

## Original Article

**Years lost due to disability for typhoid fever related to increased temperature under climate change scenarios and population changing projected burden of diseases**Elham Ahmadnezhad<sup>1\*</sup>, Zhaleh Abdi<sup>1</sup>, Farshid Fayyaz-Jahani<sup>2</sup>, Mahmood Suolduozi<sup>2</sup>, Soraya Fatholahi<sup>3</sup><sup>1</sup> Assistant Professor, National Institute for Health, Tehran University of Medical Sciences, Tehran, Iran<sup>2</sup> School of Medicine, Urmia University of Medical Sciences, Urmia, Iran<sup>3</sup> School of Public Health, Tehran University of Medical Sciences, Tehran, Iran

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## ABSTRACT

**Background & Aim:** This study aimed to estimate and project the current and future disability burden of typhoid fever in Iran associated with climate and population to provide best policies for climate change adaptation.**Methods & Materials:** Years lost due to disabilities (YLDs) were measured as burden estimation in this study. The temperature was selected as climate variable. Future temperature rising (projected for 2030 and 2050) used according to Intergovernmental Panel on Climate Change reports. Typhoid fever incidence in 2010 applied as the baseline data for YLDs calculation. The previous published regression models were considered for YLDs' future projections. Furthermore, the future demographic change was included for YLDs calculation.**Results:** Compared with the YLDs in 2010, increasing temperature and demographic change may lead to a 5.5-9% increase in the YLDs by 2030 and a 13.7-22% increase by 2050 if other factors remain constant. The highest YLDs was projected for > 45 years old (56.3%) in 2050 under temperature rising and population change scenario.**Conclusion:** Climate change and aging may impact on burden of typhoid fever in the future. Adaptive strategies should be considered to prevent and reduce the health burden of climate change.**Introduction**

Global climate change in recent decades is one of the dramatic results of human activities. The Intergovernmental Panel on Climate Change (IPCC) reported the earth's surface temperature will rise 1.4-5.8 °C until 2100. Climate change potentially may be the biggest threat of human health in the overcome century (1, 2).

Diarrheal disease is one of the health outcome issues affected by climate change, and

there are well-documented dose-response quantifications for relative risk estimation of diarrheal disease for 1 °C increasing of the temperature (3-7). Studies often focus on incidences of all diarrheal cases without studying the specific pathogens. *Salmonella enterica* serovar typhi and paratyphi are the human-adapted pathogens that cause enteric infection with systemic features that called the typhoid fever (8). Although typhoid fever is not a common cause of enteric infection, and most cases occur sporadically with no reports, in recent years, there are several reports about emerging drug-resistant cases (9, 10).

The global burden of diseases (GBDs) estimated 22 million new cases with 210,000

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deaths for typhoid fever and 5.4 million new cases for para-typhoid fever in 2000 (11). The GBDs estimated 178 (25-334) disability-adjusted life years (DALYs) for typhoid and para-typhoid fevers for worldwide in 2010. Among all causes, the DALYs' rank of disease is 52 for all regions and 57 for Middle East (12).

The global report from World Health Organization (WHO) estimated 2.4% of worldwide diarrheal cases were attributable to climate change (with 47,000 excess deaths or 459,000 of DALYs). The burden of specific pathogen of diarrheal cases has not been quantified by this report (13). While, the climate variable may influence the transmission and distribution of each pathogen, and typhoid fever agents are not excluded (14, 15). Typhoid fever is one of the endemic infections with some epidemic episodes in Iran. Although the incidence rate of disease has been decreased in recent years, there are some emerging cases with multi-drug resistant (16).

The clinical features and sequels of typhoid fever in comparison with other diarrheal diseases may be more serious and without appropriate treatments, 10-30% of cases would be died (17). All countries would develop adaptation capacities for climate change. Estimation of the burden of disease under climate change scenarios is the new emerging quantification that may provide sufficient information for useful policy-making. According to the IPCC reports, the climate is changing in Iran then studying the impacts on health outcomes is necessary (2). This study aimed to the projection of the burden of typhoid fever (according to new emerging cases and severe sequels in comparison other diarrheal diseases) under climate change scenarios and population change in Iran.

## Methods

This was an ecological study for quantification of typhoid fever (other *Salmonella* infections excluded) disabilities under climate change scenarios and population change. The year lost disabilities (YLDs) estimated as the burden of typhoid fever. Due to this fact that the death rate

of typhoid fever in Iran was very few (0.6% for 631 cases in 2010) (16), the years of life lost did not compute. In addition, for YLDs measuring, we assumed many factors can influence the incidence such as activities of the health system, promotion of care, and socio-economic status. In this study, all probable factors were assumed constant, and only the climate variables are the main associated to YLDs of typhoid fever. Although all climatic factors may impact on the diarrheal diseases, in many studies, only temperature effect quantified, then we considered the temperature as climate variable (6, 7, 13, 18).

We measured the incidence by age groups (< 15, 15-30, 31-45, > 45) and sex. Only one study has been reported the disability weight of typhoid fever. It was equal to 0.27 (0.075-0.471). We used the average disability weight (= 0.27) and average disease duration (= 0.01 year) (19).

