crude death rate of 683.7/100,000 and an ASDR of 1048.3/100,000 population. Although the ASDR declined by 42.3% from the 2000 report due to interventions taken at the millennium development goal and sustainable development programs that targeted infectious diseases, maternal and child health, and nutritional problems [7, 14, 15], this mortality rate is higher than the global average and the WHO African region averages [8].

Among the level 2 categories, infectious and parasitic diseases, cardiovascular diseases, neonatal conditions, respiratory infections, unintentional injuries,

and malignant neoplasms caused the highest number of deaths in decreasing order. Of the level 3 diseases/causes, lower respiratory infections, diarrheal diseases, ischemic heart disease, stroke, road injury, and birth asphyxia and trauma caused the highest numbers of deaths. The number of deaths due to group I causes declined, whereas the number of deaths due to non-communicable disease increased by 38% between 2000 and 2016. Mortality due to Alzheimer's disease and dementias, ovary cancer, road injury, lymphomas and myeloma, and ischemic heart disease doubled within 16 years. It is also reported that mortality due to ischemic heart disease and cardiovascular disorders is increasing globally [5, 8, 16].

The Global Burden of Disease estimates Group II causes (NCD) as the major contributor of ASDR. By

Table 4. Crude and ASDR/100,000 population for both sexes and all age groups with level 1 and 2 categories, from 2000 to 2016

Cause by group	CDR			ASDR		
	2000	2016	Change %	2000	2016	Change %
All causes	1475.8	683.7	-53.7	1816.7	1048.3	-42.3
CMNN diseases	1036.8	335.2	-67.7	1017.5	388.6	-61.8
Infectious and parasitic diseases	609.3	164.7	-73.0	688.5	218.9	-68.2
Respiratory infections	176.1	65.1	-63.0	154.3	87.1	-43.5
Maternal conditions	43.0	12.8	-70.2	54.8	14.4	-73.8
Neonatal conditions	169.2	73.8	-56.4	80.1	43.9	-45.1
Nutritional deficiencies	39.3	18.8	-52.1	39.9	24.2	-39.2
Non-communicable diseases	299.5	268.5	-10.3	634.3	554.7	-12.5
Malignant neoplasms	51.9	49.7	-4.2	103.6	93.5	-9.7
Other neoplasms	1.7	2.5	47.3	3.2	4.5	43.2
Diabetes mellitus	12.1	12.7	5.0	29.9	29.1	-2.8
Endocrine, blood disorders	7.2	4.0	-43.6	7.6	5.5	-27.4
Mental and substance use disorders	1.9	1.9	0.2	3.5	3.2	-8.9
Neurological conditions	10.9	12.4	13.3	28.4	30.3	6.8
Cardiovascular diseases	114.6	106.9	-6.7	292.9	252.9	-13.7
Respiratory diseases	18.5	15.1	-18.3	43.0	34.0	-20.9
Digestive diseases	44.2	36.0	-18.6	86.3	69.5	-19.5
Genitourinary diseases	10.1	9.1	-9.8	19.7	18.0	-9.0
Skin diseases	2.1	2.4	12.4	3.7	4.1	10.2
Musculoskeletal diseases	0.6	0.6	-8.7	1.0	0.9	-10.3
Congenital anomalies	21.7	14.1	-35.1	10.5	8.5	-19.0
Sudden infant death syndrome	1.9	1.1	-43.3	0.9	0.6	-28.7
Injuries	139.4	79.9	-42.7	164.9	105.0	-36.3
Unintentional injuries	82.2	64.8	-21.1	93.7	84.7	-9.6
Intentional injuries	57.3	15.1	-73.7	71.2	20.3	-71.5

ASDR – age-standardized death rate, CDR – crude death rate.

the year 2000, however, the major causes of age-standardized death were group I causes (communicable, maternal and child health problems and nutritional problems). It indicates that the epidemiology of the disease in Ethiopia shifted from communicable to non-communicable diseases [17]. This is in line with the global epidemiology, where the major cause of death was known to be due to non-communicable diseases [8, 16]. In most developing countries such as Ethiopia, the government's effort to prevent communicable diseases and overall improvement of sanitation and hygiene reduced the burden of communicable diseases [8, 16, 17].

Ischemic heart disease, lower respiratory infections, diarrheal diseases, stroke, and tuberculosis were the top five causes of ASDR. Even though mortality due to lower respiratory infections, tuberculo-

sis, diarrheal disease, and HIV/AIDS is strongly declining in Ethiopia [17], they remained among the top ten causes of age-standardized death. Previous studies also reported that cardiovascular and malignant conditions are increasing, while the burden of communicable disease is decreasing in Ethiopia [16, 17]. It is also in line with the global report indicating that ischemic heart disease is the leading cause of age-standardized death [16].

