Afghanistan Journal of Infectious Diseases
AJID
https://ajid.ghalib.edu.af/index.php/ajid
January 2026, Vol. 4, No.1, pp:51-56

Present and Future Trajectory of Tuberculosis Globally and In Afghanistan from 1990 to 2040: A Modelling Study

Majid Khosravi [1], *Meysam Olfatifar [1], Mahdi Fakhar [1], Fathieh Sabermahani [2]

1. *Gastroenterology and Hepatology Diseases Research Center, Qom University of Medical Sciences, Qom, Iran*
2. *Department of Infectious Disease, Kamkar-Arabnia Hospital, Qom University of Medical Sciences, Qom University of Medical Sciences, Qom, Iran*

ARTICLE INFO

Type: Original Article
Received: 15/08/2025
Accepted: 30/12/2025

*Corresponding Author:
E-mail address:
ol.meysam92@gmail.com

To cite this article:
Khosravi M, Olfatifar M, Fakhar M, Sabermahani F. Afghan J Infect Dis. 2026; 4(1): pp:51-56.

DOI:
https://doi.org/10.60141/ajid.128

ABSTRACT

Background: Tuberculosis (TB) continues to disproportionately affect vulnerable populations in conflict zones like Afghanistan, remaining a significant global health concern. We aimed to analyze TB trends in Afghanistan from 1990 to 2021 and projects the future burden to 2040, informing evidence-based public health planning.
Methods: Using sex-specific epidemiological data from the Global Burden of Disease (GBD) study (1990–2021), we projected the future prevalence of TB in Afghanistan and globally through 2040. We employed an illness-death model (IDM), calibrated to the GBD data to generate these projections.
Results: From 1990 to 2021, the global age-standardized prevalence rate (ASPR) of TB decreased by 23%, with projections indicating a further 6% decline by 2040. Afghanistan demonstrated a more substantial historical reduction of 43% and is forecast to achieve an additional 41% decrease by 2040. Although starting from a lower baseline than the global average, Afghanistan's rate of improvement is significantly more rapid. Projections for Afghanistan are associated with greater uncertainty, largely due to unique socio-political challenges. Nonetheless, these trends highlight the considerable progress made by the country despite major operational constraints.
Conclusion: While projections suggest potential progress in TB control, recent increases in case notifications and wide uncertainty intervals highlight that epidemiological outcomes in fragile states depend on political and economic factors as much as biomedical interventions, especially where case detection is suboptimal.

Keywords: Tuberculosis, Illness-death model, Conflict-affected health systems, Age-standardized prevalence sate, Health equity

Introduction

Tuberculosis (TB) continues to pose a significant challenge to global public health and serves as a critical marker of broader socioeconomic disparities (1). Due to its intricate relationship with socioeconomic factors and its propensity to disproportionately affect vulnerable populations, TB transcends a simple bacterial disease, serving instead as a robust metric for assessing a society's overall health (2). Although effective treatment regimens are available, the burden of TB persists at alarmingly high levels, especially in areas destabilized by conflict and fragility (3). The protracted nature of this pandemic demands analytical approaches that are not only vigilant but also increasingly refined and data-centric to effectively steer the course toward eradication (4).

The incidence of the disease is disproportionately high in nations experiencing protracted crises, such as Afghanistan, where fragmented health systems and barriers to treatment accessibility exacerbate its spread and impact (5). In this context, the global burden of disease (GBD) study serves as a vital analytical tool, providing standardized, comparable data that is essential for comprehending the full scope of the TB epidemic (6, 7).

In this study, we used the TB epidemiological data from GBD to depict the future trajectory of TB in Afghanistan and compare it with global estimate. This research might provide a robust scientific foundation for shaping TB control policies in Afghanistan. The objective was to deliver actionable recommendations to health authorities and global agencies, facilitating the development of effective, equitable, and evidence-based TB management strategies.

Methods

Data Sources

To estimate the prevalence of TB in Afghanistan and globally through 2040 the following epidemiological data, including gender-stratified and age standardized incidence, prevalence and mortality rate for both all-cause and TB-specific mortality in Afghanistan from 1990 to 2021, were retrieved from the GBD 2021 via https://vizhub.healthdata.org/gbd-results/. Moreover, demographic data, essential for population-level projections, were extracted from the publicly available population forecasts on the GHDx platform accessible from https://vizhub.healthdata.org/population-forecast/.

Modeling Approach

The analysis was conducted using the illness-death model (IDM), a compartmental model based on a discrete-time difference equation. The model is a dynamic compartmental framework that tracks populations through three health states: susceptible to TB, active TB infection, and death (an absorbing state). It incorporates sex-specific parameters to reflect key epidemiological variations (8, 9). Transitions are governed by rate parameters: susceptible individuals move to the infected state based on the annual incidence rate and to the death state via the general mortality rate. Those infected can revert to susceptibility or progress to death. For calibration, we fitted the model to historical GBD data (1990–2021) using a least-squares optimization approach. Complete model equations are detailed in reference (10). The objective of this approach was to produce representative annual estimates of TB prevalence for Afghanistan and the global level through 2040. Further methodological details are available in reference (10).

