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Original Article

Determinants of adverse treatment outcomes among patients treated under Revised National Tuberculosis Control Program in Wardha, India: Case-control study

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ABSTRACT

Background: Tuberculosis (TB) leads to a considerable loss of lung functions and Quality Adjusted Life Years. Several factors are associated with adverse treatment outcomes from TB which further increases this loss. We undertook the study to study the determinants of adverse treatment outcomes among tuberculosis patients treated under the Revised National Tuberculosis Control Program in a tuberculosis unit in India.

Methods: 88 cases and 187 controls from among patients registered in Wardha Tuberculosis Unit in the year 2014 were interviewed to study the determinants of adverse treatment outcomes of tuberculosis. All patients with adverse treatment outcomes were taken as cases. Controls were chosen from relapse free successfully treated patients using simple random sampling.

Results: On multivariate analysis indoor air pollution, pulmonary TB, discrimination due to TB and poor satisfaction with services significantly increased the odds of adverse treatment outcomes whereas the senior treatment supervisor visiting the patients during treatment was protective.

Conclusion: Appropriate new interventions and strengthening of the existing mechanisms to reduce treatment interruptions along with proper implementation of the program will help in reducing the adverse treatment outcomes and improving program performance.

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Introduction

Tuberculosis (TB) was declared a global emergency in 1993 by World Health Organisation (WHO).¹ India has registered a Treatment Success Rate (TSR) of >85% in New Sputum Positive (NSP) cases of TB. But the TSR of ~70% in retreatment cases is comparatively less.² Retreatment patients are at greater risk of death and further adverse treatment outcomes.^{2,3} Furthermore, treatment interruptions and defaults are associated with drug resistance which further deteriorates the treatment outcomes.⁴ TB has a negative impact on the physical and social aspects of a person's life and leads to a considerable loss in Quality Adjusted Life Years with every episode.⁵

Several factors like increasing age, male sex,^{3,6} addictions,^{3,7} type of disease,⁸ previous history of TB,⁹ poor compliance and treatment interruptions,^{7,10} comorbidities,^{8–11} and side effect of drugs⁶ have been associated with various adverse treatment outcomes. Lower education levels,¹¹ dissatisfaction with services,¹² poor information sharing by service providers and work related factors¹³ have been associated with defaulting from treatment.

As it is important to understand the local epidemiology for appropriate control measures, the present study was undertaken to study the determinants of adverse treatment outcomes among TB patients treated under RNTCP in Wardha Tuberculosis Unit (TU).

Materials and methods

The present case control study was carried out from November 2015 to September 2016 in Wardha TU in Central India. The district has 3 TUs spanning across 8 administrative blocks. The study was carried out in one of the TU (population ~5 lakh). The study population consisted of patients registered under RNTCP in the TU in the year 2014.

All patients with any adverse treatment outcome (deaths, defaults, relapse, treatment failure, shift to category IV) were selected as cases ($n = 91$). Simple random sampling was

employed for selection of controls from the successfully treated, relapse free patients. The number of controls selected ($n = 182$) were twice the number of cases and an additional 15% (15% of 182 i.e. 27) to account for loss to follow up and non-participation. Thus, the final sample size was 300 (Fig. 1).

The list of patients along with their illness and treatment details was extracted from the District TB office (DTO). Details about socio-demography, illness, treatment, addiction, work and provider related factors, were obtained by contacting the selected participants individually, using a structured questionnaire and after obtaining written informed consent for participation. The treatment outcomes were determined according to the RNTCP definitions.¹⁴ The area of residence was classified according to census definitions of statutory and census towns.¹⁵ Occupation was classified as unemployed and students, unskilled labours, semi-skilled or skilled labours, and clerical or professional.¹⁶ For socio-economic status (SES) ration cards issued by Government of Maharashtra, under the Public Distribution System was checked (yellow card for Below Poverty Line (BPL) families, orange and white card for Above Poverty Line (APL) families).¹⁷ Indoor air pollution was considered as present only when the family used solid fuel predominantly for cooking purposes, and cross ventilation was lacking in the house.¹⁷ Diseases other than acute infectious conditions e.g. hypertension, diabetes, ischaemic heart disease, HIV, anaemia, chronic respiratory diseases, psychiatric illness etc. were considered as co-morbidities.

