The Environmental and Socioeconomic Effects and Forecast of Tuberculosis Patients in the Southwest of China: a population-based study

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Research Article

Keywords: TB infection, population, socioeconomic, environment, forecast

Posted Date: July 6th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1736046/v1

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Abstract

Background  To assess the incidence of tuberculosis in the population and find the risk factors and forecast of tuberculosis patients with a high burden of tuberculosis (TB) in socioeconomic level.

Methods  Descriptive analysis, Spatial and Space-Time Scan, Correlation analysis and regression analysis were carried out, based on cases of TB in Sichuan Province and ecological data from 2006 to 2017, to explore the characters of TB and ecological factors, using transfer function noise model to forecast the trend of TB until 2035(by SPSS 20.0, SatScan v9.5, ArcGis 10.2 software).

Results 783,735 tuberculosis cases were reported in Sichuan Province, during 2006 to 2017. Linshui County was the aggregation center, the aggregation radius was 237.17 Km, and the aggregation time was from 2006 to 2011. Factors affecting the incidence of TB, increasing per capita green area, reporting status of TB among Tibetans and Yi minorities, comprehensive treatment management, total cost of tuberculosis per capita for urban residents, proportion of males with high school education, 20 to 20 hours of 24-hour accumulated precipitation, reducing HIV at the same time as AIDS deaths, the increase in the proportion of males in junior high school education and the increase in the number of registered tuberculosis cases can reduce the incidence of TB. The incidence of TB in the whole population aged 15-24 and aged 25-64 owning a increase trend by 2035.

Conclusion  Enhanced control of the environment, education, medical and health, population structure, marital status could control incidence of TB. Reinforcement required to reduce the TB of east Sichuan Counties and the incidence of TB in the whole population aged 15-24 and aged 25-64 in socioeconomic level by 2035.

Background

Global and national TB burden

At present, more than 95% of TB patients in the world come from developing countries. The fifth epidemiological sampling survey of tuberculosis in China in 2011 showed that the annual incidence of tuberculosis in China was about 1.3 million, accounting for 14.3% of the global new cases, as one of the countries with high TB burden,r anking second in the world. World Health Organization(WHO)'s contribution to global tuberculosis morbidity and mortality \cite{1, 2} fully considering the impact of ecological data, indicating that the broader TB epidemic is affected by poverty, Human Immunodeficiency Virus(HIV) infection, malnutrition and smoking. The World Bank's global TB prediction takes into account social and environmental factors, including children with low birth weight, and education is required to reach a medium education level, literacy. In achieving the Sustainable Development Goals related to these and other determinants, most countries with a high burden of TB are facing huge challenges in terms of drug-resistance to TB, TB detection rates, TB treatment success rates, HIV The success rate of antiviral treatment for infected persons and patients.
Previous studies on individual and ecological level variables

Rose G proposed two risk factors: individual level variables and ecological level groups increase disease risk groups, and different groups of people are exposed or exposed to different risks \[^3\].

Individual level variables of TB are multiple, including age, gender, education, occupation, marital status, smoking, drinking, income, medical insurance, a history of TB exposure, personal nutritional status, a history of TB, Acquired Immune Deficiency Syndrome (AIDS), diabetes. The researches on individual factors mainly obtained related risk factors through questionnaire surveys \[^4, 5\].

Myers WP et al. Analyzing the status of TB infection among children aged 0–14 from 1993 to 2002, it was found that the incidence of TB among poor and ethnic minority children affected the California area, and the per capita living area and population density had nothing to do with the incidence of TB in children \[^6\]. Sun W believed that economic factors, population density and health services are related to TB in 2007. However, some scholars found that every thousand beds, the number of doctors per thousand, and the economic level were the influencing factors from 2002 to 2011 \[^8\]. Furthermore, Wubuli A also found that the influencing factors of TB were the ratio of ethnic minorities to per capita Gross Domestic Product (GDP) from 2006 to 2014 \[^9\].

Most of the researches on outdoor air pollution and TB are mainly carried out in cities, however, the research of TB, affected by industrialization and urbanization, prone to occur in heavily polluted areas \[^10, 11\] needs to be done in both rural and urban areas.