Tuberculosis, which was the top cause of ASDR in 2000, is now ranked fifth. Similarly, diarrheal diseases and HIV/AIDS, which were the second and third top causes of ASDR in 2000, in 2016 ranked third and ninth respectively. Also, most communicable diseases, maternal and child health problems, and nutritional deficiencies ranked at the top were now displaced down by non-communicable diseases. That is due to

Table 5. Top 40 causes of ASDR/100,000 for both sexes and all age groups from 2000 to 2016

Rank	Cause (level 3 category)	ASDR 2000	Rank	Cause (level 3 category)	ASDR 2016
1	Tuberculosis	191.1	1	Ischemic heart disease	112.4
2	Diarrheal diseases	166.0	2	Lower respiratory infections	86.9
3	HIV/AIDS	159.4	3	Diarrheal diseases	86.5
4	Lower respiratory infections	153.8	4	Stroke	74.9
5	Ischemic heart disease	119.5	5	Tuberculosis	43.1
6	Stroke	101.1	6	Other circulatory diseases	38.7
7	Childhood-cluster diseases	59.5	7	Road injury	36.8
8	Collective violence	44.8	8	Cirrhosis of the liver	30.9
9	Meningitis	44.6	9	HIV/AIDS	27.7
10	Parasitic and vector diseases	41.5	10	COPD	24.6
11	Other circulatory diseases	40.5	11	Alzheimer's and dementias	24.5
12	Cirrhosis of the liver	35.3	12	Meningitis	21.2
13	Birth asphyxia and birth trauma	34.0	13	Protein-energy malnutrition	20.0
14	Protein-energy malnutrition	32.7	14	Other malignant neoplasms	18.9
15	COPD	29.5	15	Hypertensive heart disease	18.8
16	Road injury	29.0	16	Falls	16.9
17	Preterm birth complications	28.7	17	Birth asphyxia and birth trauma	16.2
18	Alzheimer's and dementias	21.2	18	Preterm birth complications	16.0
19	Hypertensive heart disease	21.0	19	Parasitic and vector diseases	15.1
20	Other malignant neoplasms	19.6	20	Breast cancer	13.4
21	Falls	18.8	21	Paralytic ileus and IO	13.2
22	Other unintentional injuries	16.9	22	Kidney diseases	12.7
23	Paralytic ileus & IO	15.5	23	Other unintentional injuries	12.6
24	Breast cancer	14.8	24	Self-harm	11.4
25	Peptic ulcer disease	14.2	25	Childhood-cluster diseases	10.7
26	Cervix uteri cancer	13.9	26	Cervix uteri cancer	9.9
27	Neonatal sepsis and infections	13.9	27	Neonatal sepsis and infections	9.6
28	Kidney diseases	13.7	28	Peptic ulcer disease	9.0
29	Self-harm	13.7	29	Interpersonal violence	8.7
30	Interpersonal violence	12.8	30	Asthma	8.3
31	Asthma	12.3	31	Other digestive diseases	7.2
32	Other digestive diseases	10.8	32	Colon and rectum cancers	6.7
33	Drowning	10.6	33	Drowning	6.4
34	Other infectious diseases	8.8	34	Leukemia	5.6
35	Fire, heat and hot substances	8.7	35	Fire, heat and hot substances	5.5
36	Colon and rectum cancers	7.4	36	Cardiomyopathy, endocarditis	5.4
37	Hepatitis	6.9	37	Lymphomas, multiple myeloma	5.4
38	Other nutritional deficiencies	6.8	38	Other urinary diseases	4.8
39	Leukemia	6.0	39	Other infectious diseases	4.7
40	STDs excluding HIV	6.0	40	Ovary cancer	4.6

Table 6. DALY in thousands for both sexes and all age groups with level 1 and 2 categories, from 2000 to 2016