Data was analysed using SPSS 12.0. The characteristics of patients were expressed as frequencies (%), and median (IQR). Univariate logistic regression was performed to study the determinants of adverse treatment outcomes and the strength of association was expressed as Odds Ratio (OR) with its 95% confidence intervals. Multiple logistic regression was performed to derive the adjusted OR to explain the effect of independent determinants on adverse treatment outcomes. All the variables were considered for multiple logistic regression. Multicollinearity was tested using tolerance and variance inflation factor and subsequently the variables type of disease (new/retreatment), smear conversion at end of Intensive Phase (IP), HIV, diabetes, co-morbidities, travel cost, delays

Fig. 1 – Patient flowchart for studying the determinants of adverse treatment outcomes.

in care seeking and diagnosis, family problems, family support, residence of service providers, type of service providers, behaviour of Directly Observed Treatment short-course (DOTS) provider, missed doses were removed from the model due to multicollinearity. Analysis of residuals suggested that there was no significant heteroscedasticity. R^2 (Nagelkerke) for the final model was 39.7%. A P -value of <0.05 was considered as significant.

Ethical approval was obtained from the Institutional Ethics Committee before conducting the study.

Table 1 – Treatment outcomes of study participants.

Cases (%) (n = 88)	Controls (%) (n = 187)
Death (n = 27, 9.8%)	Cured (n = 76, 27.6%)
Default (n = 44, 16.0%)	
Failure (n = 9, 3.3%)	Treatment completed (n = 111, 40.4%)
Relapse (n = 6, 2.2%)	
Shift to Category IV (n = 2, 0.7%)	

Results

Out of the 91 cases and 209 controls selected for participation, 3 cases and 22 controls were excluded (Fig. 1). Thus, a total of 275 patients were interviewed (88 cases and 187 controls). The treatment outcomes of participants have been shown in Table 1.

On univariate analysis, among the socio-demographic factors, the odds of adverse treatment outcome increased significantly with age, sex, lower education levels, occupation, low SES, and exposure to indoor air pollution (Table 2).

Among the factors related to the illness, the odds of adverse treatment outcomes were significantly higher for retreatment cases, pulmonary TB patients, non-conversion of smear by the end of IP, and any co-morbidity (Table 3).

A perception of delayed initial care seeking among the patients was associated with significantly higher odds of adverse treatment outcomes (Table 4). Among the factors during the treatment, family problems and lack of support

Table 2 – Association of adverse treatment outcomes with socio-demographic factors.

Factors	Cases (n = 88)	Controls (n = 187)	Odds Ratio (95% CI)	P value
	Frequency (%)			
Age group				
0–29 years	16 (18.2)	63 (33.7)	1	0.010
30–44 years	24 (27.3)	58 (31.0)	1.63 (0.79–3.37)	
45–59 years	27 (30.7)	32 (17.1)	3.32 (1.57–7.04)	
≥60 yrs	21 (23.9)	34 (18.2)	2.43 (1.12–5.27)	
Sex				
Female	23 (26.1)	81 (43.3)	1	0.007
Male	65 (73.9)	106 (56.7)	2.16 (1.24–3.77)	
Residence				
Urban	39 (44.3)	93 (49.7)	1	0.402
Rural	49 (55.7)	94 (50.3)	1.24 (0.75–2.07)	
Education				
Less than primary	19 (21.6)	24 (12.8)	4.64 (1.70–12.63)	0.012
Primary	17 (19.3)	23 (12.3)	4.33 (1.57–11.98)	
Secondary	22 (25.0)	36 (19.3)	3.58 (1.37–9.36)	
High school	23 (26.1)	63 (33.7)	2.14 (0.84–5.44)	
Graduate or above	7 (8.0)	41 (21.9)	1	
Occupation				
Clerical or professional	7 (8.0)	35 (18.7)	1	0.001
Semi-skilled or skilled labour	32 (36.4)	48 (25.7)	3.33 (1.32–8.42)	
Unskilled labour	25 (28.4)	25 (13.4)	5.00 (1.87–13.36)	
Unemployed or students	24 (27.3)	79 (42.2)	1.52 (0.60–3.86)	
Caste				
General	18 (20.5)	42 (22.5)	1	0.911
OBC	31 (35.2)	62 (33.2)	1.17 (0.58–2.35)	
SC/ST/NT	39 (44.3)	83 (44.4)	1.10 (0.56–2.14)	
Socio-economic status				
APL	48 (54.5)	128 (68.4)	1	0.026
BPL	40 (45.5)	59 (31.6)	1.81 (1.07–3.04)	
Family type				
Joint	23 (26.1)	51 (27.3)	1	0.843
Nuclear	65 (73.9)	136 (72.7)	1.06 (0.60–1.88)	
Indoor air pollution				
Absent	56 (63.6)	169 (90.4)	1	<0.001
Present	32 (36.4)	18 (9.6)	5.37 (2.80–10.30)	

Table 3 – Association of adverse treatment outcomes with illness related factors.

