ORIGINAL RESEARCH

Drug Resistance Patterns and Trends in Patients with Suspected Drug-Resistant Tuberculosis in Dalian, China: A Retrospective Study

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Purpose: The emergence of drug-resistant tuberculosis (DR-TB) represents a threat to the control of tuberculosis. This study aimed to estimate the patterns and trends of DR-TB in patients with suspected DR-TB. In addition, risk factors for multidrug-resistant tuberculosis (MDR-TB) were identified among suspected DR-TB patients in Dalian, China.

Patients and Methods: A total of 5661 patients with suspected DR-TB from Jan 1, 2013 to Dec 31, 2020 were included in the final analysis. The resistance pattern of all resistant strains was determined by drug susceptibility testing (DST) using the conventional Lowenstein-Jensen Proportion Method (LJ). DR-TB trends were estimated from 2013 to 2020. During the research period, the chi-square test was employed to analyze the significance of linear drug-resistance trends across time. Bivariate and multivariate logistic regression were performed to assess factors associated with MDR-TB.

Results: From 2013 to 2020, the resistance rates of rifampicin (RFP) and isoniazid (INH) decreased significantly, whereas the resistance rates of ethambutol (EMB) and streptomycin (SM) increased in patients with suspected DR-TB. From 2013 to 2020, the prevalence of DR-TB decreased in all patients from 34.71% to 28.01% with an average annual decrease of 3.02%. Among new cases, from 2013 to 2020, the prevalence of DR-TB (from 26.67% to 24.75%), RFP-resistant TB (RR-TB) (from 15.09% to 3.00%) and MDR-TB (from 6.08% to 2.62%) showed a significant downward trend. Among patients with a previous treatment history, DR-TB (from 54.70% to 37.50%), RR-TB (from 44.16% to 11.49%) and MDR-TB (from 26.90% to 10.34%) showed a significant downward trend from 2013 to 2020. Males (AOR 1.28, 95% CI 1.035–1.585), patients 45 to 64 years of age (AOR 1.75, 95% CI 1.342–2.284), patients 65 years and older (AOR 1.65, 95% CI 1.293–2.104), rural residents (AOR 1.24, 95% CI 1.014–1.519) and a previous treatment history (AOR 3.94, 95% CI 3.275–4.741) were risk factors for MDR-TB.

Conclusion: The prevalence of DR-TB, RR-TB and MDR-TB was significantly reduced from 2013 to 2020. Considerable progress has been made in the prevention and treatment of DR-TB during this period. However, the increasing rate of drug resistance in EMB and SM should be taken seriously. Suspected DR-TB patients who are male, older than 45 years of age, live in rural areas, and have a history of TB treatment should be given priority by health care providers.

Keywords: *Mycobacterium tuberculosis*, DR-TB, RR-/MDR-TB, prevalence, associated factors

Introduction

Tuberculosis (TB) is a communicable disease caused by *Mycobacterium tuberculosis* (MTB) and is one of the leading causes of death from a single infectious agent worldwide, ranking above HIV/AIDS.[1] Drug-resistant tuberculosis (DR-TB) remains a public health concern worldwide.[2,3] According to the Global Tuberculosis Report 2021, it is estimated that approximately 9 million people developed TB and that 1.5 million died from TB in 2020.[4] The emergence of DR-TB, specifically multidrug-resistant TB (MDR-TB), which is defined as TB resistant to at least isoniazid (INH) and rifampicin (RFP), and extensively drug-resistant TB (XDR-TB), which is defined MDR-TB with additional resistance to any fluoroquinolone and at least one of the three second-line injectable drugs, is a threat to the control of this disease.[5] It is

estimated that there were greater than 500,000 patients with RFP-resistant TB (RR-TB) globally in 2019, 78% of whom were MDR-TB patients.[6] Ofloxacin has a higher resistance rate than moxifloxacin in MDR-TB.[7]

China is one of the countries with the heaviest DR-TB burden.[8,9] In 2019, an estimated 833,000 new cases of TB were diagnosed in China.[6] Among them, MDR/RR-TB accounted for 7.1% of new cases and 21% of previous cases.[10] Despite progress in TB control, China still faces a serious epidemic of DR-TB.[11] MDR-TB is generally caused by incorrect or inadequate treatment by doctors or by patients not taking their medication consistently or not completing the entire course of treatment.[12] Many studies now demonstrate that primary DR-TB is more likely to be caused by person-to-person transmission.[13] In addition, gene mutations may also lead to the emergence of DR-TB.[14] Patients with DR-TB often experience catastrophic medical expenditures. As a result of these high costs, patients often discontinue treatment; thus, the disease worsens.

