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Nutrition Status and Comorbidities Are Important Factors Associated With Mortality During Anti-Tuberculosis Treatment

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ABSTRACT

Background: The increasing incidence and mortality rates of tuberculosis among older individuals who suffer from multiple morbidities and are vulnerable to malnutrition are major obstacles to efforts to eradicate tuberculosis in the Republic of Korea. Herein, we identified the factors associated with mortality during anti-tuberculosis treatment in patients with pulmonary tuberculosis.

Methods: We conducted a case-control study and extracted data from the database of a multi-center prospective observational cohort study in Korea. Among the participants with rifampicin-susceptible pulmonary tuberculosis, the survival group was defined as those

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The authors have no potential conflicts of interest to disclose.

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Conceptualization: Kwon OB, Kim HW, Kim JS, Min J. Data curation: Kim JS, Lee EG, Park Y, Jung SS, Kim JW, Oh JY, Lee SH, Kim S, Kim SH, Lyu J, Ko Y, Kwon SJ, Chae G, Min J. Formal analysis: Kwon OB, Kim HW, Min J. Funding acquisition: Min J. Investigation: Kwon OB, Kim HW, Min J. Methodology: Kim JS, Lee EG, Park Y, Jung SS, Kim JW, Oh JY, Lee SH, Kim S, Kim SH, Lyu J, Ko Y, Kwon SJ, Chae G, Min J. Software: Kim HW, Kim JS, Min J. Validation: Kim JS, Min J. Visualization: Kwon OB, Min J. Writing - original draft: Kwon OB, Kim HW, Kim JS, Min J. Writing - review & editing: Kwon OB, Kim HW, Kim JS, Lee EG, Park Y, Jung SS, Kim JW, Oh JY, Lee SH, Kim S, Kim SH, Lyu J, Ko Y, Kwon SJ, Chae G, Min J.

who successfully completed treatment within one year, whereas the mortality group was defined as those who died during treatment. Univariable and multivariable logistic regression analyses were performed to identify factors associated with TB mortality.

Results: Among 1,119 participants with pulmonary TB registered between 2019 and 2021, 799 and 59 were grouped in the survival and mortality groups, respectively. Age, positive smear results, alarming symptoms, nutrition risk score, Charlson comorbidity index score, and initial standard treatment regimen were significant based on univariable analysis and were selected for the multivariable logistic regression model. Nutrition risk score (adjusted odds ratio, 2.44; 95% confidence interval, 1.72–3.48) and Charlson comorbidity index score (adjusted odds ratio, 1.62; 95% confidence interval, 1.35–1.94) remained statistically significant in the multivariate analysis.

Conclusion: Nutritional status and comorbidities at baseline were identified as important factors associated with mortality in patients with pulmonary tuberculosis.

Keywords: Death; Nutrition; Morbidity; Chronic Disease; Tuberculosis

INTRODUCTION

Tuberculosis (TB) was the leading cause of death from infectious diseases globally, prior to the coronavirus disease 2019 (COVID-19) pandemic. Unfortunately, COVID-19 has impeded global efforts to eliminate TB,¹ causing substantial decline in the number of newly diagnosed TB cases. Between 2019 and 2020, an 18% reduction was observed in the number of newly diagnosed TB cases, from 7.1 million to 5.8 million, indicating underdiagnosed and untreated TB cases because of the pandemic.² This setback has undone years of progress in reducing TB mortality, with the total number of deaths in 2020 reaching 2017 levels. Mortality, in addition to the incidence and prevalence, is a crucial indicator for assessing the burden of TB from a public health perspective. The primary objective of anti-TB treatment is to prevent TB mortality. Therefore, understanding and assessing the factors associated with TB mortality is essential to achieve the goals outlined in the World Health Organization (WHO) End TB strategy.

According to the global TB report of the WHO, TB incidence among high-income countries was 9.0 per 100,000 individuals in 2022. The Republic of Korea continued to bear a disproportionately higher burden of TB than other high-income countries, with a TB notification rate of 39.8 per 100,000 individuals in 2022,³ which is approximately four times higher than that in high-income countries. The elevated TB incidence and mortality rates among older individuals present significant challenges in controlling TB endemics in Korea.⁴ Older patients with TB often experience unfavorable treatment outcomes because of coexisting chronic diseases. Undernutrition, a well-known risk factor of TB, is particularly prevalent among older individuals. Studies have revealed that concomitant chronic disease^{5,6} and undernutrition^{7,8} adversely affect the prognosis of anti-TB treatments, including mortality. As the global population ages, TB in the geriatric population has become a significant challenge to global TB control. Analyzing the unique TB epidemiology in Korea could serve as a case study for developing strategies to reduce TB mortality in countries with aging populations.

