ORIGINAL ARTICLE

Tuberculosis Burden in Ethiopia from 1990 to 2016: Evidence from the Global Burden of Diseases 2016 Study

Amare Deribew[1,2*], Kebede Deribe[3,4], Tariku Dejene[5], Gizachew Assefa Tessema[6,7],Yohannes Adama Melaku[8,9], Yihune Lakew[10], Azmeraw T.Amare[11,12], Tolessa Bekele[13], Semaw F. Abera[8,14,15] , Muluken Dessalegn[16], Andargachew Kumsa[17], Yibeltal Assefa[18], Hmwe Kyu[19], Scott D Glenn[19] , Awoke Misganaw[19] , Sibhatu Biadgilign[20]

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Affiliation and Correspondence:
[1]St. Paul Hospital Millennium Medical College, Ethiopia
[2]Nutrition International, Ethiopia
[3]Wellcome Trust Brighton & Sussex Centre for Global Health Research, Brighton & Sussex Medical School, Brighton, UK
[4]School of Medicine, Addis Ababa University, Ethiopia
[5]Center for Population Studies, Addis Ababa University, Ethiopia
[6]School of Public Health, University of Adelaide, Adelaide, Australia
[7]Department of Reproductive Health, Institute of Public Health, University of Gondar, Ethiopia
[8]School of Public Health, Mekelle University, Ethiopia
[9]School of Medicine, University of Adelaide, Adelaide, Australia
[10]Ethiopian Public Health Association, Ethiopia
[11]College of Medicine and Health Sciences, Bahir Dar University, Ethiopia
[12]Department of Epidemiology, University of Groningen, Groningen, the Netherlands
[13]College of Medicine and Health Sciences, Madda Walabu University, Ethiopia
[14]Kilte Awlaelo-Health and Demographic Surveillance Site, Tigray, Ethiopia
[15]Institute of Biological Chemistry and Nutrition, Hohenheim University, Stuttgart, Germany [16]AMREF Health Africa, Addis Ababa, Ethiopia
[17]Federal Ministry of Health, Addis Ababa, Ethiopia
[18]University of Queensland, School of Public Health, Australia
[19]Institute of Health Metrics and Evaluation, University of Washington
[20]World Health Organization, Uganda
*Email: amare.deribew@gmail.com

ABSTRACT

***BACKGROUND:** The burden of Tuberculosis (TB) has not been comprehensively evaluated over the last 25 years in Ethiopia. In this study, we used the 2016 Global Burden of Diseases, Injuries and Risk Factors (GBD) data to analyze the incidence, prevalence and mortality rates of tuberculosis (TB) in Ethiopia over the last 26 years.*

***METHODS:** The GBD 2016 is a mathematical modeling using different data source for Ethiopia such as verbal autopsy (VA), prevalence surveys and annual case notifications. Age and sex specific causes of death for TB were estimated using the Cause of Death Ensemble Modeling (CODEm). We used the available data such as annual notifications and prevalence surveys as an input to estimate incidence and prevalence rates respectively using DisMod-MR 2.1, a Bayesian meta-regression tool.*

***RESULTS:** In 2016, we estimated 219,186 (95%UI: 182,977-265,292) new, 151,602 (95% UI: 126,054-180,976) prevalent TB cases and 48,910(95% UI: 40,310-58,195) TB deaths. The age-standardized TB incidence rate decreased from 201.6/100,000 to 88.5/100,000 (with a total decline of 56%) between 1990 to 2016. Similarly, the age-standardized TB mortality rate declined from 393.8/100,000 to 100/100,000 between 1990 and 2016(with a total decline of 75%).*

***CONCLUSIONS:** Ethiopia has achieved the 50% reduction of most of the Millennium Development Goals (MDGs) targets related to TB. However, the decline of TB incidence and prevalence rates has been comparatively slow. The country should strengthen the TB case detection and treatment programs at community level to achieve its targets during the Sustainable Development Program (SDGs)-era.*

***KEYWORDS:** Tuberculosis, Burden, Ethiopia*

INTRODUCTION

The United Nations General Assembly endorsed the historical resolution of the Millennium Development Goals (MDG) in 2000. The Tuberculosis (TB) specific target of the MDG was to halt and began to reverse the incidence of TB by 2015(1,2). Despite remarkable progress during the MDG era globally, TB ranks to be the top killer infectious diseases worldwide. In 2016, there were 6.3 million new TB cases and 1.3 million TB deaths (3).