Dalian is located in Northeast China, covers an area of 12,574 square kilometers, and has a registered population of 6.95 million people. There is a high prevalence of TB in Dalian.[15] The incidence of TB in the region is 52/100,000, which is well above the global average.[16] However, the Directly Observed Treatment and Short Course (DOTS) strategy and the Global Fund for MDR-TB Prevention and Treatment project have been implemented in this region since 2012.[15] Many patients with suspected DR-TB are diagnosed in Dalian every year, and these patients can easily develop MDR-TB or even XDR-TB.

Understanding the patterns and trends of DR-TB in suspected DR-TB patients is essential for the prevention and treatment of DR-TB. However, to our knowledge, no study has focused on the patterns and trends of DR-TB in suspected DR-TB patients in Dalian, China. Therefore, the purpose of this study was to determine the patterns and trends of DR-TB in suspected DR-TB patients. In addition, to determine the risk of MDR-TB, we explored the association between demographic characteristics and MDR-TB among suspected DR-TB patients in Dalian, northeast China.

Patients and Methods
Study Population and Data Collection
This study was performed at a public health institution in Dalian, China. Sociodemographic data and drug susceptibility data were extracted periodically from the China Disease Control and Prevention Information System from a public health institution. Patients with suspected DR-TB include those who have received previous TB treatment, relapse cases, loss to follow-up and treatment failures, or TB patients infected with DR-TB strains. In the current study, a total of 9521 suspected DR-TB patients were considered for inclusion from Jan 1, 2013 to Dec 30, 2020. All patients were diagnosed by sputum smear examination and sputum culture. Based on the results of the p-nitrobenzoic acid (PNB) culture method, nontuberculous mycobacteria (NTM) were excluded. Moreover, negative sputum smears and sputum cultures were excluded. In addition, patients without drug susceptibility testing (DST) results and contaminated samples were excluded from the study. Finally, 5661 eligible patients were included in this study. The details of the inclusion or exclusion criteria for patients are shown in Figure 1.

Drug Susceptibility Test
Sputum samples were collected from suspected DR-TB patients with labeled plastic bottles in this study before the initiation of TB therapy.[17] Samples were sent to the national reference laboratory of Tuberculosis Prevention and Control Center for DST. Sputum samples were cultured on Lowenstein-Jensen (LJ) culture media.[18] DST was conducted for first-line anti-TB drugs (FLDs), including INH, RFP, ethambutol (EMB) and streptomycin (SM). The following concentrations of anti-TB drugs were administered according to the proportion method: 0.2 µg/mL for INH, 40 µg/mL for RIF, 2 µg/mL for EMB, and 4 µg/mL for SM.[19] Resistance to a specific drug was determined if the growth rate was greater than 1% compared to the control.[20,21]

Definitions
- New cases refer to a patient who has never been treated for TB or has taken TB treatment for less than one month.[22]
- Previously treated cases referred to patients who had received one month or more of TB treatment in the past.[22]
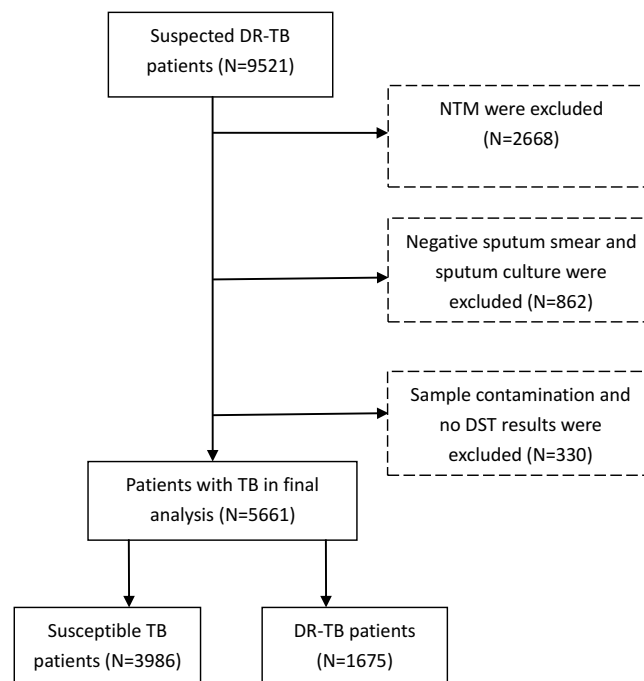
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┌─────────────────────┐
│ Suspected DR-TB     │
│ patients (N=9521)   │
└─────────────────────┘
           │          ┌─────────────────────────┐
           │─────────→│ NTM were excluded       │
           │          │ (N=2668)                │
           │          └─────────────────────────┘
           │          ┌─────────────────────────┐
           │          │ Negative sputum smear and│
           │─────────→│ sputum culture were     │
           │          │ excluded (N=862)        │
           │          └─────────────────────────┘
           │          ┌─────────────────────────┐
           │          │ Sample contamination and│
           │─────────→│ no DST results were     │
           │          │ excluded (N=330)        │
           ↓          └─────────────────────────┘
┌─────────────────────┐
│ Patients with TB in │
│ final analysis      │
│ (N=5661)            │
└─────────────────────┘
     │            │
     ↓            ↓
┌──────────┐  ┌──────────┐
│Susceptible│  │DR-TB     │
│TB patients│  │patients  │
│(N=3986)   │  │(N=1675)  │
└──────────┘  └──────────┘
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Figure 1 Flowchart for the inclusion of suspected DR-TB patients.
Abbreviations: DR-TB, drug-resistant tuberculosis; NTM, nontuberculous mycobacteria; DST, drug susceptibility testing.