Factors	Cases (n = 88)	Controls (n = 187)	Odds Ratio (95% CI)	P value
Frequency (%)				
Type of illness				
New	54 (61.4)	146 (73.0)	1	0.004
Retreatment	34 (38.6)	41 (27.0)	2.24 (1.29–3.89)	
Site of disease and sputum status				
Extra pulmonary	5 (5.7)	51 (27.3)	1	0.001
Pulmonary sputum negative	31 (35.2)	54 (28.9)	6.55 (2.45–17.49)	
Pulmonary sputum positive	52 (59.1)	81 (43.3)	5.86 (2.11–16.23)	
Smear conversion at end of IP				
Smear converted (n = 97)	23 (23.7)	74 (76.3)	1	<0.001
Smear not converted (n = 36)	29 (80.6)	7 (19.4)	13.33 (5.16–34.42)	
Co-morbidities				
Absent	44 (50.0)	139 (74.3)	1	<0.001
Present	44 (50.0)	48 (25.7)	2.90 (1.70–4.93)	
HIV status				
Negative	80 (90.9)	166 (88.8)	1	0.583
Positive	3 (3.4)	12 (6.4)	0.52 (0.14–1.89)	
Unknown	5 (5.7)	9 (4.8)	1.15 (0.37–3.55)	
Diabetic status				
Non-diabetic	38 (43.2)	70 (37.4)	1	0.421
Diabetic	4 (4.5)	5 (2.7)	1.47 (0.37–5.82)	
Unknown	46 (52.3)	112 (59.9)	0.76 (0.45–1.28)	

Table 4 – Association of adverse treatment outcomes with financial and geographical accessibility and associated delays.

Factors	Cases (n = 88)	Controls (n = 187)	Odds Ratio (95% CI)	P value
Median travel cost in INR (IQR)				
Cost of travelling to diagnostic centre	20 (10–30)	20 (10–35)	1.00 (0.99–1.01)	0.371
Cost of travelling to DOTS centre	10 (10–25)	10 (0–20)	1.00 (0.99–1.02)	0.871
Median distance of health facilities from residence in Km (IQR)				
Nearest government health facility	3.0 (1.0–6.0)	3.0 (2.0–6.0)	0.97 (0.90–1.05)	0.482
Distance of diagnostic facility	6.5 (2.0–16.0)	7.0 (2.0–15.0)	0.99 (0.97–1.02)	0.577
Distance of DOTS centre	3.0 (1.0–11.0)	3.0 (1.0–10.0)	1.00 (0.97–1.03)	0.795
Median delay in days (IQR)				
In visiting health facility after developing symptoms	10.0 (9.0–25.0)	10.0 (7.0–15.0)	1.00 (0.99–1.01)	0.708
In diagnosis from initial health facility visit	7.0 (3.0–15.0)	10.0 (5.0–20.5)	0.99 (0.97–1.01)	0.175
In treatment initiation after diagnosis	2.0 (1.0–5.0)	2.0 (1.0–5.0)	1.02 (0.98–1.07)	0.253
Perception of early or late care seeking [frequency (%)]				
Early	32 (36.4)	92 (49.2)	1	
Late	56 (63.6)	95 (50.8)	1.70 (1.01–2.85)	0.047
Missing work or education during treatment [frequency (%)]				
No	48 (54.5)	109 (58.3)	1	
Yes	40 (45.5)	78 (41.7)	1.17 (0.70–1.94)	0.559

from family members, being discriminated, low satisfaction with services, a feeling of cure during treatment, and addiction increased the odds of adverse treatment outcomes significantly (Table 5). Poor behaviour by DOTS provider also significantly increased the odds whereas Senior Treatment Supervisor (STS) visiting the patient was protective (Table 6).

On multiple logistic regression, exposure to indoor air pollution was associated with about 4 times higher odds of adverse treatment outcomes. The odds was 3.7 times and 4.5

higher in sputum positive and sputum negative patients respectively as compared to extra pulmonary (EP-TB) patients. The odds was over twice among patients who felt discriminated during their treatment. When compared to patients who were totally satisfied with the services, patients with lower level of satisfaction had at least 3 times higher odds of adverse treatment outcomes. STS visiting the patients during treatment reduced the odds of adverse treatment outcomes to 0.38 (Table 7).

