Increasing multidrug-resistant tuberculosis in Ho Chi Minh City: a retrospective study of 2,266 cases from 2011 to 2015

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Abstract

Background: Multidrug resistant tuberculosis (MDR-TB) remains a serious public health problem with poor treatment outcome. Predictors of poor outcomes vary in different regions. Vietnam is among the 30 countries with high burden of MDR-TB. We aim to describe demographic characteristics and identify risk factors for poor outcome of MDR-TB in Ho Chi Minh City (HCMC), the most populous city in Vietnam.

Methods: This retrospective study included 2,266 patients who initiated MDR-TB treatment from 2011 to 2015 in HCMC. Treatment outcomes were available in 2,240 patients. Data was collected from standardized paper-based treatment cards and electronic records. Kruskal Wallis test was used to diagnose the change of median of age and body mass index (BMI) over 5 years, and Wilcoxon test to compare median BMI of patients with and without diabetes mellitus. Chi squared test was used to compare categorical variables. Multivariate logistic regression on multiple imputation was used to identify risk factors for poor outcomes. Statistical analysis was performed using R program.

Results: Among 2,266 eligible cases, 60.2% were failure of category I or II regimen, 57.7% were underweight, 30.2% had diabetes mellitus and 9.6% were HIV positive. Notification rate increased 24.7% from 2011 to 2015.Treatment success rate was 73.3%. Risk factors for poor treatment outcome included HIV co-infection (adjusted odds ratio (aOR): 2.94), advanced age (aOR: 1.45 for every increase of 5 years for patients 60 years or older), having history of MDR-TB treatment (aOR: 5.53), sputum smear grade scanty and 1+ (aOR: 1.47), smear grade 2+ or 3+ (aOR: 2.06), low BMI (aOR: 0.83 for every increase of 1kg/m2 of BMI for patients with BMI<21).

Conclusion: Our study describes the increasing cases of MDR-TB in HCMC during 2011 to 2015. Patients with HIV, high smear grade, malnutrition and history of previous MDR-TB treatment should receive additional care.

Keywords: multidrug resistant tuberculosis; retrospective; treatment outcome; risk factors; Vietnam

Background

Multidrug resistant tuberculosis (MDR-TB), defined as tuberculosis (TB) with resistance to at least rifampicin and isoniazid, is a serious public health problem. In 2017, there were an estimated 558,000 incident cases and 230,000 deaths due to MDR/Rifampicin resistant (RR)-TB worldwide. Treatment of MDR-TB is lengthy, toxic and expensive, with success rates reported at 55% in 2017 (1). HIV co-infection, low body mass index (BMI) and positive sputum smear are predictors of poor MDR-TB outcomes, but the effects of these predictors may vary in different regions (2) (3) (4) (5) (6).

Vietnam is among high TB and MDR-TB burden countries. Its estimated incidence of TB in 2017 was 129 per 100,000 people. A national survey in 2011 showed resistance to any drug was 32.7% in new TB patients and 54.2% in previously treated patients (7). The prevalence of MDR-TB was 4.1% in new patients and 17% in previously treated patients with 4900 estimated new cases annually countrywide (1). Ho Chi Minh City (HCMC) is the most populous city in Vietnam (around 8 million people) and also the center for TB and drug-resistant TB management in Southern Vietnam. In 2009, the Vietnam National TB Programme initiated the Programmatic Management of Drug-resistant TB (PMDT) under the support of Global Fund (Switzerland) to provide free treatment and support for MDR-TB patients (2). Pham Ngoc Thach hospital (PNTH) is a tertiary referral center for TB and lung diseases in Southern Vietnam, which provided treatment for 81% of registered MDR-TB patients in Vietnam in 2010 (8). The number of patients enrolled in PMDT rapidly increased from 2010 to 2014; yet, the total number of MDR-TB patients enrolled

for treatment in Vietnam in 2014 was still very low, with only a third of the estimated 5100 cases receiving treatment (2). From 2011, all 24 district TB units (DTUs) of HCMC participated in the MDR-TB management. However, until now, there has been no information about the notification trend, treatment outcome and factors associated with poor treatment outcome of MDR-TB patients in HCMC. In this study, we retrospectively investigated the demographic characteristics and risk factors for poor treatment outcomes of MDR-TB in HCMC from 2011 to 2015.

