

Forecasting the Future Burden of Typhoid Fever: Global Projections and Afghanistan Estimates to Inform Public Health Planning Through 2040

*Meysam Olfatifar

Gastroenterology and Hepatology Diseases Research Center, Qom University of Medical Sciences, Qom, Iran

ARTICLE INFO

Type: Original Article
Received: 11/04/2026
Accepted: 17/07/2026

*Correspondence:
E-mail:
ol.meysam92@gmail.com

To cite this article:

Olfatifar M. Forecasting the Future Burden of Typhoid Fever: Global Projections and Afghanistan Estimates to Inform Public Health Planning Through 2040. *Afghan J Infect Dis*. 2026, 4(2):163-170.

DOI:
<https://doi.org/10.60141/ajid.174>

ABSTRACT

Background: Typhoid fever remains a significant public health challenge in many low- and middle-income countries, particularly in regions with inadequate water, sanitation, and hygiene (WASH) infrastructure. The Global Burden of Disease (GBD) study estimates that typhoid caused more than 6 million infections and more than 71,000 deaths globally in 2023. Understanding future trajectories of disease burden is essential for guiding public health policy and resource allocation.

Methods: We extracted age-standardized prevalence rates (ASPR) for typhoid fever from the GBD 2023 for both global and Afghanistan-specific estimates, disaggregated by sex, from 1990 to 2023. A cubic spline regression model was fitted to historical data using a least squares technique and used to project ASPR through 2040. Confidence intervals (95% UI) are reported for all estimates.

Results: In 2023, the global ASPR for typhoid fever stood at 5.34 per 100,000 for both sexes combined, with males experiencing a greater burden (5.68 per 100,000) compared to females (4.98 per 100,000). Afghanistan recorded an ASPR of 1.29 per 100,000 for both sexes. On a global scale, the ASPR is forecasted to fall to 1.68 per 100,000 by 2040, representing a 68.5% decrease from the 2023 level, whereas Afghanistan's ASPR is projected to drop to 0.43 per 100,000, a 67.0% reduction.

Conclusion: Typhoid fever prevalence is projected to continue its long-term decline through 2040 in both global and Afghanistan settings. However, the pace of decline may decelerate compared to historical trends, and sex-based differences may persist in some settings. Continued investments in WASH infrastructure and accelerated typhoid conjugate vaccine introduction are essential to sustain progress.

Keywords: Typhoid fever, Age-standardized prevalence rate, Global Burden of Disease, Afghanistan, Forecasting, Sex disparity

Introduction

Typhoid fever, caused by *Salmonella enterica* serovar Typhi, is a bacterial infection transmitted through contaminated food and water (1).

The disease remains a substantial public health burden in many low- and middle-income countries, particularly in South Asia and sub-

Saharan Africa, where access to safe water and adequate sanitation remains limited (2,3). According to the Global Burden of Disease (GBD) study 2023, enteric infectious diseases resulted in an estimated 1.27 million deaths globally in 2023, declining from 3.69 million in 1990 (4). Typhoid fever alone accounted for more than 6 million infections and over 71,000 deaths in 2023 (5).

The global epidemiology of typhoid fever has changed substantially over the past three decades. Liu and colleagues reported that from 1990 to 2021, global typhoid new cases decreased by 62.12%, with an estimated annual percent change of -3.92% (6). Another trend analysis from 1990 to 2021 found an EAPC of -4.15% for typhoid and paratyphoid fever combined (7). These declines have been attributed to improvements in water quality, sanitation infrastructure, and, more recently, the introduction of typhoid conjugate vaccines (TCVs) (8,9).

Afghanistan presents a unique case study in typhoid epidemiology. The country has suffered decades of military and civil conflict that have seriously impaired economic development and public health infrastructure (10). Sanitation access remains limited, with over 50% of households lacking access to upgraded sanitation facilities, and the typhoid vaccine is not currently included in Afghanistan's Expanded Program on Immunization (EPI) (11,12). Despite these challenges, analysis of Afghanistan's Disease Early Warning System from 2009 to 2015 found that rates of typhoid decreased during that period, likely tied to improvements in sanitation in the country (10).