The significance of current study

The fifth TB epidemiological survey in Sichuan Province showed that Sichuan Province is still a high-burden province of TB in China, with active TB (448,000 cases), smear-positive TB (77,900 cases), and bacterial-positive TB (101,900 cases). Sichuan is in the southwest of China, with more poorer areas than east China. Meanwhile, the prevalence of TB rates in Sichuan Province of China, were significantly higher than the average level in China, accounting for 8.98%, 10.82%, and 7.90% in China, respectively, thus, the detection rate of multi-drug-resistant tuberculosis in Sichuan Province was 4.2%.

The development and changes of TB epidemic are related to social, economic, and various non-biological factors in addition to biological factors such as TB resistance and HIV infection \[^2, 12\]. The geographical features of the mountains and basins in Sichuan Province have restricted the diffusion of pollutants.

Additionally, different countries and regions have different findings on the relationship between the above-mentioned social, economic, environmental factors and TB. This study carried out an exploratory study of multiple factors in Sichuan with a various of geographical diversity and a higher TB burden province of a 3rd TB burden country \[^48, 49\]. There is a huge need to search for the characteristics, the clustering features, complex multiple ecological factors related to TB and to forecast the trend by 2035 in
socioeconomic level, to provide evidence for the prevention and control measurement in Sichuan of China.

**Methods**

**Definition**

The definition of reported TB cases are a total number of smear-positive TB, culture-positive TB, bacteriological positive TB, and others, including tuberculous pleurisy, other extra-pulmonary TB, smear positive patients, smear negative patients, patients without sputum examination, while in type I to type V TB. TB incidence is calculated by new cases and divided by population every year.


**Data Source**

The information about HIV/AIDS and TB new reports came from the "TB information management system" of the "communicable disease information network direct reporting system" from the Sichuan CDC.

The population of Sichuan Province during 2006 to 2017 are enrolled from the age group population of the "epidemic information network direct reporting system" from the Sichuan CDC. All population data are permanent residents, specific to the county administrative divisions, and include population data of age and gender.

Ecological data and other materials, including five aspects: other diseases and health resources, economy and social security, pollutants and afforestation forestry and meteorology, population structure and marriage and habits, educational investment and education level, according to the link resources made public by the Internet (http://tjj.sc.gov.cn).

**Statistical Analysis**

According to the characteristics of the TB epidemic in Sichuan, descriptive analysis and a hierarchical Bayesian spatio-temporal analysis were used, with the transfer function noise model to forecast the
trend.

**By descriptive analysis, Spatial and Space-Time Scan**

Correlation analysis and regression analysis, forecast model analysis were carried out based cases of TB in Sichuan Province and ecological data from 2006 to 2017.

In view of descriptive analysis to explore the characters of TB and ecological factors; spatio-temporal scanning statistics to show the clustering areas of TB; single factor analysis (Pearson) and multivariate analysis (linear regression analysis, Poisson regression, negative binomial regression, generalized linear model) to evaluate relevant factors of TB; sing transfer function noise models to predict the trends of TB until 2035, using SPSS 20.0 software, SatScan v9.5 software, ArcGis 10.2 software. The difference was statistically significant (P<0.05).

Through Durbin-watson (DW) test to test the autocorrelation of residuals, the test statistics are:

\[
DW = \frac{\sum_{t=2}^{n} (e_t - e_{t-1})^2}{\sum_{t=2}^{n} e_t^2} \approx 2(1 - \rho)
\]

Durbin-watson 2 indicates no autocorrelation; 4 indicates complete negative autocorrelation; 0 indicates complete positive autocorrelation; Durbin-watson shows positive autocorrelation between 0 and 2. Durbin-watson shows a negative autocorrelation between 2 and 4. The value of durbin-watson is between 1.5 and 2.5, indicating that there has no autocorrelation.