- Mono-resistant TB (MR-TB) is defined as resistance to one FLDs only.[22]
- Polydrug-resistant TB (PDR-TB) is defined as resistance to more than one FLDs (other than both INH and RFP).[22]
- RR-TB is defined as resistance to RFP with or without resistance to other anti-TB drugs.[22]

Statistical Analysis

All data were entered into the database established by MS Excel 2010 (Microsoft Corporation, Redmond, WA, USA), and DR-TB trends were plotted. We estimated the drug resistance trends of different patterns of drug resistance types between new and previously treated patients. The chi-square test for trends was used to determine the changes and temporal trend in the different resistance patterns over time. To identify the link between a collection of independent variables and dependent variables, multivariate logistic regression was performed on all variables with p values < 0.2 in univariate logistic regression. Two-sided P<0.05 was considered statistically significant. Statistical analyses were performed using the SPSS 22.0 statistical package (IBM Corporation, Armonk, NY, USA).

Ethical Considerations

This study received ethical approval from the Ethics Committee of Dalian Medical University and Tuberculosis Specialist Hospital. Permission to use the data were obtained from the hospital administration. Patient consent for this retrospective study was waived because all data were from the China Information System for Disease Prevention and Control. All data were deidentified and analyzed. The research methods used in this article are in full compliance with the Helsinki Declaration.

Results

Patient Characteristics

In this retrospective study, a total of 5661 patients were eligible for inclusion and were enrolled between Jan 1, 2013 and Dec 31, 2020. Of the 5661 patients, the median age was 54 years (IQR 41–65), and approximately three-quarters were men (76.79%). A total of 3986 (70.41%) were drug-susceptible patients, and 1675 (29.59%) were DR-TB patients who were resistant to at least one anti-TB drug. The majority of patients were 45–64 years old (62.37%). Among drug-

susceptible and DR-TB patients, the number and proportion of patients with a previous treatment history were 905 (22.70%) and 704 (42.03%), respectively. The basic sociodemographic characteristics of suspected DR-TB patients are shown in Table 1.

Drug Resistance Patterns

In this retrospective study, the DST results of all 5661 suspected DR-TB patients were analyzed. Of these, the prevalence of DR-TB was 29.59%. Among 4052 new cases, the highest proportion of any resistance to four FLDs was observed in INH 504 (12.44%) followed by RFP 372 (9.18%), SM 357 (8.81%), and EMB 74 (1.83%). Among 1609 previously treated cases, the highest proportion of any resistance to four FLDs was observed in INH 464 (28.84%) followed by RFP 440 (27.35%), SM 203 (12.62%), and EMB 95 (5.90%).

Of the patients with MR-TB, the number and proportion of MR-TB to FLDs, including INH, RFP, EMB, and SM, were 159 (3.92%), 74 (1.83%), 8 (0.20%), and 191 (4.71%) among new cases and 103 (6.40%), 78 (4.85%), 6 (0.37%), and 47 (2.92%) among previously treated cases, respectively. The number and proportions of MDR-TB among new and previously treated cases were 251 (6.19%) and 394 (24.49%), respectively (Table 2).

Annual Drug Resistance Trends

From 2013 to 2020, the prevalence of DR-TB decreased in all patients with suspected DR-TB from 34.71% to 28.01% with an average annual decrease of 3.02% and a significant downward trend ($\chi2 = 44.916$, P<0.001). Among new cases, DR-TB decreased from 26.67% to 24.75% from 2013 to 2020 with an average annual decrease of 1.06% and a significant downward trend ($\chi2 = 12.242$, P<0.001). Among previously treated cases, DR-TB decreased from 54.70% to 37.50% from 2013 to 2020 with an average annual decrease of 5.25% and a significant downward trend ($\chi2 = 33.147$, P<0.001) (Figure 2).