Sex differences in typhoid fever burden have been documented in previous studies. Research using GBD data has found that males have higher rates of incidence, mortality, and DALYs than females for both typhoid and paratyphoid fever (6,13). The mortality of enteric fever was higher for males than females in both 1990 (M/F = 1.18) and 2019 (M/F = 1.17) (14).

However, the reasons for these disparities remain incompletely understood and may reflect a combination of biological, behavioral, and occupational factors (15).

Given the ongoing changes in typhoid epidemiology and the availability of new tools such as TCVs, there is a need for updated forecasts of future disease burden to inform policy and resource allocation. We aimed to forecast typhoid fever prevalence trends from 2024 to 2040 at the global level and in Afghanistan, while also examining sex-specific differences in disease burden.

Methods

Data Sources

To project the future burden of typhoid fever, age-standardized prevalence rates (ASPR) were derived from the GBD 2023, which is available through the Global Health Data Exchange repository (<https://vizhub.healthdata.org/gbd-results/>). Data broken down by sex for both Afghanistan and the global population, covering the period from 1990 to 2023, were retrieved for analysis. Within the GBD 2023 framework, enteric fever comprising typhoid and paratyphoid was classified under enteric infectious diseases.

Modeling Approach

A cubic spline regression model was employed to forecast the future trend of typhoid fever prevalence. The model was calibrated using historical data from 1990 to 2023, with a least square method applied to reduce error. Once fitted, this model was utilized to project ASPR values out to the year 2040. All estimates are accompanied by 95% confidence intervals (CIs). The cubic spline technique was chosen for its ability to flexibly capture nonlinear patterns while guarding against overfitting, rendering it well-suited for extrapolating epidemiological time-series data.

Results

Global and Afghanistan Burden in 2023

In 2023, the global ASPR for typhoid fever was 5.34 per 100,000 for both sexes combined. A notable sex disparity was observed, with males bearing a higher burden (5.68 per 100,000) compared to females (4.98 per 100,000). Afghanistan, a country with longstanding chal-

lenges in water and sanitation infrastructure, reported lower rates than the global average. The ASPR in Afghanistan was 1.29 per 100,000 for both sexes, with males again showing higher rates (1.38 per 100,000) than females (1.20 per 100,000) (Table 1).

Table 1: Projected age-standardized prevalence rate (ASPR) of typhoid fever globally and in Afghanistan from 2024 to 2040

Sex	Country/Region	2024	2025	2030	2035	2040	1990 vs. 2023(%)	2023 vs. 2040(%)
Both	Global	4.37 (4.27- 4.47)	4.06 (3.95- 4.18)	2.82 (2.68- 2.98)	1.96 (1.81- 2.12)	1.36 (1.23- 1.51)	-81.8	-71.9
	Afghanistan	1.51 (1.49- 1.53)	1.41 (1.39- 1.43)	0.99 (0.96- 1.02)	0.69 (0.66- 0.73)	0.49 (0.46- 0.52)	-82.5	-69.9
Female	Global	3.98 (3.88- 4.07)	3.68 (3.58- 3.79)	2.52 (2.38- 2.66)	1.72 (1.58- 1.87)	1.18 (1.05- 1.31)	-82.0	-73.5
	Afghanistan	1.43 (1.40- 1.46)	1.34 (1.30- 1.38)	0.96 (0.90- 1.01)	0.68 (0.63- 0.74)	0.49 (0.44- 0.54)	-82.5	-67.7
Male	Global	4.76 (4.66- 4.87)	4.44 (4.32- 4.56)	3.13 (2.97- 3.29)	2.20 (2.04- 2.38)	1.55 (1.40- 1.72)	-81.5	-70.4
	Afghanistan	1.59 (1.58- 1.61)	1.48 (1.46- 1.49)	1.02 (1.00- 1.04)	0.71 (0.69- 0.73)	0.49 (0.47- 0.51)	-82.6	-71.6

