# Incidence and treatment outcomes of pulmonary tuberculosis in Islamic Republic of Iran

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## Abstract

**Background:** Pulmonary tuberculosis is the most common type of tuberculosis and few studies have investigated the incidence and treatment outcome of smear-positive pulmonary tuberculosis in Golestan Province, Islamic Republic of Iran.

**Aims:** To estimate the cumulative incidence and trends in incidence of smear-positive pulmonary tuberculosis in Golestan Province between 2014 and 2019, and to determine the treatment outcomes.

**Methods:** All smear-positive pulmonary tuberculosis cases between 2014 and 2019 recorded in the tuberculosis registry in Golestan Province, Islamic Republic of Iran, were included in this study. The yearly incidence and cumulative incidence were calculated, and differences by sex and residence were examined. Treatment outcomes classified as success and failure were determined. The Mann–Kendall test was used to assess the significance of the trend in incidence.

**Results:** A total of 2047 smear-positive pulmonary tuberculosis cases were evaluated. The cumulative incidence was 18.52 [95% confidence intervals (CI): 17.72–19.33] per 100 000 population during 2014–2019. The incidence of smear-positive pulmonary tuberculosis declined from 23.84 (95% CI: 21.57–26.11) per 100 000 population in 2014 to 15.02 (95% CI: 13.29–16.75) in 2019. Incidence rate was higher among men and among rural residents. Most patients (85.34%) were cured, 2.05% completed their treatment, 1.17% were lost to follow-up, 4.40% had treatment failure, and 6.45% died.

**Conclusion:** The incidence of pulmonary tuberculosis in Golestan Province, Islamic Republic of Iran, declined during the period of study. However, the proportion of patients who were cured decreased and the proportion who died increased. Interventions are needed to improve the treatment success rate for pulmonary tuberculosis in the province.

Keywords: tuberculosis, pulmonary, incidence, treatment outcome, Iran.

## Introduction

Tuberculosis, caused by *Mycobacterium tuberculosis*, is one of the oldest infectious diseases of humankind *(1)*. It is estimated that tuberculosis infected 10 million individuals (132 per 100 000 population) and was responsible for about 1.4 million deaths worldwide in 2019 *(2)*. However, the incidence of tuberculosis decreased 2% annually between 2015 and 2019, 9% overall *(3)*. Tuberculosis has a specific regional pattern: in 2019, the World Health Organization's South-east Asian region had the highest percentage of the new tuberculosis cases (44%), followed by the African region (25%) and the Western Pacific region (18%) *(4)*. In Eastern Mediterranean region, in 2020, Pakistan accounted for 70% of tuberculosis cases, Afghanistan for 9%, Iraq for 1.3% and the Islamic Republic of Iran for 1.3% *(5)*.The incidence of the disease in the Islamic Republic of Iran was reported at 16 cases per 100 000 population in 2015, which decreased to 13 cases per 100 000 in 2019 *(3,6)*. Golestan Province in the north had the second highest

incidence of smear positive tuberculosis in the country after Sistan and Baluchestan Province in the south-east *(7)*, despite the long distance between the two provinces. Migration from Sistan and Baluchestan Province to Golestan Province after natural disasters in recent years and the easily available transportation between the two provinces may explain their similar rankings.

*M. tuberculosis* attacks different organs *(8)*, mostly the lungs. Pulmonary tuberculosis is bacteriologically confirmed in 84% of patients (smear-positive tuberculosis) in high-income countries, with lower rates in low-income countries. The remaining 16% pulmonary tuberculosis cases are confirmed clinically *(2,9)*. In the Islamic Republic of Iran, the incidence of smear-positive pulmonary tuberculosis was 6.25 per 100 000 population in 2015 which decreased to 5.46 per 100 000 population in 2018 *(7)*. Therefore, smear-positive pulmonary tuberculosis could be used as an epidemiological indicator of tuberculosis distribution, and it is useful to evaluate its incidence and the outcome of its treatment.

Tuberculosis is a complicated disease to treat and different indicators, such as proportion of cured patients, completed treatment, lost to follow-up and death, are used to show treatment outcomes (10). For example, the World Health Organization in its End TB strategy until 2020 set a target of a 35% reduction in deaths and 20% reduction in the incidence of tuberculosis for 2020 compared with 2015 (11).

In this study we aimed to estimate the cumulative incidence of and trends in smear-positive tuberculosis cases in Golestan Province between 2014 and 2019. We compared the incidence of smear-positive pulmonary tuberculosis by sex and residence, and determined the distribution of smear-positive pulmonary tuberculosis treatment outcomes.