Methods

Study setting and population

Patients were hospitalized in PNTH for 7 to 14 days to initiate treatment, and then referred to DTUs for outpatient follow-up. Treatment modalities did not change during the study time, with the standardized combination of 6 drugs for a total of 18 to 24 months of treatment (2).

Sputum samples from suspected MDR-TB patients or from patients with MDR/RR-TB detected by XpertMTB/RIF or line probe assay (LPA) were sent to the laboratory in PNTH for confirming MDR-TB by drug susceptibility testing (DST). Culture and DST in solid and liquid media were the main initial diagnostic method prior 2012. Pyrazinamide and ethambutol were components of standardized MDR-TB regimen, but detecting these drugs' resistance were challenging because of unreliable phenotypic DST results (9). GenoType MTBDR*plus* (Hain Lifescience GmbH, Germany - LPA) since 2010and XpertMTB/RIF (Cepheid, USA) since 2012 were used to detect MDR/RR-TB.

We included all patients who initiated treatment with second-line drugs in HCMC under PMDT from January 2011 to December 2015. Patients who started their MDR-TB treatment after 2015 might not have treatment outcomes available at the time of data collection. We then excluded the patients who 1) had evidence of irrelevant diagnosed MDR either by DST, Xpert or LPA test, or 2) were enrolled in the STREAM trial (10) to receive a 9-month regimen, or 3) did not start treatment (Figure 1).

Data collection

Demographic and clinical information, radiographs, acid-fast bacilli (AFB) staining, DST results, treatment regimens and treatment outcomes were recorded into structured paper forms. To improve reliability, we collected data from both standardized paper-based treatment cards and electronic records and verified data during the data collection, entry and analysis processes.

Statistical analysis

Data analysis was performed using R program version 3.5.2 (11). The baseline characteristics were summazied as number of cases and percentage for categorical variables and median with interquartile range (IQR) for continuous variables. We used Kruskal Wallis test to identify the change of median of age and BMI over 5 years, and Wilcoxon test to compare median BMI of diabetes mellitus (DM) and non-DM patients. Chi squared test was used to compare categorical variables.

To identify the risk factors which contribute to the poor treatment outcome, we performed a multivariate logistic regression model. The outcome is a binary treatment outcome variable with "success" (cured, completed) and "non-success" (death, failure, lost to follow-up) as defined in (12). All the risk factors (HIV co-infection, history of previous

MDR-TB treatment, AFB smear grade and BMI) were included as covariates in the model. The model also adjusted for potential confounders (gender, age and DM status). In the model, we model covariate age with and BMI with a piecewise linear form. In particular, for covariate age, we used index variable (age ≤ 60 years old) and linear pattern for age greater than 60 years old. Similarly, for BMI covariate, we used index variable (BMI ≥ 21kg/m^2) and a linear pattern for BMI less than 21kg/m^2. To minimize bias caused by missing data, we imputed them by using multiple imputation by chained equation ("mice" package in R (13)) and we performed multivariate logistic regression models using both imputed data analysis and complete case analysis. There were only small differences in the results between the two analyses. Therefore, we presented the Forrest plot of results from imputed data analysis and provided results of both imputed and non-imputed analysis.

Results

Characteristics of MDR/RR-TB patients

From 2,395 electronic records and 1,913 paper-based records available, 2,266 MDR/RR-TB cases were included (Figure 1). Twenty-three patients had two episodes of treatment during the study time, including eight relapse cases, 13 retreatment after lost to follow-up cases and two retreatment after failure cases. Baseline characteristics are presented in Table 1. Of 2,266 cases, the median age was 43 years (IQR: 33–53 years) and did not change during 2011 to 2015 (p = 0.481). A total of 204 patients (9.6% of tested patients) were HIV co-infected; of these, 33 (16.1%) were registered as new patients, 21 (10.3%) had extra-pulmonary MDR-TB including 10 MDR-TB meningitis cases (4.9%), which was higher than in non-HIV patients (p<0.001). Eighty four of 204 HIV co-infected patients (41.2%) already received antiretroviral therapy before the start of MDR-TB treatment. The remaining HIV co-infected patients (58.8%) started ART after at least two weeks from the start of MDR-TB treatment. Among 1,815 cases with BMI information available, 57.8% was classified as underweight with 25.1% severe underweight. Median of BMI did not differ during 5 years (p = 0.966). DM status was available for 1,189 patients (52.5%), 359 of whom (30.2%) had DM. Median BMI of DM patients (20.0 kg/m^2) was higher than non-DM patients (17.8 kg/m^2) (p<0.001) and HIV co-infection in DM patients (0.9%) was lower than in non-DM patients (9.8%) (p<0.001).