In this study, we presented the clinical characteristics of TB mortality cases and analyzed the factors associated with mortality, focusing on nutritional status and comorbidities among patients with pulmonary TB in Korea, a setting characterized by an intermediate TB burden and a high-income status.

METHODS

Study design and population

We conducted a case-control study to evaluate the factors associated with TB mortality and extracted data from the Cohort Study of Pulmonary Tuberculosis (COSMOTB), a prospective observational cohort study conducted in the Republic of Korea. We enrolled patients with pulmonary TB who were aged ≥ 19 years between 2019 and 2021 from 18 university-affiliated hospitals across the country. Patients with rifampicin-resistant TB or a history of multidrug-resistant TB treatment were excluded from the analysis. Patients undergoing anti-TB treatment were regularly monitored, and treatment outcomes were recorded. Anti-TB treatment outcomes were defined according to the Korean TB guidelines adopted from the WHO.⁹ We further excluded individuals with other categories of anti-TB treatment outcomes such as loss-to-follow-up, failure, not evaluated, and still-on-treatment at one year. The survival group was defined as patients who successfully completed treatment within one year, whereas the mortality group was defined as patients who died during treatment.

Demographic, socioeconomic, and clinical information were prospectively collected using an electronic case report form. Baseline demographic variables including sex, age, smoking status, body weight, height, and comorbidities were documented. Laboratory tests at baseline included sputum acid-fast bacilli smear tests, chest radiography, white blood cell count, and albumin and total cholesterol levels. Co-variables used for the current analysis were collected before the initiation of anti-TB treatment.

Variable definition

We selected the co-variables associated with TB mortality a priori for inclusion in the logistic regression model. The Nutrition Risk Score (NRS) was defined by Kim.¹⁰ Variables including body mass index (BMI), serum albumin and cholesterol levels, and lymphocyte count were selected. For each variable, a score of 1 was assigned if the following conditions were met; BMI $< 18.5 \text{ kg/m}^2$, serum albumin $< 3.0 \text{ g/dL}$, serum cholesterol $< 90 \text{ mg/dL}$, and lymphocyte count $< 7 \times 10^5 \text{ cells/L}$. Consequently, the NRS scores ranged from 0 to 4. Comorbidities were assessed using self-reported and physician-recorded conditions, and the Charlson Comorbidity Index (CCI) was used to quantify their burden. Age was categorized into < 65 years and ≥ 65 years. Furthermore, we introduced a new variable, “alarming symptoms,” which was considered positive if a patient exhibited any of the following symptoms: chest pain, hemoptysis, or dyspnea. The initial combination regimen of isoniazid, rifampicin, ethambutol, and pyrazinamide (HREZ) were defined as the standard anti-TB treatment regimen. The primary outcome was all-cause mortality, defined as death during anti-TB treatment, irrespective of the cause, in accordance with the WHO.⁹

Statistical analysis

Data are expressed as a percentage for categorical variables and as mean $\pm$ standard deviation for continuous variables. Categorical variables were analyzed using the χ^2 test or Fisher's exact test. Continuous variables were analyzed using *t*-tests. Univariable and multivariable logistic regression analyses were performed to determine variables associated with mortality. Variables with $P < 0.20$ in the univariable analysis were included in the multivariable analysis. For all analyses, $P < 0.05$ was considered statistically significant. We also conducted a subgroup analysis, categorizing the patients into two groups based on whether they were < 65 years. The same logistic regression analysis method was adopted for age-based subgroup analysis. Analyses were performed using the R software (version 4.02; The R foundation, Vienna, Austria).

Ethics statement

This study was performed in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of the Catholic University of Korea (IRB No. C19ONDI0458). All adult participants provided written informed consent to participate in the COSMOTB.