Historical Trends (1990–2023)

From 1990 to 2023, the global ASPR for typhoid fever declined substantially. For both sexes combined, the global ASPR fell by 78.1% over this period. Afghanistan demonstrated a similarly steep declining trend, with a historical decline of 82.7% for both sexes from 1990 to 2023, slightly larger than the global figure. These declines reflect sustained improvements in water quality, sanitation infrastructure, and, more recently, vaccination efforts.

Projected Trends (2024–2040)

Global Trends

Globally, typhoid fever prevalence is projected to decline further through 2040, continuing the steep historical decline observed from 1990 to 2023 (Figure 1A-C). From the 2023 baseline of 5.34 per 100,000, the ASPR for both sexes is forecast to drop to 1.68 (95% CI: 1.50–1.89) in 2040, representing an additional 68.5% reduction from 2023 levels. This downward trajectory is consistent across both sexes. Females are projected to decline from 4.98 per 100,000 in 2023 to 1.47 (95% CI: 1.30–1.65) in 2040, while males decline from 5.68 to 1.90 (95% CI: 1.69–2.12) over the same period. The male-to-

female disparity persists throughout the projection horizon, with males consistently maintain-

ing a higher prevalence. (Figure 1B & C).

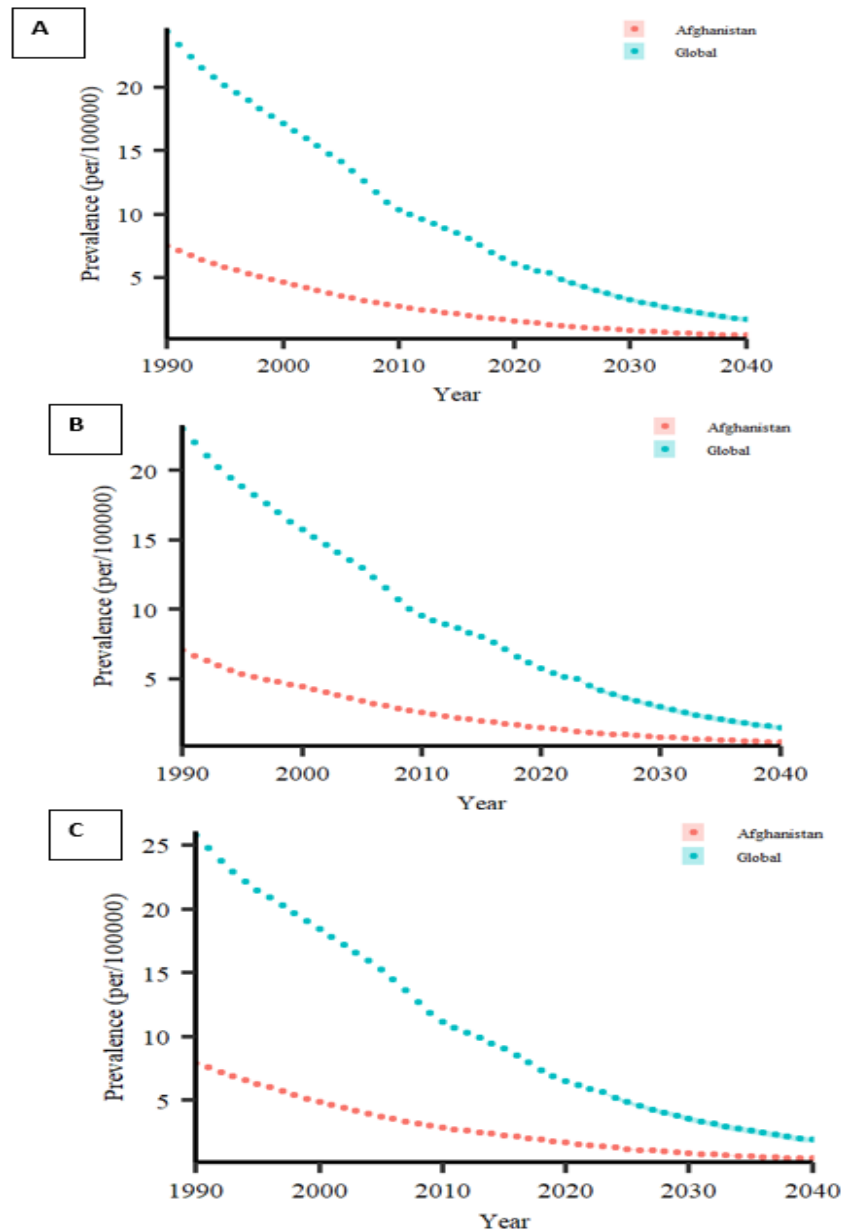


Figure 1: Observed and projected age-standardized prevalence rate (ASPR) of typhoid fever, 1990–2040 globally and in Afghanistan by (A) both sex, (B) female, and (C) male. Solid lines represent observed data (1990–2023); dashed lines represent projected data (2024–2040). Shaded areas indicate 95% confidence intervals. Data source: GBD 2023; data analyzed by the authors

Afghanistan Trends

Afghanistan demonstrates a similarly steep declining trend, albeit from a lower baseline. From the 2023 baseline of 1.29 per 100,000, the

ASPR for both sexes is forecast to fall to 0.43 (95% CI: 0.42–0.43) in 2040, a reduction of 67.0% from 2023. Females in Afghanistan are projected to decline from 1.20 per 100,000 in

2023 to 0.42 (95% CI: 0.39–0.44) in 2040, while males decline from 1.38 to 0.43 (95% CI: 0.43–0.44). Notably, by 2040, the projected prevalence for both sexes in Afghanistan converges to approximately 0.43 per 100,000, with overlapping confidence intervals suggesting a potential elimination of sex-based differences by the end of the projection period.