Drug resistance pattern

Table 2 outlines the drug resistance pattern of MDR-TB patients. Of the 502 DST results from 490 patients that were retrievable, 10 patients had two DST at different time points, one patient had three DST. Of 490 patients with DST, 55.0% and 63.1% had resistance to pyrazinamide and ethambutol, respectively. Fluoroquinolone resistance and any injectable agent resistance accounted for 12.7% and 8.1%, respectively. Among 378 patients with DST for second-line drugs, there were 63 (16.7%) pre extensively drug-resistant (XDR) TB and 8 (2.1%) XDR-TB patients.

MDR-TB trend

Figure 2 shows increasing temporal trend from 2011 to 2015 for both the absolute number of cases and the notification rate per 100,000 population. Numbers of notified MDR/RR-TB patients decreased by 9% between 2011 and 2012, and increased an average of 15.9% annually from 2012 to 2015. Number of MDR-TB cases and notification rate increased 41.0% and 24.7% from 2011 to 2015, respectively.

Treatment outcomes

Table 3 summarizes the treatment outcomes of 2,240 MDR-TB patients whose treatment outcomes were retrievable. Successful outcomes were achieved in 1,641 (73.3 %) patients, including 55.6% cured and 17.7% completed. Among those with unsuccessful outcomes, 10.1% died, 5% failed treatment and 11.6% lost to follow-up. Characteristics of patients with success and non-success treatment outcome are further described in supplementary material (table C). In 204 HIV patients, 49 (23.0%) died, 8 (3.9%) failed the treatment and 42 (20.5%) lost to follow-up. Ten out of 21 (47.6%) TB meningitis patients had success outcome while nine (42.6%) died and two (9.5%) lost to follow-up. The success rate for 64 pre-XDR-TB patients was 53.1% while 14.1% died, 23.4% failed treatment and 7.8% lost to follow-up. Of 8 XDR-TB patients, 1 (12.5%) cured with a bedaquiline regimen, 2 (25%) died including 1 who received bedaquiline regimen and 5 (62.5%) failed.

Of 259 lost to follow-up patients, median treatment duration was 200 days (IQR: 60–340) with 56% occurring during intensive phase, 17.3% had HIV co-infection, 32% had positive AFB smear and 35.9% had culture positive prior the time of lost to follow-up.

Risk factors for poor outcomes

We evaluated the association between poor treatment outcome and HIV co-infection, history of previous MDR-TB treatment, AFB smear grade and BMI. We also included potential risk factors of male gender, age and DM status into multivariate logistic regression model. Further analysis failed to show the interaction between HIV co- infection and other risk factors (age, gender, AFB smear grade, BMI, DM status and history of previous MDR-TB treatment) ($p = 0.93$). Since MDR-TB patients received standardized treatment in 24 different DTUs, we did not include treatment site covariate in our final logistic regression model.

Independent risk factors for poor outcomes were older age (OR for every increase of 5 years when patients are older than 60: 1.45, 95% CI: 1.14–1.79, $p<0.001$), HIV co-infection (OR: 2.94, 95% CI: 2.07–4.16, $p<0.001$), a history of MDR-TB treatment (OR: 5.53, 95% CI: 2.85–10.72, $p<0.001$), AFB positive (OR: 1.47 for low smear grade (1+ and <1+), 95%CI: 1.08–2.00, $p = 0.01$ and OR: 2.06 for high smear grade (2+ and 3+), 95%CI: 1.49–2.87, $p<0.001$), and low BMI (OR: 0.83 for every increase of 1kg/m2 for patients with BMI<21, 95%CI: 0.79–0.87, $p<0.001$) (Figure 3).