The GBD was using the different discounting and also weighting of age. 3% discounting and non-uniform weighting for age (YLDs: 3,1) or no discounting with uniform age weighting (YLDs: 0,0) are the common measures (20). 3% without age weighting used in present study. For final estimation, the YLDs computed by following:

$$YLD = \frac{1 \times DW \times (1 - e^{-rL})}{r}$$

Where, I: Incidence rate, DW: Disability weight, L: Average duration of disability (years), discount rate (0.03);

In the next step, we projected YLDs for the future (2030 and 2050). There is only one dose-response quantification with the future projection of diarrheal cases rate with 1° C temperature increasing. This study has been done by WHO. 8% increasing estimated for diarrheal cases for 1 °C mean temperature rising (21). The different diarrheal pathogens did not included in the WHO report, and we did not find the published report, which quantified the climate change impacts on typhoid fever in Iran. Therefore, the above quantification was applied. The baseline information for the future projection was the incidence rate of disease that reported for 2010, therefore, we selected 2010

due to availability, while we believe the incidence rate of disease in recent decades may not be varied (16). Mean temperature and population changing were considered for analysis. IPCC (1) projection models for the country (mean temperature) and the World Bank demographic information (22) were applied for analysis. Mean temperatures may be rising 0.5-1 °C for 2030 and 1.5-2.4 °C for 2050 in Iran (1, 2).

## Results

The YLDs computed for baseline (2010) and the future (2030 and 2050). Demographic changes in Iran are provided in table 1. Based on the table 1 information, Iran will experience the population growing in the future. Table 2 shows the YLDs estimation for typhoid fever. YLDs were estimated by sex and age categories and also total estimation provided. The total YLDs in the baseline (2010) were 54.4. There were more in females (28.5) than males (25.3), and the highest YLDs in 2010 were estimated for

those under the age of 15 and the lowest reported for those above the age of 45. In both sexes, under different climate change scenarios, YLDs increased in projected years in comparison with baseline. Therefore, it will increase 3-4 more times up to 2030 and 8-9 up to 2050. As the under-15 had the most YLDs in the baseline, it has the highest rank among age categories in both projected years and different scenarios. For 30-45 years old, the YLDs did not change under different scenarios for 2050. Figure 1 shows the YLDs trend of typhoid fever. The total YLDs have an increasing trend in 2030 and 2050 in comparison with the baseline.

## Discussion

This is the first projection of burden of typhoid fever with linked on climate change. We projected YLDs (as a quantitative measure) of disease with consideration of climate and populations changing for 2010 (as the baseline), 2030, and 2050.

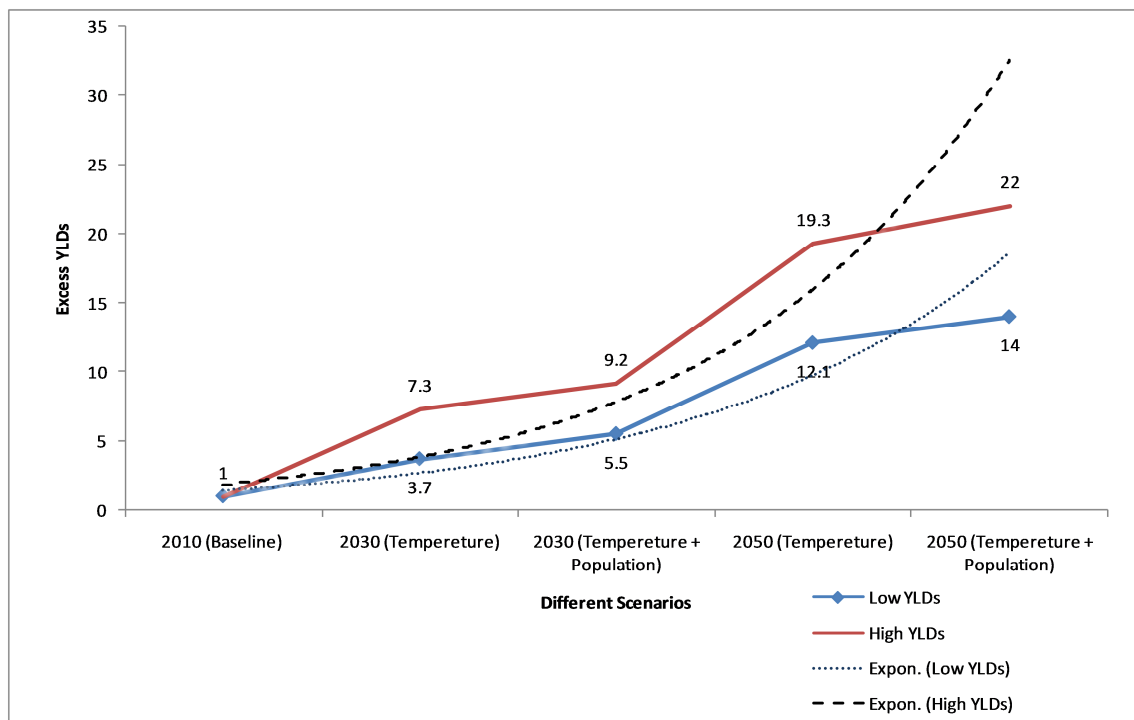
**Table 1.** Baseline and future demographic changes based on sex and age in Iran (2010, 2030 and 2050)