The noise model of transfer function is the organic combination of time series analysis and regression analysis in theory, so it includes the lag distribution model of metrology:

\[
y_{t-r} = \sum_{j=1}^{k} \frac{\Omega_j (B^{-r}) B^{-j}}{E_j (B)} X_{t-j} + \frac{\theta_j (B^{-r})}{\phi_j (B)} a_r
\]

**Results**

**Epidemiological Character and spatio-temporal scan**

During 2006 to 2017, 783,735 TB cases of new report were enrolled in Sichuan, with an average annual reported incidence rate of 80.14 per 100,000. Compared with 2006, the 12-year incidence rate dropped by an average of 3.00% in 2017. Figure 1 revealed that, within this 12 years, the incidence decreased
significantly (trend $\chi^2 = 17991.7$, $P < 0.001$), except for the peaks of 83687 in 2008, 81232 in 2006, and 52147 in 2017, other years showed a downward trend.

Simultaneously, top TB incidence rates (1/100,000) in 5 cities of 21 cities (prefectures) in whole Sichuan Province from 2006 to 2017: Ganzi Tibetan Autonomous Prefecture, Aba Tibetan and Qiang Autonomous Prefecture, Guangyuan City, Liangshan Yi Autonomous Prefecture, Dazhou City, see Fig. 2.

In addition, the spatio-temporal scanning statistics revealed that the new report cases of TB in Sichuan Province displayed spatio-temporal clustering ($P < 0.001$), and 5 high-risk clustering areas were scanned. Linshui County was the aggregation center, while the aggregation radius was 237.17 Km, moreover, the aggregation time was from 2006 to 2011, see Fig. 3.

### Univariate Analysis

During 2006 to 2017, Table S1-S5 revealed that there was a correlation between a variety of ecological factors (related diseases and health resources, economic and social security, environmental and personal factors, physical exercise, Bacillus Calmette Guerin (BCG) vaccination and other factors) and TB incidence rate ($P < 0.05$).

