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Beyond Cure: Post-Treatment Survival and Health Outcomes Among Pulmonary Tuberculosis Survivors in Rural India

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ABSTARCT

Background: Tuberculosis (TB) remains a major public health challenge in India, particularly in rural areas. While successful treatment is marked by microbiological cure, many individuals continue to face long-term physical and emotional health complications. Globally and nationally, post-treatment outcomes are gaining attention due to their impact on quality of life, relapse risk, and mortality. Recognizing factors associated with survival and post-treatment health is essential for targeted follow-up and support. This study aimed to assess the post-

treatment survival and health status of pulmonary tuberculosis (TB) patients and to identify factors influencing these outcomes.

Methods: A retrospective descriptive design was used. The study was conducted among 200 pulmonary TB patients who had completed treatment at selected villages in Ramanagara district, Bangalore. Data were collected using a structured questionnaire covering socio-demographic details, treatment adherence, clinical variables, post-treatment survival, and health status including clinical, functional, and emotional domains. Descriptive and inferential statistics were used for analysis, including chi-square tests for associations.

Results: Among the 200 patients, 96.5% were alive and 3.5% had died post-treatment. Most patients (90.7%) had optimum clinical health, 58% showed high functional ability, and 93.8% reported only mild emotional symptoms. Statistically significant associations were found between post-treatment survival and age, occupation, and income. Post-treatment health status was significantly influenced by ventilation, hypertension, smoking, and tobacco chewing. Clinical variables such as BMI and type of medication were not significantly associated with health outcomes.

Conclusions*:* Post-treatment survival was high among pulmonary TB patients, but several continued to experience health limitations. Socio-demographic factors, comorbidities, and personal habits played a crucial role in determining long-term health outcomes. Emphasis on follow-up care, lifestyle modification, and supportive interventions is essential for improving the quality of life of TB survivors.

Key words: Tuberculosis, survival, post-treatment health status, retrospective study, rural population, comorbidities.

BACKGROUND

Tuberculosis (TB) remains a significant global public health concern and continues to carry social stigma in many regions. While successful treatment is marked by microbiological cure, many individuals continue to face long-term physical and emotional health complications. Globally and nationally, post-treatment outcomes are gaining attention due to their impact on quality of life, relapse risk, and mortality. Recognizing factors associated with survival and post-treatment health is essential for targeted follow-up and support [1,2,3].

A successful treatment course for patients with tuberculosis (TB) has typically been considered the ultimate point of treatment. Nonetheless, recent findings reveal that microbiological recovery does not necessarily lead to full recovery. In many cases, persons who have recovered from pulmonary TB still suffer from persistent disabilities which persist for months or years after their treatment is completed. This condition, termed the post-tuberculosis sequelae , has become a matter of major public health significance [4,5].

Post-TB disease involves a wide range of chronic illnesses that arise from the damage caused by tuberculosis to the lungs, general inflammation, and the disease itself. Post-TB patients often suffer from chronic respiratory complaints, compromised lung functions, low exercise capacity, fatigue, and poor health-related quality of life. In addition to the physical manifestations, post-TB sufferers still struggle with issues of depression, anxiety, social isolation, stigmatization, and poverty, among others, which have a negative impact on their well-being and re-integration within their families and communities [1,5,6,7,8,9,10]. For this reason, the definition of health by the WHO as "complete physical, mental, and social well-being" stresses the need for a holistic treatment of the disease [11].

Recent international research findings have revealed that individuals who survive from TB continue to have a significantly higher likelihood of premature death as compared to their

counterparts in the general population despite being successfully treated for their disease. Various longitudinal studies have shown continued excess deaths resulting from chronic respiratory illness, heart-related problems, repeated cases of tuberculosis, and other medical conditions [2,3,12,13]. Further, systematic literature reviews have identified various factors such as age, poor nutritional status, smoking, diabetes mellitus, economic poverty, and late access to health services to be responsible for poor post-treatment outcomes [4].

Despite this, India remains the country with the largest prevalence of tuberculosis worldwide and thus forms a major part of the global challenge posed by post-TB morbidity [14,15]. The National Tuberculosis Eradication Programme (NTEP) has done tremendously well in offering diagnostic tests, providing free medications and improving the success rate of treatments offered. However, most of the program indicators still measure the microbiological and therapeutic outcomes and not much is said about the well-being of those who have completed their treatment [16].With an increasing number of individuals recovering from TB infections, the impact of this illness must be assessed more seriously.

These difficulties may be further compounded for rural communities in the recovery process following treatment. Insufficient access to healthcare, poverty, poor housing conditions, inadequate ventilation, malnutrition, occupation, tobacco smoking, and lack of access to rehabilitation facilities are some of the elements that may have an adverse effect on the health status of patients following their recovery from TB [17,18]. Such elements are especially prevalent in rural areas of India where patients tend to engage in strenuous activity almost immediately following their treatment due to respiratory weakness.