Baseline factors	2010	2030	2050
Population (millions)	73,973	84,208	84,343
Population sex ratio (male per 100 female)	103	100	98
Percentage aged			
< 15	23	17	14
15-30	35	20	14
31-45	22	25	20
> 45	20	38	52

**Table 2.** The YLDs for typhoid fever in Iran: 2010 (Baseline), 2030, and 2050

Scenarios	Total	By sex		By age (years old)			
		Male	Female	< 15	15-30	31-44	> 45
2010	54.4	25.3	28.5	16.8	14.9	11.6	10.3
2030							
Increasing temperature	56.4-58.4	26.3-27.3	29.6-30.7	17.5-18.2	15.5-16.0	12.1-12.6	10.7-11.2
Increasing temperature + population change	57.4-59.4	26.4-27.5	29.8-31.1	17.3-17.9	15.3-15.7	12.2-12.8	11.2-12.1
2050							
Increasing temperature	61.0-64.9	28.3-30.1	32.0-34.0	18.9-20.0	16.9-17.8	13.0-13.9	11.6-12.3
Increasing temperature + population change	62.0-66.4	28.6-30.6	32.4-34.4	19.0-19.4	15.7-16.2	13.0-13.9	13.9-16.1

YLD: Year lost disabilities



**Figure 1.** Projected excess year lost disabilities for typhoid fever in Iran (2010, 2030, and 2050)

While the exact quantifications were not very significant, an increasing trend in all age groups and both sexes was found. Up to 2030 and 2050, the overall morbidity burden of typhoid fever may increase in the country if other factors remain constant. It will be increased 1.2 times in 2050 in comparison with baseline. The latest GBD without consideration, the environmental factors, also estimated DALYs of typhoid fever may be two times (178 in 2010) more than baseline (175 in 1990) (12). The highest incidence of typhoid fever occurs among under 15 years old (children) (17). Although the mortalities from diarrheal cases are significantly decreasing, it remains one of the main causes of morbidity all over the world (12, 17). Our results were consistent with the rest of the world, and the highest YLDs of typhoid fever occurred in children in 2010 and the future.

Aging is the new emerging issues among Iranian population (23), also we projected population changing plus the temperature rising had the more impacts. Despite the under - 15 had the highest YLDs in baseline and in the future, the highest increasing found among > 45

years old in our study. It was 7.7% total excess YLDs in 2050 for > 45 age group. The GBD reported the highest DALYs for under five similar to baseline results of our study, but it seems that the pattern will be changed in the future (24). The highest YLDs of *Salmonella* infections reported for under 15 in two separate regions of Australia. It is similar to results of age group in the present study (18).

The YLDs of females were 1.1 times more than male in baseline, and there are higher than in all age groups for both 2030 and 2050. Based on the results, females are more affected than males, despite lower population ratio (103 males per 100 females). There are different results about gender difference of typhoid fever, but the studies did not refer to the cause of difference (25-27). It may be complete random distribution.

There are some quantitative measures for health risk estimation of climate change (28, 29). YLDs are one of the estimations while results provide useful quantitative measures of the future risk of typhoid fever, but like other estimations, it has some unavoidable uncertainties. YLDs do not take into account the

aspects of the quality of life, well-beings, or impacts of one individual's health conditions on other people and also mortality (20). In addition, the impacts of climate change on the burden of typhoid fever are more complex, and it depends on variety numbers of factors (28). The results of our study may influence the limitations of YLDs estimation. However, despite the limitations, it increases our understanding of the implications of the climate change on health impacts in Iran. The implication for the future analysis suggests that climate change will cause more additional disabilities (in term of burden). While the climate change is unavoidable, the YLDs estimations can help to take policy actions for adaptations. Taking actions would be considered based on WHO recommendation (30).

We did not consider the mortality from typhoid fever because based on surveillance data; death rates are very low in the country (16). The sub-national estimation was not including for projection due to data availability. Despite there are different climate in the country, the control and prevention measures of disease are the same in whole part of Iran. One study projected Salmonella infection in temperate regions may cause the extra burden due to the future climate change (18). Then projection may be useful if the studies consider sub-national estimation. Underreporting is a common problem of the surveillance system, and results may be underestimated. Other sources for underestimation are: (1) The diagnosis criteria of typhoid fever, which the blood culture is mostly common test for diagnosis, but it has only 50% sensitivity (17), (2) we did not consider the adverse sequels of disease.

## Conclusion

With remaining constant of other factors that influence the incidence of typhoid fever, our results projected YLDs will be increased in the context of climate change (as environmental factors). Measures and scenarios are the main uncertainty in our study.

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