Discussion

This is the first study to describe the characteristics and identify the risk factors for poor outcomes of MDR-TB in HCMC, Vietnam. Although the incidence of TB in Vietnam has been declining (1), MDR-TB cases are on the rise. There was a shortage of Hain test in the late 2011 and early 2012, which caused the drop in notified cases (information from annual report of HCMC TB program 2011—2012). The improvement in diagnostic technologies with the introduction of Xpert in the end of 2012 and changes in MDR-TB diagnostic policies might be part of the reasons for the increasing numbers of notified cases, together with the ongoing transmission of drug-resistant TB. With the rollout of Xpert, all smear positive patients were able to be screened for drug resistance, even new patients. High rates of failure of regimen 1 (22.6%) and regimen 2 (37.6%) in MDR-TB patients reflect the insufficient screening for drug resistance prior treatment of new and retreated patients, and highlight the need for drug resistance screening for all TB patients regardless of their TB history.

In this RR/MDR-TB cohort, almost all strains were resistant to streptomycin (96.3%), comparable to previous studies in Vietnam (14) (15) (16). This could be explained by the fact that the streptomycin was widely used in regimen 1 and 2 during the intensive phase for both new and retreated patients.

We found high rates of resistance to pyrazinamide (55.0%) and ethambutol (63.1%) in our MDR-TB cohort, as reported by other studies (17) (18). This may reflect the fact that the majority of MDR-TB patients (94.3%) already had exposure to first line anti-TB drugs and might have developed resistance to pyrazinamide and ethambutol during previous treatment. This questions the effectiveness of empirical use of these two drugs in the standardized MDR-TB regimen (19) and emphasizes the need for an approved genotypic DST to rapidly detect pyrazinamide resistance.

Resistance rates to fluoroquinolones (12.7%) and injectable agents (8.1%) were comparable to those of the survey in Vietnam in 2011 (20) but lower than in South Korea (17) and average global rates (1). Resistance to second-line drugs were high although they are not used in the regimen 1 and 2. It might partly due to easy access to antibiotics without prescription in Vietnam (21).

HIV co-infection, positive baseline AFB smear, older age and previous treatment with second-line drugs are main risk factors for poor treatment outcomes in our cohort, which were also observed in cohorts in Estonia, Latvia, Philippines, Russia, Peru (4), Ukraine (3). Malnutrition was common (57.8%) and also a risk factor for poor outcome (OR: 0.81 for every 1kg/m^2 increase of BMI). Low BMI might be a consequence of severe disease and low social-economic status, which are well-known risk factors for poor outcome of TB. PMDT should focus on nutrition support to improve treatment outcomes.

The prevalence of DM in our cohort (30.2%) was double that of other TB patients (13.7%) in Hanoi, Vietnam (22) and was almost 6 times higher that of general Vietnamese population in 2013 (5.4%) (23). Although DM is a known risk factor for poor treatment outcome of TB, developing MDR-TB and reducing sputum conversion rate during MDR-TB treatment (24) (25) (26), whether DM also leads to poor treatment outcome of MDR-TB is still controversial (24) (27) (28). After adjusted for other factors, DM was not an independent risk for poor outcomes in our cohort, which agrees with pooled data analysis from cohorts in Latvia, Korea and Italy (29). Due to the unavailability of DM treatment information, we do not know whether the effect of DM on MDR-TB treatment was influenced by the use of metformin, a hypoglycemic agent that might improve TB treatment outcomes (30) (31). Furthermore, levels of glycemic control of MDR-TB patients with DM were unable to retrieve to access its effect on treatment outcome. Despite these limitations, DM is a common but neglected comorbidity in MDR-TB patients and should be screened for prior MDR-TB treatment.

This study has several limitations. This is a retrospective study and some records were irretrievable at the study time. Demographic information and records of smear, culture and DST was not completely recorded on the electronic database. The majority of patients (78.4%) did not have DST results, and we could not include drug resistance information into multivariate logistic regression models. Finally, the information on smoking and alcohol use were not available in our cohort, although they are known risk factors for poor outcome (32) (33). Therefore, a prospective study is necessary to provide a comprehensive assessment of risk factors for poor treatment outcome of MDR-TB.

Conclusion

Despite these limitations, the present study emphasizes the increasing trend of MDR-TB in HCMC between 2011 and 2015 and the need for drug resistance screening for all TB patients. Patients with HIV, high smear grade, malnutrition and history of previous MDR-TB treatment are at high risk of poor outcomes and should receive additional medical care.