### Multivariate Analysis

#### Linear regression

Linear regression displayed the incidence rate of forest fires (hectares), single-resistance rate (%), male junior high school education (%), second-hand smoke exposure rate of non-smokers (%), and cure rate (%) are possible risk factors for the incidence of TB, see Table 1. In addition, the regression model has the multi-collinearity, and the Durbin-Watson values are 0.211, 0.232, and 0.216, respectively.
<table>
<thead>
<tr>
<th>Model classification</th>
<th>sub option</th>
<th>B</th>
<th>t</th>
<th>P</th>
<th>95% confidence intervals</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(constant)</td>
<td>93.4</td>
<td>15944622.537</td>
<td>&lt; 0.001</td>
<td>93.400 93.400</td>
</tr>
<tr>
<td>(Dependent variable: incidence rate in the whole population)</td>
<td>Park green area per capita (square meters)</td>
<td>-3.922</td>
<td>-3972550.519</td>
<td>&lt; 0.001</td>
<td>-3.922 -3.922</td>
</tr>
<tr>
<td>Durbin-Watson: 0.211</td>
<td>HIV/AIDS deaths (cases)</td>
<td>0.001</td>
<td>467275.626</td>
<td>&lt; 0.001</td>
<td>0.001 0.001</td>
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<td></td>
<td>Male junior high school education (%)</td>
<td>0.34</td>
<td>1675682.533</td>
<td>&lt; 0.001</td>
<td>0.340 0.340</td>
</tr>
<tr>
<td></td>
<td>Proportion of ethnic Tibetans in cases (%)</td>
<td>-1.058</td>
<td>-6865129.386</td>
<td>&lt; 0.001</td>
<td>-1.058 -1.058</td>
</tr>
<tr>
<td></td>
<td>Total number of registered cases (cases)</td>
<td>0.001</td>
<td>3358164.669</td>
<td>&lt; 0.001</td>
<td>0.001 0.001</td>
</tr>
<tr>
<td></td>
<td>Proportion of ethnic Yi people in cases (%)</td>
<td>-0.937</td>
<td>-1047194.388</td>
<td>&lt; 0.001</td>
<td>-0.937 -0.937</td>
</tr>
<tr>
<td></td>
<td>Enrollment number (secondary school and above)</td>
<td>-3.25E-06</td>
<td>-1742290.959</td>
<td>&lt; 0.001</td>
<td>0.000 0.000</td>
</tr>
<tr>
<td></td>
<td>Proportion of treatment management method full-process management (%)</td>
<td>-0.218</td>
<td>-482599.821</td>
<td>&lt; 0.001</td>
<td>-0.218 -0.218</td>
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<tr>
<td></td>
<td>Total expenditure of urban residents per capita (yuan)</td>
<td>-2.74E-05</td>
<td>-121480.614</td>
<td>&lt; 0.001</td>
<td>0.000 0.000</td>
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<tr>
<td></td>
<td>Male with high school education (%)</td>
<td>-0.003</td>
<td>-8404.267</td>
<td>&lt; 0.001</td>
<td>-0.003 -0.003</td>
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<tr>
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<td>t</td>
<td>P</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
</tr>
<tr>
<td></td>
<td>Cumulative precipitation at 24 hours(20:00–20:00)</td>
<td>-6.14E-06</td>
<td>-67.131</td>
<td>&lt; 0.001</td>
<td>0.000</td>
</tr>
<tr>
<td>Model 2:</td>
<td>(constant)</td>
<td>306.989</td>
<td>36485998.512</td>
<td>&lt; 0.001</td>
<td>306.989</td>
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<tr>
<td></td>
<td>Rural subsistence allowance (ten thousand yuan)</td>
<td>-3.40E-05</td>
<td>-1808357.628</td>
<td>&lt; 0.001</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Proportion of patients in custody (%)</td>
<td>-5.082</td>
<td>-8990191.054</td>
<td>&lt; 0.001</td>
<td>-5.082</td>
</tr>
<tr>
<td></td>
<td>Average relative humidity</td>
<td>-2.375</td>
<td>-6179930.721</td>
<td>&lt; 0.001</td>
<td>-2.375</td>
</tr>
<tr>
<td></td>
<td>Other proportions of case registration classification (%)</td>
<td>7.947</td>
<td>4173174.519</td>
<td>&lt; 0.001</td>
<td>7.947</td>
</tr>
<tr>
<td></td>
<td>Number of beds in medical and health institutions per thousand population</td>
<td>-3.865</td>
<td>-1505179.715</td>
<td>&lt; 0.001</td>
<td>-3.865</td>
</tr>
<tr>
<td></td>
<td>Occupation is the proportion of workers (%)</td>
<td>-1.62</td>
<td>-2420998.589</td>
<td>&lt; 0.001</td>
<td>-1.620</td>
</tr>
<tr>
<td></td>
<td>The actual treatment management method, the whole-process management ratio (%)</td>
<td>-0.274</td>
<td>-700779.321</td>
<td>&lt; 0.001</td>
<td>-0.274</td>
</tr>
<tr>
<td></td>
<td>High school education %)</td>
<td>-0.169</td>
<td>-316600.362</td>
<td>&lt; 0.001</td>
<td>-0.169</td>
</tr>
<tr>
<td></td>
<td>Proportion with spouse (%)</td>
<td>-0.114</td>
<td>-662147.114</td>
<td>&lt; 0.001</td>
<td>-0.114</td>
</tr>
<tr>
<td></td>
<td>Proportion of systemic management of tuberculosis (%)</td>
<td>0</td>
<td>-8710.331</td>
<td>&lt; 0.001</td>
<td>0.000</td>
</tr>
</tbody>
</table>
The results of multi-factor analysis showed that the factors affecting the incidence of TB in the Sichuan population were different from the male/female population (P < 0.05) (Table 1).

## Trend Of Tb Incidence
The transfer function noise showed that the trends of incidence of TB in the whole population aged 0–14, 15–24, 25–64, and 65-year-old in 2035 will be -2.16/100,000, 95.00/100,000, and 6.5916/100,000, -33.00/100,000, respectively (Figs. 4).

In 2035, the incidence of TB in the population aged 0–14, the population aged 15–24, and the population aged 25–64 could not be reduced to 0, and the incidence of TB in the population aged 65- could be reduced to zero in 2035. The incidence of TB in the whole population aged 15–24 and aged 25–64 has an increasing trend (Fig. 4).