Causes of death	2000	2016	% change
All causes	71354.0	46507.4	-34.8
CMNN diseases/conditions	52762.5	25204.1	-52.2
Infectious and parasitic diseases	28666.6	11042.7	-61.5
Respiratory infections	9303.0	4303.8	-53.7
Maternal conditions	1809.7	847.2	-53.2
Neonatal conditions	10428.2	7186.5	-31.1
Nutritional deficiencies	2555.0	1823.9	-28.6
Non-communicable diseases	12053.5	15849.8	31.5
Malignant neoplasms	1386.7	2012.5	45.1
Other neoplasms	49.9	104.4	109.3
Diabetes mellitus	346.4	528.7	52.6
Endocrine, blood, immune disorders	411.8	340.4	-17.3
Mental and substance use disorders	1304.8	2089.7	60.1
Neurological conditions	614.8	895.2	45.6
Cardiovascular diseases	2375.0	3009.9	26.7
Respiratory diseases	605.3	721.1	19.1
Digestive diseases	1341.3	1483.3	10.6
Genitourinary diseases	467.5	622.5	33.2
Skin diseases	284.8	450.0	58.0
Musculoskeletal diseases	390.4	679.9	74.2
Congenital anomalies	1444.5	1497.6	3.7
Sudden infant death syndrome	115.9	101.3	-12.7
Injuries	6538.0	5453.5	-16.6
Unintentional injuries	4026.8	4448.7	10.5
Intentional injuries	2511.1	1004.8	-60.0

DALY – disability-adjusted life years lost.

the fact that intensive public health intervention leads to improvement of health status and further leads to the decline of ASDR due to communicable, maternal, neonatal, and nutritional causes by 65% [10, 17].

DALY due to all causes among all ages declined by 34.8% between 2000 and 2016. Of the 46,507,400 DALYs in 2016, Group 1 causes accounted for 54% of national DALYs, with NCDs leading to 34% and injuries to 11.7%. Globally, however, Group II causes (NCD) accounted for 61.4% of the global DALYs in 2015. Even though DALYs due to NCD declined by 37% between 1990 and 2016, the burden was not reduced remarkably as it was in communicable diseases, maternal and child health problems, and nutritional deficiencies [8, 16, 17].

Since 2000, DALYs due to group 1 causes and many of the leading communicable causes have substantially declined. Particularly, DALYs due to infectious and parasitic diseases, respiratory infections, and maternal conditions declined by more than 50%, while neo-

natal conditions and nutritional deficiencies declined by 31% and 28.6% respectively. However, DALYs due to group 2 causes (NCD) increased by 31.5%. Especially, malignant neoplasms, other neoplasms, diabetes mellitus, mental and substance use disorders, neurological conditions, skin diseases, and musculoskeletal diseases increased by 45–109% [18]. It is also in line with the global trend of non-communicable diseases, where the burden is highly increasing [8, 16].

In Ethiopia, lower respiratory infections, diarrheal diseases, birth asphyxia, and birth trauma, preterm birth complications, and road injury caused the highest DALYs lost in 2016, whereas ischemic heart disease, cerebrovascular disease, and lower respiratory infections, comprising 16.1% of all DALYs, were the first three causes of DALYs globally [16].

The findings of this study might suffer from the fact that it is from a secondary data source based on records; the reliability of the recorded data could not

be ascertained and there exists potential bias associated with estimation. Some methodological problems may have been encountered in this research. Most of the data were originally estimated from model predictions and the data source for the model was either reports of vital registration or sample survey, which could again affect the reliability of the data. Moreover, the values forecasted from the trend may change through time due to change in intervention programs; this affects the reliability of the estimate.

Conclusions

CDR and ASDR declined nearly by half from the 2000 estimate. Group II causes contributed to more than 50% and group I and III less than group I of ASDR. Also, ASDR due to group I declined by two thirds. Ischemic heart disease, lower respiratory infections, diarrheal diseases, stroke, and tuberculosis were the top five causes of ASDR.

DALYs due to all causes among all ages declined by more than one third in the same year. Group I causes accounted for more than half of national DALY due to all causes among all ages. Group I causes accounted for more than half of national DALYs, NCDs leading to 34% and injuries to 11.7%. DALYs due to infectious and parasitic diseases, respiratory infections, and maternal conditions declined by more than 50%. However, DALYs due to group II causes increased by 31.5%. Lower respiratory infections, diarrheal diseases, birth asphyxia and birth trauma, preterm birth complications, and road injury caused the highest DALYs lost in 2016.

Therefore, the existing disease prevention strategies designed to achieve universal health coverage should be strengthened and particular emphasis should be given to non-communicable diseases and high burden communicable disease.

Acknowledgments

Availability of data and materials: The GBD 2015 data are available at the GBD website (<https://vizhub.healthdata.org/gbd-compare/>) and Global Health Estimates 2016 is also available (http://www.who.int/healthinfo/global_health_estimates/en/); both are freely accessible.

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Conflict of interest

The authors declare no conflict of interest.

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