RESULTS

Between 2019 and 2021, 1,119 patients with pulmonary TB were registered in the cohort database (Fig. 1). Forty-eight participants with rifampicin-resistant TB or a history of multidrug-resistant TB treatment were excluded. Among the 1,071 participants with rifampicin-susceptible pulmonary TB, 59 (5.5%) died. A total of 858 participants were included in this study after excluding those with other treatment outcomes. The survival and mortality groups had 799 and 59 participants, respectively; their clinical characteristics are presented in Table 1. The mean age was higher in the mortality group than that in the survival group (74.3 vs. 60.4, $P < 0.001$). The proportion of positive sputum smear test results was higher in the mortality group than in the survival group (39.0% vs. 20.8%, $P = 0.001$). Patients in the mortality group experienced alarming symptoms more frequently than those in the survival group (47.5% vs. 27.8%, $P = 0.001$). The four components of the NRS, comprising BMI (20.4 ± 3.3 vs. 22.0 ± 3.3 kg/m², $P = 0.010$), serum albumin levels (3.2 ± 0.7 vs. 4.0 ± 0.6 g/dL, $P < 0.001$), total cholesterol (133.3 ± 40.3 vs. 161.3 ± 41.7 mg/dL, $P < 0.001$), and serum lymphocyte count ($12.5 \pm 9.5\%$ vs. $23.6 \pm 10.0\%$, $P < 0.001$) were significantly lower in the mortality group than those in the survival group. Approximately one-third of participants in the mortality group had an NRS of ≥ 1 . Individuals in the mortality group had a higher NRS ($P < 0.001$) and CCI scores ($P = 0.004$) than those in the survival group.

The results of the univariable and multivariable logistic regression analyses of the variables associated with mortality are presented in Table 2. Among the variables, age ≥ 65 years (odds ratio [OR], 6.23; 95% confidence interval [CI], 3.58–10.86; $P < 0.001$), positive smear result (OR, 2.44; 95% CI, 1.41–4.22; $P = 0.002$), alarming symptoms (OR, 2.35; 95% CI, 1.38–4.00;

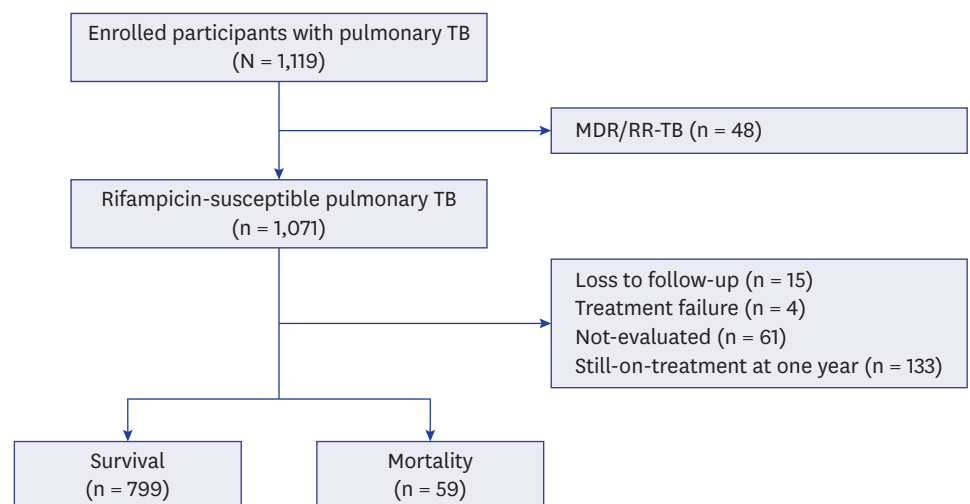


Fig. 1. Flow chart of participant enrollment.

TB = tuberculosis, MDR/RR-TB = multidrug-resistant/rifampicin-resistant tuberculosis.

Table 1. Baseline characteristics of enrolled pulmonary tuberculosis patients with and without mortality during anti-tuberculosis treatment