Table 1 Sociodemographic Characteristics of Suspected DR-TB Patients

Characteristics	Total, N (%)	Susceptible TB, N (%)	DR-TB, N (%)
Gender			
Male	4347 (76.79)	3071 (77.04)	1276 (76.18)
Female	1314 (23.21)	915 (22.96)	399 (23.82)
Age (years)			
<45	573 (10.12)	436 (10.94)	137 (8.18)
45–64	3531 (62.37)	2395 (60.09)	1136 (67.82)
>64	1557 (27.50)	1155 (28.98)	402 (24.00)
Patient residence			
Urban	3783 (66.83)	2587 (64.90)	1196 (71.40)
Rural	1878 (33.17)	1399 (35.10)	479 (28.60)
Patient category			
New cases	4052 (71.58)	3081 (77.30)	971 (57.97)
Previously treated cases	1609(28.42)	905(22.70)	704(42.03)
Occupation			
Employed	420 (7.42)	288 (7.23)	132 (7.88)
Unemployed	5241 (92.58)	3698 (92.77)	1543 (92.12)
Nationality			
Han	5590 (98.75)	3930 (98.57)	1660 (99.10)
Others	71 (1.25)	56 (1.40)	15 (0.90)
Migrant			
No	5210 (92.03)	3649 (91.55)	1561 (93.19)
Yes	451 (7.97)	337 (8.45)	114 (6.81)

Note: Migrant refers to people who leave their domicile for various reasons and go to other provinces and cities with registered tuberculosis patients.
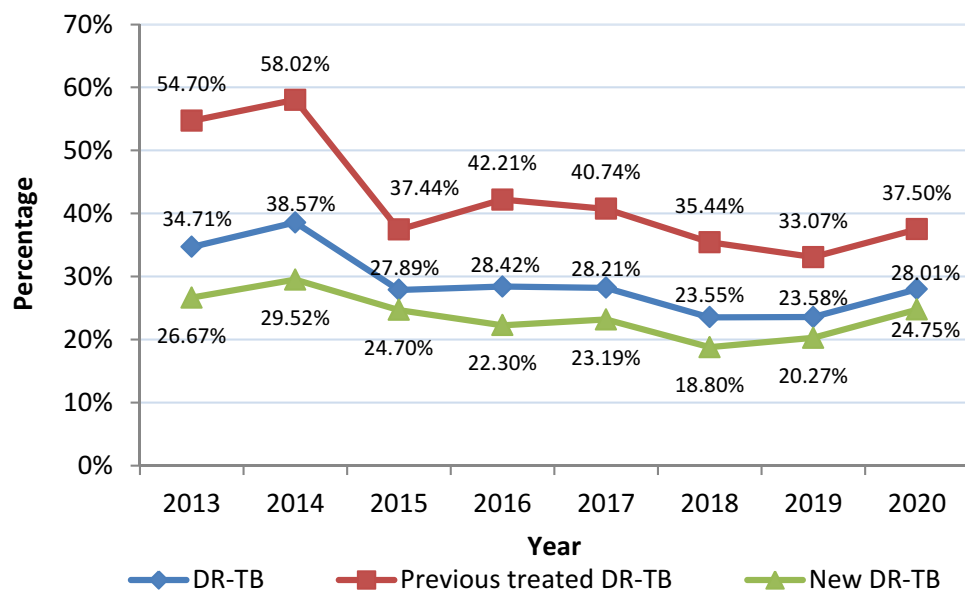**Abbreviations**: N, number; TB, tuberculosis; DR-TB, drug-resistant tuberculosis.

Table 2 Drug Resistance Patterns in New and Previously Treated Patients with Suspected DR-TB

Drug Resistance Pattern	New Cases, N (%)	Previously Treated Cases, N (%)	Total, N (%)
DR-TB	971 (23.96)	704 (43.75)	1675 (29.59)
Any INH	504 (12.44)	464 (28.84)	968 (17.10)
Any RFP	372 (9.18)	440 (27.35)	812 (14.34)
Any EMB	74 (1.83)	95 (5.90)	169 (2.99)
Any SM	357 (8.81)	203 (12.62)	560 (9.89)
MR-TB			
INH	159 (3.92)	103 (6.40)	262 (4.63)
RFP	74 (1.83)	78 (4.85)	152 (2.69)
EMB	8 (0.20)	6 (0.37)	14 (0.25)
SM	191 (4.71)	47 (2.92)	238 (4.20)
PDR-TB			
RFP+EMB	61 (1.51)	85 (5.28)	146 (2.58)
RFP+SM	96 (2.37)	118 (7.33)	214 (3.78)
INH+SM	136 (3.36)	125 (7.77)	261 (4.61)
INH+EMB	53 (1.31)	72 (4.47)	125 (2.21)
RFP+EMB+SM	25 (0.62)	48 (2.98)	73 (1.29)
INH+EMB+SM	19 (0.47)	40 (2.49)	59 (1.04)
MDR-TB	251 (6.19)	394 (24.49)	645 (11.39)
INH+RFP	149 (3.68)	274 (17.03)	423 (7.47)
INH+RFP+EMB	30 (0.74)	29 (1.80)	59 (1.04)
INH+RFP+SM	53 (1.31)	51 (3.17)	104 (1.84)
INH+RFP+EMB+SM	19 (0.47)	40 (2.49)	59 (1.04)

Abbreviations: N, number; DR-TB, drug-resistant tuberculosis; INH, isoniazid; RFP, rifampicin; SM, streptomycin; EMB, ethambutol; MR-TB, mono-resistant tuberculosis; PDR-TB, polydrug resistant tuberculosis; MDR-TB, multidrug-resistant tuberculosis.