Table 5 – Association of adverse treatment outcomes with treatment related factors.

Factors	Cases (n = 88)	Controls (n = 187)	Odds Ratio (95% CI)	P value
Frequency (%)				
Family problem				
Yes	29 (33.0)	26 (13.9)	3.04 (1.66–5.59)	<0.001
No	59 (67.0)	161 (86.1)	1	
Family support				
Yes	71 (80.7)	181 (96.8)	1	<0.001
No	17 (19.3)	6 (3.2)	7.22 (2.74–19.06)	
Felt discriminated ever				
No	46 (52.3)	142 (75.9)	1	<0.001
Yes	42 (47.7)	45 (24.1)	2.88 (1.69–4.93)	
Satisfaction with services at DOTS/diagnostic centre				
Totally satisfied	7 (8.0)	39 (20.9)	1	0.001
Good	33 (37.5)	88 (47.1)	2.09 (0.85–5.13)	
Average or less	48 (54.5)	60 (32.1)	4.46 (1.83–10.85)	
Missing any dose during treatment				
No	34 (38.6)	79 (42.2)	1	0.570
Yes	54 (61.4)	108 (57.8)	1.16 (0.69–1.95)	
Felt cured and the need to stop medicines during treatment				
No	69 (78.4)	170 (90.9)	1	0.005
Yes	19 (21.6)	17 (9.1)	2.75 (1.35–5.61)	
Experienced side effects of medicines				
No	13 (14.8)	34 (18.2)	1	0.484
Yes	75 (85.2)	153 (81.8)	1.28 (0.64–2.57)	
Addiction				
No addiction	24 (27.3)	99 (52.9)	1	<0.001
Any addiction	64 (72.7)	88 (47.1)	3.00 (1.73–5.20)	
Smokeless tobacco	42 (47.7)	56 (29.9)	2.14 (1.27–3.60)	0.004
Smoking	18 (20.5)	19 (10.2)	2.27 (1.13–4.59)	0.022
Ever smoked	41 (46.6)	35 (18.7)	3.79 (2.17–6.61)	<0.001
Alcohol	39 (44.3)	33 (17.6)	3.71 (2.11–6.53)	<0.001

Discussion

In this study out of the 275 participants about 28% patients were cured, 40% were declared treatment completed, 10% died, 16% defaulted, 2% relapsed after successfully completing the therapy, 3% experienced treatment failures, and 0.7% were shifted to Category IV. Indoor air pollution, pulmonary TB, discrimination, satisfaction with services, and STS visits at patient's residence were seen to influence the odds of adverse treatment outcomes significantly.

Indoor air pollution was associated with about fourfold increase in the odds of adverse treatment outcomes. Smoke is a risk factor for lung pathologies and the association between solid cooking fuel and increased risk of TB is known¹⁸ but there is little evidence of its effect on adverse treatment outcomes. The mechanism for association of indoor air pollution with adverse treatment outcomes is unclear and needs further exploration, however mechanisms like loss of ciliary functions and reduced immune response might be responsible.

In the present study the odds of adverse treatment outcomes was 3.7 times and 4.5 times higher for sputum positive and sputum negative patients respectively as compared to EP-TB patients. In Uzbekistan, EP-TB disease was seen to be protective from treatment failures and deaths as

compared to pulmonary TB patients and had a lesser odds for default as compared to smear negative patients.¹⁹ EP-TB disease are generally milder. However, few studies contradict from these findings.²⁰ The difference may be due to differential care or weak health system. In USA, where the health system is strong, the deaths did not differ with the site of TB.²¹

Being discriminated anytime during the treatment was associated with over 2 fold odds of adverse treatment outcomes. When compared to totally satisfied patients, those with relatively lesser satisfaction levels had over thrice the odds of adverse treatment outcomes. Other factors like family problems, role of service providers, pre-treatment counselling and DOTS provider giving the medicines at patients' residence have been linked with default previously, although an association of these factors with adverse treatment outcomes was not found in the present study. The reason may be that regular visits by the DOTS provider may compromise the confidentiality of patients' disease status. Lack of support from health care providers reportedly increases the odds of defaulting by 8 folds and dissatisfaction with services increases it by 12 folds.¹² Address verification by STS has been also reported to be protective from defaulting.¹³ In our study, the STS visiting the patients' residence during treatment decreased the odds of adverse treatment outcomes to

Table 6 – Association of adverse treatment outcomes with provider related factors.