In Ethiopia, TB is still a major public health problem (1-3). The country is still among the 22 high TB burden countries with high number of missed and infectious TB cases in the community (1-3). The prevalence and incidence of TB in Ethiopia in 2014 were 211 and 214 per 100,000 populations respectively (4). Increasing the trends of multidrug resistance TB (2% among new cases in 2006 vs. 4.5% among new cases in 2016) is a serious public health challenge for the country (4,5). TB is among the top ten causes of admission and deaths in adults in Ethiopia (6). In line with the Sustainable Development Goals (SDGs), Ethiopia recently launched a five years' ambitious Health Sector Transformation Plan (HSTP) to address major diseases of public health importance including TB (6). Information revolution is one of the core agenda items of the HSTP to inform decision makers for timely action. However, Ethiopia still does not have a strong health management information system to capture the burden of TB and track the progresses of TB interventions. Because of weak health information system and very few national surveys, the burden of TB was not comprehensively assessed in Ethiopia over the last 3 decades. In the last few years, there were few TB studies with limited geographic areas (5) that may not provide national representative information. In this article, we used the Global Burden of Disease Study (GBD) 2016 data (7-11) to assess the mortality, incidence, prevalence and Disability-adjusted Life Years Lost (DALY) rates of TB over the last 26 years. The rationale of using the GBD data include: i) GBD modeling strategy provides nationally representative estimates which cannot be obtained through small scale studies or surveys; ii) GBD uses standard modeling approach globally and our finding (Ethiopian performance) can be compared with others who are using GBD; iii) The study provides evidence on the achievement of Ethiopia on the MDG targets and the findings will also serve as a baseline for future tracking of TB targets. The performance of Ethiopia cannot be measured by data from small scale surveys; iv) Lastly, the study also helps decision makers to allocate resources based on the burden of TB.

METHODS

Ethiopian population (approximately 100 million) is the second largest in Africa with diverse population mix and unique cultural heritage (6). The GBD 2016 data were used to identify the trends in the incidence, prevalence and mortality rates of TB. The GBD 2016 utilizes available sources of data and rigorous analysis to estimate trends in the burden of TB for 195 countries and territories. The detailed methods used to estimate the TB burden have been published elsewhere (11-13), and we provided a detailed description of the modeling in the following section.

Data sources: This study used a mathematical modeling using the GBD data. The GBD 2016 used a different data sources for Ethiopia (http://ghdx.healthdata.org/). The key sources of data for TB include verbal autopsy (VA) studies, national and subnational tuberculosis prevalence surveys that are published, published population-based tuberculin surveys, case notifications and cohort studies reporting on the risk of developing active TB disease as a function of induration size. We excluded unpublished data and hospital records.

Data analysis and modeling : Causes of death by age groups, sex and year for TB were estimated using the Cause of Death Ensemble modeling (CODEm). A detailed description of CODEm is reported elsewhere (14-17). In brief, CODEm tests a wide range of models such as mixed effects linear models and spatial-temporal Gaussian process regression (ST-GPR) models using

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various combinations of covariates and constructs an ensemble model based on the performance of the different models (15). All models are assessed using out-of-sample predictive validity tests and an ensemble of models that perform best is selected. Non-fatal TB modeling prevalence and incidence rates of TB were estimated using a Bayesian Regression model using the input data such as prevalence surveys and case notifications (http://ghdx.healthdata.org/gbd-2016/data-input-sources). The detailed methodology is described elsewhere (11). First, we estimated the risk-weighted prevalence of latent TB infection (LTBI) using data from population-based tuberculin surveys and cohort studies examining the risk of developing active TB as a function of induration size (11). Next, we divided the inputs on prevalence (from TB prevalence surveys), incidence (estimated based on a mortality-to-incidence ratio approach) and cause specific mortality estimates by the risk-weighted LTBI prevalence to model TB among those at risk. We used DisMod-MR 2.1, the GBD Bayesian meta-regression tool to generate internally consistent estimates of incidence, prevalence and mortality. We then multiplied the DisMod-MR 2.1 outputs by the risk-weighted prevalence of LTBI to get population-level estimates of incidence and prevalence (11).