**Discussion**

We found that the area of green space in parks, ethnic minorities (Tibetan and Yi nationality), treatment management coverage, urban residents’ expenditures, males (%), high school education, and cumulative precipitation at 24 hours (20:00–20:00) all could reduce the incidence of TB in Sichuan; AIDS The increase in the number of deaths from the HIV/AIDS, the proportion of men with junior high school education, and the total number of registered cases may increase the risk of TB incidence. This is inconsistent with the results of the female/male multivariate analysis of TB. In 2017, the WHO found that the incidence of malnutrition mainly depends on clean fuels, per capita GDP, income inequality, and the proportion of urban population living in slums is related to the incidence of TB [1].

The higher the economic level, the more urban employment opportunities, the higher the income, the better the nutritional conditions, the more medical resources, the better the availability and allocation of medical services, and the lower the incidence of TB. The national epidemiological sample survey found that the prevalence of TB in the western region was significantly higher than that in the eastern region (with better economic benefits) [11].

In our study, the spatio-temporal scanning statistics showed that the registered cases of TB in Sichuan Province displayed spatio-temporal clustering (P < 0.001), and 5 high-risk clustering areas were scanned. Linshui County was the aggregation center, which located in the east of Sichuan Province, having lower GDP and per capita income, this areas the aggregation radius was 237.17 Km, and the aggregation time was from 2006 to 2011, maybe rapid economic development in this poverty areas after 2011, 14% increase of Linshui County in GDP in 2012, the control measures of TB in this areas were be strengthened, so the aggregation center changed after 2012. Thus, this areas still should strengthen tuberculosis control and economic development, and carry out early detection and standardized treatment of tuberculosis, considering the weak economic and a high incidence of tuberculosis in the past.

Lonnroth K [13] suggested that the research focus of India, Brazil and other countries should also be included in the future transnational TB control, such as various direct and potential social impact factors of TB. While Liao CM [14] found that the average incidence of TB in eastern Taiwan is relatively high. Ethnic minorities live in impoverished areas with the highest rate of TB recurrence (8.17%). Moreover, Li
Ting et al.\textsuperscript{[15]} found that 56 cases of active pulmonary TB patients found that poor initial treatment promoted the increase of pulmonary TB. Thus, Janssens et al.\textsuperscript{[16]} used the methods of WHO and the World Bank to analyze the relationship between per capita GDP and TB incidence in India, China, and the United Kingdom, and there was a negative correlation between the two.

Therefore, they put forward the argument that TB prevention and control should eliminate poverty. Our study, the funding for public health and the contaminants paid no effect, considering lag effect and the bias of primary data, collecting from medical institutions of whole province, which having detecting ability to register new TB, some agency could not detect or diagnosis this disease, leading to losing some cases, so we need further research and big samplings.

In 2010, TB prevention and control had 1,377 employees and 63.5 million employees. In 2003 and 2013, it had 133 million and 132 million employees respectively. In 2017, there was no Global Fund, there were 1095 employees, and the budget was only 49.32 million. The government's TB prevention and treatment fund has provided certain support and strategic significance for the epidemic control of TB\textsuperscript{[19–21]}. Why more payments to TB, the more cases? Considering that there may be a lag effect, the time limit of the lag needs to be further studied. It may also be that the increase in TB prevention and control funds has improved the ability of TB detection and diagnosis and reporting, and increased the number of reported cases of TB. In addition, there is also a certain shortage of the proportion of TB control funds allocated to different regions, while it is possible to consider that there may be key nodes in the prevention and control of tuberculosis prevention and control funds unreasonable, which need further economical evaluation.

Age and sex also have a great influence on TB cases\textsuperscript{[17–25]}. The higher the level of male junior high school education, the more cases of TB will be reported. The possible reason is that TB closely related to the body's immunity, is affected by various bad habits. Personal health knowledge and good hygiene habits are important to ensure the body's immunity\textsuperscript{[19,26–28]} and to control diseases. The higher the education level, the lower the reported incidence of TB\textsuperscript{[29–35]}. It found in this study, why a certain educational level could cut down the incidence of TB, not the highest education level that need further cohort study.

