Section: Microbiology

Original Research Article

BURDEN AND GENDER-SPECIFIC PATTERNS OF TUBERCULOSIS, RIFAMPICIN RESISTANCE, AND TREATMENT DEFAULT IN SOUTH INDIA

S. Raj Arul Mercy[1], T. Sundarajan[2], G.Ruba[3], J.Sathiyanathan[4]

[1]Assistant professor, Department of Microbiology, Government Mohan Kumaramangalam Medical College, Salem, Tamilnadu, India.
[2]Associate professor, Department of Microbiology, Government Mohan Kumaramangalam Medical College, Salem, Tamilnadu, India.
[3]Laboratory technician, VRDL, Government Mohan Kumaramangalam Medical College, Salem, Tamilnadu, India.
[4]Data Operator, VRDL, Government Mohan Kumaramangalam Medical College, Salem, Tamilnadu, India.

Received : 10/03/2026
Received in revised form : 29/04/2026
Accepted : 14/05/2026

Keywords:
Drug resistance, Rifampin, Sex Factors, Tuberculosis, Treatment Adherence.

Corresponding Author:
Dr. S. Raj Arul Mercy,
Email: mercysebastian@ymail.com

DOI: 10.47009/jamp.2026.8.3.153

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (3); 851-855

ABSTRACT

Background: Tuberculosis (TB) remains a major public health concern in India, with significant variation across age and gender. In addition to disease burden, rifampicin resistance and treatment default continue to challenge TB control programs. This study aimed to assess the burden and gender-specific patterns of tuberculosis, including rifampicin resistance and treatment default, across different age groups in a hospital-based population in South India. **Materials and Methods:** This retrospective observational study included 15,200 patients diagnosed with tuberculosis and registered under the National Tuberculosis Elimination Programme at a government tertiary care hospital in South India from January 2020 to December 2023. Data on age, sex, rifampicin resistance status, and treatment outcomes were collected from hospital records. Patients were categorised by age groups and gender. Data were analysed using descriptive statistics and presented as frequencies and percentages. **Results:** Among 15,200 patients, 67.1% were males and 32.9% were females (male-to-female ratio 2:1), with a mean age of 44.8 ± 10 years. Rifampicin-sensitive TB accounted for 96.3% of cases, while 2.69% were rifampicin-resistant and 1.06% were treatment defaulters. Males showed higher rifampicin resistance (2.9% vs. 2.2%) and default rates (1.04% vs. 0.93%) compared to females. The highest TB burden was observed in males aged 41–50 years and females aged 21–30 years. Rifampicin resistance and treatment default were predominantly seen in young and middle-aged adults. **Conclusion:** Tuberculosis burden, rifampicin resistance, and treatment default demonstrate distinct age- and gender-specific patterns, with higher vulnerability among middle-aged males. Targeted demographic-specific interventions are essential to improve TB control outcomes.

INTRODUCTION

Tuberculosis (TB) is an important health problem worldwide, with approximately 10.8 million new cases and 1.2 million deaths per year, making TB the leading cause of death from a single infectious disease in low- and middle-income countries, especially Southeast Asia (44%), Africa (25%), and the Western Pacific (18%).[1,2] Tuberculosis control programs have achieved great progress globally, with a 24% decrease in TB deaths, and successful treatment interventions have reduced the mortality rate to 37%. Drug-resistant TB is one of the major barriers to the elimination of tuberculosis with over 6,00,000 rifampicin-resistant cases annually.[3,4] Among drug-resistant TB, Rifampicin-resistant TB (RR-TB) is an important global health problem that requires urgent early detection and risk stratification for TB control.

