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Changing dynamics of tuberculosis incidence in Northwest Iran (East Azerbaijan): 15-Year joinpoint time trend analysis

Lotfali Haghiri¹ , Fatemeh Rostampour¹ and Mohammad Heidari^{1*}

Abstract

Background Tuberculosis remains a major public health challenge in Iran due to changing demographic and epidemiological patterns. Understanding these trends is essential for disease control. We used Joinpoint regression to analyze tuberculosis trends in northwest Iran during 2005–2019.

Methods All tuberculosis cases from East Azerbaijan Province (2005–2019) were extracted from the national TB surveillance database. Population data were obtained from the national census, with inter-census years estimated by linear interpolation. Temporal incidence trends were assessed using Joinpoint regression, yielding annual percent change and 95% confidence intervals. Analyses were stratified by age and sex to examine incidence differences.

Results Between 2005 and 2019, 3,827 tuberculosis cases were reported in East Azerbaijan Province, with women comprising 53% of cases and a median patient age of 55 years. The age-standardized incidence rate increased until 2012 (APC: +2.6%, 95% CI: 1.2–4.1), then declined significantly (APC: –6.4%, 95% CI: –8.1 to –4.7), reaching 2.8 per 100,000 by 2019. The most marked decreases were observed in men aged 15–34 years (APCs: –11.6% and –23.3%), with similar reductions among women in this age group. Trends among older adults were more variable, but after the joinpoint, the decline became significantly steeper among women (APC: –7.7%, $P < 0.001$).

Conclusion The decline in tuberculosis incidence since 2012, especially among younger groups, indicates progress in local TB control. However, rising rates among older men highlight new demographic concerns. Continued surveillance and targeted interventions are crucial to sustain gains and further reduce tuberculosis in the province.

Keywords Tuberculosis (TB), Joinpoint regression, Incidence rate, Time trend, East azerbaijan

*Correspondence:

Mohammad Heidari
heidari.m1358@gmail.com

¹Department of Biostatistics and Epidemiology, School of Medicine, Urmia University of Medical Sciences, Urmia, Iran



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Introduction

Tuberculosis (TB) continues to be a major global public health concern, and the analysis of its incidence trends is particularly crucial, as such studies aid in the formulation of effective disease control strategies [1]. Despite existing evidence indicating the potential to eradicate the TB epidemic, the rise and dissemination of drug-resistant tuberculosis (DR-TB) have added new challenges to these initiatives. Over the past two centuries, TB has resulted in the deaths of hundreds of millions of people. In 2017 alone, over 1.6 million individuals succumbed to the disease, and if left unaddressed, TB remains a significant global threat [2].

More than 90% of tuberculosis (TB) cases and associated fatalities occur in developing countries, where 75% of TB cases are within the most economically active age group (ages 15 to 54 years) [3]. This situation presents significant economic challenges, as an adult diagnosed with TB is, on average, unable to work for 3 to 4 months, leading to a 20% to 30% reduction in annual household income. Tragically, the death of such an individual often results in the loss of 15 years of potential household income [4]. TB, which is more prevalent among economically disadvantaged populations, can further intensify poverty [5]. According to a 2023 study, approximately 10 million new TB cases and 1.4 million deaths occur annually worldwide [6]. Nevertheless, the global incidence rate of TB has declined from 180 cases per 100,000 population in 2000 to 134 cases per 100,000 population in 2023 [7].

In Iran, the incidence rate of smear-positive TB is reported to be approximately 6.3 cases per 100,000 population, and the overall incidence of various forms of TB is estimated at 12.6 per 100,000 population. Furthermore, 12.7% of registered TB patients are Afghan nationals. The mortality rate attributed to TB stands at 7.5%, and the highest rate of antibiotic resistance observed is for isoniazid, affecting around 10% of cases [8]. The incidence of tuberculosis (TB) in South-West of Iran rose from 2010 to 2013, followed by a downward trend starting in 2013 [9]. These variations in TB incidence trends across different regions of Iran indicate that a comprehensive analysis of these trends can yield valuable insights for health planning and interventions. East Azerbaijan Province in north-west Iran was selected as the study setting given its particular epidemiological relevance. The province's border location, population mobility, and the increasing proportion of older adults represent contextual factors that may shape local tuberculosis transmission and notification patterns. Moreover, although East Azerbaijan is among the most populous provinces in the region, detailed longitudinal evidence describing age- and sex-specific TB trends remains scarce. Major challenges in managing tuberculosis (TB) include delays in

diagnosis, a high disease burden among refugees, cases of multidrug-resistant (MDR) TB, and significant disparities among various populations, such as differences in gender and pre-existing health conditions. The World Health Organization (WHO) has established ambitious targets for TB reduction, aiming for a 50% decrease in incidence by 2025, with further reductions anticipated by 2035 [10].