Quality assurance: VA data were corrected for garbage coding based on the GBD algorithm (15). Garbage coding is a bias due to the assignment of causes of death that are not underlying causes of death (14). We included published articles and surveys. Unpublished data or reports were excluded.

Ethical approval: The study used secondary data from the GBD 2016 study, and permission was obtained from Institute of Health Metrics and Evaluation at Washington University in the United States to utilize the data. The GBD 2016 data can be caccessed at the GBD website (http://vizhub.healthdata.org/gbd-compare/).

RESULTS

An estimated 219,186 (95%UI: 182,977-265,292) incident of TB cases occurred in Ethiopia in 2016. The age-standardised TB incidence rate decreased from 201.6/100,000 to 88.5/100,000 (with a total decline of 56%) between 1990 to 2016. Males had higher TB incidence rate than females during the last 26 years (P-value for trend<0.05). Annualized rate of change (ARC) for the age-standardised incidence rate was -3.2%. The ARC between males and females was not statistically significant (P=0.06) (Figure 1).

In 2016, about 151,602 (95% UI: 126054-180,976) prevalent TB cases were estimated to occur in Ethiopia. The annualized rate of decline for the age-standardised TB prevalence rate was nearly 3% during the last 26 years. The age standardized TB prevalence rate declined by 51% (from 139.4/100,000 to 68.2/100,000) between 1990 to 2016 (Figure 2).

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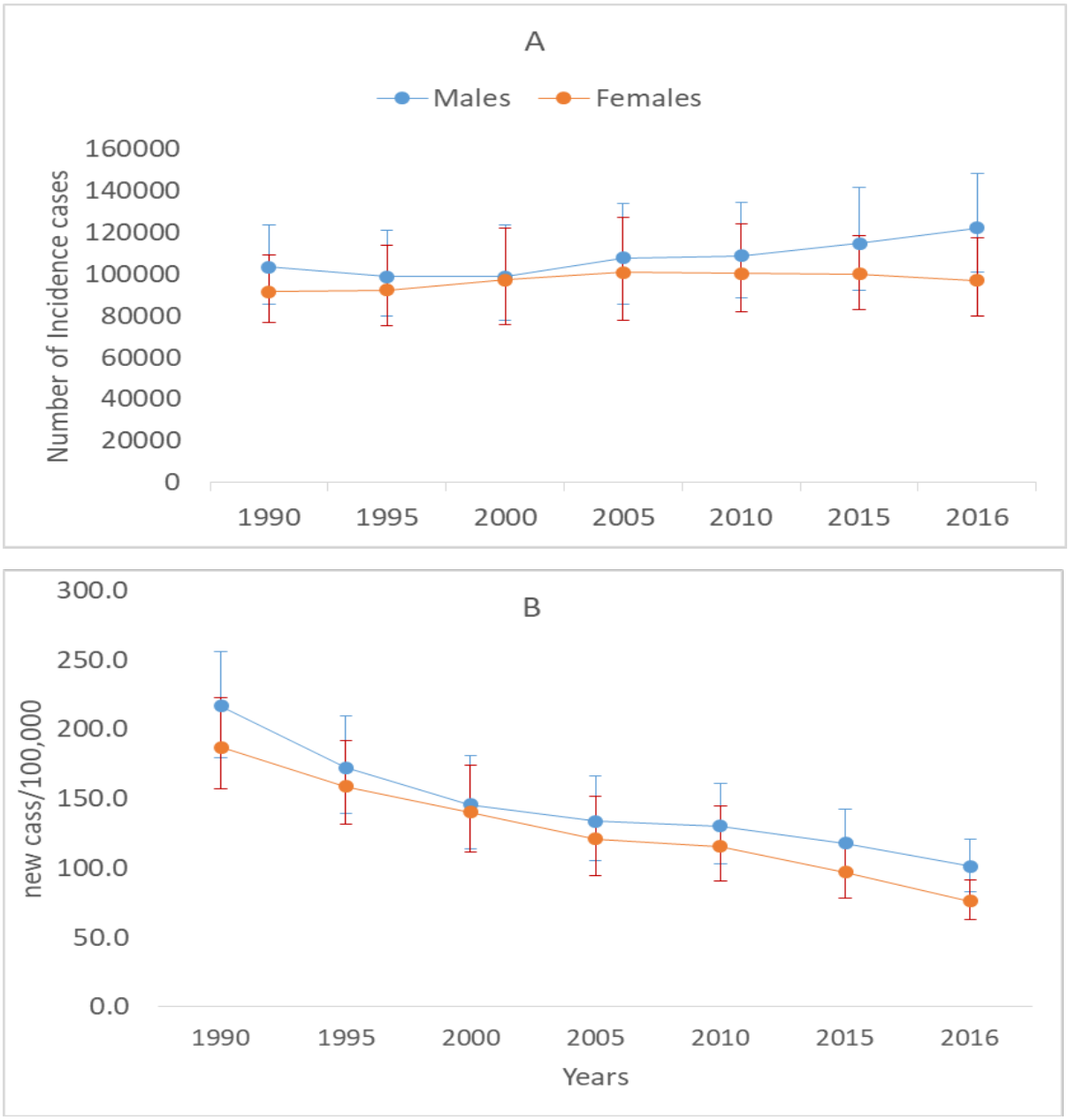