First-Line Drug Resistance Rates Among New and Previously Treated Patients with Suspected DR-TB, 2013 to 2020

Among new cases with suspected DR-TB, the resistance rate of INH decreased significantly from 17.11% in 2013 to 11.84% in 2020 ($\chi 2$ = 20.388, P<0.001). The resistance rate of RFP decreased significantly from 16.00% in 2013 to

Figure 2 Trends in new and previously treated DR-TB among patients with suspected DR-TB from 2013 to 2020.
Abbreviation: DR-TB, drug-resistant tuberculosis.

3.62% in 2020 ($\chi2$ = 39.609, P<0.001). The resistance rate of EMB increased significantly from 0.22% in 2013 to 1.97% in 2020 ($\chi2$ = 4.420, P=0.036). The resistance rate of SM increased significantly from 0.22% in 2013 to 13.82% in 2020 ($\chi2$ = 21.123, P<0.001) (Figure 3).

Among previously treated cases with suspected DR-TB, the resistance rate of INH decreased significantly from 38.67% in 2013 to 25.96% in 2020 ($\chi2$ = 22.030, P<0.001). The resistance rate of RFP decreased significantly from 44.20% in 2013 to 11.54% in 2020 ($\chi2$ = 74.140, P<0.001). The resistance rate of EMB increased from 1.66% in 2013 to 8.65% in 2020 ($\chi2$ = 1.975, P=0.160), but the upward trend was not statistically significant. The resistance rate of SM increased from 2.76% in 2013 to 8.65% in 2020 ($\chi2$ = 0.007, P=0.934), but the upward trend was not statistically significant (Figure 4).
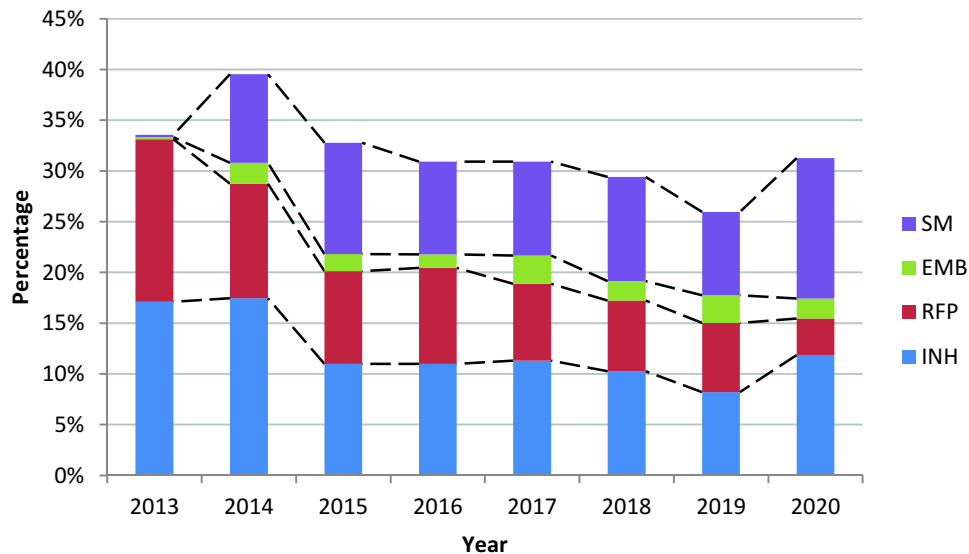
Figure 3 Rates and trends of resistance to four first-line drugs in new TB patients from 2013 to 2020.
Abbreviations: INH, isoniazid; RFP, rifampicin; EMB, ethambutol; SM, streptomycin.
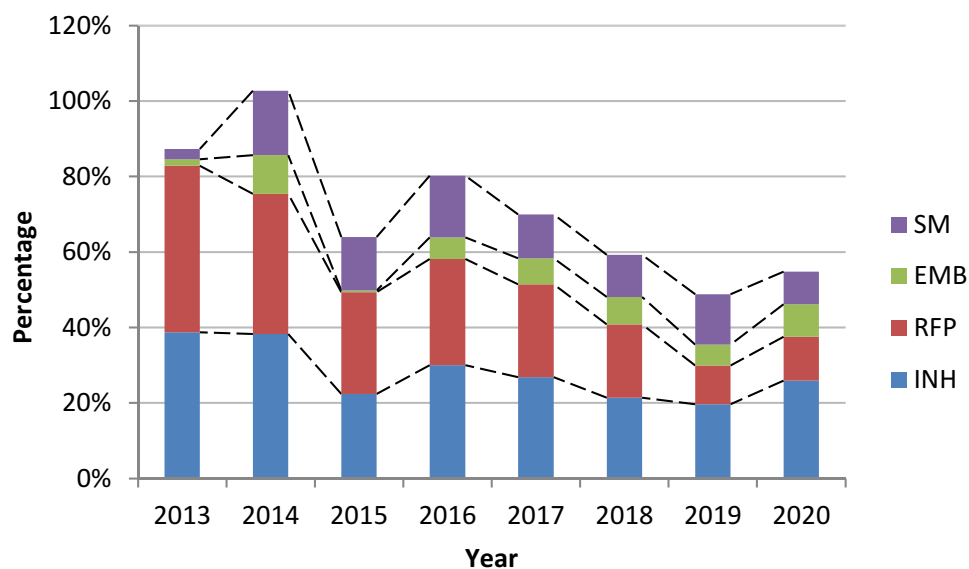
Figure 4 Rates and trends of resistance to four first-line drugs in previously treated TB patients from 2013 to 2020.
Abbreviations: INH, isoniazid; RFP, rifampicin; EMB, ethambutol; SM, streptomycin.