Utilizing the Joinpoint Regression Model for trend analysis facilitates a detailed examination of changes in incidence rates over designated periods and aids in identifying significant shifts in tuberculosis (TB) trends [11]. Recognizing the importance of understanding TB incidence trends and the related factors, this study aims to model the changes in TB incidence in North-West of Iran from 2005 to 2019 using Joinpoint Regression. The results of this study can support policymakers and health planners in developing and implementing more effective TB control interventions.

Methods

This study employed data from the national tuberculosis (TB) registration system, which encompasses information on patients with smear-positive pulmonary TB, smear-negative pulmonary TB, and extrapulmonary TB. All cases were documented by health professionals in the East Azerbaijan Provinces. As anti-tuberculosis medications are dispensed exclusively through public health centers, the registry captures all notified TB cases who initiated treatment. Therefore, data completeness is considered high for reported and treated cases; however, undiagnosed or unreported cases may not be fully represented. Information such as disease type, age, gender, and place of residence was extracted from the system, and patients from 2005 to 2019 were included in the study. To gather demographic information, national population census data from the years 2006, 2011, and 2016 were sourced from the Iranian National Statistics Portal (<https://amar.org.ir/>), and with population estimates for the intervening years between two census calculated using the interpolation technique, assuming a constant growth rate. Data grouping and preparation for advanced analysis was done using STATA-18 software. Baseline characteristics were summarized using mean $\pm$ standard deviation (SD) for continuous variables and frequency (percentage) for categorical variables. Differences between groups were assessed using independent samples t-tests for continuous variables and chi-square tests for categorical variables. A P value < 0.05 was considered statistically significant.

The Joinpoint Regression software was utilized to analyse trends and identify joinpoints. This method employs nonlinear models and the Monte Carlo Permutation test to detect significant joinpoints in trends. Using a Poisson regression model, the annual percent change (APC)

was calculated along with a 95% confidence interval. The effects of age and gender variables were assessed through stratification, and incidence trends within each stratum were calculated and compared to the overall trend. The results included a graph showing the trends, the join-points, and the final APCs. Year-to-year fluctuations in crude incidence rates may partly reflect changes in case detection practices and reporting efficiency rather than true variations in disease occurrence.

Data Availability

The datasets used and analyzed during the current study are not publicly available due to confidentiality agreements with the Iranian Ministry of Health and Medical Education but are available from the corresponding author on reasonable request.

Table 1 Demographic characteristics of tuberculosis cases in East Azerbaijan Province from 2005 to 2019

	Sex			P_Value
	Female	Male	Total	
N	2,056 (52.5%)	1,858 (47.5%)	3,914 (100.0%)	
Age	51.980 (21.235)	53.966 (20.728)	52.923 (21.017)	0.003
Weight	52.171 (7.111)	52.787 (7.898)	52.463 (7.500)	0.010
Pulmonary	1,273 (62.0%)	1,252 (67.4%)	2,525 (64.5%)	< 0.001
Extrapulmonary	781 (38.0%)	606 (32.6%)	1,387 (35.5%)	
Rural	662 (32.2%)	569 (30.6%)	1,231 (31.5%)	0.290
Urban	1,393 (67.8%)	1,288 (69.4%)	2,681 (68.5%)	
	Type			
	Pulmonary	Extrapulmonary	Total	
N	2,525 (64.5%)	1,387 (35.5%)	3,912 (100.0%)	
Age	56.892 (20.931)	45.702 (19.185)	52.924 (21.020)	< 0.001
Weight	52.420 (7.469)	52.544 (7.564)	52.464 (7.502)	0.620
Rural	835 (33.1%)	394 (28.4%)	1,229 (31.4%)	0.003
Urban	1,688 (66.9%)	993 (71.6%)	2,681 (68.6%)	
	Residence			
	Rural	Urban	Total	
N	1,231 (31.5%)	2,681 (68.5%)	3,912 (100.0%)	
Age	53.073 (22.355)	52.857 (20.384)	52.925 (21.021)	0.766
Weight	51.850 (6.729)	52.748 (7.816)	52.466 (7.501)	< 0.001

Ethical considerations

This study was reviewed and approved by the Ethics Committee of Urmia University of Medical Sciences, Urmia, Iran (Ethics code: IR.UMSU.REC.1399.273). As this study used anonymized data from routine surveillance records, the requirement for informed consent was waived by the Ethics Committee of Urmia University of Medical Sciences. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Results