Figure 1: *TB incidence cases (A) and TB incidence rate (B) by sex in Ethiopia in 2016*

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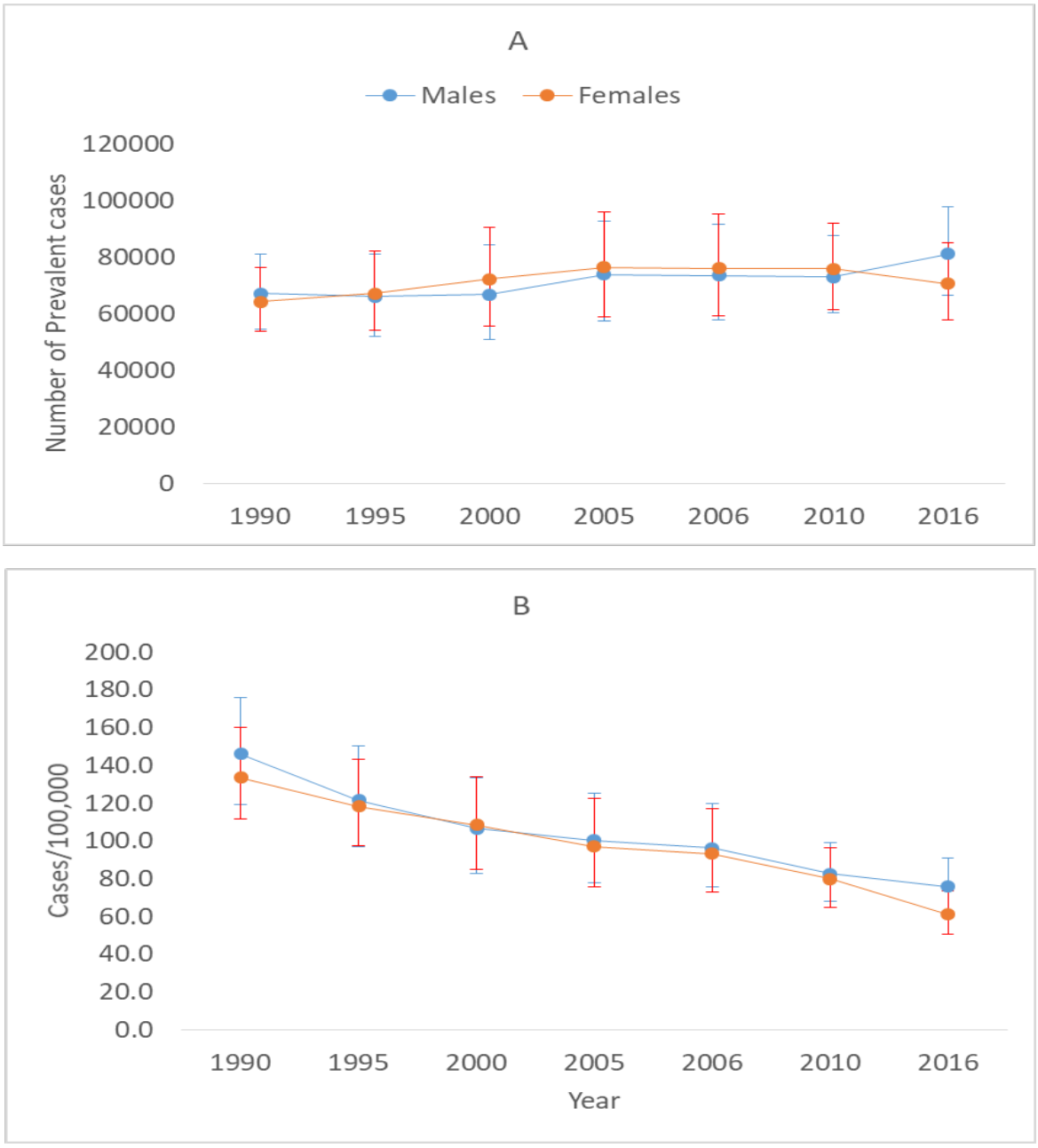