Results

Analysis of Age-Standardized Prevalence Rate (ASPR) Trends: Global and Afghanistan (1990-2040)

Global ASPR Trends

From 1990 to 2021, the global ASPR decreased significantly by 23.07% among both sexes, reflecting sustained improvements in healthcare access, preventive measures, and treatment protocols worldwide. In 2021, the global ASPR was recorded at 23,614.01, with sex-specific rates of 22,847.87 for females and 24,386.29 for males. Projections from 2021 to 2040 indicate a continued yet slower decline, with an estimated net reduction of 6.44%, resulting in an ASPR of 22,092.18 (95% CI: 21,423.18–22,782.06) for both sexes. Female ASPR is expected to decline by 7.12% to 21,219.96 (95% CI: 20,561.46–21,899.56), while male ASPR is projected to decrease by 5.93% to 22,940.53 (95% CI: 22,239.35–23,663.81) (Table 1; Figure 1). The narrow confidence intervals suggest high forecast certainty, supported by robust and consistent global data.

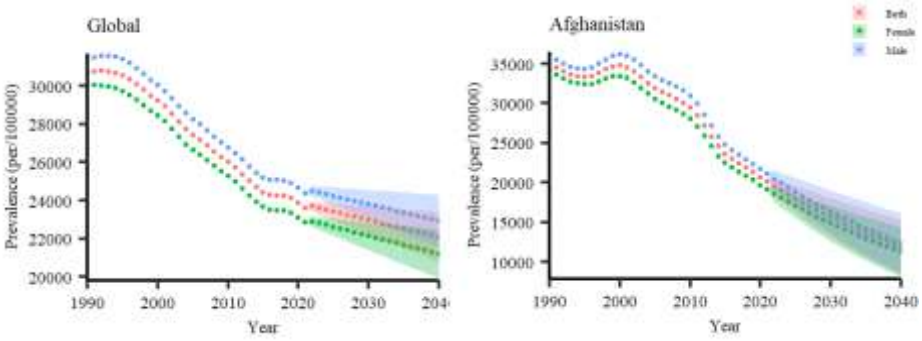

Figure 1: Age-standardized prevalence rates of tuberculosis for global and Afghanistan, 1990-2021 (historical, dotted line) and 2021-2040 (projected, dotted line with 95% confidence interval).

Afghanistan ASPR Trends

Between 1990 and 2021, Afghanistan exhibited a pronounced decline in ASPR, with a reduction of 42.65% for both sexes—one of the most rapid decreases globally, though beginning from an initially high disease burden. By 2021, Afghanistan's ASPR reached 20,114.49, with lower rates observed among females (19,113.25) compared to males (21,076.51). Projections through 2040 suggest a further accelerated decline, exceeding global trends, with an overall reduction of 40.94% to an ASPR of 11,879.53. Sex-specific projections indicate a decline of 41.09% for females (to 11,259.51) and 41.21% for males (to 12,390.86). These projections, however, are associated with wide confidence intervals (e.g., 10,218.83–13,810.04 for both sexes), indicating substantial uncertainty influenced by socioeconomic instability, health system fragility, and constraints in data quality and availability.

Comparison Between Global and Afghanistan Trends

A comparative assessment of ASPR trends reveals notable differences between global and Afghan patterns. Although both exhibited considerable declines from 1990 to 2021, Afghanistan's reduction of 42.65% was nearly twice the global average of 23.07%, albeit from a differing baseline. The 2021 ASPR baseline was higher globally (23,614.01) than in Afghanistan (20,114.49). Projections for 2021–2040 indicate divergent trajectories: global ASPR is expected to decline modestly by 6.44%, whereas Afghanistan is projected to experience a sharp accelerated decline of 40.94%. These differences highlight Afghanistan' remarkable progress in reducing TB prevalence under challenging conditions, though significant uncertainty remains in long-term forecasts due to contextual vulnerabilities.