Table 1 presents the demographic characteristics of tuberculosis (TB) cases in East Azerbaijan Province between 2005 and 2019. Of the total 3,914 TB cases, 52.5% were female and 47.5% were male. The mean age of patients was significantly higher in males (53.97 ± 20.73 years) compared to females (51.98 ± 21.24 years) ($P=0.003$). Likewise, the average body weight was slightly higher in males (52.79 ± 7.90 kg) than in females (52.17 ± 7.11 kg), with a statistically significant difference ($P=0.010$). Regarding the type of tuberculosis, pulmonary TB was more common in males (67.4%) compared to females (62.0%), while extrapulmonary TB was more frequent among females (38.0%) than males (32.6%). This sex-based difference in disease type was statistically significant ($P<0.001$). In terms of residence, 68.5% of the patients lived in urban areas and 31.5% in rural areas, with no significant difference in distribution between sexes ($P=0.290$).

When comparing pulmonary and extrapulmonary TB cases, pulmonary TB accounted for 64.5% of all cases, and extrapulmonary TB for 35.5%. Patients with pulmonary TB had a significantly higher mean age (56.89 ± 20.93 years) than those with extrapulmonary TB (45.70 ± 19.19 years) ($P<0.001$). However, there was no significant difference in average weight between the two groups ($P=0.620$). Urban residency was more common in both groups, but extrapulmonary TB cases were more likely to be from urban areas (71.6%) compared to pulmonary TB cases (66.9%), and this difference was statistically significant ($P=0.003$). Analysis based on place of residence showed that urban residents had significantly higher body weight (52.75 ± 7.82 kg) than rural residents (51.85 ± 6.73 kg) ($P<0.001$). However, no significant difference was found in mean age between rural and urban patients ($P=0.766$).

Figure 1 shows the age-specific incidence rates of tuberculosis in East Azerbaijan Province from 2005 to 2019, by sex. Overall, TB incidence increased with age in both males and females. The lowest rates were observed in children under 15, while the highest rates occurred in individuals over 65 years. In most age groups, the incidence was relatively similar between the sexes, though females had slightly higher rates in the 15–24 and over 65

Age Distribution of TB Incidence in East Azerbaijan(2005-2019)

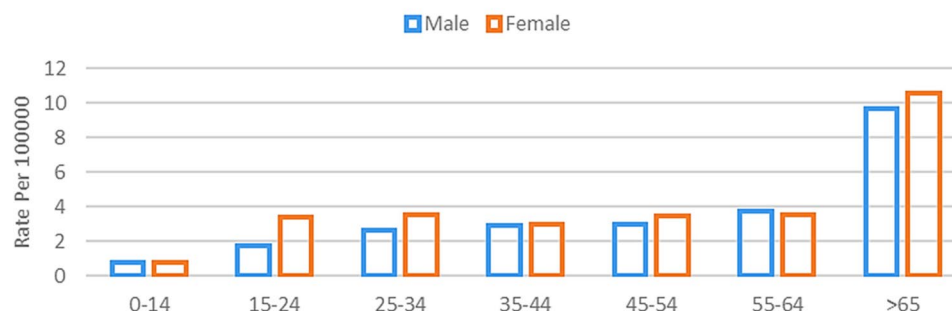


Fig. 1 The average tuberculosis (TB) incidence rate from 2005 to 2019, by age group and sex Crude Rate trends

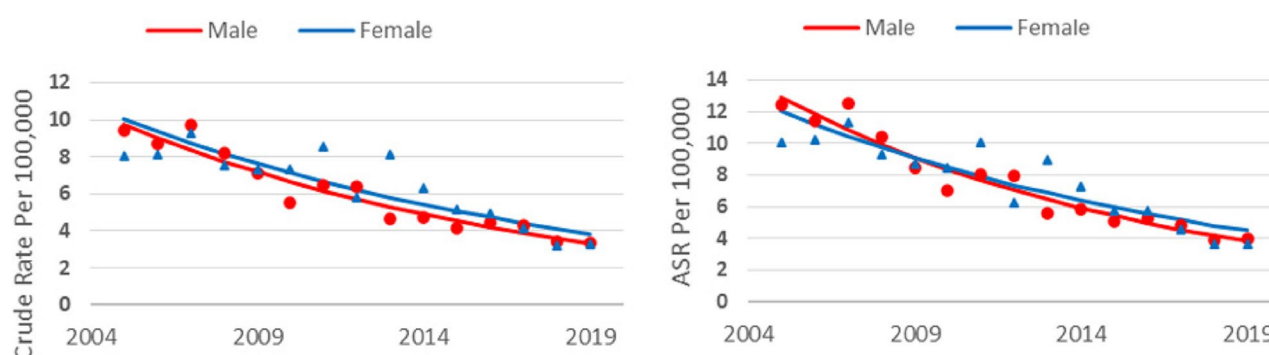


Fig. 2 Trends in crude and age-standardized tuberculosis incidence rates by sex, 2005–2019