These unmet needs require the active participation of community health nurses. The scope of their duties is not only about ensuring that patients adhere to their therapy regimen but also conducting a thorough evaluation after treatment, detecting signs of ongoing infection, follow-

ups in the domestic environment, health education, nutrition counselling, smoking cessation, psychosocial support, family counselling, environmental evaluation, and referral for rehabilitation purposes. Nursing interventions in the community can help in facilitating recovery, enhancing patient management skills, minimizing any possible complications and improving the quality of life of people who survived TB [1].

Even with the growing awareness of the post-TB state among the international community, there still seems to be an inadequacy of evidence coming from India, specifically, multidimensional health-related outcomes of rural TB patients. The majority of evidence obtained so far seems to have concentrated more on TB therapy-related variables like outcomes of treatment, relapses, or mortality rates, while only a small proportion have considered the impact on community-based health, functional status, psychosocial outcome, and survival [5,12,19]. Moreover, there appears to be a gap in evidence with regards to the effects of demographic factors, environmental factors, lifestyle, and comorbidity on recovery of TB patients in rural areas.

Filling these knowledge gaps is important to facilitate the development of a holistic approach to designing community interventions, which will take TB treatment efforts beyond the point of treatment completion. Knowledge of the factors affecting the process of recovery after TB treatment will help community health nurses identify high-risk persons and intervene by promoting healthy living.

Consequently, this research project was designed to measure the survival rate and multidimensional health status of pulmonary TB patients living in selected rural areas of Ramanagara district in Karnataka. The objective of the research was to find out survival rate after treatment, assess their clinical, functional, and psychological health status, and identify the factors influencing their post-treatment condition. The results of the research are anticipated

to provide information that can be used for the development of community-based follow-up programs led by nurses.

METHODS

Study Design

A community-based, retrospective descriptive study was carried out in order to evaluate the survival and health status of the adults who have undergone successful treatment for pulmonary TB. The study was carried out in accordance with the STROBE guidelines for observational studies.

Setting

This study was conducted in selected villages of Ramanagara District, Karnataka, India. These villages were chosen based on the availability of treated TB patients and accessibility for data collection. It is mainly a rural setting where farming is the main occupation, and the provision of community health services is done through primary health care centres and community health workers. The study was carried out from January 2025 to April 2025.

Participants

The participants for the study involved adults who have been under treatment for bacteriologically confirmed pulmonary tuberculosis from January 2020 to January 2025. Potential participants for the study were identified from the treatment registers of the National Tuberculosis Elimination Programme (NTEP) at the Community Health Centre.

Criteria for participation in the study included age 18 years or above, completion of the treatment for tuberculosis, residency in the study site, and willingness to take part in the study. Exclusion criteria for the study included diagnosis of extrapulmonary tuberculosis, severe mental disorders that prevented participation, critical illnesses, and unavailability despite multiple home visits.

Sample Size and Sampling

A sample of 200 participants who met the inclusion criteria were selected for the study. The sample size for the present retrospective study was determined using Cochran's formula to ensure adequate statistical power and representativeness. Since the total number of post treatment pulmonary tuberculosis (TB) patients in the selected villages were known and finite, the finite population correction was applied to refine the sample size.

Initially, the sample size was calculated using Cochran's formula:

For a population proportion, we can use the Cochran formula:

$$n^0 = \frac{Z^2 P(1-P)}{d^2}$$

Where:

n^0 =required sample size for infinite population.

Z = 1.96 (Z-score for 95% confidence level)

P = 0.5 estimated proportion of TB patients with a certain outcome

d = 0.05 (margin of error 0.05 or 5%)

$$n^0 = \frac{(1.96)^2 . 0.5(1-0.5)}{(0.05)^2}$$

$$= \frac{3.8416.0.25}{0.0025} = 384.16$$

The initial sample size for an infinite population was 384.

Since the actual population of interest (N) was 412 patients, the sample size was adjusted using the Finite Population Correction (FPC) formula:

$$n = \frac{384}{1 + \frac{384-1}{412}} = \frac{384}{1 + \frac{383}{412}}$$

$$= \frac{384}{1.9296} = 199.1$$

For a total population of 412, the adjusted sample size calculation is 199.1.