Table 1: Historical (1990-2021) and projected (2021-2040) age-standardized prevalence rates (ASPR) of tuberculosis for global and Afghanistan, with corresponding percentage changes

Sex	*Country/ region*	*1990*	*2021*	*2022*	*2025*	*2030*	*2035*	*2040*	*Percentage change 1990 vs. 2021*	*Percentage change 2021 vs. 2040*
Both	Global	30696.644 (27716.498-33776.959)	23614.01 (21451.098-26020.10)	23698.953(23561.27-23837.44)	23423.052(23194.26-23654.1)	22970.504(22589.38-23358.06)	22526.93(21998.71-23067.83)	22092.18(21423.18-22782.06)	-23.073	-6.444
	Afghanistan	35074.17 (31926.676-38424.95)	20114.488 (17699.784-23081.23)	19534.412(18985.61-20099.07)	17972.03(17129.57-18855.92)	15644.866(14415.33-16979.25)	13626.384(12132.52-15304.15)	11879.529(10218.83-13810.04)	-42.6516	-40.9404
Female	Global	30032.31 (27123.349-33116.137)	22847.871 (20741.372-25213.65)	22905.686(22769.26-23042.93)	22615.588(22389.14-22844.33)	22140.333(21763.8-22523.38)	21675.194(21154.3-22208.91)	21219.963(20561.46-21899.56)	-23.9224	-7.12499
	Afghanistan	34171.295 (30843.979-37637.707)	19113.254 (16621.384-22146.53)	18569.27(18067.16-19085.33)	17078.796(16307.98-17886.03)	14858.577(13733.65-16075.62)	12931.292(11564.98-14458.98)	11259.509(9742.1-13013.19)	-44.0663	-41.0906
Male	Global	31390.562 (28353.762-34502.776)	24386.291 (22176.671-26832.46)	24495.575(24351.92-24640.08)	24228.918(23990.03-24470.19)	23791.19(23392.75-24196.42)	23361.755(22808.84-23928.07)	22940.525(22239.35-23663.81)	-22.3133	-5.9286
	Afghanistan	36169.048 (33113.684-39552.118)	21076.508 (18484.537-24200.97)	20447.713(19846.44-21067.2)	18797.198(17875.35-19766.58)	16342.293(14999.58-17805.19)	14218.864(12590.14-16058.27)	12390.855(10581.42-14509.73)	-41.7278	-41.2101

Discussion

This study elucidates the epidemiological trajectory of TB in Afghanistan by projecting ASPR from 2021 to 2040, revealing both encouraging trends and considerable uncertainties. A central finding is the projected 40.94% decline in ASPR for both sexes, suggesting a potential rapid reduction in TB burden, consistent with the substantial historical decrease of 42.65% observed between 1990 and 2021. However, this optimistic forecast must be interpreted alongside recent short-term fluctuations, including a 3.3% increase in case notifications from 2023 to 2024 (11), and the exceptionally wide confidence intervals around the 2040 estimates indicating high uncertainty dependent on non-biological factors.

These projections reconcile seemingly conflicting reports and complete the knowledge puzzle when contextualized within the broader evidence. The decline in TB trends likely reflects improved detection rates due to expanded GeneXpert networks and enhanced screening (12), especially among returning migrants (13), rather than decreased transmission(14). Alternatively, the decline may be due to underreporting resulting from a lack of robust surveillance and monitoring. While global declines reflect gradual improvements in stable health systems, Afghanistan's steeper decline likely represents accelerated "catching-up" through evidence-based interventions (15, 16). However, the substantial difference in confidence interval widths (3,591 points for Afghanistan versus 1,359 points globally) quantitatively demonstrates how political instability, aid dependency, and security challenges threaten health gains (17). This divergence underscores that conflict settings require distinct analytical approaches and intervention strategies(18).

Several methodological considerations should be considered when interpreting these findings. The compartmental IDM framework, calibrated with GBD 2021 data, offers a robust approach for estimating the future TB burden by accounting for fluctuations and interactions among key epidemiological rates over time. This model provided the foundation for our national, sex-stratified projections. However, these projections are subject to some limitations.

First, the model's reliability is inherently constrained by its dependence on surveillance data, which is incomplete in settings like Afghanistan where case detection remains suboptimal (19). Consequently, the accuracy of model parameters may be affected. Second, the IDM does not incorporate sudden political shifts, economic instability, or other systemic disruptions that could substantially alter healthcare accessibility and transmission dynamics. Relatedly, the model cannot reflect Afghanistan's critical dependence on external funding for TB programs—a major programmatic vulnerability not quantifiable in projections. Third, the absence of subnational data restricts the assessment of spatial variations in risk and health service access, meaning our national estimates may mask localized epidemic intensities. Finally, the projections assume sustained implementation of current TB control efforts; any deviation from this stable trajectory due to societal or political crises could significantly alter the anticipated outcomes.

Our analysis also revealed the counter-intuitive finding of Afghanistan's lower ASPR in 2021 compared to the global average. This could potentially be attributed to a combination of demographic factors—such as a younger population structure less susceptible to TB—severe underreporting due to fragmented health systems, or the effects of substantial outward migration from high-risk groups.

This finding underscores that a lower modeled prevalence does not necessarily indicate a lower disease burden but may reflect systemic surveillance gaps and unique population dynamics. Therefore, for these optimistic projections to be realized, TB control strategies in Afghanistan must be not only technically sound but also resilient to political and economic shocks, with future research prioritizing subnational data to guide tailored interventions.