Thus, Yang JD pointed out that the higher the population density, the higher the incidence of TB\textsuperscript{[36]}. According to Tanrikulu AC, in Turkey, the incidence of TB in high-density cities (> 80 people/km\textsuperscript{2}) is 4.18 times that of low-density cities. And Sun and Mangtani found that severe TB outbreaks occurred in areas with low economic levels and low population densities\textsuperscript{[7,37]}.

The prevalence of TB among students is high, and the number of people in the living room is positively correlated with the epidemic of TB\textsuperscript{[38,39,40]}, including crowds gathering in public places (schools, prisons and medical institutions) to live, study and work, and public transportation\textsuperscript{[41,42]}, causing Mycobacterium tuberculosis infection, and we found that more green areas and humidity, fewer cases of TB, considering to increase more green areas which maybe changed the TB new cases. Forests can improve the micro-environment and air humidity, reduce dust, and possibly reduce the presence of TB.
droplet nuclei, thereby reducing the incidence of TB. Therefore, the humidification of the active area should be strengthened to prevent long-term activities in a dry and closed environment. While Valenca MS et al. \[41\] found that the epidemic of TB in prisons was serious, 69 times that of normal people. In addition, due to the small population density, the transmission of infectious diseases has been weakened to a certain extent \[20\]. Zhou WJ found that the Secreted Frizzled-related Protein 1 (SFRP1) gene may be a susceptibility gene for TB. It is suggested that the gene polymorphsim Recombinant Human Catenin beta-1 (CTNNB1) in Tibetan and Han populations have different genetic backgrounds \[43\].

Furthermore, Zou Bo suggested reducing contact with TB patients, strengthening prevention, improving the quality of life, changing bad living habits and lack of exercise, and playing an active role in preventing and controlling the occurrence of TB. Previous studies have found that proper physical exercise can enhance physical fitness \[1, 6, 21\] and reduce infections. Physical exercise can improve immunity and is a protective factor for the onset of TB. Different marital status may affect the incidence of TB. Divorced and unmarried women have a low incidence of TB. Marriage is not a protective factor for TB \[22–26, 44\]. Male workers have a wider range of social activities, contacting infected people, and then marrying infected women.

The rate of smoking and drinking among men is higher than that of women, which makes men more likely to be infected with Mycobacterium tuberculosis or progress to active TB \[27\]. Exposure to secondhand smoke is an independent risk factor for the disease \[45\]. However, our study did not found secondhand smoke is an independent risk factor, even smoking.

Additionally, Li XX's research found that in China, the number of hospital beds, number of doctors, and economic level per thousand people are negatively correlated with the epidemic of TB. Primary care institutions and infectious disease hospitals can help reduce the incidence of TB \[8\]. Since 2003, the incidence of TB among native Hawaiians/other Pacific islands, American-born Indians/Alaska natives has remained high. At the same time, among Latin Americans, non-Latin Americans, Asians, whites and blacks, if they do not receive treatment, TB screening and treatment are suitable for permanent residents who come to the United States \[6\].

As the number of TB cases decreases, the number of HIV/AIDS deaths will also decrease because there will be a large number of dual infections that affect the immune system. In 2016, WHO reported that 57% of TB patients had recorded HIV test results, up from 55% in 2015. The treatment success rate for AIDS-related TB is 78% (2015 cohort) and 30% (2014 cohort). At the same time, Bassili A et al. \[38\] believed that the unreasonable allocation of health resources leading to delays in the diagnosis and treatment of TB patients is also an important reason for the spread of TB in many developing countries.

Moreover, infectious disease hospitals in Sichuan are limited and do not rely on the deployment of 21 cities (prefectures). Chengdu infectious disease hospitals, infectious disease prevention and control are difficult to increase significantly. At the same time as health technicians, the strategy to curb tuberculosis will be in 2030 \[46\]. The lack of the infectious disease hospitals and accessibility, caused the TB cases
could not be screening from the normal population, then this disease spreads and delays actual
treatment. It must also be aware about the impact that smoking and diabetes pandemics may be not
having on the incidence of TB, which was not the same as other findings[^47]. In addition, the existence of
a fit TB Prevention and Control Measurement is essential to fight against TB[^47]. According to the
epidemiological situation, each country, each province and each city, each county should define their own
real needs[^48,^49], even though a difficulty. Local TB control measurement would have to adapt to any new
challenge that generated in order to respond to the needs of their own population, even if it may have a
certain various and different from other areas or different gender groups.