Abbreviations

MDR: Multidrug resistant tuberculosis *TB:* tuberculosis *RR:* Rifampicin resistant *BMI:* body mass index *HCMC:* Ho Chi Minh City *PNTH:* Pham Ngoc Thach Hospital *PMDT:* Programmatic Management of Drug-resistant Tuberculosis *DTU:* district tuberculosis unit *LPA:* line probe assay *DST:* drug susceptibility testing *AFB:* acid-fast bacilli *IQR:* interquartile range *OR:* odds ratio *DM:* diabetes mellistus *XDR:* extensively drug resistantce

Declarations

Ethics approval and consent to participate

The study was approved by Institutional Review Board (IRB) at PNTH (Reference number: 546/NCKH-PNT) and Oxford Tropical Research Ethics Committee (OxTREC Reference number: 24–17), UK.

Individual consent to participate was waived by the IRB because this is a retrospective collection and data were recorded and analyzed anonymously.

Consent to publish

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

All authors declare no competing interests.

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Authors’ contributions

GET and NTTT conceptualized, designed and revised the manuscript. LHV designed the study, collected, interpreted the data, and draft the manuscript. NHL, TVV, NTMT and DTMH participated in the design and data collection. PTP,

VTS and NTH coordinated the study and collected the data. DNV and LTHN participated in data analysis and revised manuscript. All authors read and approved the final manuscript.

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Tables

Table 1: Characteristics of MDR-TB patients in HCMC from 2011 to 2015

Characteristic	n (%)
Total	2,266
Age at diagnosis (years, median (IQR))	43 (33-53)
60 years old	197 (8.7%)
18-60 years old	2,037 (89.9%)
18 years old	32 (1.4%)
Male	1,715 (75.7%)
Site of disease	
Pulmonary	2,237 (98.7%)
Multi-organ *	37 (1.7%)
Extra pulmonary	66 (3%)
Lymphadenitis	22
Meningitis	21
Pleuritis	8
Bone and vertebral	4
Soft tissue	1
Gastro-intestinal	1
Registration group	
New	128 (5.6%)
Relapse	678 (29.9%)
Failure of regimen 1	512 (22.6%)
Failure of regiment 2	852 (37.6%)
Treatment after lost to follow-up	47 (2.1%)
Transfer	1 (0%)
Other	46 (2%)
Not recorded	2 (0.1%)
Regimen of previous treatment	
I	913 (40.3%)
II	1012 (44.6%)
III	2 (0.1%)
IV	54 (2.4%)
No history of previous treatment	128 (5.6%)
Unclear history	157 (7%)
BMI at diagnosis (kg/m^2)	n=1816
Median (IQR)	17.88 (15.78-19.98)
Overweight (BMI 25)	46 (2.5%)
Normal BMI (BMI: 18.5-25)	721 (39.7%)
Mild underweight (BMI: 17-18.5)	343 (18.9%)
Moderate underweight (BMI: 16-17)	250 (13.8%)
Severe underweight (BMI 16)	456 (25.1%)
HIV positive	204/2,136 tested for HIV (9.6%)
Diabetes	359/1,189 (30.2%)

Unknown history of diabetes	1,077 (47.5%)
Initial Diagnosis Method	
DST	274 (12.1%)
Xpert	1,276 (56.3%)
Hain	705 (31.1%)
DST of last treatment episode	7 (0.3%)
Missing data	4 (0.2%)
AFB smear at baseline	
Positive	1,748 (77.1%)
< 1+	158 (9%)
1+	895 (51.1%)
2+	357 (20.5%)
3+	275 (15.7%)
Unknown grade	63 (3.7%)
Negative	475 (21%)
Not recorded	43 (1.9%)
Culture at diagnosis	
Positive	1,371 (60.5%)
Negative	178 (7.8%)
Non-Tuberculosis Mycobacterium (but Xpert positive)**	4 (0.2%)
Contaminated	19 (0.8%)
Not recorded	694 (30.6%)

* involved both pulmonary and extra pulmonary TB

** All four cases of culture positive for *Non-Tuberculosis Mycobacterium* also had GeneXpert detected *Mycobacterium tuberculosis.*

Table 2: Frequency of first and second-line drug resistance of MDR-TB in HCMC, 2011-2015