Table 2 Average annual percent change (AAPC) in crude and age-standardized tuberculosis incidence rates by sex in Northwest Iran, 2005–2019

	Sex	APC (95% CI)	P_Value
Crude	Male	-7.45 (-8.43 : -6.47)	<0.001
	Female	-6.62 (-8.34 : -4.86)	<0.001
ASR	Male	-8.30 (-9.44 : -7.14)	<0.001
	Female	-6.80 (-8.90 : -4.46)	<0.001

age groups. These patterns highlight the increased risk of TB in older adults and suggest age and sex differences in disease burden.

The Joinpoint regression analysis of crude tuberculosis (TB) incidence rates in East Azerbaijan Province from 2005 to 2019 revealed several statistically significant trends across age and sex subgroups. Figure 2 shows average annual percent change (AAPC) of trends from 2005 to 2019, presented for both crude incidence rates and age-standardized rates (ASR, per 100,000 population). Statistically significant declining trend was observed in both sexes. For crude incidence rates, the AAPC was -7.45% (95% CI: -8.43 to -6.47 ; $P < 0.001$) in males and -6.62% (95% CI: -8.34 to -4.86 ; $P < 0.001$) in females (Table 2). Similarly, age-standardized rates decreased significantly, with an AAPC of -8.30% (95% CI: -9.44 to -7.14 ; $P < 0.001$) among males and -6.80%

(95% CI: -8.90 to -4.46 ; $P < 0.001$) among females. Overall, the decline was more pronounced in males than in females for both crude and age-standardized measures, and the persistence of these trends after age standardization suggests that the observed reductions reflect a true decrease in incidence rather than changes in population age structure. Figure 2 illustrates trends in crude and age-standardized tuberculosis incidence rates by sex from 2005 to 2019, showing a statistically significant declining pattern in both males and females. Among males aged 15–24 years, a significant declining trend was observed throughout the study period, with an annual percent change (APC) of -11.61% (95% CI: -16.10 to -6.87 ; $P < 0.001$). In females of the same age group, two distinct trends were detected: a sharp and significant decrease between 2013 and 2017 (APC = -35.84% , 95% CI: -47.61 to -21.43 ; $P < 0.001$), followed by a non-significant increase thereafter (Table 3).

In the 25–34 age group, females experienced a significant increase in TB incidence from 2005 to 2012 (APC = 9.83% , 95% CI: 2.44 to 17.76 ; $P = 0.015$), followed by a non-significant downward trend. Among females aged 45–54, there was a consistent and significant decline in incidence throughout the entire period (APC = -7.43% , 95% CI: -10.16 to -4.62 ; $P < 0.001$), indicating successful control efforts in this subgroup.

Table 3 Annual percentage change (APC) of crude and Age-Standardized rate (ASR) for tuberculosis incidence in East Azerbaijan Province from 2005 to 2019, by sex

	Age Groups	Sex	Segment	APC (95% CI)	P_Value
Crude Rate	0–14	Male	2005–2019	-3.12 (-9.02 : 3.15)	0.291
		Female	2005–2019	-2.02 (-9.04 : 5.53)	0.562
	15–24	Male	2005–2019	-11.61 (-16.10 : -6.87)	<0.001
		Female	2005–2013	-0.81 (-4.74 : 3.28)	0.648
			2013–2017	-35.84 (-47.61 : -21.43)	0.001
	25–34	Male	2017–2019	29.07 (-17.38 : 101.64)	0.218
			2005–2015	3.38 (-0.39 : 7.30)	0.074
			2015–2019	-23.26 (-35.05 : -9.33)	0.005
		Female	2005–2012	9.83 (2.44 : 17.76)	0.015
			2012–2017	-6.09 (-21.33 : 12.09)	0.428
ASR	35–44	Male	2017–2019	-50.72 (-78.05 : 10.64)	0.077
			2005–2019	1.74 (-1.04 : 4.60)	0.202
			2005–2013	5.77 (-0.65 : 12.61)	0.073
	45–54	Male	2013–2019	-10.92 (-19.41 : -1.53)	0.027
			2005–2019	-1.07 (-4.72 : 2.70)	0.544
			2005–2019	-7.43 (-10.16 : -4.62)	<0.001
	55–64	Male	2005–2019	1.56 (-0.63 : 3.81)	0.145
		Female	2005–2019	-3.90 (-5.76 : -2.01)	<0.001
	>=65	Male	2005–2019	3.94 (-0.25 : 8.32)	0.062
		Female	2005–2012	2.57 (0.25 : 4.94)	0.032
			2012–2019	-7.69 (-9.77 : -5.55)	<0.001
	Overall	Male	2005–2012	2.67 (1.01 : 4.35)	0.004
			2012–2019	-5.10 (-6.62 : -3.54)	<0.001
		Female	2005–2012	2.57 (0.25 : 4.94)	0.032
	Male		2012–2019	-7.69 (-9.77 : -5.55)	<0.001
			2005–2012	1.28 (-1.64 : 4.30)	0.354
			2012–2019	-6.37 (-9.42 : -3.22)	0.001
	Female		2005–2012	1.84 (-1.51 : 5.32)	0.252
			2012–2019	-9.34 (-12.97 : 5.56)	<0.001
	Overall		2012–2019	1.56 (-1.12 : 4.33)	0.226
			2012–2019	-7.91 (-10.77 : -4.96)	<0.001