***Figure 2**: Number of TB prevalent cases (A) and TB prevalence rate (B) between 1990 and 2016*

An estimated 48,910(95% UI: 40,310-58,195) TB deaths occurred in 2016. The age-standardised TB mortality rate declined from 393.8/100,000 to 100/100,000 between 1990 and 2016 (with a total decline of 75%) (Table 1). TB deaths increased as age increased, and males had higher TB mortality rate than females (Figure 3).

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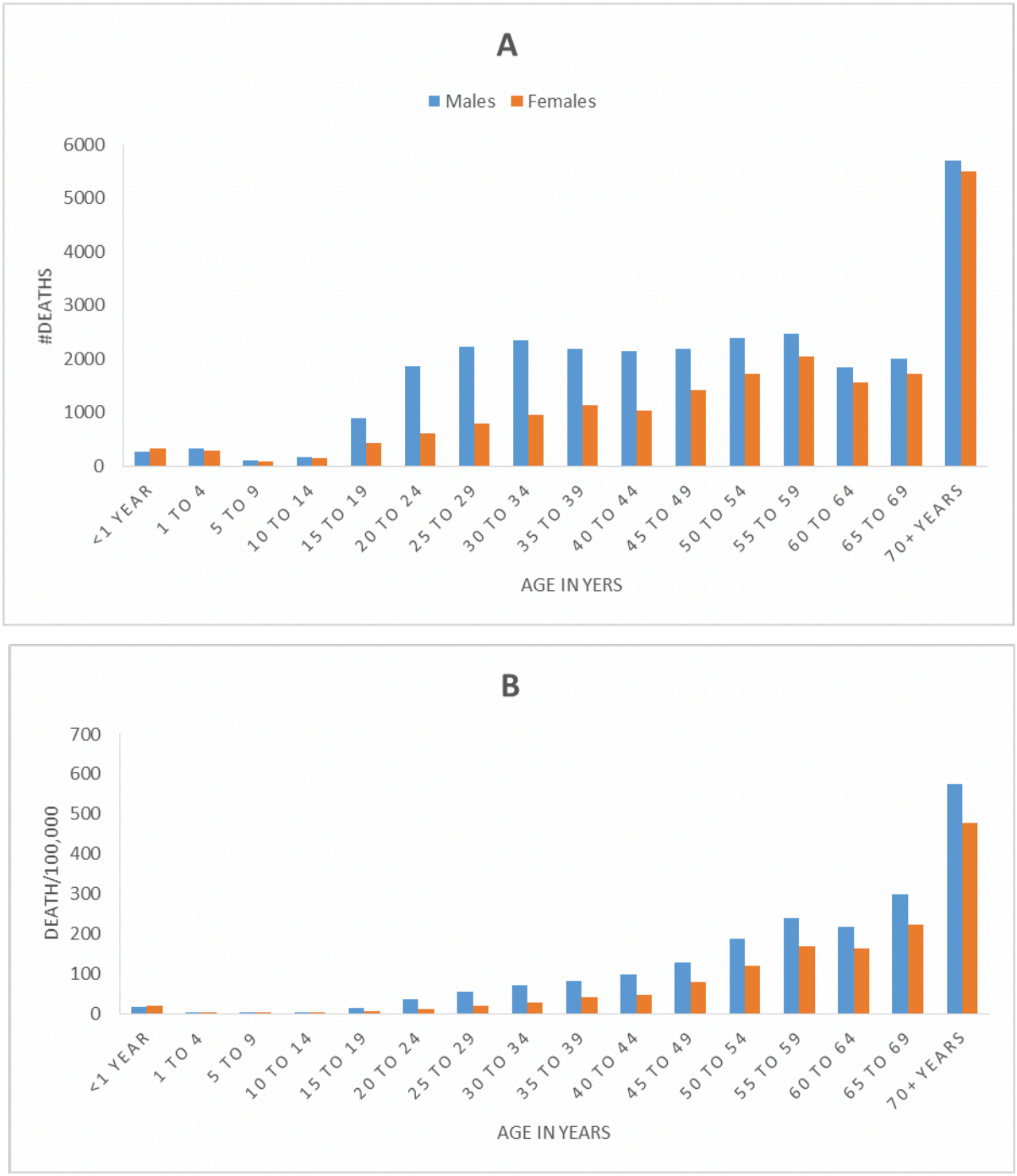