Conclusion

While these projections suggest potential accelerated progress in TB control, the recent case notification increases and wide uncertainty intervals serve as crucial reminders that epidemiological outcomes in fragile states remain determined equally by political and economic factors as biomedical interventions where case detection remains suboptimal.

Acknowledgments

This work was conducted without funding from any organizations.

Conflict of interest

The authors declare that there is no conflict of interests.

References

1. Rasanathan K, Sivasankara Kurup A, Jaramillo E, Lonnroth K. The social determinants of health: key to global tuberculosis control. Int J Tuberc Lung Dis. 2011;15 Suppl 2(6):30-6.
2. Farmer P. Social scientists and the new tuberculosis. Soc Sci Med. 1997;44(3):347-58.
3. Gilmour B, Alene KA. Ending tuberculosis: Challenges and opportunities. Front Tubercul. 2024;2:1487518.
4. Owolabi BO, Owolabi FA. Predictive AI-Driven Epidemiology for Tuberculosis Outbreak Prevention in Achieving Zero TB City vision. Int J Adv Res Publication Rev.2025;02(05):318-40.
5. Zenner D. Crisis-Affected Populations and Tuberculosis. Microbiol Spectr. 2017;5(1):10.
6. Kyu HH, Maddison ER, Henry NJ, Mumford JE, Barber R, Shields C, et al. The global burden of tuberculosis: results from the Global Burden of Disease Study 2015. Lancet Infect Dis. 2018;18(3):261-84.
7. Kyu HH, Maddison ER, Henry NJ, Ledesma JR, Wiens KE, Reiner R, et al. Global, regional, and national burden of tuberculosis, 1990–2016: results from the Global Burden of Diseases, Injuries, and Risk Factors 2016 Study. Lancet Infect Dis. 2018;18(12):1329-49.
8. Brinks R. Illness-Death Model in Chronic Disease Epidemiology: Characteristics of a Related, Differential Equation and an Inverse Problem. Comput Math Methods Med. 2018;2018(1):5091096.
9. Brinks R, Hoyer A. Illness-death model: statistical perspective and differential equations. Lifetime Data Anal. 2018;24(4):743-54.
10. Ito C, Kurth T, Baune BT, Brinks R. Illness-death model as a framework for chronic disease burden projection: application to mental health epidemiology. Front Epidemiol. 2022;2:903652.
11. (WHO) WHO. WHO: Tuberculosis Increased by 3.3% in Afghanistan in 2024 2025 (Available from: https://tolonews.com/health-193594.
12. Khan MM, Tahoun MM, Meredith LW, Barakat A, Safi H, Hanifi AN, et al. Implementation and expansion of laboratory capacity for molecular diagnostics in response to COVID-19 and preparedness for other emerging infectious diseases in the Islamic Emirate of Afghanistan. Influenza Other Respir Viruses. 2023;17(11):e13210.
13. Brown S, Leavy JE, Jancey J. Implementation of GeneXpert for TB Testing in Low- and Middle-Income Countries: A Systematic Review. Glob Health Sci Pract. 2021;9(3):698-710.
14. Majamanda JG, Hosseinipour MC, Chagomerana MB, Munyewende P, Ndlovu N. Barriers to GeneXpert utilization for tuberculosis detection at a regional referral hospital in Malawi: a qualitative study. Pan Afr Med J. 2025;50:59.
15. du Cros P, Greig J, Alffenaar JC, Cross GB, Cousins C, Berry C, et al. Standards for clinical trials for treating TB. Int J Tuberc Lung Dis. 2023;27(12):885-98.
16. Aibana O, Dauria E, Kiriazova T, Makarenko O, Bachmaha M, Rybak N, et al. Patients' perspectives of tuberculosis treatment challenges and barriers to treatment adherence in Ukraine: a qualitative study. BMJ Open. 2020;10(1):e032027.
17. Lamberti-Castronuovo A, Valente M, Bocchini F, Trentin M, Paschetto M, Bahdori GA, et al. Exploring barriers to access to care following the 2021 socio-political changes in Afghanistan: a qualitative study. Confl Health. 2024;18(1):36.
18. Tao NPH, Nguyen D, Sediqi SM, Tran L, Huy NT. Healthcare collapse in Afghanistan due to political crises, natural catastrophes, and dearth of international aid post-COVID. J Glob Health. 2023;13:03003.
19. Sanaie A, Mergenthaler C, Nasrat A, Seddiq MK, Mahmoodi SD, Stevens RH, Creswell J. An Evaluation of Passive and Active Approaches to Improve Tuberculosis Notifications in Afghanistan. PLoS One. 2016;11(10):e0163813.