Thus, it is rounded up to 200 to ensure adequate representation

Data Collection Instruments

A structured questionnaire was used as the primary tool for data collection in this study. It consisted of six sections, each designed to gather specific types of information from patients who had completed tuberculosis treatment. Section A consists of Socio-demographic variables(6 items), Section B: Structured Questionnaire on Factors influencing Survival & Health Status(7 items), Section C: Self-reported checklist on Adherence to Tuberculosis Treatment(8 items), Section D: Structured questionnaire on Clinical Variables(6 items), Section E: Self-reported questionnaire on Post-Treatment Survival(6 items), Section F: Self-reported questionnaire on Health Status after treatment(Clinical assessment-7 items ,Functional assessment-5 items, Mental & emotion assessment -5 items).The questionnaire was developed specifically for this study by the researchers based on study objectives and variables. It was not published anywhere as a standalone questionnaire. The English language version of the questionnaire is provided as supplementary file 1.

The content validity and reliability of the tools were established before data collection. The content validity was established by submitting tool to 7 experts. As per the suggestions of the experts, modifications were made in the tool. The researcher used Cronbach's alpha method for scale-based items and split half method for dichotomous items.

Data Collection procedure

With permission from the district health authorities, identification of potential candidates was done from the NTEP treatment files. House visits were made by the lead researcher at a pre-scheduled time with each of the study participants.

Prior to data collection, the investigator provided an explanation of the study's nature to the participants, along with a Participant Information Sheet. Written informed consent was then

obtained from the participants, with assurances of confidentiality and anonymity of the provided information.

Face-to-face interviews were conducted with the help of the structured questionnaire and lasted for about 30-40 minutes. Information related to treatment history and clinical characteristics was cross verified with available medical records whenever possible.

Ethical Considerations

Ethical clearance was taken from the Institutional Ethics Committee before conducting the study (Approval No.: DSU/NSG/071/2025). Permission was taken from the District Health Officer and the Medical Officer of the Community Health Centre.

The study adhered to the ethical principles mentioned in the Declaration of Helsinki and the Indian Council of Medical Research (ICMR) National Ethical Guidelines for Biomedical and Health Research Involving Human Participants. Informed written consent was taken from all participants before taking part in the study; for participants who were illiterate, informed consent was obtained from their legal guardians. Participation in the study was entirely voluntary, and the participants were made aware of their right to discontinue participation in the study at any time without any implications on their health care.

Data Analysis

The data were analysed using IBM SPSS Statistics software (version 26.0; IBM Corporation, Armonk, NY, USA). The descriptive statistics included frequency, percentage, mean, and standard deviation for various participant characteristics and outcomes after treatment.

The associations between survival after treatment, multidimensional health condition, and some demographic, environmental, lifestyle, and clinical factors were determined using the Pearson's chi-square test or Fisher's exact test, as applicable. The two-sided p value of <0.05 was considered statistically significant.

RESULTS

Participants Demographic Characteristics

The study included a total of 200 pulmonary tuberculosis patients who have been cured between January 2020 and January 2025. Majority of the participants (75.5%) were males above 50 years old, with highest percentage from the 51-60 years age category. Almost all the participants (88.5%) were married, with most participants being educated up to secondary level. Most participants earned between ₹10,000- ₹20,000 per month and were working as farmers or manual labourers. Table 1 provides information on participant characteristics.

Table 1: Participants demographic characteristics

n=200

Sociodemographic variables	Frequency(n)	Percentage (%)
Age in years, Med (IQR)	43	32-56
Gender		
Male	151	75.50
Female	49	24.50
Educational level		
No formal education	43	21.50
Primary	49	24.50
Secondary	60	30.00
Diploma and above	48	24.00
Marital status		
Married	177	88.50
Single	14	7.00
Widow	9	4.50

Occupation		
Employed	70	35.00
Farmer	65	32.50
Business	35	17.50
Housewife	30	15.00
Income		
<10,000	10	5.00
10,000–20,000	90	45.00
20,001–30,000	65	32.50
>30,000	35	17.50

Clinical and Environmental Characteristics

Most subjects were on first line therapy HRZE, while nearly one-third was receiving treatment based on DOTS protocol. The commonest radiological manifestation at time of diagnosis was miliary tuberculosis, and most subjects had sputum acid fast bacilli positivity. More than half of the subjects had normal body mass index.

In terms of environment, all the subjects belonged to rural areas and stayed in permanent houses. Most households had sufficient room size and ventilation. The most commonly associated comorbidities among the subjects were hypertension and diabetes. The most commonly associated lifestyle risk factors were smoking and smokeless tobacco use, while alcohol use was less common. Clinical and environmental features have been described in detail in Tables 2 and 3.