Factors	Cases (n = 88)	Controls (n = 187)	Odds Ratio (95% CI)	P value
Frequency (%)				
Residence of service provider at the DMC				
Same village/ward	6 (6.8)	15 (8.0)	1	0.726
Different village/ward	82 (93.2)	172 (92.0)	1.19 (0.45–3.20)	
Counselling before treatment initiation				
Yes	60 (68.2)	133 (71.1)	1	0.619
No	28 (31.8)	54 (28.9)	1.15 (0.66–1.99)	
Residence of regular DOTS provider				
Same village/ward	58 (65.9)	117 (62.6)	1	0.591
Different village/ward	30 (34.1)	54 (37.4)	0.87 (0.51–1.47)	
Type of DOTS provider				
Public health facility based	35 (39.8)	79 (42.2)	1	0.348
ASHA/community volunteer	46 (52.3)	101 (54.0)	1.03 (0.61–1.75)	
Others	7 (7.9)	7 (3.8)	2.26 (0.74–6.92)	
DOTS provider visited home for giving medicines				
Yes	38 (43.2)	91 (48.7)	1	0.396
No	50 (56.8)	96 (51.3)	1.25 (0.75–2.08)	
Behaviour of DOTS provider				
Very good	3 (3.4)	22 (11.8)	1	0.028
Good	49 (55.7)	106 (56.7)	3.39 (0.97–11.87)	
Average	32 (36.4)	57 (30.5)	4.12 (1.14–14.83)	
Bad	4 (4.5)	2 (1.1)	14.67 (1.83–117.68)	
STS ever visited patient				
No	49 (55.7)	75 (40.1)	1	0.016
Yes	39 (44.3)	112 (59.9)	0.53 (0.32–0.89)	

Table 7 – Multiple logistic regression model for studying determinants of adverse treatment outcomes.

Factors	Adjusted OR* (95% CI)	P value
Indoor air pollution		
Absent	1	0.002
Present	4.06 (1.67–9.89)	
Site of disease and sputum status		
Extra pulmonary	1	0.025
Pulmonary sputum positive	3.76 (1.18–11.96)	
Pulmonary sputum negative	4.53 (1.36–15.10)	0.014
Ever felt discriminated		
No	1	0.030
Yes	2.20 (1.08–4.51)	
Satisfaction with services at diagnostic facility/DOTS centre		
Totally satisfied	1	0.011
Good	4.08 (1.39–11.97)	
Average or less	3.18 (1.06–9.51)	0.039
STS visited residence of patient		
Ever	0.38 (0.19–0.74)	0.005
Never	1	

* Adjusted for age group, sex, residence, education, occupation, caste, socio-economic status, type of family, distance of DOTS centre from residence, missing education or work, delay in treatment initiation, pre-treatment counselling, DOTS provider visiting patient for providing drugs, side effects, and addiction.

about two-fifths. These visits may improve the trust and confidence of patients in the health system and thus improve compliance.

In the present study, age, sex, and area of residence were not found have significant association with adverse treatment outcomes. A study in Turkey found that age > 65 years was

associated with over 3 times higher odds of adverse treatment outcome.⁹ The difference in the age groups studied might be responsible for the difference in results. Males have been reported to be at a higher risk for adverse treatment outcomes than females in other studies due to reasons like different societal responsibilities, rate of addiction etc.⁹ However, few

studies did not find any such relation.²² A study in Uzbekistan found that urban residence was associated with higher odds for deaths, treatment failures as well as loss to follow up. The reason behind such difference in the results may be the involvement of community volunteers in our setting, whereas the anti-tuberculosis treatment in Uzbekistan is overlooked by the TB dispensaries as outpatient care.¹⁹

In our study, co-morbidity increased the odds of adverse outcomes to nearly thrice on univariate analysis. Diabetes and HIV did not affect treatment outcomes in the present study. Several studies have established the association between deaths in TB patients and HIV,^{8,21} diabetes and other co-morbid conditions.⁴ The small numbers of diabetics and HIV patients along with a significant proportion of unknown status might have restricted the establishment of a causal association in our study. In the present study, adverse treatment outcomes were not seen to differ between new and retreatment patients.