RR-TB is defined as resistance to rifampicin (a first-line anti-TB agent) which necessitates the use of longer and more complex treatment regimens than those for drug-susceptible disease.[5,6] Over 0.5 million new RR-Tb cases were reported worldwide, and around 0.15 million cases were notified, with one-third detected and treated annually. This is an alternative measure for multidrug-resistant TB (MDR-TB), as most rifampicin-resistant isolates also exhibit isoniazid resistance.[6,7] Clinical diagnostics include prolonged treatment duration, increased toxicity, increased costs, and poor outcomes, and the

ISSN (O): 2687-5365; ISSN (P): 2753-6556

implementation of molecular diagnostics, such as Xpert MTB/RIP which enables rapid detection, remains inconsistent.[5,8] Demographic factors such as male sex and young adulthood significantly influence the TB rate and drug resistance, which shows that there is a need for sex- and age-differentiated intervention in RR-TB. Treatment adherence remains a critical component of tuberculosis control. Treatment default contributes to ongoing transmission, disease recurrence, and the emergence of drug resistance. Studies have shown that default rates vary across demographic groups, with higher rates often observed among males and working-age populations. Understanding these patterns is essential for strengthening programmatic interventions.

The diagnosis of TB was reported in approximately 70% of males worldwide, with a test positivity of 47% in males versus 39% in females.[9] However, DR-TB's sex differentiation is reported minimally across 106 countries, with a male-to-female risk ratio of 1.04, although males reported increased risk in high-burden settings, such as the Soviet Union (1.16).[10] Age patterns showed differences in vulnerability, with younger adults in the 15-40 years age range showing higher MDR/RR-TB rates in 52-58% of cases, while older patients reported a higher rate of drug-susceptible TB in 44% of cases in >60 years of age.[11] In South Korea, MDR/RR-TB decreased significantly from 8.6% in younger patients to 3.3% in older patients. Gender differences in DR-TB showed the importance of demographic stratification for prevention and treatment strategies.[12,13]

Although global data exist on tuberculosis and rifampicin resistance, there is limited literature integrating overall TB burden, drug resistance, and treatment outcomes across age and sex. Most studies focus either on resistance patterns or overall incidence without detailed demographic stratification. In India, despite widespread implementation of universal drug sensitivity testing, region-specific analyses incorporating treatment default and demographic variation remain scarce, particularly in tertiary care settings in South India.

Aim

This study aimed to assess the burden and gender-specific patterns of tuberculosis, including rifampicin resistance and treatment default, across different age groups in a hospital-based population in South India.

MATERIALS AND METHODS

This retrospective cohort observational study was conducted in patients registered under the National Tuberculosis Elimination Programme who attended a government tertiary care hospital in Salem, South India, from January 2020 to December 2023. Ethical approval was obtained from the Institutional Ethics Committee prior to the data collection.

Inclusion and Exclusion criteria

This study included patients of either sex diagnosed with tuberculosis during the study period who underwent upfront Xpert MTB/RIF testing and were registered under the National Tuberculosis Elimination Programme. Patients with incomplete records, missing rifampicin resistance status, or inadequate documentation of demographic and clinical details were excluded.

Methods

Data of patients (N=15,200) who underwent standard diagnostic evaluation, including upfront Xpert MTB/RIF testing, were retrieved from hospital records. Demographic details, including age, sex, clinical history, and rifampicin resistance status, were recorded. Patients were categorised based on their tuberculosis status and rifampicin resistance patterns. Data were presented as mean, standard deviation, frequency, and percentage.

RESULTS

Among 15,200 patients, 10,185 (67.1%) were men and 5,015 (32.9%) were women, with a male-to-female ratio of 2:1, and the mean age of the patients was 44.8 ± 10 years. [Table 1]

Table 1: Baseline Demographic Characteristics

		N (%)
Gender	Male	10,185 (67.1%)
	Female	5,015 (32.9%)
	Male: Female ratio	2:1
Mean age (in years)		44.8 ± 10

Among male patients with rifampicin-resistant Among males, 9,784 (96.06%) were rifampicin-sensitive, 295 (2.9%) were rifampicin-resistant, and 106 (1.04%) were defaulters. For females, 4,853 (96.7%) were rifampicin-sensitive, 115 (2.2%) were rifampicin-resistant, and 47 (0.93%) were defaulters. Males had higher rifampicin resistance and defaulter rates, whereas females showed higher sensitivity. [Table 2]

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 2: Gender-wise Distribution of Rifampicin Status

		N (%)		
		Rifampicin Sensitive	Rifampicin Resistant	Defaulters
Gender	Male	9,784 (96.06%)	295 (2.9%)	106 (1.04%)
	Female	4,853 (96.7%)	115 (2.2%)	47 (0.93%)