Table 2: Clinical characteristics

n=200

Clinical Variables	Frequency (n)	Percentage (%)
Medication Regimen		
HRZE regimen	126	63.00
DOTS	74	37.00
Common Side Effects*		
Fatigue	135	67.50
Loss of appetite	97	48.50
Indigestion	85	42.50
Gastritis	46	23.00
Peripheral neuropathy	5	2.50
Chest X-ray Findings		
Miliary tuberculosis	101	50.50
Cavitation	46	23.00
Infiltrates	37	18.50
Consolidation	16	8.00
Sputum AFB Results		
Positive	161	80.50
Scanty	39	19.50
Body Mass Index (BMI)		
Underweight	69	34.50
Normal weight	125	62.50
Overweight	6	3.00
Weight Loss After Treatment		
None	127	63.50
Slight	62	31.00
Significant	11	5.50
Adherence to treatment		
Good	192	96.00
Moderate	8	4.00

*Multiple responses were possible for side effects; therefore, percentages do not total 100%.

Table 3: Environmental, lifestyle and comorbidity characteristics

Variable	Category	Frequency (n)	Percentage (%)
Place of residence	Rural	200	100.0
Type of family	Nuclear	121	60.5
	Joint	79	39.5
Type of house	Pucca	200	100.0
Room availability	Adequate	180	90.0
	Inadequate	20	10.0
Ventilation	Adequate	176	88.0
	Inadequate	24	12.0
Comorbidities	None	121	60.5
	Hypertension	53	26.5
	Diabetes mellitus	31	15.5
	HIV infection	1	0.5
	Chronic obstructive pulmonary disease (COPD)	1	0.5
Personal habits	None	108	54.0
	Smoking	88	44.0
	Alcohol consumption	33	16.5
	Tobacco chewing	32	16.0

Note: Categories under personal habits are not mutually exclusive; therefore, percentages may not total 100%.

Post-Treatment Survival Among Pulmonary Tuberculosis Survivors

The survival of the patients after the treatment process was relatively high. A total of 193 people (96.5%) survived during follow-up while seven people (3.5%) died after undergoing treatment. The majority of the participants underwent anti-tuberculosis treatment process within six months and had no problems such as recurrence during follow up period. The causes of death among the seven people that died included respiratory failure, chronic obstructive pulmonary disease,

tuberculosis recurrence and stroke. A detailed description of survival outcomes is provided in Figure1, 2 and 3