Drug resistance	n/ total tested (%)
Patients with DST result*	490
First line drugs	
Pyrazinamide	210/382 (55.0%)
Ethambutol	298/472 (63.1%)
Streptomycin	438/455 (96.3%)
Second-line drugs	
Fluoroquinolones†	48/378 (12.7%)
Any injectable agents†	31/384 (8.1%)
All injectable agents	9/115 (7.8%)
Cycloserine	2/240 (0.8%)
Ethionamide/Prothionamide	21/223 (9.4%)

* A total of 502 DST of 490 patients were retrievable

†fluoroquinolones include moxifloxacin, levofloxacin, ofloxacin

‡ injectable agents include kanamycin, amikacin and capreomycin

Table 3: Treatment outcomes of 2,240 MDR-TB patients in HCMC, 2011-2015

Treatment outcome	2011 n (%)	2012 n (%)	2013 n (%)	2014 n (%)	2015 n (%)	Total n (%)
Total (n)	405	365	438	476	576	2,240
Cured	246 (60.7%)	190 (52.1%)	225 (51.4%)	289 (60.7%)	296 (53.2%)	1,246 (55.6%)
Completed	64 (15.8%)	80 (21.9%)	85 (19.4%)	71 (14.9%)	96 (17.3%)	396 (17.7%)
Died	27 (6.67%)	39 (10.7%)	45 (10.3%)	51 (10.7%)	64 (11.5%)	226 (10.1%)
Failed	19 (4.69%)	20 (5.48%)	23 (5.25%)	22 (4.62%)	29 (5.22%)	113 (5%)
Lost to follow-up	49 (12.1%)	36 (9.86%)	60 (13.7%)	43 (9.03%)	71 (12.8%)	259 (11.6%)

Table 4: Comparison of multivariate logistic regression models using complete case and multiple imputation analysis

Risk factors	Success n (%)	Non-success n (%)	Complete case analysis*		Multiple imputation analysis	
			aOR	95% CI	aOR	95% CI
Gender: male	1231 (75.0%)	471 (78.8%)	1.55	0.99-2.42	1.10	0.84-1.44
Age ≤ 60 years			0.98	0.90-1.07	1.01	0.96-1.06
Age > 60 years			1.79	1.26-2.54	1.45	1.14-1.79
	For every increase of 5 years of age					
Diabetes	285 (34.1%)	71 (21.3%)	0.84	0.55-1.31	0.81	0.61-1.08
HIV positive	102 (6.5%)	99 (17.9%)	3.12	1.66-5.84	2.94	2.07-4.16
History of previous MDR-TB treatment	18 (1.2%)	38 (7.0%)	20.37	5.52-75.17	5.53	2.85-10.72
Low smear grade†	788 (48.9%)	259 (44.1%)	1.72	1.00-2.95	1.47	1.08-2.00
High smear grade‡	416 (25.8%)	209 (35.6%)	2.25	1.28-3.93	2.06	1.49-2.87
AFB positive unknown	40 (2.5%)	22 (3.7%)	2.70	1.08-6.78	2.80	1.47-5.36
BMI < 21			0.82	0.76-0.89	0.83	0.79-0.87
BMI ≥ 21			0.96	0.81-1.15	1.06	0.93-1.2
	For every 1 increase of BMI					