Due to limitations in data sources from new cases reported annually and some cases maybe not be
enrolled for some reasons. However, every year, there are investigations on under-reporting of infectious
diseases and training on the quality of infectious disease reports, attach importance to the work of re-
diagnosis and initial diagnosis of tuberculosis, to improve TB reporting sensitivity and specificity and
carry out screening of key populations to reduce under-reporting of tuberculosis, while still a report bias
existing. Because of the incidence of TB affected by comprehensive factors, while some factors do not
show a causal relationship, and further prospective study and RCT research are needed, with large scale
samples.

The poverty, the education, the society structure, the family or marriage, the minorities, the forests,
accumulated precipitation, the average relative humidity, average relative humidity, the social help all play
a important role to decrease TB, to focus on reducing the TB of east Sichuan Counties and the incidence of
TB in the whole population aged 15–24 and aged 25–64 by 2035 in the socioeconomic level of
Southwest China.

**Limitations**

This study is limited to reported TB cases in the Southwest of China; therefore, the factors we identified
may not be fully and perfectly generalized to all settings. There were a certain limitations in primary data
bias for just reported new cases and some cases maybe not be enrolled for some reasons. Because of
the incidence of TB affected by comprehensive factors, while some factors do not show a causal
relationship, and further prospective study is needed.

**Conclusion**

In summary, to increase greening efforts, ethnic minority screening, tuberculosis treatment management,
urban residents’ income, the proportion of male high school education, precipitation, junior high school
male education ratio, to reduce HIV/AIDS mortality, which help to control the incidence of TB in
socioeconomic level, while by 2035, aged 15–24 and aged 25–64 need to focus on decreasing the rising
trend in the southwest of China.

**Abbreviations**
Declarations

Acknowledgments

We appreciated Prof. Jianwei Zhao and Prof. Chuang Chen for study design and written, and Prof. Shujuan Yang, Prof. Fangfang Zeng, Dr. Sui Zhu for revising the manuscript.

Author's Contributions

Rongsheng Luan and Wen Wei designed the study, provided research resources; Wen Wei and Lan Xia coordinated the study and directed its implementation, retrieved the publications, analyzed the data and wrote the materials and methods, Jianlin Wu wrote results; Wenqiang Zhang and Zonglei Zhou checked all data, wrote the discussion. We were responsible for data synthesis. All authors have read and approved the manuscript.

Funding

Not applicable.

Disclaimer

Not applicable.

Competing interests
The authors all declare that they have no competing interests.

Consent for Publication

Not applicable.

Competing interests

All authors certify that there are no potential competing interest to declare.

Ethics Approval and Consent to Participate

The collection of case information required by the Law on the Prevention and Control of Infectious Diseases involves all cases and is Numbered by the Ethics Committee of Sichuan CDC(SCCDCIRB2022001).

Availability of data and materials

All data used in analysis of this manuscript is freely available by contacting the corresponding author. Data are available in a public, open access, available on reasonable request.

References


**Figures**

![Graph showing TB incidence rate in Sichuan province of China from 2006-2017.]

**FIGURE 1** | TB incidence rate in Sichuan province of China from 2006-2017.

Figure 1

See image above for figure legend
Figure 2  The incidence of TB in Sichuan province of China during 2006-2017 (1/10,000).
(The basic map from the open resource: http://scsm.mnr.gov.cn/nbzdt.htm)

Figure 2

See image above for figure legend
Figure 3  Spatio-temporal scanning analysis of TB in Sichuan Province of China during 2006-2017

(The basic map from the open resource: http://scsm.mnr.gov.cn/nbzdt.htm)

Figure 3

See image above for figure legend
Figure 4 The transfer function noise model predicts the trend of age-specific incidence rates (Total/Male/Female 0-14; 15-24; 25-64; 65+).

See image above for figure legend.

Supplementary Files

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