Discussion

We aimed to forecast typhoid fever prevalence trends from 2024 to 2040 at the global level and in Afghanistan, while also examining sex-specific differences in disease burden. The key finding is that typhoid fever prevalence is projected to continue its long-term decline through 2040 in both settings, with an additional 65–70% reduction from 2023 levels. The global both-sex prevalence rate is expected to fall from 5.34 per 100,000 in 2023 to 1.68 per 100,000 in 2040, while in Afghanistan it is projected to drop from 1.29 to 0.43 per 100,000 over the same period. A consistent sex disparity was observed, with males bearing a higher burden than females across both geographic regions in 2023. However, in Afghanistan, this sex gap is projected to converge by 2040, whereas globally the male predominance is forecast to persist. These findings confirm that while substantial progress in typhoid control is anticipated, the pace of decline may slow compared to historical trends, and sex-based differences in disease burden may not be uniformly eliminated across all settings.

Our findings align with recent GBD studies that have documented declining typhoid fever trends globally (4,6,7). A recent study reported that from 1990 to 2021, global typhoid new cases decreased by 62.12%, with an estimated annual percent change of -3.92% (6). Similarly, another trend analysis from 1990 to 2021 found an EAPC of -4.15% for typhoid and paratyphoid fever combined (7). The GBD 2023 study documented those enteric infectious diseases

resulted in 1.27 million deaths globally in 2023, declining from 3.69 million in 1990, with the global age-standardized mortality rate decreasing from 74.1 to 16.4 per 100,000 population during the same period (4). Our study extends these observations by forecasting continued declines through 2040, with global both-sex prevalence falling by an additional 68.5% from 2023 levels. However, our projected reductions from 2023 onward (approximately two-thirds) are somewhat lower than the historical reductions observed from 1990 to 2023 (approximately 78–83%). This deceleration is consistent with the phenomenon of diminishing returns, where early gains from basic sanitation improvements and vaccination campaigns are followed by a slower decline as remaining cases become concentrated in harder-to-reach populations (4).