## Methods

This was a cross-sectional study of notification data from Golestan Province between 2014 and 2019. Golestan Province is one of the 31 provinces of the Islamic Republic of Iran. It is located in the north-east of the country and had a population of 1.8 million in 2016. All smear-positive pulmonary tuberculosis patients (bacteriologically confirmed) whose data were recorded in the tuberculosis registration system at Golestan University of Medical Sciences and Health Services between 21 March 2014 and 20 March 2019 were included in the study. The tuberculosis registry collects detailed data on all tuberculosis patients, including on demographic and disease characteristics and treatment outcomes at the Golestan Province level. Data on age, sex, residence and smear-test results were extracted from register. More information on the tuberculosis register software are reported elsewhere (12). Data on total population of the province for each year of the study were obtained from the Golestan electronic health record system which has collected these data for the past 10 years. The records of eligible patients were reviewed from diagnosis to the treatment outcomes of interest or end of study. The treatment outcomes of interest were based on WHO definitions (10): cured and treatment completed were categorized as a successful treatment; treatment failure, lost to follow-up and died were categorized as unsuccessful treatment.

Smear-positive pulmonary tuberculosis diagnosis was based on WHO guideline (13) in the Islamic Republic of Iran. A smear-positive pulmonary tuberculosis patient was: someone who had had at least 2 positive acid-fast bacilli sputum smears; or someone who had only 1 positive acid-fast bacilli smear plus signs of pulmonary tuberculosis in X-ray; or someone with 1 positive acid-fast bacilli sputum smear and 1 positive acid-fast bacilli sputum culture (14).

### Statistical analysis

Demographic and clinical characteristics and treatment outcomes were reported using descriptive statistics. The cumulative incidence by sex and the residence (urban/rural) of the smear-positive pulmonary tuberculosis patients was calculated by the formula: number of cases/total population × 100 000. The relative risk to compare the incidence by sex and residence was calculated using formula: cumulative incidence in males/cumulative incidence in females, and cumulative incidence in rural patients/cumulative incidence in urban patients. The Mann–Kendall test was used to determine the incidence trend. R software version 4.0.2 was used for data analysis.

### Ethical considerations

All anonymized data were extracted from the tuberculosis register and Golestan electronic health record system with permission of the Ethical Committee of Golestan University of Medical Sciences (ethics code: IR.GOUMS.REC.1399.168).

## Results

A total of 2047 smear positive pulmonary tuberculosis cases were evaluated. The mean (standard deviation) age of the patients was 50.94 (20.19) years, 55.00% were male, 60.00% lived in rural areas and 36.20% had been diagnosed with three or more smear tests. The average cumulative incidence of smear-positive pulmonary tuberculosis was 18.52 [95% confidence interval (CI): 17.72–19.33] per 100 000 population for years 2014 to 2019. The trend in smear-positive pulmonary tuberculosis incidence decreased during the study period (Table 1, Figure 1).

The highest cumulative incidence of smear-positive pulmonary tuberculosis was among men living in the

**Table 1 Incidence of smear-positive pulmonary tuberculosis, Golestan, Islamic Republic of Iran, 2014–2019**

| Year | New cases, no. | Population, no. | Incidence, no. per 100 000 (95% CI) | P-value[a] | Annual percentage decrease |
|------|----------------|-----------------|-------------------------------------|------------|----------------------------|
| 2014 | 424 | 1 778 359 | 23.84 (21.57–26.11) | < 0.001 | NA |
| 2015 | 372 | 1 801 163 | 20.65 (18.55–22.75) | | 13.38 |
| 2016 | 363 | 1 821 774 | 19.93 (17.88–21.97) | | 3.49 |
| 2017 | 313 | 1 844 767 | 16.97 (15.09–18.85) | | 14.85 |
| 2018 | 286 | 1 879 911 | 15.21 (13.45–16.98) | | 10.37 |
| 2019 | 289 | 1 923 701 | 15.02 (13.29–16.75) | | 1.25 |
| Total | 2047 | 11 049 675 | 18.52 (17.72–19.33) | NA | NA |

CI: confidence intervals; NA: not applicable.
[a] Mann–Kendall test.

rural areas; the lowest incidence was among women living in the urban areas (Table 2). Our findings indicated that rural residence with cumulative incidence rate 1.78 (95% CI: 1.63–1.95) and male sex with cumulative incidence rate 1.22 (95% CI: 1.12–1.33) could be considered as risk factors for smear positive pulmonary tuberculosis incidence.