***Figure 3**: Number of TB deaths (A) and TB mortality rate (B) by age group in 2016*

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Table 1: Number of deaths and mortality rate of Tuberculosis in Ethiopia, between 1990 and 2016

Year	Number of deaths	95%UI		Rate/100,000	95%UI	
1990	91150	62040	107222	393.8	265.1	472.7
1995	84245	65653	96138	311.1	240.4	359.9
2000	74563	63272	84064	242.6	205.4	275.0
2005	70921	62195	79623	201.2	177.4	225.6
2010	59597	52167	69144	145.7	128.1	167.4
2015	49875	41423	59434	105.3	89.0	124.7
2016	48910	40310	58195	100.0	83.4	118.5

An estimated of 1.8 million (95%UI: 1.5 million-2.2 million) TB related DALY were registered in Ethiopia in 2016. Age-standardised TB DALY rate declined from 11411/100,000 in 1990 to 2771.9/100,000 in 2016 with a total reduction of 76%. ARC for TB DALY rate was -5.4% (Table 2).

Table 2: Number of DALY and DALY rates due to Tuberculosis between 1990 and 2016

Year	Number of DALY	95%UI		DALY rate/100,000	95%UI	
1990	3573109	2454050	4191207	11411.0	7893.6	13400.5
1995	3277927	2587075	3759007	8936.5	7040.2	10222.8
2000	2916341	2462535	3300836	6968.6	5921.4	7842.8
2005	2795015	2455346	3155602	5724.0	5003.2	6437.8
2010	2296405	1982065	2646342	4095.5	3569.1	4774.8
2015	1886205	1574282	2238669	2924.5	2429.2	3452.9
2016	1842618	1521283	2209096	2771.9	2286.5	3312.6

DISCUSSION

Ethiopia has reduced the TB mortality rate by 75% and the TB incidence rate by more than 50% during 1990 and 2016. This is in line with the MDG targets of halving mortality rate of TB by 2015 and efforts to reverse the incidence of these diseases (1,2).

Other reports also show that Ethiopia has achieved most of the MDG targets related to TB (18-20). Assefa and colleagues reported that TB incidence rate and TB mortality rate e declined by 54% and by 72% respectively during the MDG era (20). The World Health Organization (WHO) report indicates that the performance of Ethiopia in reducing TB mortality and incidence rates has been remarkable over the last decade. Since 2010,

Ethiopia has reduced the TB mortality rate by more than 6% annually and the incidence rate of TB by more than 4% annually (3). The WHO estimates of TB prevalence and incidence rates were higher than the GBD estimates particularly in the early 1990s. However, the WHO estimates are lower than the GBD estimates over the years particularly after 2010. The GBD estimation of prevalence was derived from local or national prevalence survey (10,15). However, the WHO estimated TB prevalence as a product of incidence and duration of the diseases in the absence of national TB prevalence survey (15,21). Estimation of TB incidence rate by WHO was based on case-notification and expert judgment (21).