Proper care for TB may be delayed due to various reasons like delay in care seeking, diagnosis, and treatment initiation. Low levels of awareness, poverty, loss of wages, domestic preoccupation, accessibility of health centre etc. may be responsible for such delays. Some of these factors are also associated with defaults.²³ Unlike expected, the median delay for diagnosis in our study was higher in controls than cases (23 days vs 7 days) as was also reported in another systematic review.²⁴ This may be attributed to a greater proportion of EP-TB patients in controls which is milder and generally needs invasive investigations that are not as readily performed as sputum examination for pulmonary TB. Stigma and discrimination may also result in delayed care seeking and defaulting. Awareness generation, reducing the stigma, mechanisms for financial and social support, and improving accessibility of diagnostic facilities are some of the steps which may help in reducing the associated delays.²³

Treatment interruptions by patients favour development of drug resistance, heralds potential future defaults and is also associated with relapse. Almost 60% of the participants in the present study reported having missed some doses. Better communication and information exchange strategies between the DOTS provider and the patient need to be worked upon to prevent such instances.^{10,25} The distance of DOTS centre from residence of patient was not associated with adverse treatment outcome in our study as in other studies¹² and similar was the case with addiction.

There exist few challenges in controlling TB and achieving the SDG and End TB targets. Some of them are the existing funding gap, inefficiencies and weak accountability of health systems, inadequate outreach activities, unregulated private sector and lack of partnership with the TB control program, insufficient collaboration with other health programs to manage co-morbidities, increasing rate of DR-TB and lagging scaling up of PMDT, accessibility of services, and lack of strategies to address other social determinants of health to name a few.²⁶ The End TB strategy puts forth some of the ways in which these challenges can be overcome. Building on the basic principles of public health like primary health care and universal health coverage along with assessment and identification of strengths and problems at local level and adopting other suitable strategies of advocacy, collaboration and

appropriate health system response are needed to overcome these challenges and achieve the goal of a world free from TB.^{27,28} In our setup the important modifiable determinants identified were indoor air pollution, discrimination, satisfaction with services, and STS visits.

The importance of retrieval activities for patients defaulting from treatment has been recognised and is also being carried out in the study district but it has not been able to reduce the number of defaults to an acceptable level.⁶ Follow-up visits and early retrieval action may be tailored according to the specific case. In the present study approximately 33% of the defaulters died before the data collection. Furthermore, when the defaulters restart treatment, they are already at higher risk of death. We assume that reducing the defaults would not only improve the treatment outcomes but also minimise the associated deaths. Training and reorientation of service providers is needed for improving and strengthening the quality of services and satisfaction levels of the patients and hence improve adherence. It has been proposed in the recent RNTCP guidelines that a patient centric model should be followed which identifies a set of facilities and services that should be available at each stage of the patient's illness.²⁹

Social determinants of health play an important role in shaping individual as well as the overall health of the society. Appropriate action is needed to modify the negative determinants into positive ones. In our study indoor air pollution was seen to influence the treatment outcomes. Steps to improve accessibility of LPG or alternate smokeless chulhas by subsidy, better supply chains needs to be ensured to prevent the associated adverse treatment outcomes. The Government of India has taken a step to this effect by means of national scheme for subsidy to poor households in the name of *Pradhan Mantri Ujjwala Yojana*. A further step towards linking it with the RNTCP may help in improving treatment outcomes.³⁰

Discrimination and stigma act as social barriers in availing health facilities, thus spreading the information in the community holds prime importance. Aggressive measures to tackle discrimination with community involvement need to be undertaken for awareness generation, like widespread health education campaigns focussing on breaking the transmission chain using a multitude of methods, counselling of family members to support and help the patient complete the treatment would also help in reducing stigma and bring a positive behaviour change.²³ Pre-treatment counselling was not seen to affect the treatment outcomes in our study. This reinstates our belief that mere counselling is not enough but empathy and appropriate advice tailored as per the need of the individual case is required.¹³ Incentivising timely treatment completion may reduce treatment interruptions. Mere improvement of geographical accessibility may not be the only answer to reduce delays as it may become difficult for some class of workers to attend the public health facilities which operate during the regular working hours. Appropriate measures are needed to reduce the inconvenience to patients.²³

Another reason for the higher adverse treatment outcomes may be understaffing. As per the recent change in program strategy, population norms of TUs has been revised from the previous 1 TU per 5 lakh population to 1 TU per block (and 1 TU per 1.5–2.5 lakh population in urban areas) for better program

performance by increasing the health workforce, better management and monitoring of the program.²⁹ However, the revision has not been materialised in Wardha district till date. There is an urgent need to increase the number of TUs in the district which will mean more STSs, thus better coverage of the home visits by them.