Conversely, An increasing but non-significant trend was observed among males aged 65 years and older (APC=3.94%, 95% CI: -0.24 to 7.82; $P=0.062$), suggesting an epidemiologic shift toward older age groups. When examining overall trends, both sexes showed a statistically significant decline in crude TB incidence rates during the latter part of the study period. For males, from 2012 to 2019, the APC was -5.10% (95% CI: -6.62 to -3.54; $P<0.001$), while females experienced an even steeper decline with an APC of -7.69% (95% CI: -9.77 to -5.55; $P<0.001$). These findings reflect the impact of public health interventions over time, although the rising incidence in elderly men highlights the need for targeted strategies in this vulnerable population. Only APCs with $P<0.05$ were interpreted as statistically significant trends (Table 3).

ASR trends

Among males, the annual percentage change (APC) during the first period (2005–2012) was +1.28% (95% CI:

-1.64 to +4.30), which was not statistically significant ($P=0.354$). However, a significant downward trend was observed in the second period (2012–2019), with an APC of -6.37% (95% CI: -9.42 to -3.22; $P=0.001$), indicating a meaningful reduction in TB incidence among men in the latter years. In females, the APC for 2005–2012 was +1.84% (95% CI: -1.51 to +5.32), also not statistically significant ($P=0.252$). In contrast, the trend in 2012–2019 showed a sharp and statistically significant decline in ASR, with an APC of -9.34% (95% CI: -12.97 to -5.56; $P<0.001$), suggesting a more pronounced decrease in TB incidence among women during this period. Overall, when both sexes were combined, the ASR trend from 2005 to 2012 was not significant (APC=+1.56%, 95% CI: -1.12 to +4.33; $P=0.226$). However, from 2012 to 2019, a significant reduction was observed, with an APC of -7.91% (95% CI: -10.77 to -4.96; $P<0.001$) (Table 3). In summary, a statistically significant decline in TB incidence was evident in the second half of the study period (2012–2019) across both sexes, with a steeper

decline observed among females. Joinpoint analysis identified significant trend changes around the year 2012, after which both crude and age-standardized rates of TB incidence exhibited a marked decline in East Azerbaijan Province. Notably, the annual percentage decline was steeper among females (APC = -9.34%) compared to males (APC = -6.371%) during the 2012–2019 period, as depicted in Fig. 2. However, an increasing trend in TB incidence was observed in males aged 65 years and older, and to a lesser extent in younger females (aged 15–24), following initial declines (Figs. 3 and 4).

Short-term fluctuations in crude tuberculosis incidence rates, particularly within specific age- and sex-specific subgroups, should be interpreted with caution. These variations are largely driven by small population sizes and low case counts in certain subgroups, leading to statistical instability in year-to-year estimates. Moreover, tuberculosis surveillance data reflect notification rather than true biological incidence and are sensitive to changes in case detection and reporting practices. Accordingly, age-standardized trends and AAPC estimates were used as the primary measures to describe long-term patterns, as they are less influenced by random variation and better represent underlying temporal.

Discussion

Over the fifteen-year study period in East Azerbaijan, the overall incidence of tuberculosis showed a downward trend, which accelerated most notably after an inflection in 2012—an effect observed most strongly among women. However, this progress was not uniform; among men aged 65 and older, the declining trend stalled in recent years and even began to reverse, while young women aged 15 to 24 also exhibited early signs of a renewed increase after previous declines. These observations highlight emerging vulnerabilities in these specific groups that warrant heightened attention. Throughout the entire study, women consistently had higher rates of TB than men, both in crude and age-standardized analyses. This difference persisted after adjusting for age, suggesting that the higher burden among women cannot be explained by population structure alone but represents a real epidemiological pattern in this region. Taken together, these findings underscore the importance of sustained surveillance and targeted interventions to maintain hard-won gains and respond proactively to evolving risks in particularly affected groups. Gender differences in tuberculosis trends may partly reflect differences in access to healthcare and case detection between women and men in Iran, rather than true epidemiological differences [12].