The trend in the incidence of smear-positive pulmonary tuberculosis was significantly higher in males than females and in rural areas than urban areas; Mann–Kendall $P < 0.01$ (Figure 2).

Of the 2047 cases of smear-positive pulmonary tuberculosis registered during 2014 to 2019, 87.39% had a successful treatment outcome (85.34% cured and 2.05% completed treatment) and 12.02% had an unsuccessful treatment outcome. The proportion with unsuccessful treatment increased in the last 3 years of the study period. The highest prevalence of death and loss to follow-up was seen in 2019 (Table 3). A significant difference in treatment outcomes by subgroup was seen between 2014 and 2019 ($P < 0.05$). We found that deaths increased considerably in 2018 and 2019 compared with the previous years.

## Discussion

The results of our study show that with the implementation of the end tuberculosis strategy, the incidence of smear-positive pulmonary tuberculosis in Golestan Province decreased from 2014 to 2019. However, it was still about 4 times higher than the national average level. The declining trend observed in our study is similar to other areas in the Islamic Republic of Iran [15,16], the Eastern Mediterranean [17], Oman [18] and other parts of the world [19]. However, contrary to the results of our study, a study in the Iranian province of Hamadan reported a notable increase in the incidence of tuberculosis during a 7-year period [20]. It seems some factors such as health system interventions, especially the implementation of the end tuberculosis strategy, improving economic situation, and increasing access to health services may be influencing the declining trend of tuberculosis in the world, including in the Islamic Republic of Iran and Golestan Province.

Our results show that the incidence of smear-positive pulmonary tuberculosis is higher in the rural areas, which concurs with the results of other studies [21–23]. The high incidence of tuberculosis in the rural population of Golestan Province compared with urban areas could be due to the economic situation, population density in rural families and the low literacy of residents in these areas.

The incidence of smear-positive pulmonary tuberculosis was higher among men than women in our study. Two other studies also showed a higher risk of pulmonary tuberculosis among men in northern Islamic Republic of Iran [23]. However, studies in Hamedan during 1995–2012 and in Golestan during 2005–2014 did not report a difference in the incidence of tuberculosis by sex [24]. Another study on tuberculosis patients in Golestan Province during the 2007–2016 showed that the standardized incidence rate of the disease was about 41.29 per 100 000 population and this rate was 41.22 and 41.40 per 100 000 for women and men, respectively, a non-significant difference [21]. The difference between our result and those of other studies may be because of the different periods of the studies, tuberculosis type, or differences between incidence and the standardized incidence rate.

The average 6-year incidence of tuberculosis was reported as 11.40 and 9.94 cases per 100 000 population among females and males, respectively, in Kerman Province during 2011–2016 [25]. The difference between these results and our findings may be due to the relationship between disease incidence and geographical location, and social or occupational behaviours. In other words, more social contact and more contact with the tuberculosis patients increases the risk of developing tuberculosis in both men and women.

Our results show that the average rate of treatment success was 87.39% in Golestan Province. This result is a little lower than the Iranian national goal (in the End TB strategy) for the treatment of smear-positive pulmonary tuberculosis patients as well as the 93% treatment success rate in Pakistan [26]. However, it is consistent with another study in two cities of Golestan Province during 2012–2013, which reported a treatment success rate of 85.63% [14]. Other studies in Kepong

Figure 1 **Cumulative incidence of smear-positive pulmonary tuberculosis, Golestan, Islamic Republic of Iran, 2014–2019**
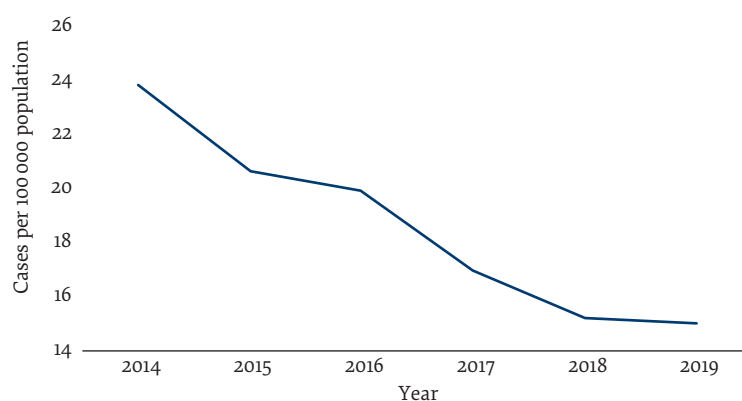
**Table 2 Incidence of smear positive pulmonary tuberculosis by sex and residence, Golestan, Islamic Republic of Iran, 2014–2019**