Follow-up of patients after successful treatment may help in early identification of relapses. This has also been proposed by the program recently and if implemented properly this can effectively reduce the diagnostic delay and related morbidity and mortality in such cases.²⁹

Our study has some inherent limitations like recall bias due to the study design. Further, the subgroup analysis could not be performed due to small number of subjects in the groups. The association between HIV, diabetes and adverse treatment outcomes may be subject to bias as they were unknown for a considerable number of patients.

In conclusion, high rates of adverse treatment outcomes especially deaths and defaults are a constant hurdle in achieving the targets of RNTCP. Our study shows the need for newer interventions and strengthening the existing ones with proper implementation along with mechanisms to reduce the treatment interruptions for reducing the adverse treatment outcomes and better program performance. The potential interventions include concentrated efforts for greater community involvement, appointing specialist counsellors, training and reorientation of service providers focusing on better quality of services and patient satisfaction, incentivising timely treatment completion and increasing the number of TUs in Wardha district.

Conflicts of interest

The authors have none to declare.

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REFERENCES

- Kim JY, Shakow A, Castro A, Vande C, Farmer P. Tuberculosis Control. World Health Organization. Available from: http://www.who.int/trade/distance_learning/gpgh/gpgh3/en/index1.html [cited 01.10.16].
- Central TB Division. *Reach, treat, cure TB. TB India 2015 RNTCP annual status report*. New Delhi: DGHS, Ministry of Health and Family Welfare, Government of India; 2015. Available from: <http://tbcindia.nic.in/showfile.php?lid=3166> [cited 15.09.16].
- Vasantha M, Gopi PG, Subramani R. Survival of tuberculosis patients treated under DOTS in a rural Tuberculosis Unit (TU), South India. *Indian J Tuberc*. 2008;55(April (2)):64–69.
- Kwon Y-S, Kim YH, Song J-U, et al. Risk factors for death during pulmonary tuberculosis treatment in Korea: a multicenter retrospective cohort study. *J Korean Med Sci*. 2014;29(September (9)):1226–1231.
- Miller TL, McNabb SJN, Hilsenrath P, Pasipanodya J, Weis SE. Personal and societal health quality lost to tuberculosis. *PLoS ONE*. 2009;4(4):e5080.
- Jha UM, Satyanarayana S, Dewan PK, et al. Risk factors for treatment default among re-treatment tuberculosis patients in India, 2006. *PLoS ONE*. 2010;5(January (1)):e8873. Available from: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0008873>.
- Santha T, Garg R, Frieden TR, et al. Risk factors associated with default, failure and death among tuberculosis patients treated in a DOTS programme in Tiruvallur District, South India, 2000. *Int J Tuberc Lung Dis*. 2002;6(9):780–788. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/12234133>.
- Shuldiner J, Leventhal A, Chemtob D, Mor Z. Mortality of tuberculosis patients during treatment in Israel, 2000–2010. *Int J Tuberc Lung Dis*. 2014;18(July (7)):818–823. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/24902558>.
- Babalik A, Kılıçaslan Z, Kızıldaş S, Gencer S, Ongen G. A retrospective case-control study, factors affecting treatment outcomes for Pulmonary Tuberculosis in Istanbul, Turkey. *Balkan Med J*. 2013;30(2):204–210. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/25207101>.
- Panjabi R, Comstock GW, Golub JE. Recurrent tuberculosis and its risk factors: adequately treated patients are still at high risk [review article]. *Int J Tuberc Lung Dis*. 2007;11(8):828–837.
- Garrido MDS, Penna ML, Perez-Porcuna TM, et al. Factors associated with tuberculosis treatment default in an endemic area of the Brazilian Amazon: a case control-study. *PLoS ONE*. 2012;7(January (6)):e39134.
- Vijay S, Kumar P, Chauhan LS, Vollepore BH, Kizhakkethil UP, Rao SG. Risk factors associated with default among new smear positive TB patients treated under DOTS in India. *PLoS ONE*. 2010;5(January (4)). Available from: <https://www.ncbi.nlm.nih.gov/pubmed/20386611>.
- Thirunavukarasu M, Lopamudra. Dongre A. Tuberculosis default: a qualitative exploration in rural Puducherry. *Natl J Res Community Med*. 2014;3(3):245–251. Available from: http://www.commedjournal.in/article/Volume3Issue3July-Sep2014/fulltext/Thiru_NJRCM_251.pdf.
- Central TB Division. *Revised National Tuberculosis Control Programme: Training Course for Program Manager (Modules 1–4)*. New Delhi: DGHS, Ministry of Health and Family Welfare, Government of India; 2011. Available from: <http://www.tbcindia.nic.in/index1.php?lang=1&level=3&sublinkid=4262&lid=2906> [cited 15.09.16].
- Directorate of Census Operations: Maharashtra. *Census of India 2011, Maharashtra; District Census Handbook, Wardha. Village and Town Wise Primary Census Abstract*. New Delhi: Registrar General and Census Commissioner, India; 2011. Available from: http://www.censusindia.gov.in/2011census/dchb/2708_PART_B_DCHB_WARDHA.pdf [cited 15.09.16].
- Woodward M. *Epidemiology: Study Design and Data Analysis*. 3rd ed. CRC Press; 2013. 27 pp..
- Kumar R, Deshmukh PR, Garg BS. Incidence and correlates of “Growth Faltering” among 0–6 y children: a panel study from rural Wardha. *Indian J Pediatr*. 2012;79(3):333–341.
- Mishra VK, Retherford RD, Smith KR. Biomass cooking fuels and prevalence of tuberculosis in India. *Int J Infect Dis*. 1999;3(3):119–129.
- Gadoev J, Asadov D, Tillashaykhov M, et al. Factors associated with unfavorable treatment outcomes in new and previously treated TB patients in Uzbekistan: a five year countrywide study. *PLOS ONE*. 2015;10(6).
- Liew SM, Khoo EM, Ho BK, et al. Tuberculosis in Malaysia: predictors of treatment outcomes in a national registry. *Int J Tuberc Lung Dis*. 2015;19(7):764–771.
- Horne DJ, Hubbard R, Narita M, Exarchos A, Park DR, Goss CH. Factors associated with mortality in patients with