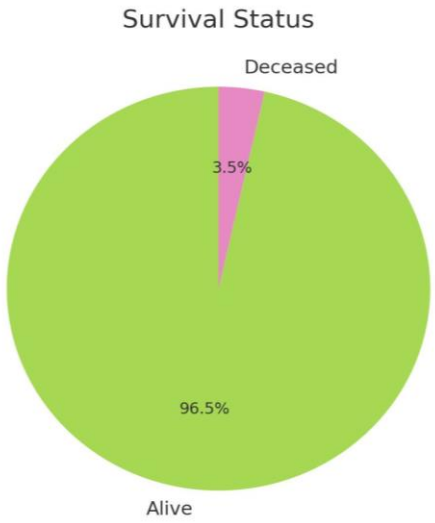


Figure 1: Pie diagram showing Survival Status

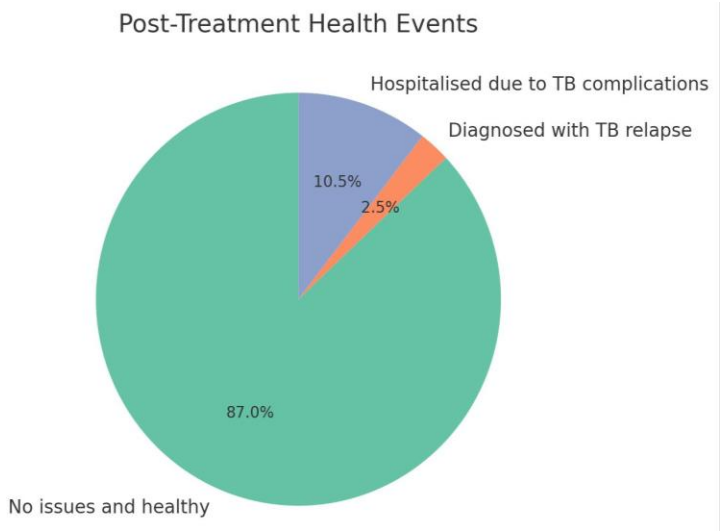


Figure 2: Pie diagram showing post treatment health events

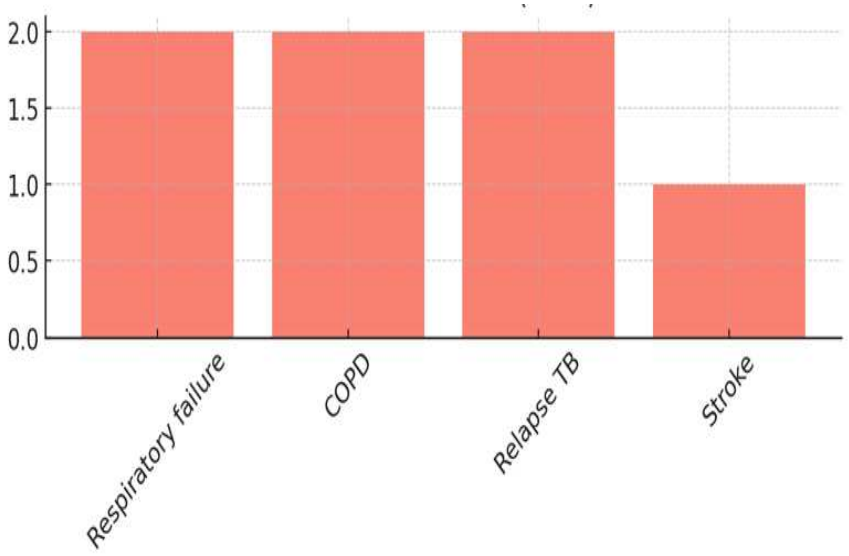


Figure 3: Bar chart showing causes of death

Post-Treatment Health Status

Out of the 193 participants who survived after the treatment period, most showed positive results on their recovery status. Over 90% were at optimal clinical health, more than half of them had good functional health status, and most of them exhibited mild emotional problems. While recovery results were mostly positive, there were some participants who had continuing functional and emotional problems even after the treatment period. Overall, the data suggest that a substantial proportion of patients achieved favourable clinical, functional, and psychological recovery following tuberculosis treatment. Clinical, functional, and emotional health outcomes are shown in Figure 4 and 5.

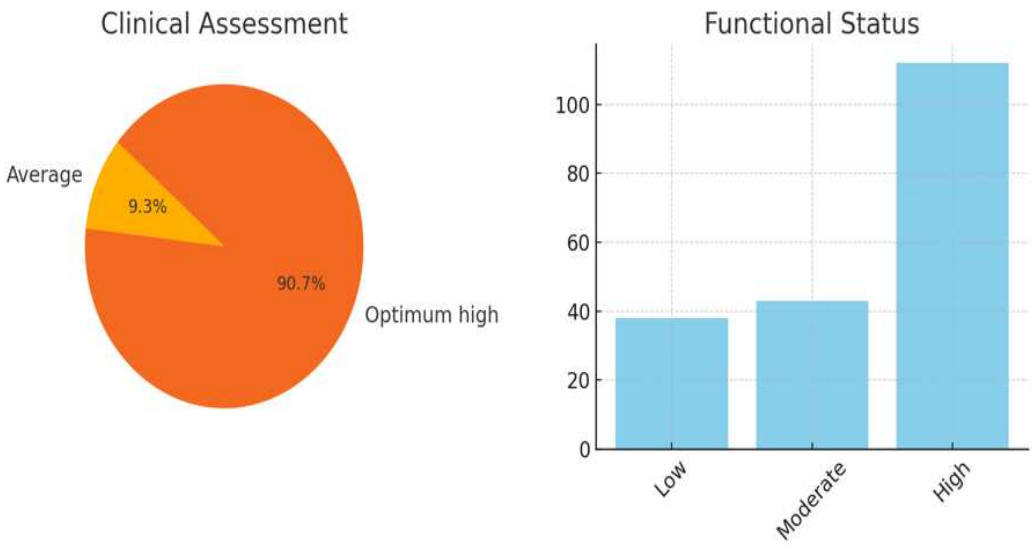


Figure 4: Clinical and functional health outcomes

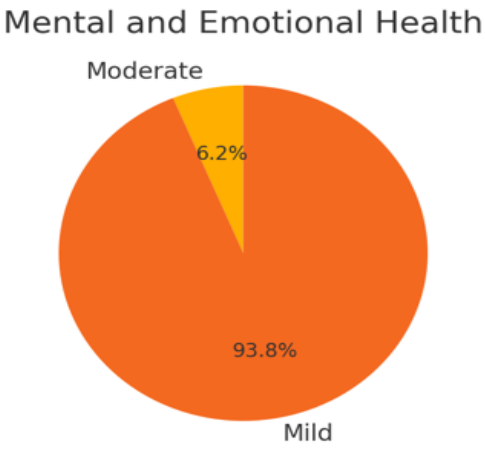


Figure 5: Mental and Emotional health outcomes

Association between post treatment survival with Selected demographic variables

Significant associations were observed with age, occupation, monthly family income, diabetes mellitus, chronic obstructive pulmonary disease (COPD), smoking, and tobacco chewing ($p < .05$). Mortality was more frequent among participants aged >50 years, farmers, those with lower

monthly family income, and individuals with diabetes, COPD, smoking, or tobacco chewing habits. No significant associations were found between survival status and gender, hypertension, HIV infection, or alcohol consumption ($p > .05$). (Table 4).