| Residence | Cumulative incidence, no. per 100 000 (95% confidence intervals) | | |
|---|---|---|---|
| | **Males** | **Females** | **Total** |
| Urban | 15.89 (14.49–17.31) | 11.43 (10.22–12.64) | 13.66 (12.73–14.59) |
| Rural | 25.74 (23.76–27.72) | 23.02 (21.14–24.90) | 24.39 (23.02–25.75) |
| Total | 20.34 (19.15–21.53) | 16.69 (15.62–17.78) | 18.52 (17.72–19.33) |

District, Kuala Lumpur (Malaysia) during 2014–2018 *(27)* and Afar, Eastern Ethiopia during 2011–2013 *(28)* reported treatment success rates of 77.20% and 81.8% respectively. The differences in treatment success rates could be due to differences: in implementation of directly observed treatment short course (DOTS); in structures of the health system; in socioeconomic status; or in disease distribution such as AIDS in Malaysia and Ethiopia compared with the Islamic Republic of Iran. The Islamic Republic of Iran implemented DOTS as its main strategy to manage tuberculosis treatment 20 years ago using trained healthcare workers or other designated individuals (excluding a family member) for service provision *(12)*. Based on this strategy and the stop tuberculosis and end tuberculosis strategies, healthcare workers provide patients with the tuberculosis treatment drugs, which they take under their direct supervision. Moreover, all laboratory tests and prescribed medicines are provided free for tuberculosis patients.

A study in Kota Bharu, Kelantan during 2006–2007 reported a 93% treatment success rate *(29)*, which is higher than our success rate. This difference could be due to the differences in the periods of the studies. In fact, the study in Kelantan was conducted when there was a higher incidence of tuberculosis worldwide and therefore the treatment success would appear higher. Another reason could be the detection system, as most patients in the Kelantan study were diagnosed with a low-grade smear, while in our study, 36.7% of patients were diagnosed with three positive acid-fast bacilli sputum smears.

On average, 12.02% of cases had an unsuccessful treatment outcome during the study period (2014–2019); the highest rate was due to death (6.45%) and the lowest was due to loss to follow-up (1.17%). Studies in Malaysia *(30)*, Republic of Korea *(31)* and in Hamadan Province *(32)* reported death as the most frequent outcome for unsuccessful treatment. However, studies in Morocco (2014–2016) *(33)* and Ethiopia (2008–2017) *(34)* reported that loss to follow-up was most frequent reason for unsuccessful treatment. Timely detection of tuberculosis cases, prevention of loss to follow-up, and reduction in the number of deaths could be the reason for the decline in unsuccessful treatments. Therefore, each community should adopt and implement strategies based on their

**Figure 2 Cumulative incidence of smear-positive pulmonary tuberculosis, by sex (panel A) and residence (panel B), Golestan, Islamic Republic of Iran, 2014–2019**
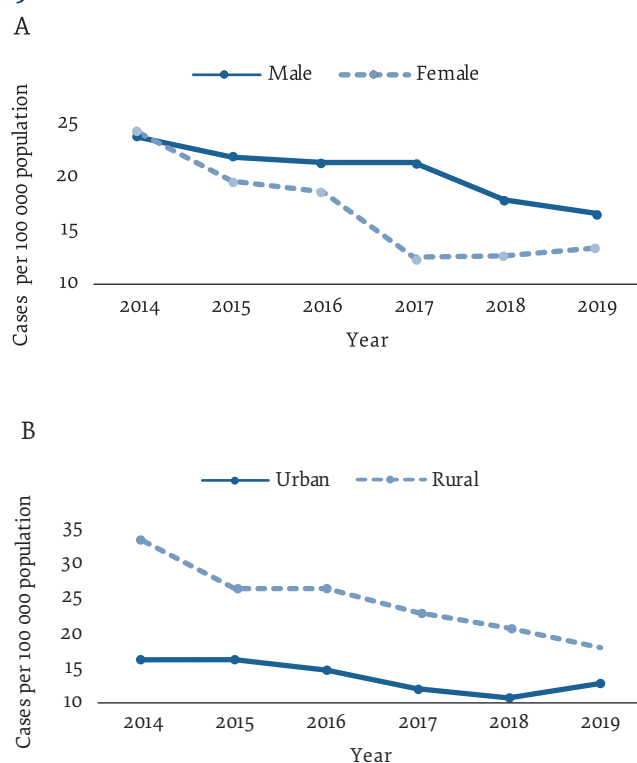
**Table 3 Treatment outcomes of registered smear-positive pulmonary tuberculosis cases, Golestan, Islamic Republic of Iran, 2014–2019**