The sex disparity observed in our study with males consistently showing higher typhoid prevalence rates than females globally corroborate findings from major GBD analyses (6,13). For typhoid fever, males had higher rates of incidence, mortality, and DALYs than females, although among older patients the absolute number of new cases and DALYs was higher in women (6). The mortality of enteric fever was higher for males than females in 1990 (M/F = 1.18) and 2019 (M/F = 1.17) (14). The higher typhoid burden observed in males is likely driven by multiple factors. A retrospective study conducted in South Africa reported that intestinal perforation and occult blood loss were more common among male patients, whereas females tended to present with more severe illness at the time of hospital admission and exhibited higher frequencies of typhoid-related hepatitis and glomerulonephritis (16). These differences may reflect sex-based variations in host immune responses to *S. typhi* infection, as well as potential differences in exposure risk related to occupational and behavioral factors (15,17). Notably, a review on sex bias in infectious disease epidemiology suggested that no

clear pattern is evident for typhoid fever, and behavioral factors likely modulate male-female differences (15). Our finding that sex disparities persist globally through 2040 suggests that underlying exposure differences may not be fully eliminated by broad public health improvements alone.

Our work offers novel projections specifically for Afghanistan, a country with limited typhoid fever data. An evaluation of the nation's Disease Early Warning System from 2009 to 2015 indicated falling rates of meningitis, typhoid, and acute viral hepatitis during that time, which was probably driven by ongoing improvements in sanitation throughout Afghanistan (10). However, the typhoid vaccine is not currently included in Afghanistan's Expanded Program on Immunization (EPI), and the country continues to face substantial challenges in public health infrastructure, including limited sanitation access and high rates of internal displacement (11,12). Our projection that Afghanistan's both-sex prevalence will fall to 0.43 per 100,000 by 2040 represents a 67.0% reduction from 2023 levels. Notably, the sex disparity in Afghanistan, males 1.38 versus females 1.20 per 100,000 in 2023 is projected to converge by 2040 (both approximately 0.43 per 100,000, with overlapping confidence intervals). This convergence may reflect the fact that as overall disease burden declines, absolute sex differences become negligible at very low prevalence levels, or it may indicate that in highly resource-constrained settings, transmission is more generalized across the population than in higher-burden settings where sex-specific risk behaviors maintain a persistent gap (15).

The projected declines in typhoid burden through 2040 are plausibly attributable to ongoing improvements in water, sanitation, and hygiene (WASH) infrastructure, as well as the expanding rollout of TCVs (8,9). The WHO recommends the introduction of TCV as part of a comprehensive approach to disease control in countries with a high burden (18). A systematic

review and meta-analysis demonstrated that the pooled efficacy of a single dose of TCV at 2 years post-immunization was 83% (77-87%; four trials; 111,130 participants; I^2 0%; moderate certainty) (19). TCVs have high-level efficacy ($\geq 80\%$) against typhoid fever in diverse field settings (9,19). Global TCV introduction campaigns have now reached millions of children worldwide, and vaccine demand forecasts predict that Asian countries will generate most demand until 2030, after which demand will track birth cohorts (20). However, only a limited number of countries have added TCVs to their national immunization programs to date, highlighting the need for accelerated vaccine rollout to achieve the projected reductions observed in our study (12,20).