- tuberculosis. *BMC Infect Dis.* 2010;10(January (1)):258. Available from: <http://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-10-258>.
22. Choi H, Lee M, Chen RY, et al. Predictors of pulmonary tuberculosis treatment outcomes in South Korea: a prospective cohort study, 2005–2012. *BMC Infect Dis.* 2014;14(January):360. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4094632/>.
 23. Rajeswari R, Chandrasekaran V, Suhadev M, Sivasubramaniam S, Sudha G, Renu G. Factors associated with patient and health system delays in the diagnosis of tuberculosis in South India. *Int J Tuberc Lung Dis.* 2002;6(9):789–795. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/12234134>.
 24. Storla DG, Yimer S, Bjune GA. A systematic review of delay in the diagnosis and treatment of tuberculosis. *BMC Public Health.* 2008;8(15):1–9. Available from: <https://bmcpubhealth.biomedcentral.com/articles/10.1186/1471-2458-8-15>.
 25. Dooley KE, Lahlou O, Ghali I, et al. Risk factors for tuberculosis treatment failure, default, or relapse and outcomes of retreatment in Morocco. *BMC Public Health.* 2011;11(January (1)):140.
 26. World Health Organization. *Tuberculosis control in South-East Asia Region: Annual report 2016*. New Delhi: World Health Organization; 2016. [http://dx.doi.org/10.1016/S0140-6736\(16\)00709-1](http://dx.doi.org/10.1016/S0140-6736(16)00709-1).
 27. Lönnroth K, Glaziou P, Weil D, Floyd K, Uplekar M, Raviglione M. Beyond UHC: monitoring health and social protection coverage in the context of tuberculosis care and prevention. *PLoS Med.* 2014;11(September (9)):e1001693.
 28. World Health Organization. *The END TB Strategy*. Geneva: World Health Organization; 2015.
 29. Central TB Division. *Revised National TB Control Programme: Technical and operational guidelines for Tuberculosis control in India 2016*. New Delhi: DGHS, Ministry of Health and Family Welfare; 2016. Available from: <http://tbcindia.nic.in/WriteReadData/Revised Technical and Operational Guidelines/index.html> [cited 15.09.16].
 30. Ministry of Petroleum and Natural Gas, Government of India. *Pradhan Mantri Ujjwala Yojana – Scheme Guidelines*. 2016. India. Available from: <http://www.petroleum.nic.in/docs/UJJWALA.pdf> [cited 15.11.16].