* Complete case analysis: non-imputed data

† Low smear grade: scanty or 1+ on AFB smear

‡ High smear grade: 2+ or 3+ on AFB smear

Figures

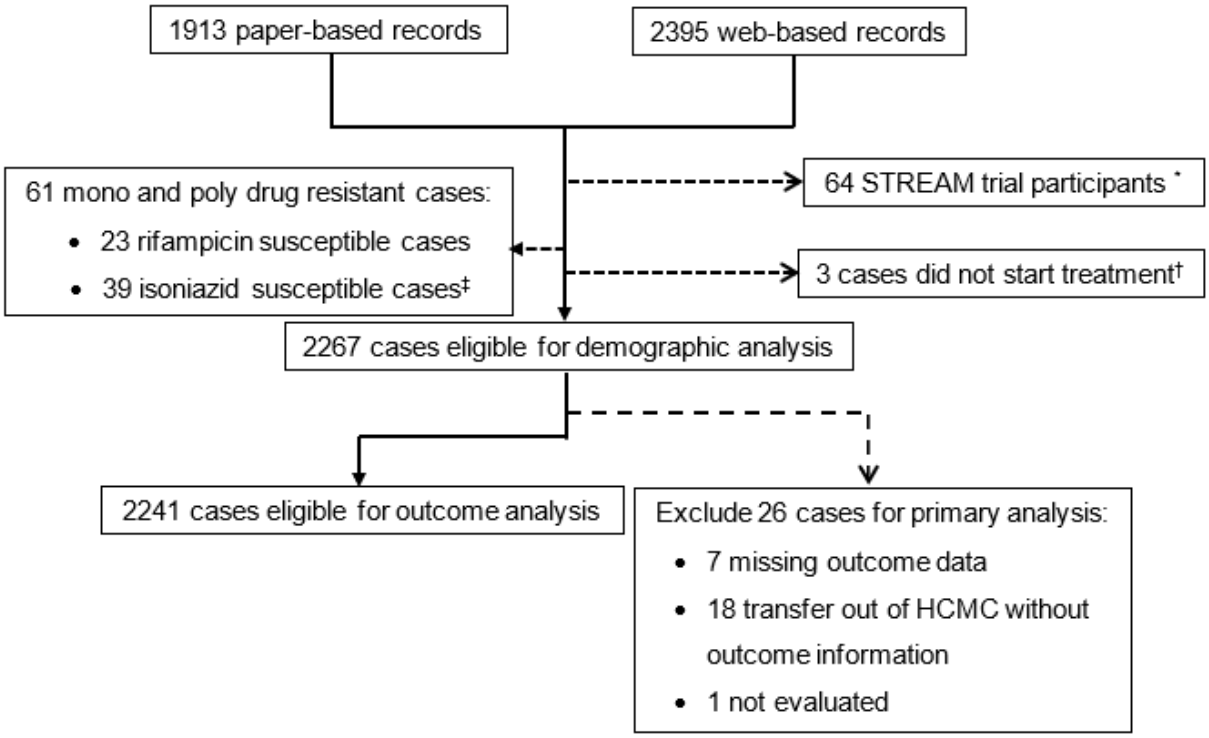

Figure 1: Flow diagram of eligible cases for analysis

* 64 STREAM trial participants from 2012 and 2015 were excluded as they received 9-month regimen and were not enrolled in the PMDT.

† 3 patients died before MDR-TB treatment

‡ 39 isoniazid susceptible cases included 1 patient who was also susceptible to rifampicin.

Figure 1

Flow diagram of eligible cases for analysis * 64 STREAM trial participants from 2012 and 2015 were excluded as they received 9-month regimen and were not enrolled in the PMDT. † 3 patients died before MDR-TB treatment ‡ 39 isoniazid susceptible cases included 1 patient who was also susceptible to rifampicin.

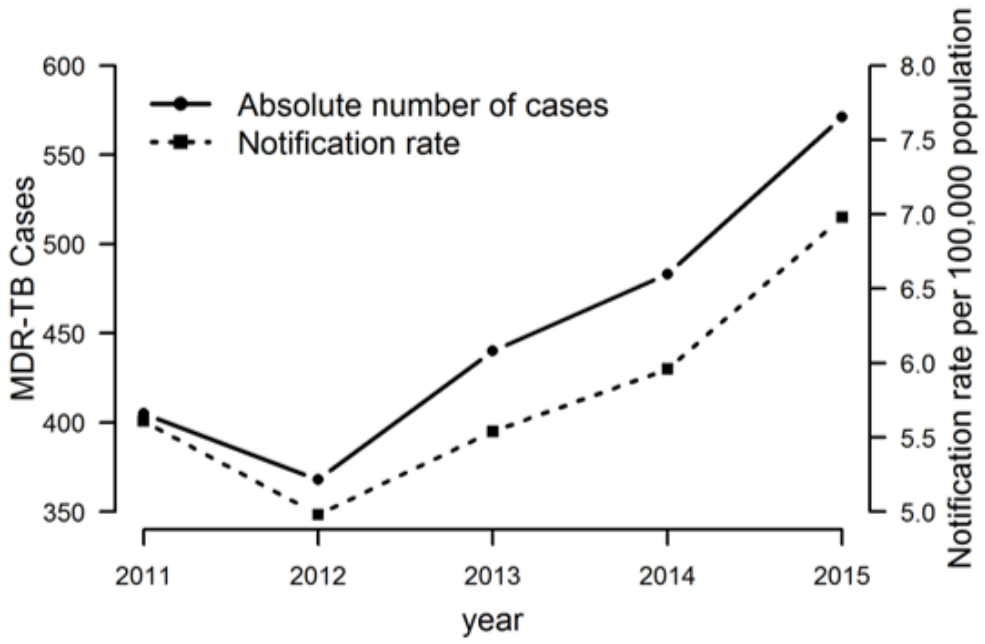

Figure 2: MDR-TB trend for a five year period. The absolute number of MDR-TB cases are showned in the solid line, and the notification rate per 100,000 population in the dashed line.