In ages 0-10, males were 28 (0.27%) males and 13 (0.26 %) females. For ages 11-20, females were 146 females (2.91%) versus males 212 (2.08%). In ages 21-30, females were 2,545 females (50.75%) and 2,244 males (22.03 %). For ages 31-40, males were 2,256 males (22.16%) versus females 842 (16.79%). In ages 41-50, males were 4,763 (46.77%) males and 1,296 (25.84%) females. For the ages of 51-60, males were 543 (5.33%) males and 122 (2.43%) females. In ages 61-70, males were 139 (1.36%) were men and 51 (1.02%) were women. [Table 3]

Table 3: Age Group Distribution According to Gender

		Gender N (%)	
		Male	Female
Age Group (in years)	0-10	28 (0.27%)	13 (0.26%)
	11-20	212 (2.08%)	146 (2.91%)
	21-30	2,244 (22.03%)	2,545 (50.75%)
	31-40	2,256 (22.16%)	842 (16.79%)
	41-50	4,763 (46.77%)	1,296 (25.84%)
	51-60	543 (5.33%)	122 (2.43%)
	61-70	139 (1.36%)	51 (1.02%)

In the 0-10 age group, all male 28 (0.29%) and female 13 (0.27%) patients were rifampicin-sensitive. In the 11-20 years, sensitivity was observed in 211 (2.16%) males and 140 (2.89%) females, with resistance in two (1.74%) females only. For 21-30, rifampicin-sensitive patients were 2,123 (21.70%) males and 2,528 (52.09%) females with rifampicin-sensitive TB, with higher resistance in males 114 (38.64%) than in females at 14 (12.17%). In the 31-40, sensitivity was higher in males at 2,186 (22.34%) than in females at 790 (16.28%), while resistance was more common in females at 22 (19.13%) than in males at 38 (12.88%).

For the 41-50, sensitive cases were mainly male at 4,560 (46.62%) versus 1,204 (24.81%) females, with resistance higher in males at 139 (47.12%) and females at 78 (67.83%). In the 51-60, sensitivity was observed in 536 (5.48%) men and 121 (2.49%) women, with resistance in 4 (1.36%) men and 1 (0.87%) woman. In the 61-70, all were rifampicin-sensitive: 139 (1.42%) males and 51 (1.05%) females. [Table 4]

Table 4: Age- and Gender-wise Distribution of Rifampicin Sensitivity and Resistance

		Gender N (%)			
		Rifampicin Sensitive		Rifampicin Resistant	
		Male	Female	Male	Female
Age Group (in years)	0-10	28 (0.29%)	13 (0.27%)	0	0
	11-20	211 (2.16%)	140 (2.89%)	0	2 (1.74%)
	21-30	2,123 (21.70%)	2,528 (52.09%)	114 (38.64%)	14 (12.17%)
	31-40	2,186 (22.34%)	790 (16.28%)	38 (12.88%)	22 (19.13%)
	41-50	4,560 (46.62%)	1,204 (24.81%)	139 (47.12%)	78 (67.83%)
	51-60	536 (5.48%)	121 (2.49%)	4 (1.36%)	1 (0.87%)
	61-70	139 (1.42%)	51 (1.05%)	0	0

No defaulters occurred in the 0-10 and 61-70 age groups for either sex. In 11-20, female defaulters were 4 (8.51%) versus males 1 (0.94%). The 21-30 group showed defaulter rates of 7 (6.60%) for males and 3 (6.38%) for females. In the 31-40 age group, female defaulters were higher at 30 (63.83%) versus males at 32 (30.19%). For 41-50, male defaulters were higher at 64 (60.38%) compared to females at 14 (29.79%). Ages 51-60 had only male defaulters (n = 3, 2.83%). [Table 5]

Table 5: Age- and Gender-wise Distribution of Defaulters

		Gender N (%)	
		Male	Female
Age Group (in years)	0–10	0	0
	11–20	1 (0.94%)	4 (8.51%)
	21–30	7 (6.60%)	3 (6.38%)
	31–40	32 (30.19%)	30 (63.83%)
	41–50	64 (60.38%)	14 (29.79%)
	51–60	3 (2.83%)	0
	61–70	0	0