Despite the encouraging projections, this study has several limitations. First, the forecasts are based on extrapolation of historical trends and assume that past drivers of decline such as improvements in sanitation, water quality, and vaccination coverage continue at similar rates. Unforeseen events, including the emergence of antimicrobial-resistant *S. typhi* strains, climate change affecting waterborne transmission patterns, or political instability disrupting health services in countries like Afghanistan, could substantially alter these trajectories (21). Second, spline-based projections, while flexible for capturing smooth long-term trends, may not adequately account for abrupt shocks such as sudden disease outbreaks, population displacement due to conflict, migration patterns, climate-related extreme events, or changes in surveillance quality and reporting completeness all of which could introduce unmodeled variability and affect forecast accuracy. Third, the Afghanistan estimates may suffer from underreporting due to limited surveillance infrastructure and incomplete health facility coverage in rural and conflict-affected areas, potentially biasing baseline rates downward and affecting forecast accuracy (10). Fourth, the confidence intervals for 2040 projections widen considerably, reflecting

increasing uncertainty over longer forecast horizons. Fourth, our analysis did not account for age-specific patterns, which are particularly relevant given that children bear the highest burden of typhoid fever in endemic regions (3,6). Fifth, the potential impact of serotype replacement or the emergence of paratyphoid fever as a competing cause of enteric fever was not modeled (22). Finally, we did not incorporate the potential effects of future climate change on waterborne disease transmission or the dynamic interplay between antimicrobial resistance and treatment efficacy (21).

To our knowledge, this is the first study to provide sex-disaggregated forecasts of typhoid fever prevalence from 2024 to 2040 at both the global level and for Afghanistan, offering a unique contribution to the typhoid epidemiology literature. The study's strengths include the use of recent GBD-aligned data, separate analyses for males and females to elucidate sex disparities, and the inclusion of both global and country-specific projections to inform targeted public health interventions.

Conclusion

Typhoid fever prevalence is projected to continue its long-term decline through 2040 at both the global level and in Afghanistan. The global ASPR is expected to fall by an additional 68.5% from 2023 levels, while Afghanistan is projected to experience a 67.0% reduction. However, the pace of decline may decelerate compared to historical trends, and sex-based differences may persist in some settings. Sustained investments in water, sanitation, and hygiene infrastructure, coupled with accelerated introduction of typhoid conjugate vaccines, are essential to achieve and maintain these projected reductions. Particular attention should be paid to hard-to-reach populations, conflict-affected areas, and settings where sex-based disparities in disease burden remain pronounced. Continued surveillance and regular updating of forecasts will be critical to monitor

progress and adapt strategies as new challenges emerge.

Acknowledgments

The authors would like to express their sincere gratitude to all colleagues and institutions that contributed valuable insights and support throughout the course of this study.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics

This study utilized publicly available, aggregated data from the GBD database. No individual or identifiable human or animal data were used; therefore, ethical approval and informed consent were not required.

Conflicts of interest

The authors declare no competing interests.

References

1. World Health Organization. Typhoid fever. Available at: <https://www.who.int/news-room/fact-sheets/detail/typhoid>
2. Stanaway JD, Reiner RC, Blacker BF, Goldberg EM, Khalil IA, Troeger CE, et al. The global burden of typhoid and paratyphoid fevers: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet Infect Dis*. 2019 Apr 1;19(4):369-81.
3. Francois Watkins LK, Shih DC, Dorrough L. Typhoid and paratyphoid fever. In: *CDC Yellow Book: Health Information for International Travel* [Internet]. 2026 ed. Atlanta (GA): Centers for Disease Control and Prevention; 2026 [cited 2026 Jul 20]. Available from:

4. <https://www.cdc.gov/yellow-book/hcp/travel-associated-infections-diseases/typhoid-and-paratyphoid-fever.html>
Vongpradith A, Dominguez RM, Car LT, Movo A, Ostroff SM, He J, et al. Global burden of enteric infectious diseases, diarrhoeal diseases, and corresponding aetiologies, 1990–2023: a systematic analysis for the Global Burden of Disease Study 2023. *Lancet Infect Dis.* 2026; S1473-3099(26)00194-5.
5. Global Burden of Disease Study 2023. Global Health Data Exchange repository. Available at: <https://vizhub.healthdata.org/gbd-results/>
6. Liu G, Zhang X, Cao Q, Chen T, Hu B, Shi H. The global burden of typhoid and paratyphoid fever from 1990 to 2021 and the impact on prevention and control. *BMC Infect Dis.* 2025;25:919.
7. Shi K, You T. Global trends in typhoid and paratyphoid, and invasive non-typhoidal *Salmonella*, and the burden of antimicrobial resistance: a trend analysis study from 1990 to 2021. *Front Med.* 2025 May 20;12:1588507.
8. World Health Organization. Typhoid conjugate vaccines. Available at: <https://www.who.int/teams/immunization-vaccines-and-biologicals/diseases/typhoid>
9. Chen J, Long JE, Vannice K, Shewchuk T, Kumar S, Duncan Steele A, Zaidi AK. Taking on typhoid: eliminating typhoid fever as a global health problem. In *Open Forum Infectious Diseases* 2023 May (Vol. 10, No. Supplement_1, pp. S74-S81). US: Oxford University Press.
10. Trends of vaccine-preventable diseases in Afghanistan from the Disease Early Warning System, 2009–2015. *PLoS ONE.* 2017;12(6):e0178677.
11. World Bank. Afghanistan: Sanitation. Available at: <https://data.worldbank.org/>
12. TechNet-21. Guide for introduction of Typhoid Conjugate Vaccine (TCV) into national immunization programmes - interim guidance [Internet]. 2025 [cited 2026 Jul 20]. Available from: [https://www.technet-21.org/en/resources/guidance/guide-for-introduction-of-typhoid-conjugate-vaccine-tcv-](https://www.technet-21.org/en/resources/guidance/guide-for-introduction-of-typhoid-conjugate-vaccine-tcv-into-national-immunization-programmes-interim-guidance)
13. Piovani D, Figlioli G, Nikolopoulos GK, Bonovas S. The global burden of enteric fever, 2017–2021: a systematic analysis from the global burden of disease study 2021. *EClinicalMedicine.* 2024 Nov 1; 77:102883.
14. Wang H, Zhang P, Zhao Q, Ma W. Global burden, trends and inequalities for typhoid and paratyphoid fever among children younger than 15 years over the past 30 years. *J Travel Med.* 2024 Dec;31(8):taae140.
15. Guerra-Silveira F, Abad-Franch F. Sex bias in infectious disease epidemiology: patterns and processes. *PloS One.* 2013 Apr 24;8(4):e62390.
16. Khan M, Coovadia YM, Connolly C, Sturm AW. Influence of sex on clinical features, laboratory findings, and complications of typhoid fever. *Am J Trop Med Hyg.* 1999 Jul 1;61(1):41-6.
17. Khan M. A plausible explanation for male dominance in typhoid ileal perforation. *Clin Exp Gastroenterol.* 2012 Nov 12:213-7.
18. World Health Organization. Typhoid vaccines: WHO position paper, March 2018–Recommendations. *Vaccine.* 2019 Jan 7;37(2):214-6.
19. Batool R, Qamar ZH, Salam RA, Yousafzai MT, Ashorn P, Qamar FN. Efficacy of typhoid vaccines against culture-confirmed *Salmonella* Typhi in typhoid endemic countries: a systematic review and meta-analysis. *The Lancet Global Health.* 2024 Apr 1;12(4):e589-98.
20. Debellut F, Hendrix N, Pitzer VE, Neuzil KM, Constenla D, Bar-Zeev N, et al. Forecasting Demand for the Typhoid Conjugate Vaccine in Low- and Middle-income Countries. *Clin Infect Dis.* 2019 Mar 15;68(Suppl 2):S154-S160.
21. Baker RE, et al. Climate change and infectious diseases: a review of the evidence. *N Engl J Med.* 2024;390(8):742-754.
22. Arndt MB, Mosites EM, Tian M, Forouzanfar MH, Mokhdad AH, Meller M, Ochiai RL, Walson JL. Estimating the burden of paratyphoid a in Asia and Africa. *PLoS Neg Trop Dis.* 2014 Jun 5;8(6):e2925.