| Year | Treatment successful | | | Treatment unsuccessful | | | | P-value[c] |
|------|---------------------|---|---|------------------------|---|---|---|---------|
| | Cured, no. (%) | Completed, no. (%) | Total, no. (%) | Lost to follow-up, no. (%) | Treatment failed, no. (%) | Died, no. (%) | Total, no. (%) | |
| 2014 | 368 (86.79) | 2 (0.47) | 370 (87.26) | 2 (0.47) | 25 (5.90) | 27 (6.37) | 54 (12.74) | 0.002 |
| 2015 | 326 (87.63) | 7 (1.88) | 333 (89.52) | 5 (1.34) | 19 (5.11) | 15 (4.03) | 39 (10.48) | |
| 2016 | 318 (87.60) | 7 (1.93) | 325 (89.53) | 5 (1.38) | 12 (3.31) | 21 (5.79) | 38 (10.47) | |
| 2017 | 276 (88.18) | 3 (0.96) | 279 (89.14) | 2 (0.64) | 13 (4.15) | 19 (6.07) | 34 (10.86) | |
| 2018 | 239 (83.57) | 9 (3.15) | 248 (86.71)[a] | 4 (1.40) | 13 (4.55) | 21 (7.34) | 38 (13.29) | |
| 2019[b] | 220 (76.12) | 14 (4.84) | 234 (80.97)[a] | 6 (2.08) | 8 (2.77) | 29 (10.03) | 43 (14.88) | |
| Total | 1747 (85.34) | 42 (2.05) | 1789 (87.39) | 24 (1.17) | 90 (4.40) | 132 (6.45) | 246 (12.02) | |

[a] Based on the completion date of the follow-up (1 February 2019). Patients in 2018 and 2019 had a shorter follow-up, which led to the lower treatment success rate these years.

[b] Twelve patients did not complete the treatment process and were excluded from this analysis.

[c] The chi-squared test was used to compare the frequency distribution of treatment outcomes (cured, completed, lost to follow-up, failed, died) in smear-positive pulmonary tuberculosis during 2014–2019.

demographic conditions, health system infrastructure and treatment protocols.

Our study had some limitations. We used available data for our analysis. However, we had data for many tuberculosis cases which could be reprehensive of the patients with tuberculosis disease in the population. Moreover, we could not include some potential confounders such as ethnicity in our study because data on these variables were not collected in the tuberculosis register.

## Conclusion

The incidence of pulmonary tuberculosis showed a declining trend from 2014 to 2019 in Golestan Province, Islamic Republic of Iran . At the same time, the proportion of patients who were cured fell and number of deaths increased. It seems the Iranian health system needs to implement appropriate multidimensional interventions. Such interventions should include strategies to improve the treatment success rate, for example: implementation of the end tuberculosis strategy by treatment support; better management of drug side-effects; stigma reduction; and improving the quality-of-life of patients (better access to treatment or healthy food, increased insurance coverage for comorbidities and better access to palliative cares). Efforts to educate the community to mitigate the stigma, improve control of the underlying diseases such as diabetes and provide social support should be considered. These interventions could help achieve the targets of the end tuberculosis strategy by the end of 2030.

## Incidence de la tuberculose pulmonaire et issue thérapeutique en République islamique d'Iran

### Résumé

**Contexte :** La tuberculose pulmonaire est le type de tuberculose le plus courant et peu d'études ont examiné l'incidence de la tuberculose pulmonaire à frottis positif et l'issue du traitement associé dans la province du Golestan, en République islamique d'Iran.

**Objectifs :** Évaluer l'incidence cumulée et l'évolution de l'incidence de la tuberculose pulmonaire à frottis positif dans la province du Golestan entre 2014 et 2019, et analyser les résultats du traitement.