ISSN (O): 2687-5365; ISSN (P): 2753-6556

DISCUSSION

Our study revealed a prominent male preponderance, with twice as many male patients as female patients. Tuberculosis mainly affects middle-aged individuals in the economically active age group. Dhamnetiya et al., in their study on the TB burden in India (1990-2019) revealed a higher morbidity and mortality rate of TB in males.[14] Seifert et al., in their study of 332,657 Xpert MTB/RIF test results from Myanmar, reported that 70% of TB cases were males, with positivity rates of 47% and 39% in males and females. However, the pattern differed in terms of age, with Seifert et al. reporting the highest positivity in the 16-20 years age group.[9] Moon et al., in their study of 148,055 patients with TB in South Korea, reported that among patients aged ≥65 years, 48.2% were female and 38.1% were males.[15] These studies thus support the predominance of males in TB but vary in their pattern of age distribution. The predominance of males with a peak incidence in middle-aged patients suggests that tuberculosis in this South Indian population affects economically active males.

In our study, rifampicin-sensitive tuberculosis was the most common in both sexes, with resistance being more common in males. Treatment default was more prevalent in males, whereas rifampicin sensitivity was slightly higher in females. In a global analysis of 106 countries, there was no significant difference in the risk of MDR/RR-TB between the sexes (M:F ratio 1.04, 95% CI 0.97-1.11), with males having a higher risk only in high-burden countries.[10] In a study from Myanmar, rifampicin resistance was found to be higher in females (11.4% vs. 9.3% in males). 9 In a meta-analysis of 11 studies, there was no significant difference in treatment default between the sexes, although women were less likely to be lost to follow-up (OR 0.52).[16] In studies conducted in India and Nepal, women had lower rates of unfavourable treatment outcomes, while males were more common in RR-TB.[17,18] The increased burden of rifampicin resistance and treatment default in males indicates gender-related vulnerability, although this may be dependent on the setting.

In our study, rifampicin sensitivity was observed across age groups, with resistance predominantly observed in young and middle-aged adults. Among younger adults, resistance was more common in men, whereas middle-aged women showed higher resistance. Peak resistance occurred in middle age for both sexes. Seifert et al. found that young adults were more rifampicin resistant, with females showing higher resistance (11.4%) than males (9.3%).[9] Lee et al. (2020) reported that MDR/RR-TB rates decreased with age, from 8.6% (15-34 years) to 3.3% (≥60 years).[12] McQuaid et al. found a similar MDR/RR-TB risk between the sexes globally, although males faced an increased risk in high-burden countries. The concentration of resistance in young and middle-aged adults suggests that transmission- or treatment-related factors drive resistance in active populations.[10] Together, these observations indicate that tuberculosis burden, resistance, and treatment adherence are closely linked and vary across demographic groups.

In our study, treatment default was absent in the youngest and oldest age groups and occurred mainly in young and middle-aged adults with gender variations. Females showed a higher default in early adulthood, whereas males showed a higher default in middle age. Defaults were minimal in the later decades, mostly among males. Dey et al. found 81.6% of defaulters were aged 15-59 years, with a higher male risk.[19] Barathi et al. showed male sex association with unfavourable TB outcomes was mediated through treatment adherence. The clustering of defaults within economically productive age groups suggests that adherence challenges are more pronounced during active adult years and are shaped by social and behavioural determinants. 20 These patterns emphasise the importance of gender- and age-specific strategies in tuberculosis control programs.

CONCLUSION

Tuberculosis shows a clear male predominance, with the highest burden observed in middle-aged individuals. Rifampicin resistance and treatment default were more common among males and were concentrated in economically productive age groups. In contrast, females showed higher rifampicin sensitivity and a relatively lower default rate. These findings indicate that tuberculosis burden, drug resistance, and treatment adherence are closely linked and vary across age and gender. Targeted, gender- and age-specific interventions focusing on early detection and improved treatment adherence are essential to strengthen tuberculosis control efforts.

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ISSN (O): 2687-5365; ISSN (P): 2753-6556

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ISSN (O): 2687-5365; ISSN (P): 2753-6556