Analysis of our data revealed a progressive increase in tuberculosis incidence with advancing age, reaching its highest values in those aged 65 years and older. This

age-dependent pattern has been documented across various geographic regions. Shen et al. [13]. (2023) demonstrated a similar trend in China, where the elderly were disproportionately affected by TB. Likewise, research from Europe and North America attributes heightened susceptibility among older adults to factors such as waning immune function and a higher burden of comorbid conditions [14, 15]. Nonetheless, the age distribution of TB is not uniform globally. For instance, studies from sub-Saharan Africa report the greatest incidence among younger, working-age populations, which is thought to reflect differences in HIV prevalence and distinct regional epidemiological drivers [16].

Our findings indicate a higher incidence of tuberculosis among women, which stands in contrast to the global pattern where men are typically more affected, as consistently highlighted by recent WHO reports and major epidemiological analyses [12, 17]. Globally, this male predominance has been attributed to a combination of behavioral and biological factors: men are more likely to engage in risk behaviors such as smoking, alcohol use, and employment in high-exposure environments, and may also have different patterns of healthcare-seeking and immune response compared to women. However, studies conducted in Iran and certain Eastern Mediterranean countries have suggested that these trends may diverge in specific regional or cultural contexts. For example, research by Bagheri Amiri et al. [18] described a narrowing or even reversal of the sex gap in TB incidence in parts of Iran, with women sometimes experiencing rates equal to or surpassing those of men. Such variations may be shaped by a combination of sociocultural determinants—including household exposure due to caregiving roles, differences in health service access, and sociopolitical barriers—as well as biological factors such as comorbidities and nutritional status. Additionally, differences in TB notification practices, diagnostic bias, and population demographics (such as higher life expectancy among women or migration patterns among men) may contribute to these disparities. Nonetheless, the majority of international studies continue to document a consistent male predominance in TB incidence, particularly in regions such as Africa and South-East Asia, where epidemiological and behavioral risk profiles strongly favor higher rates among males [19]. These findings underscore the need for region-specific TB control strategies that account for unique local determinants of risk.

The marked difference we observed between crude and age-standardized TB incidence rates in this study underscores how profoundly demographic structure can shape estimates of disease burden. As populations age or undergo demographic shifts, crude rates alone may mislead and mask underlying epidemiological patterns. Age-standardization thus remains indispensable for robust