**Méthodes :** Tous les cas de tuberculose pulmonaire à frottis positif inscrits au registre de la tuberculose de la province du Golestan (République islamique d'Iran) entre 2014 et 2019 ont été inclus dans cette étude. L'incidence annuelle et l'incidence cumulée ont été calculées et les différences selon le sexe et le lieu de résidence ont été

examinées. Les résultats du traitement, classés en fonction de leur réussite ou de leur échec, ont été déterminés. Le test de Mann-Kendall a été utilisé pour évaluer la significativité de l'évolution de l'incidence.

**Résultats :** Au total, 2047 cas de tuberculose pulmonaire à frottis positif ont été évalués. L'incidence cumulée était de 18,52 [intervalles de confiance (IC) à 95 % : 17,72-19,33] pour 100 000 personnes entre 2014 et 2019. L'incidence de la tuberculose pulmonaire à frottis positif a diminué, passant de 23,84 (IC à 95 % : 21,57-26,11) pour 100 000 en 2014 à 15,02 (IC à 95 % : 13,29-16,75) en 2019. Le taux d'incidence était plus élevé chez les hommes et parmi les habitants de zones rurales. La plupart des patients (85,34 %) ont été guéris, 2,05 % ont terminé leur traitement, 1,17 % ont été perdus au suivi, 4,40 % ont connu un échec thérapeutique et 6,45 % sont décédés.

**Conclusion :** L'incidence de la tuberculose pulmonaire dans la province du Golestan a diminué au cours de la période couverte par l'étude. Cependant, la proportion de patients guéris a diminué et celle des patients décédés a augmenté. Des interventions sont nécessaires pour augmenter le taux de réussite du traitement de la tuberculose pulmonaire dans la province.

## معدل الإصابة بالسل الرئوي ومخرجات علاجه في جمهورية إيران الإسلامية

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### الخلاصة

**الخلفية:** يُعد السُّل الرئوي أكثر أنواع السُّل شيوعًا، وقد استقصت دراساتٌ قليلةٌ معدل الإصابة بالسُّل الرئوي الإيجابي اللُّطَاخة ومخرجات علاجه في محافظة جلستان، جمهورية إيران الإسلامية.

**الأهداف:** هدفت هذه الدراسة الى تقدير المعدل التراكمي للإصابة بالسُّل الرئوي الإيجابي اللُّطَاخة والاتجاهات السائدة في معدل الإصابة به في محافظة جلستان في المدة بين عامَي 2014 و2019، وتحديد مخرجات علاجه.

**طرق البحث:** أُدرجت في هذه الدراسة جميع حالات الإصابة بالسُّل الرئوي الإيجابي اللُّطَاخة في الفترة بين عامي 2014 و2019 التي قُيدت في سجل السُّل في محافظة جلستان، جمهورية إيران الإسلامية. وحُسب معدل الإصابة السنوي ومعدل الإصابة التراكمي، ودُرست الاختلافات حسب نوع الجنس ومحل الإقامة. وحُددت مخرجات العلاج المُصنفة على أنها حالات نجاح أو فشل. واستُخدم اختبار مان–كيندال لتقييم أهمية الاتجاه السائد في معدلات الإصابة.

**النتائج:** قُيِّمت 2047 حالة إصابة بالسُّل الرئوي الإيجابي اللُّطَاخة. وبلغ معدل الإصابة التراكمي 18.52 [فاصل الثقة 95٪: 17.72–19.33] لكل 100000 نسمة خلال المدة بين عامَي 2014–2019. وانخفض معدل السُّل الرئوي الإيجابي اللُّطَاخة من 23.84 (فاصل الثقة 95٪: 21.57–26.11) لكل 100000 نسمة في عام 2014 إلى 15.02 (فاصل الثقة 95٪: 13.29–16.75) في عام 2019. وكان معدل الإصابة أعلى بين الرِّجال وبين سكان الريف. وشُفي معظم المرضى (85.34٪)، واستكمل 2.05٪ علاجهم، وانقطع 1.17٪ عن المتابعة، وفشل علاج 4.40٪، وتُوفي 6.45٪.

**الاستنتاجات:** انخفض معدل الإصابة بالسل الرئوي في محافظة جلستان، جمهورية إيران الإسلامية أثناء الفترة التي غطتها الدراسة. ومع ذلك، انخفضت نسبة المرضى الذين شُفوا، وارتفعت نسبة الذين تُوفوا، وهناك حاجة إلى تنفيذ تدخلات لتحسين معدل نجاح علاج السُّل الرئوي في المحافظة.