Table 4: Association between post treatment survival with Selected variables.

Variable	Category	Alive n (%)	Deceased n (%)	χ^2	p-value
Age (years)	≤50	135 (69.9)	0 (0.0)	15.20	<0.001*
	>50	58 (30.1)	7 (100.0)		
Gender	Male	145 (75.1)	6 (85.7)	0.41	0.522
	Female	48 (24.9)	1 (14.3)		
Occupation	Employed	67 (34.7)	0 (0.0)	8.70	0.013*
	Farmer	56 (29.0)	6 (85.7)		
	Business	37 (19.2)	0 (0.0)		
	Housewife	33 (17.1)	1 (14.3)		
Monthly family income (₹)	<10,000	11 (5.7)	0 (0.0)	8.40	0.036*
	10,000–20,000	85 (44.0)	7 (100.0)		
	20,001–30,000	64 (33.2)	0 (0.0)		
	>30,000	33 (17.1)	0 (0.0)		
Diabetes mellitus	Yes	26 (13.5)	5 (71.4)	17.32	<0.001*
	No	167 (86.5)	2 (28.6)		
Hypertension	Yes	51 (26.4)	2 (28.6)	0.02	0.899
	No	142 (73.6)	5 (71.4)		
HIV infection	Yes	1 (0.5)	0 (0.0)	0.04	0.849
	No	192 (99.5)	7 (100.0)		
COPD	Yes	0 (0.0)	1 (14.3)	27.71	<0.001*
	No	193 (100.0)	6 (85.7)		
Smoking	Yes	82 (42.5)	6 (85.7)	5.12	0.024*
	No	111 (57.5)	1 (14.3)		
Alcohol consumption	Yes	30 (15.5)	3 (42.9)	3.66	0.056
	No	163 (84.5)	4 (57.1)		
Tobacco chewing	Yes	27 (14.0)	5 (71.4)	16.58	<0.001*
	No	166 (86.0)	2 (28.6)		

Statistically significant at $p < 0.05$

Association Between Selected Variables and Post-Treatment Health Status Among Pulmonary Tuberculosis Survivors

Significant associations were observed with age, occupation, family income, household ventilation, hypertension, smoking, and tobacco chewing ($p < .05$). Older participants, farmers, those with lower income, individuals with inadequate household ventilation, hypertension, smoking, and tobacco chewing were more likely to have poorer post-treatment health. No significant associations were found with gender, treatment regimen, chest radiographic findings, sputum acid-fast bacilli status, body mass index, family type, room availability, diabetes mellitus, HIV infection, or alcohol consumption ($p > .05$) (Table 5).

Table 5: Association Between Selected Variables and Post-Treatment Health Status Among Pulmonary Tuberculosis Survivors (N = 193)

Variable	Category	Average Health n (%)	Optimum Health n (%)	χ^2	p-value
Age (years)	≤50	3 (16.7)	132 (75.4)	15.20	<0.001*
	>50	15 (83.3)	43 (24.6)		
Gender	Male	15 (83.3)	130 (74.3)	0.41	0.569
	Female	3 (16.7)	45 (25.7)		
Occupation	Employed	1 (5.6)	66 (37.7)	8.70	<0.001*
	Farmer	14 (77.8)	42 (24.0)		
	Business	0 (0.0)	37 (21.1)		
	Housewife	3 (16.7)	30 (17.1)		
Monthly family income (₹)	<10,000	8 (44.4)	3 (1.7)	8.40	<0.001*
	10,000–20,000	8 (44.4)	77 (44.0)		
	20,001–30,000	2 (11.1)	62 (35.4)		
	>30,000	0 (0.0)	33 (18.9)		