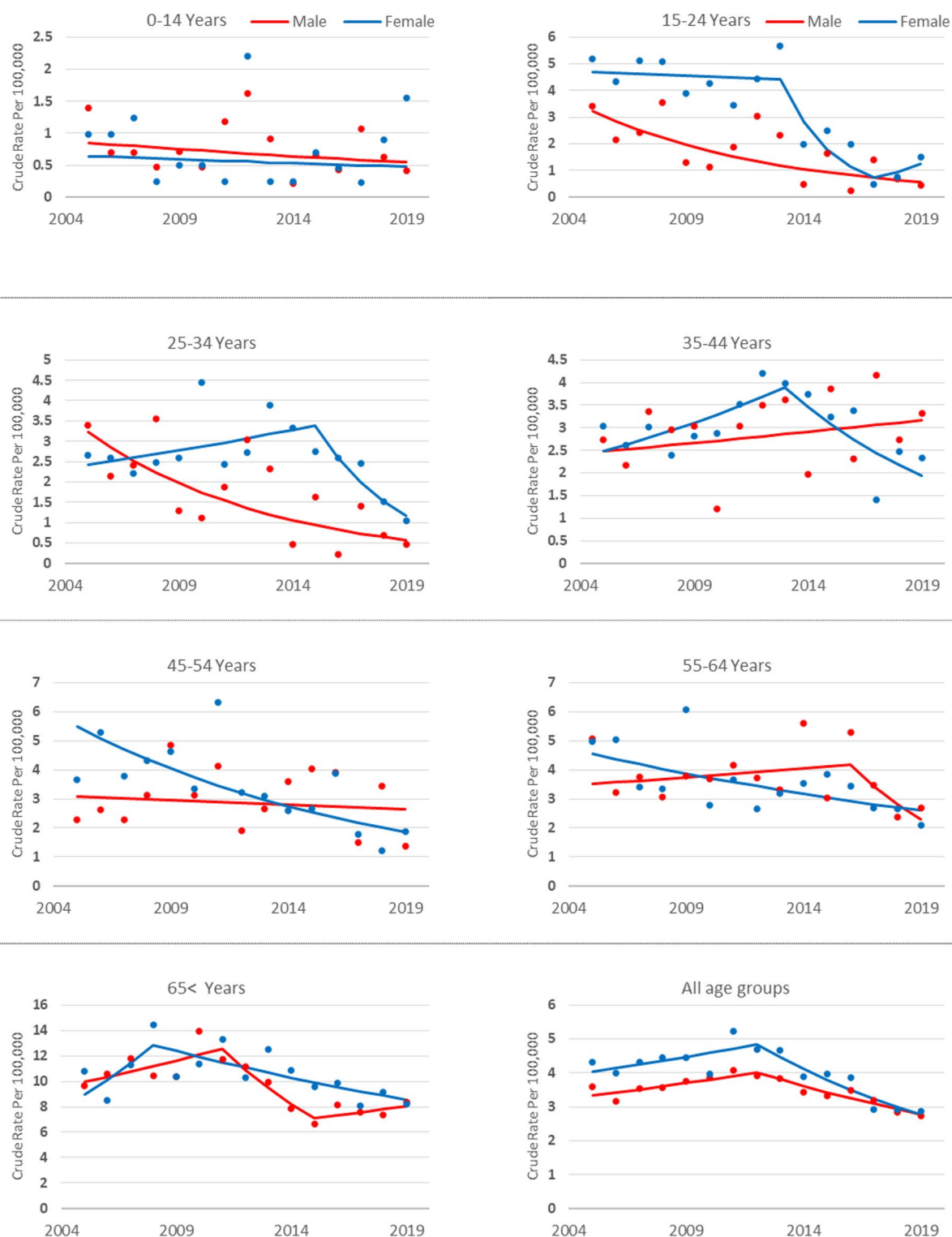


Fig. 3 Temporal Trends in Tuberculosis Incidence Rates in East Azerbaijan Province, Iran, 2005–2019. Crude and age-standardized incidence rates of tuberculosis by sex, based on Joinpoint regression analysis