## References

1. Zaman K. Tuberculosis: a global health problem. J Health Popul Nutr. 2010;28(2):111–3. https://doi.org/10.3329/jhpn.v28i2.4879

2. Global tuberculosis report 2020: executive summary. Geneva: World Health Organization; 2020 (https://apps.who.int/iris/handle/10665/337538, accessed 17 December 2022).

3. Global tuberculosis report 2019. Geneva: World Health Organization; 2019 (https://apps.who.int/iris/handle/10665/329368, accessed 17 December 2022).

4. Tuberculosis [Internet]. Geneva: World Health Organization; 2022 (https://www.who.int/news-room/fact-sheets/detail/tuberculosis, accessed 17 December 2022).

5. TB country, regional and global profiles [Internet}. Geneva: World Health Organization; 2022 (https://www.who.int/teams/global-tuberculosis-programme/data, accessed 17 December 2022).

6. Global tuberculosis report 2015. Geneva: World Health Organization; 2015 (https://apps.who.int/iris/handle/10665/191102, accessed 17 December 2022).

7. Kiani B, Rahmati AR, Bergquist R, Hashtarkhani S, Firouraghi N, Bagheri N, et al. Spatio-temporal epidemiology of the tuberculosis incidence rate in Iran 2008 to 2018. BMC Public Health. 2021;21(1):1093. https://doi.org/10.1186/s12889-021-11157-1

8.  Adigun R, Singh R. Tuberculosis [Internet]. Treasure Island, FL: StatPearls Publishing LLC; 2022 (https://www.ncbi.nlm.nih.gov/books/NBK441916/, accessed 5 January 2022).

9.  Heshmati H, Ravanbakhsh K, Khajavi S, Behnampour N. Epidemiologic study of tuberculosis in Galikesh city during 2006–2011. Iran J Med Microbiol. 2015;9(1):61–5.

10. Meeting report of the WHO expert consultation on drug-resistant tuberculosis treatment outcome definitions, 17–19 November 2020. Geneva: World Health Organization; 2021 (https://apps.who.int/iris/handle/10665/340284, accessed 17 December 2022).

11. Global tuberculosis report 2021. Geneva: World Health Organization; 2021 (https://apps.who.int/iris/handle/10665/346387, accessed 17 December 2022).

12. Zadeh JH, Nasehi M, Rezaianzadeh A, Tabatabaee H, Rajaeifard A, Ghaderi E. Pattern of reported tuberculosis cases in Iran 2009–2010. Iran J Public Health. 2013;42(1):72.

13. Treatment of tuberculosis: guidelines, fourth edition. Geneva: World Health Organization; 2010 (https://apps.who.int/iris/handle/10665/44165, accessed 17 December 2022).

14. Mohammadzadeh K, Gayoomi A, Maghsoudloo D. Evaluation of factors associated with failure of tuberculosis treatment under DOTS in northern Islamic Republic of Iran. East Mediterr Health J. 2016;22(2):87–94. 10.26719/2016.22.2.87

15. Arsang JS, Mansourian M, Amani F, Jafari KT. Epidemiologic trend of smear-positive, smear-negative, extra pulmonary and relapse of tuberculosis in Iran (2001–2015); a repeated cross-sectional study. 2017. J Res Health Sci. 2017;17(2):e00380

16. Khazaei S, Soheilyzad M, Molaeipoor L, Khazaei Z, Rezaeian S, Khazaei S. Trend of smear-positive pulmonary tuberculosis in Iran during 1995–2012: a segmented regression model. Int J Prev Med. 2016;7:86. https://doi.org/10.4103/2008-7802.184317

17. MacNeil A, Glaziou P, Sismanidis C, Maloney S, Floyd K. Global epidemiology of tuberculosis and progress toward achieving global targets—2017. Morb Mortal Wkly Rep. 2019;68(11):263. https://doi.org/10.15585/mmwr.mm6811a3

18. Is global TB elimination still a feasible goal by 2035? And can Oman stand the test as a pathfinder for TB elimination? [Internet]. Brookline, MA: nternational Society for Infectious Diseases; 2021 (https://isid.org/world-tb-day-2021/, accessed 17 December 2022)

19. Kazemnejad A, Arsang Jang S, Amani F, Omidi A. Global epidemic trend of tuberculosis during 1990–2010: using segmented regression model. J Res Health Sci. 2014;14(2):115–21.