Drug Resistance Trends in RR-TB and MDR-TB Among New and Previously Treated Cases with Suspected DR-TB, 2013 to 2020

Among new cases with suspected DR-TB, the rate of RR-TB decreased from 15.09% in 2013 to 3.00% in 2020 with an average annual decrease of 20.61%, showing a significant downward trend ($\chi 2 = 35.429$, P<0.001). The rate of MDR-TB decreased from 6.08% in 2013 to 2.62% in 2020 with an average annual decrease of 11.33%, showing a significant downward trend ($\chi 2 = 10.040$, P=0.002) (Figure 5).

Between 2013 and 2020, the rate of RR-TB in cases with a prior treatment history decreased significantly from 44.16% to 11.49% with a mean annual decrease of 17.50% ($\chi 2 = 70.382$, P<0.001). Between 2013 and 2020, the rate of MDR-TB in cases with a prior treatment history decreased significantly from 26.90% to 10.34% with a mean annual decrease of 12.77% ($\chi 2 = 37.401$, P<0.001) (Figure 6).
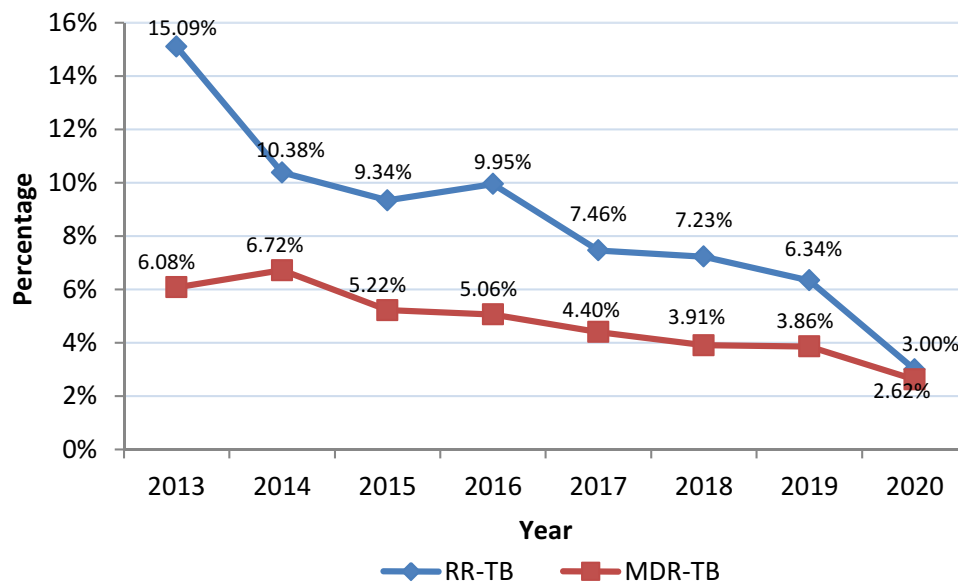
Figure 5 Drug resistance trends in RR-TB and MDR-TB among new TB patients from 2013 to 2020.
Abbreviations: RR-TB, RFP-resistant TB; MDR-TB, multidrug-resistant tuberculosis.
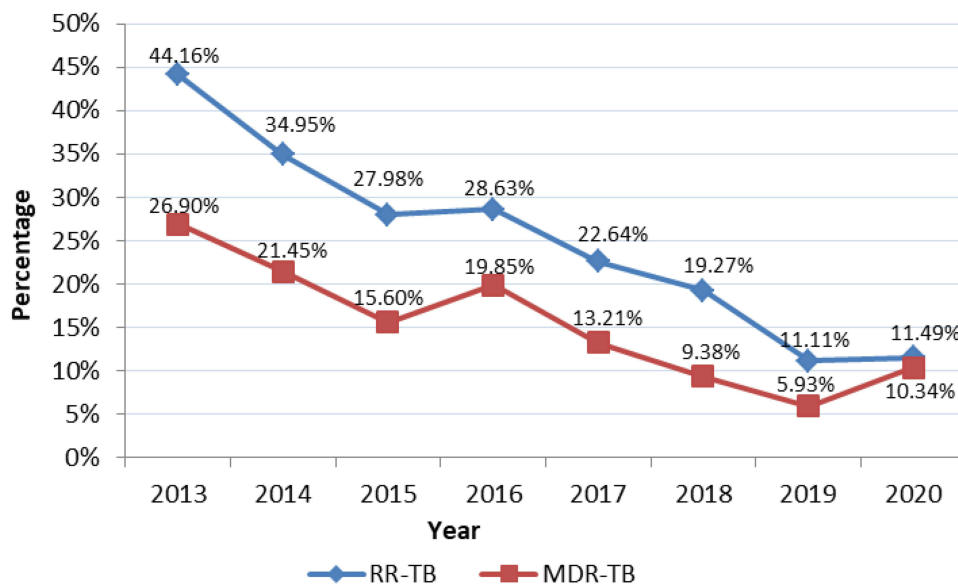