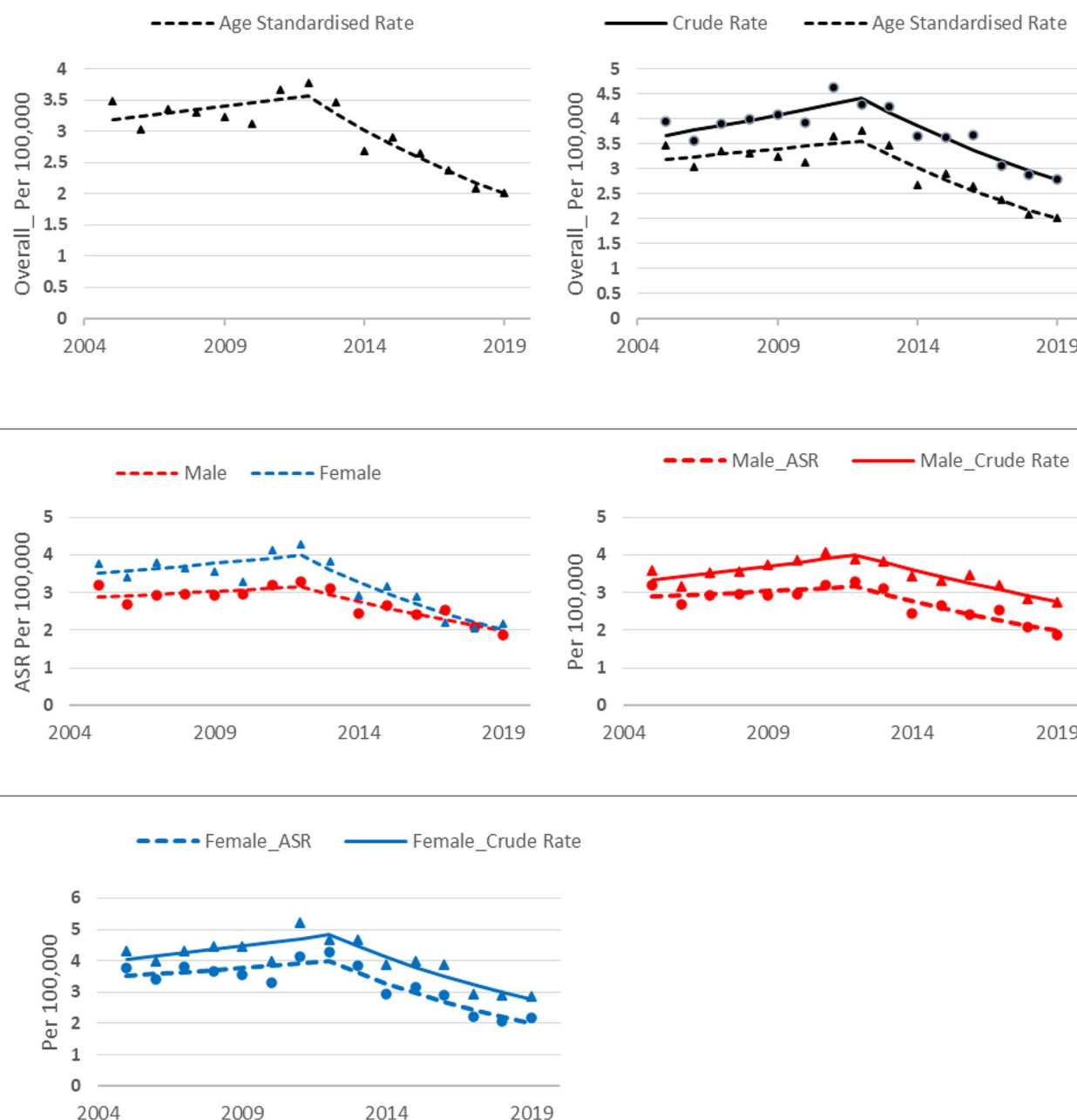


Fig. 4 Age- and Sex-Specific Trends in Tuberculosis Incidence Rates, East Azerbaijan Province, 2005–2019

comparisons over time or across different groups, a point frequently emphasized in the epidemiological literature [20]. Notably, our findings align closely with those of Gharehghanlou et al. [21] in Iran, who also demonstrated that crude rates tend to overstate TB incidence in older populations, whereas age-adjusted figures yield a more accurate and equitable picture both cross-sectionally and longitudinally.

Encouragingly, the overall decline in TB incidence observed in the later years of our study is consistent with broader progress reported from other parts of Iran and neighboring countries [22], likely reflecting the impact of

strengthened control programs, expanded case finding, and improved treatment coverage. Nonetheless, progress has not been universal. The COVID-19 pandemic has disrupted TB services in many regions, slowing or even reversing gains in some settings by diverting health resources and impeding access to care, as highlighted in recent global analyses [23]. These realities underscore the ongoing need for meticulous surveillance and sustained investment in TB control, to both safeguard the advances achieved and to respond flexibly to emerging threats.

From a public health standpoint, the patterns observed in this study carry clear implications for tuberculosis

control in East Azerbaijan Province. The consistently higher incidence among women, together with recent indications of increasing risk in older men, suggests that prevention efforts may need to be more finely targeted. Expanding active case finding among adults aged 65 years and older—particularly through routine evaluation in primary healthcare services—could help reduce diagnostic delays in this group. At the same time, health education and early detection initiatives tailored to women, especially younger age groups, may be important for addressing household exposure and obstacles to timely care. Linking TB screening with existing programs for chronic disease management in older adults, strengthening household contact tracing, and maintaining reliable access to diagnostic and treatment services are likely to play a key role in preserving recent progress and addressing emerging areas of vulnerability in the province.

Limitations

As with most observational studies relying on surveillance data, this study is subject to certain limitations. There is a potential for underreporting or misclassification of tuberculosis cases, particularly among individuals with limited access to healthcare services. Such limitations may have led to an underestimation of the true burden of tuberculosis; however, the overall trends and associations observed are unlikely to be substantially affected.

Conclusion

Our findings show a clear decline in tuberculosis incidence in northwest Iran over recent years, but the risk remains unequally distributed. The burden of disease is highest among older adults, and in our region, women appear to be more affected than men—a pattern that differs from many global reports. These results underline the need for targeted public health strategies that consider the unique demographic and social context of each region. Ongoing monitoring, investment in comprehensive data collection, and flexible approaches tailored to local trends will be key to sustaining progress in TB control, especially in the face of challenges such as population aging and disruptions brought about by events like the COVID-19 pandemic.

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Authors' contributions

L.H. and F.R. performed the data analysis and prepared the tables and figures. M.H. contributed to the study design and interpretation of results. F.R. and L.H. wrote the main manuscript text. All authors reviewed and approved the final version of the manuscript.

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Data availability

The datasets used and analyzed during the current study are not publicly available due to confidentiality agreements with the Iranian Ministry of Health and Medical Education but are available from the corresponding author on reasonable request.

Declarations

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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