20. Khazaei S, Roshanaei G, Saatchi M, Rezaeian S, Zahiri A, Bathaei SJ. The epidemiological aspects of tuberculosis in Hamadan Province during 2005–11. Int J Health Policy Manag. 2014;2(2):75–80. https://doi.org/10.15171/ijhpm.2014.18

21. Yazdani-Charati J, Sheykholeslami AS, Kamalinia H, Sheikhi M, Rahimi E, Gorgan I. Epidemiologic study of pulmonary tuberculosis in Golestan Province, Iran 2007–2016. J Mazandaran Univ Med Sci. 2018;28(165):119–28.

22. Sathiyamoorthy R, Kalaivani M, Aggarwal P, Gupta SK. Prevalence of pulmonary tuberculosis in India: a systematic review and meta-analysis. Lung India. 2020;37(1):45–52. https://doi.org/10.4103/lungindia.lungindia_181_19

23. Babamahmoodi F, Alikhani A, Yazdani Charati J, Ghovvati A, Ahangarkani F, Delavarian L, et al. Clinical epidemiology and paraclinical findings in tuberculosis patients in north of Iran. Biomed Res Int. 2015;2015:381572. https://doi.org/10.1155/2015/381572

24. Honarvar MR, Charkazi A, Mirkarimi K, Sheikhi M, Kamalinia HR, Arbabi ER. Eleven year epidemiological study of tuberculosis in Golestan Province, Northern of Iran. Iran J Public Health. 2020;49(3):563–69. https://doi.org/10.18502/ijph.v49i3.3154

25. Behzadinejad R, Rezaeian M, Khalili P, Vazirinejad R. Study of spatial pattern of tuberculosis by geographical information system in Kerman Province, 2011–2016: an ecological study. J Rafsanjan Univ Med Sci. 2020;19(2):193–212. https://doi.org/10.29252/jrums.19.2.193

26. Global tuberculosis report 2016. Geneva: World Health Organization; 2016 (https://apps.who.int/iris/handle/10665/250441, accessed 17 December 2022).

27. Arsad FS, Ismail NH. Unsuccessful treatment outcome and associated factors among smear-positive pulmonary tuberculosis patients in Kepong district, Kuala Lumpur, Malaysia. J Health Res. 2021;36(3):484–93. https://doi.org/10.1108/JHR-10-2020-0478

28. Zenebe T, Tefera E. Tuberculosis treatment outcome and associated factors among smear-positive pulmonary tuberculosis patients in Afar, Eastern Ethiopia: a retrospective study. Braz J Infect Dis. 2016;20(6):635–6. https://doi.org/10.1016/j.bjid.2016.07.012

29. Nik Nor Ronaidi NM, Mohd N, Sharina D, Nik Rosmawati NH. Factors associated with unsuccessful treatment outcome of pulmonary tuberculosis in Kota Bharu, Kelantan. Malays J Public Health Med. 2011;11(1):6–15.

30. Atif M, Sulaiman SAS, Shafie AA, Ali I, Asif M. Treatment outcome of new smear positive pulmonary tuberculosis patients in Penang, Malaysia. BMC Infect Dis. 2014;14(1):1–8. https://doi.org/10.1186/1471-2334-14-399

31. Mok J, An D, Kim S, Lee M, Kim C, Son H. Treatment outcomes and factors affecting treatment outcomes of new patients with tuberculosis in Busan, South Korea: a retrospective study of a citywide registry, 2014–2015. BMC Infect Dis. 2018;18(1):1–9. https://doi.org/10.1186/s12879-018-3574-y

32. Khazaei S, Hassanzadeh J, Rezaian S, Ghaderi E, Khazaei S, Hafshejani AM, et al. Treatment outcome of new smear positive pulmonary tuberculosis patients in Hamadan, Iran: a registry-based cross-sectional study. Egypt J Chest Dis Tuberc. 2016;65(4):825–830. https://doi.org/10.1016/j.ejcdt.2016.05.007

33. El Hamdouni M, Bourkadi JE, Benamor J, Hassar M, Cherrah Y, Ahid S. Treatment outcomes of drug resistant tuberculosis patients in Morocco: multi-centric prospective study. BMC Infect Dis. 2019;19(1):1–7. https://doi.org/10.1186/s12879-019-3931-5

34.  Ejeta E, Beyene G, Balay G, Bonsa Z, Abebe G. Factors associated with unsuccessful treatment outcome in tuberculosis patients among refugees and their surrounding communities in Gambella Regional State, Ethiopia. PLoS One. 2018;13(10):e0205468. https://doi.org/10.1371/journal.pone.0205468