There are very limited studies in Ethiopia that assessed the burden of TB comprehensively during the MDG era. A study conducted in Oromia region in 2016 shows that incidence and prevalence rates of TB were 214/100,000 and 109/100,000 respectively (22). The prevalence of bacteriologically confirmed TB at the national level in 2011 was 277/100,000 (23). On the other hand, Berhe and colleagues reported a prevalence rate of bacteriologically confirmed TB of 352/100,000 in Tigray in 2012 (24). The GBD TB prevalence estimates are lower than the estimates of the

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aforementioned studies (12,13). On the other hand, our prevalence estimates are higher than the estimate reported by Deribew et al in Jimma (108/100,000) (25) and Yimer et al in Gondar (80/100,000) (26).

The performance of Ethiopia in reducing the burden of TB and reversing these epidemics is remarkable particularly since 2010 (15). Several factors could have helped Ethiopia to achieve the MDG targets. First, the commitment and leadership of the health sector leaders in Ethiopia could have helped Ethiopia to achieve most of the MDG targets (27). Second, the Health Extension Programs (HEP) in Ethiopia would have created an opportunity to improve access to care and treatment for TB suspects. Some reports show that the HEP has been instrumental to make health services accessible to the poor (19, 27-29). It also improves TB case detection rates at community level (30). Implementation of the Directly Observed Treatment for TB (DOTS) over the last two decades could have also significant impact on the burden of TB in Ethiopia. Third, the contribution of development partners to fight TB (PEPFAR) has been also vital in fighting TB in Ethiopia. The government has used flexible modalities of One-plan, One-budget and One-Report concept and effectively utilized the funding to scale up interventions towards TB (31). Donors' funding could decline during the coming years and Ethiopia should strengthen the low-cost and high impact HEP-based interventions to sustain progress (6,32).

Despite a remarkable progress, Ethiopia has to overcome several challenges to achieve the End TB Targets of reducing TB mortality by 90% and TB incidence rate by 80% by 2030 (33). TB/HIV co-infection and its impact on stigma and mental health problems could also be a big hurdle for the HIV/AIDS control program (34,35). In the rural part of the country, stigma and prejudices are still widespread which needs tailored intervention (36). Continuous community mobilization, stigma reduction, and care and support services have been vital for increasing utilization of ART services and improving retention in care that helps to reduce early mortality due to HIV/AIDS in Ethiopia (37).

On the other hand, very low TB case detection rate and presence of infectious TB cases at the community without treatment poses serious problems on the TB control program. Despite the implementation of the directly-observed treatment, short-course for TB (DOTS) since 2000(38), the TB case detection rate of 36%, remains very low in the country (39). So, decentralization of TB diagnostic and treatment services down to the lower health facilities and involvement of health extension workers in TB control program to revitalize and improve case detection system in the country is acceptable (28,40).

On the other hand, the burden of TB is highly variable by region and population groups, which requires proper planning. Some regions have higher TB prevalence that needs to be addressed to bring equity (24,41). The TB epidemic is also concentrated in some vulnerable populations particularly in prison inmates (42,43). The increasing trends of multi-drug resistant TB (MDR-TB), which requires expensive and more toxic drugs, remain a serious challenge ahead in the coming years (44).

This study is based on the GBD 2016 that uses comprehensive data sources and rigorous analysis. However, the study has some limitations. First, the use of verbal autopsy (VA) data in morality estimation may introduce misclassification bias. Use of published articles could introduce publication bias since unfavorable findings may not be published.

In conclusion, Ethiopia has achieved most of the MDG targets related to TB. However, the decline in TB incidence and prevalence rates has been slow. The country thus should strengthen TB case detection and treatment programs at community level through the HEP to reduce the burden of these diseases during the SDG-era.

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