Figure 6 Drug resistance trends in RR-TB and MDR-TB among previously treated TB patients from 2013 to 2020.
Abbreviations: RR-TB, RFP-resistant TB; MDR-TB, multidrug-resistant tuberculosis.

Table 3 Univariable and Multivariable Logistic Regression Analyses of Sociodemographic Characteristics for MDR-TB Among Suspected DR-TB Patients

Characteristics	Non MDR-TB, N (%)	MDR-TB, N (%)	OR (95% CI)	P value	AOR (95% CI)	P value
Gender						
Female	1174 (22.92)	140 (25.97)	1		1	
Male	3948 (77.08)	399 (74.03)	1.18 (0.963–1.446)	0.111	1.28 (1.035–1.585)	0.023
Age (years)						
<45	1532 (29.91)	169 (31.35)	1		1	
45–64	2239 (43.71)	268 (49.72)	1.46 (1.131–1.888)	0.004	1.75 (1.342–2.284)	<0.001
>64	1351 (26.38)	102 (18.92)	1.59 (1.250–2.011)	<0.001	1.65 (1.293–2.104)	<0.001
Patient residence						
Urban	3398 (66.34)	385 (71.43)	1		1	
Rural	1724(33.66)	154 (28.57)	1.27 (1.043–1.543)	0.017	1.24(1.014–1.519)	0.037
Patient category						
New cases	3817 (74.52)	235 (43.60)	1		1	
Previously treated cases	1305 (25.48)	304 (56.40)	3.78 (3.156–4.537)	<0.001	3.94 (3.275– 4.741)	<0.001
Occupation						
Employed	373 (7.28)	47 (8.72)	1		-	
Unemployed	4749 (92.72)	492 (91.28)	1.22 (0.886–1.670)	0.226	-	
Nationality						
Han	5054 (98.67)	536 (99.44)	1		1	
Others	68 (1.33)	3 (0.56)	2.40 (0.754–7.666)	0.138	2.19 (0.674–7.082)	0.193
Migrant						
No	4704 (91.84)	506 (93.88)	1		1	
Yes	418 (8.16)	33 (6.12)	1.363 (0.945–1.965)	0.098	1.33 (0.908–1.934)	0.144

Note: Migrant refers to people who leave their domicile for various reasons and go to other provinces and cities with registered tuberculosis patients.
Abbreviations: N, number; MDR-TB, multidrug-resistant tuberculosis; CI, confidence interval; OR, odds ratio; AOR, adjusted odds ratio.

Association Between Sociodemographic Characteristics and MDR-TB in Patients with Suspected DR-TB

In a multifactorial analysis, men were more likely to develop MDR-TB than women (AOR 1.28, 95% CI 1.035–1.585). TB patients aged 45 to 64 years had a 1.75-fold risk of developing MDR-TB (AOR 1.75, 95% CI 1.342–2.284) compared with those younger than 45 years, and those aged 65 years and older had a 1.65-fold risk of developing MDR-TB (AOR 1.65, 95% CI 1.293–2.104). Patients living in rural areas were more likely to develop MDR-TB than those living in urban areas (AOR 1.24, 95% CI 1.014–1.519). Patients with a history of TB treatment were at higher risk of developing MDR-TB than new patients (AOR 3.94, 95% CI 3.275–4.741) (Table 3).