Variable	Category	Average Health n (%)	Optimum Health n (%)	χ^2	p-value
Type of medication	HRZE	14 (77.8)	108 (61.7)	1.81	0.178
	DOTS	4 (22.2)	67 (38.3)		
Chest X-ray findings	Infiltrates	1 (5.6)	36 (20.6)	3.30	0.343
	Cavitation	6 (33.3)	36 (20.6)		
	Consolidation	1 (5.6)	14 (8.0)		
	Miliary TB	10 (55.6)	89 (50.9)		
Sputum AFB	Present	15 (83.3)	140 (80.0)	1.00	1.000
	Scanty	3 (16.7)	35 (20.0)		
Body Mass Index	Underweight	7 (38.9)	56 (32.0)	2.00	0.653
	Normal	10 (55.6)	114 (65.1)		
	Overweight	1 (5.6)	5 (2.9)		
Family type	Nuclear	8 (44.4)	110 (62.9)	2.33	0.127
	Joint	10 (55.6)	65 (37.1)		
Room availability	Adequate	14 (77.8)	159 (90.9)	2.47	0.098
	Inadequate	4 (22.2)	16 (9.1)		
Ventilation	Adequate	10 (55.6)	161 (92.0)	13.90	<0.001*
	Inadequate	8 (44.4)	14 (8.0)		
Diabetes mellitus	Yes	5 (27.8)	21 (12.0)	3.19	0.074
	No	13 (72.2)	154 (88.0)		
Hypertension	Yes	12 (66.7)	39 (22.3)	15.50	<0.001*
	No	6 (33.3)	136 (77.7)		
HIV infection	Yes	1 (5.6)	0 (0.0)	2.81	0.093
	No	17 (94.4)	175 (100.0)		
Smoking	Yes	12 (66.7)	70 (40.0)	4.77	0.029*
	No	6 (33.3)	105 (60.0)		
Alcohol consumption	Yes	4 (22.2)	26 (14.9)	0.47	0.491
	No	14 (77.8)	149 (85.1)		
Tobacco chewing	Yes	7 (38.9)	20 (11.4)	7.79	0.005*
	No	11 (61.1)	155 (88.6)		

Note: *χ^2 = Chi-square test; AFB = Acid-Fast Bacilli; HRZE = Isoniazid, Rifampicin, Pyrazinamide, and Ethambutol; DOTS = Directly Observed Treatment, Short-course.* Statistically significant at $p < 0.05$.

DISCUSSION

The current community-based retrospective study examined survival and health-related factors in individuals who have been cured of pulmonary TB in rural Karnataka. While cure from TB is

generally defined as microbiological cure for NTEP, the current findings highlight that many patients still suffer from physical, functional, and psychological problems even after completing their treatment. The current findings further support the emerging concept of post-TB disease, which emphasizes that curing an infection does not necessarily mean complete restoration of health status and quality of life[1,6,20].

The total survival rate of 96.5%, as observed in this study, is a clear indication of the efficacy of standard treatments for TB infection and good treatment compliance by the patients involved. However, mortality cases following completion of treatment indicate that TB survivors can easily develop some complications in the future. This observation has been reported by various longitudinal cohort studies conducted in South Korea, Uganda, and South India, where significantly high rates of post-treatment mortality were noted among TB survivors than the general population even after completing the course of treatment successfully [2,3,12].Causes of deaths in this study included respiratory failure, recurrent TB infection, COPD, and stroke, which correspond with earlier studies reporting the same complications following successful completion of TB treatment[2,3,20].

However, many patients had favourable clinical outcome, with over 90% achieving optimal clinical outcome and almost 60% having good functional health. Nevertheless, a substantial number of participants continued to have poor functional health and mild emotional symptoms following their treatment. This is consistent with results of some systematic reviews that have indicated the existence of symptoms such as persistent respiratory symptoms, lung impairment, exercise intolerance, fatigue and reduced health-related quality of life among survivors of tuberculosis [4,5,7,21]. Impairment may arise due to damage of the lungs through fibrosis,

bronchiectasis and chronic inflammation[6,21].Thus, completion of anti-tuberculosis treatment must be seen as the start of recovery process.

Age was found to be one of the important factors in determining the success of treatment and survival status after completion of the treatment period. Those who were above the age of 50 years showed poor results compared to those who were younger in age. Such findings have been described in previous systematic reviews as well as population-based studies, in which increasing age has been found to correlate with mortality, decreased pulmonary reserve, co-morbidity problems, and slower recovery from TB infection [2,4,12].

Socioeconomic factors played an important role as well. The patients from the farming profession and low-income households showed worse results compared to those of other professions. These connections were observed earlier in other studies as well [4,18]. Poverty can hinder access to nutrition, healthcare, and rehabilitation, and physically demanding jobs like farming might be a hindering factor for recovering from TB in terms of respiratory issues. These results underscore the need to work on the social determinants of health in the course of community nursing interventions, nutrition counselling, and linking to social assistance programs.

The environment was also an important factor contributing to the success of the recovery process. Patients from homes where there was poor ventilation showed worse results in terms of their health condition after the therapy. Poor ventilation makes people constantly exposed to air pollutants and insufficient air exchange, thus making the problem of their respiratory system more severe[17]. Community health nurses have an opportunity to lower this risk.

Lifestyle factors continue to be very important determinants of health that can be modified. Smokers and chewers had a significantly higher likelihood of poor survival and poor health after treatment. In a similar vein, there have been other studies showing that tobacco use accelerates loss of pulmonary function, leads to inflammation, and makes patients vulnerable to respiratory diseases[4,5,20]. Giving up smoking is perhaps one of the most useful interventions for community nurses to include in their follow-up programs.