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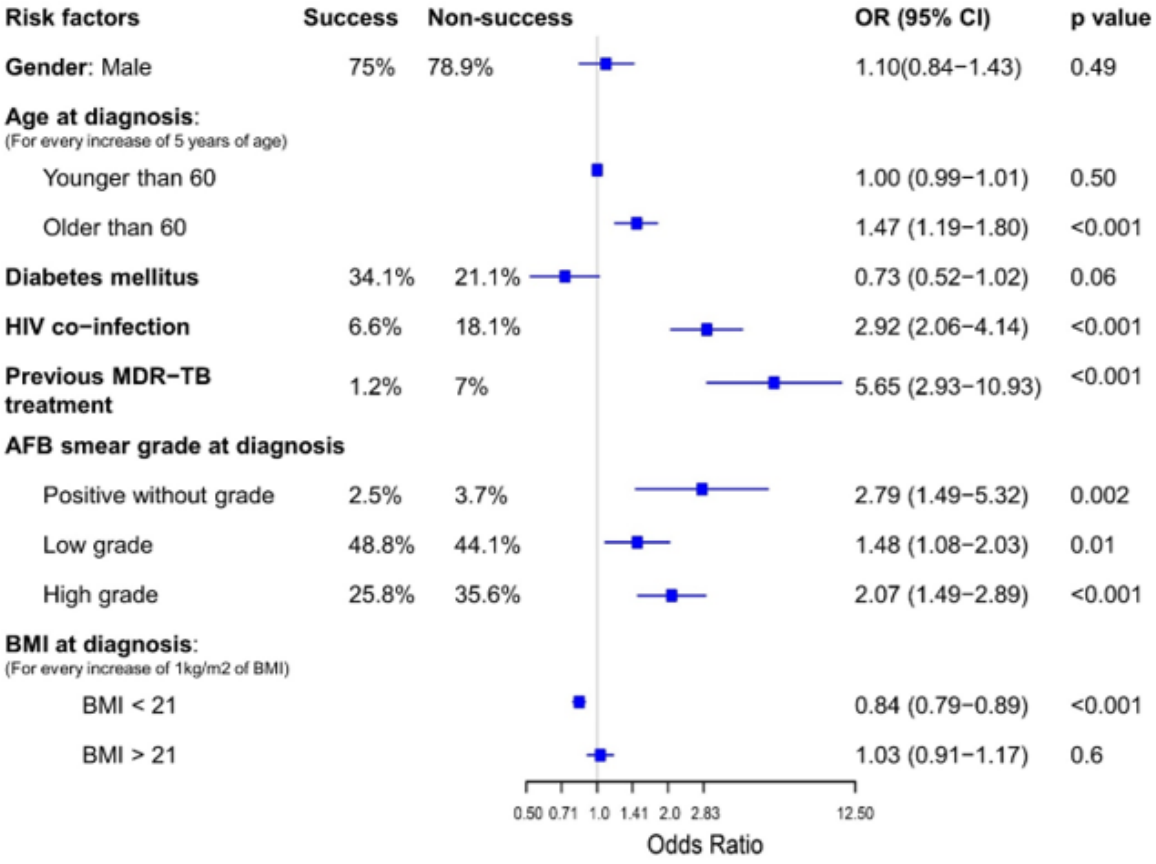

Figure 3: Forrest plot showing the risk factors for non-success outcome of 2241 MDR-TB patients. OR, odds ratio; CI, confidence interval

Figure 3

Forrest plot showing the risk factors for non-success outcome of 2241 MDR-TB patients. OR, odds ratio; CI, confidence interval

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SUPPLEMENTARYDATAclean.docx
- Tables.pdf