Discussion

This is the first retrospective study to focus on drug resistance patterns and trends in suspected DR-TB patients in Dalian, China. Among patients with suspected DR-TB, the prevalence of DR-TB, RR-TB and MDR-TB showed a significant decrease in both new and previously treated patients with suspected DR-TB, from 2013 to 2020. We hypothesize that several reasons could explain this finding. First, the DR-TB control strategy, including the implementation of short-course chemotherapy strategies under DOTS and improved adherence to medication among TB patients at the site, is effective. Other studies have shown that poor adherence to medication is a risk factor for the development of DR-TB.[23–25] In addition, other prevention and control measures were also taken during this period, such as placing DR-TB patients in separate wards from susceptible TB patients for treatment. This separation policy effectively prevented the nosocomial transmission of DR-TB. The second is the continued government investment in special funds for TB treatment subsidies, such as regular transportation grants and nutrition payments. This policy helps to reduce the financial burden on patients. As a disease of poverty, poorer economic conditions are an important risk factor for the development of DR-TB.[26] Finally, the development

of new rapid detection technologies, such as line probe assay (LPA) and Xpert MTB/RIF, has improved accessibility to DST, further reducing the development of DR-TB.

Regarding resistance to specific drugs, the rates of resistance to RFP and INH decreased significantly in both new and previously treated TB patients. However, the resistance rates of SM and EMB showed an increasing trend. This finding can be explained. The DST results of EMB and SM were less accurate than those of other FLDs tested in vitro for DST.[27,28] This feature may have contributed to the findings in the study. These findings will help to adjust the control measures for DR-TB and further reduce the number of DR-TB patients.

Using multifactorial regression analysis, we found that among patients with suspected DR-TB, men were more likely to develop MDR-TB than women. A systematic review of studies confirmed our study results.[29] We suggest that this finding is potentially explained by the notion that men are more likely to consume more tobacco and alcohol than women.[30] Moreover, another reason may be that men are less compliant with TB treatment than women, thus increasing their risk of developing MDR-TB.[31] In our study, it was found that patients aged 45 years and older with suspected TB were more likely to develop MDR-TB than patients aged less than 45 years. This finding is similar to the results of other previous studies.[24,32] In contrast to this finding, previous studies have found that MDR-TB is more common in patients younger than 45 years of age given that they are busier with work or study than older patients and subsequently more exposed to the risk of DR-TB.[33–35] This discrepancy may be related to the different study populations. Patients with suspected DR-TB living in rural areas are more likely to develop MDR-TB than those living in urban areas. This finding is similar to that reported in a previous study.[36] One possible reason for this is that patients living in rural areas usually have poorer adherence to TB treatment than those living in urban areas.[25] In addition, this finding is noted potentially because rural patients live in remote areas with insufficient socioeconomic development, low education and a lack of nutrition and sanitation facilities, which have an important impact on the development of MDR-TB.[35] TB patients with a history of treatment were significantly associated with MDR-TB ($P<0.05$).[37] A similar result was found in a study conducted in Ethiopia.[38] TB patients with a history of treatment often have poor medication habits, which then lead to suppression of the growth of susceptible bacilli and the development of resistance in the remaining strains.[39]

Limitations

Some limitations of the current study should be noted. First, given that our study was conducted on patients with suspected DR-TB, our findings cannot be generalized to patients with other types of TB. Second, due to limited data, we only studied the status of INH, RFP, SM and EMB in suspected DR-TB, whereas the status of resistance to other anti-drugs (eg, pyrazinamide and ofloxacin) was not analyzed. Third, some important information, such as smoking, alcohol consumption, and nutritional status were not included.

Conclusion

This study identified a significant decrease in the proportion of DR-TB, RR-TB and MDR-TB among patients with suspected DR-TB from 2013 to 2020. This finding implies that the regional preventive and control measures for DR-TB are effective. An increasing trend of drug resistance against SM and EMB were noted among patients with suspected DR-TB. In addition, sex, age, residence and patient type were significantly associated with MDR-TB. The development of targeted measures among patients with suspected DR-TB would be beneficial for the control of DR-TB.

Consent for Publication

Not applicable as details like videos or images related to study subjects were not recorded for this study.

Acknowledgments

Author Contributions

YP contribute to conception and study design, analysis, interpretation of data and drafting the article. All authors made substantial contributions to acquisition of data, revising or critically reviewing the article; agreed to submit to the current journal; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

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