In terms of the co-morbid diseases, DM and COPD showed significant association with high mortality rates, while hypertension was associated with poorer post-TB treatment health. This is consistent with earlier research, which has shown that chronic non-communicable diseases have a major impact on patient outcomes after TB treatment [2,4,21]. Combining TB follow up with managing patients with hypertension, DM, COPD, among others could hence lead to improved survival and quality of life.

Interestingly, clinically related factors in relation to therapy such as drug combination, chest X-ray findings, sputum acid-fast bacilli findings, and body mass index were not found to be significantly related to health status after therapy. This indicates that when the microbiological clearance is done, the factors which affect the recovery include demographics, environment, behaviour, and chronic illness rather than the disease itself. Similar reports have been made in the recent guidelines for management of patients after tuberculosis treatment [20,21,22,23].

The findings have important implications for community health nursing practice. Community health nurses act as the first point of contact for TB survivors in rural areas and are ideally suited to facilitate post-treatment care programs. Frequent visits to patients' homes, early detection of respiratory problems, nutrition counseling, helping individuals stop smoking, counseling on

psychological issues, conducting environmental assessments, checking chronic disease conditions, and referral to pulmonary rehabilitation can all be integral parts of post-TB care programs[1,6,8,20,24]. These community-level interventions have the potential to produce favorable health outcomes and reduce disability among TB survivors.

The current findings reinforce the growing awareness that the completion of anti-tuberculosis treatment is not necessarily the final stage of TB management. The findings from systematic reviews show that individuals who have completed the treatment of TB, have not always returned to health and their long-term survival is reduced. According to a systematic review and meta-analysis, there were significant disturbances in the spirometry values among patients treated for TB, and more recent studies confirmed the significantly lower lung function of TB patients compared to controls[25,26,27] The above-mentioned results suggest that it may be necessary to introduce post-treatment evaluations and identification of problems related to chronic lung pathologies in TB management. The continuing global burden of TB indicates the necessity for a comprehensive approach to the TB treatment with regard to all aspects of the ailment [28].

Despite its strengths, this study has certain limitations. The retrospective descriptive design limits causal inference, while the study was conducted in selected rural villages of a single district, which may limit generalizability to other populations. Some variables relied on participant recall, introducing the possibility of recall bias. Additionally, objective pulmonary function tests and standardized quality-of-life instruments were not included. Future multicentre prospective cohort studies incorporating pulmonary function assessment and long-term follow-up are recommended to better understand the evolving health needs of TB survivors.

CONCLUSIONS

The patients surviving from tuberculosis in the lungs showed excellent post-treatment survival rates. However, post-microbiological cure did not guarantee total recovery in some cases. Factors contributing to the development of persistent functional and psychosocial impairments include old age, lower socioeconomic status, poor household ventilation, smoking, tobacco chewing, as well as hypertension, diabetes mellitus, and chronic obstructive pulmonary disease as comorbid conditions. This highlights the importance of systematic post-treatment follow-up as a component of community healthcare. Community health nurses can effectively conduct home visits, provide health education, implement lifestyle changes, manage chronic diseases, offer psychosocial assistance, and make rehabilitation referrals, thus enhancing patient outcomes and supporting the WHO End TB Strategy. Further research is required to assess nurse-led post-TB rehabilitation programs and develop guidelines for survivor treatment.

List of Abbreviations

TB- Tuberculosis

WHO -World Health Organization

NTEP- National Tuberculosis Elimination Programme

Declarations

Ethics approval and consent to participate: The investigators adhered to the ethical guidelines and principles outlined by the Indian Council of Medical Research and the Declaration of Helsinki. The study was approved by Institutional Ethics Committee of College of Nursing Sciences, Dayananda Sagar University (Approval No.: DSU/NSG/071/2025). Informed written consent was taken from all participants before taking part in the study; for participants who were illiterate, informed consent was obtained from their legal guardians. Participation in the study was entirely

voluntary, and the participants were made aware of their right to discontinue participation in the study at any time without any implications on their health care.

Consent for publication: Not applicable

Availability of data and materials: Data sets generated and analysed for the current study are available from authors upon reasonable request.

Competing interest: The authors declare that they have no competing interests.

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Authors contribution:

Jayanti Rai: Conceptualization, Methodology, Investigation, Data Curation, Formal Analysis, Writing – Original Draft, Supervision, Project Administration, Validation.

Shejila Chillakunnel Hussain Rawther: Conceptualization, Methodology, Validation, Formal Analysis, Investigation, Supervision, Writing – Review & Editing.

Ravi Kulal : Conceptualization, Methodology, Validation, Investigation ,Supervision, Writing – Review & Editing.

All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work.

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