Variables	Mortality (n = 59)	Survival (n = 799)	All (N = 858)	P value
Age, yr	74.3 ± 14.6	60.4 ± 17.4	60.2 ± 17.5	< 0.001***
Age ≥ 65 yr	27 (45.8)	95 (11.9)	122 (14.2)	< 0.001***
Male	44 (74.6)	511 (64.0)	555 (64.7)	0.100
Prior tuberculosis treatment	12 (20.3)	122 (15.3)	134 (15.6)	0.300
Ever smoker	33 (55.9)	446 (55.8)	479 (55.8)	0.987
Extra-pulmonary involvement	8 (13.6)	70 (8.8)	78 (9.1)	0.216
Positive sputum smear test	23 (39.0)	166 (20.8)	189 (22.0)	0.001**
Cavity in chest X-ray	8 (13.6)	150 (18.8)	158 (18.4)	0.319
Presence of alarming symptoms ^a	28 (47.5)	222 (27.8)	250 (29.1)	0.001**
Body mass index, kg/m ²	20.4 ± 3.3	22.0 ± 3.3	21.9 ± 3.3	0.010*
Laboratory blood tests				
Albumin, g/dL	3.2 ± 0.7	4.0 ± 0.6	3.9 ± 0.7	< 0.001***
Total cholesterol, mg/dL	133.3 ± 40.3	161.3 ± 41.7	159.0 ± 42.3	< 0.001***
Lymphocyte count, %	12.5 ± 9.5	23.6 ± 10.0	22.8 ± 10.4	< 0.001***
Nutrition risk score	1 (0–2)	0 (0–1)	0 (0–1)	< 0.001***
Score 0	21 (35.6)	613 (76.7)	634 (73.9)	
Score 1	19 (32.2)	147 (18.4)	166 (19.3)	
Score 2 or more	19 (32.2)	39 (4.9)	58 (6.8)	
CCI score	6.1 ± 2.1	3.9 ± 1.8	4.0 ± 2.0	< 0.001***
Initial treatment regimen				0.004**
HREZ	53 (89.8)	775 (97.0)	828 (96.5)	
Others	6 (10.2)	24 (3.0)	30 (3.5)	

Values were expressed as number (percentage), mean ± standard deviation or median (interquartile range).

CCI = Charlson Comorbidity Index, HREZ = isoniazid, rifampicin, ethambutol, and pyrazinamide.

^aAlarming symptoms were defined if one of the following symptoms were present; dyspnea, chest pain, and hemoptysis.

P* < 0.05, *P* < 0.01, ****P* < 0.001.

Table 2. Factors associated with mortality during anti-tuberculosis treatment among patients with pulmonary tuberculosis

Variables	Univariable logistic regression		Multivariable logistic regression	
	OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Age ≥ 65 yr	6.23 (3.58–10.86)	< 0.001***	1.13 (0.55–2.30)	0.745
Positive sputum smear result	2.44 (1.41–4.22)	0.002**	1.76 (0.88–3.51)	0.112
Presence of alarming symptoms	2.35 (1.38–4.00)	0.002**	1.59 (0.85–2.95)	0.143
Nutrition risk score	3.04 (2.24–4.13)	< 0.001***	2.63 (1.86–3.71)	< 0.001***
CCI score	1.67 (1.47–1.90)	< 0.001***	1.64 (1.40–1.92)	< 0.001***
Initial treatment regimen				
HREZ	Reference		Reference	
Others	2.42 (1.32–4.43)	0.004**	1.17 (0.39–3.58)	0.777

OR = odds ratio, CI = confidence interval, CCI = Charlson Comorbidity Index, HREZ = isoniazid, rifampicin, ethambutol, and pyrazinamide.

P* < 0.01, *P* < 0.001.

P = 0.002), NRS (OR, 3.04; 95% CI, 2.24–4.13; *P* < 0.001), CCI score (OR, 1.67; 95% CI, 1.47–1.90; *P* < 0.001), and HREZ as the initial treatment regimen (OR, 2.42; 95% CI, 1.32–4.43; *P* = 0.004) were selected and included in the multivariable logistic regression. NRS (adjusted OR, 2.63; 95% CI, 1.76–3.71; *P* < 0.001) and CCI score (adjusted OR, 1.64; 95% CI, 1.40–1.92; *P* < 0.001) remained statistically significant in the multivariable analysis.

Age-based subgroup analysis was conducted, categorizing the patients into two groups based on whether they were < 65 years (Table 3). Among patients aged < 65 years, alarming symptoms (adjusted OR, 3.86; 95% CI, 1.00–14.89; *P* = 0.049), NRS (adjusted OR, 2.81; 95% CI, 1.38–5.69; *P* = 0.004), and CCI score (adjusted OR, 2.13; 95% CI, 1.45–3.13; *P* < 0.001) remained statistically significant in the multivariate analysis. For patients aged ≥ 65 years, NRS (adjusted OR, 2.21; 95% CI, 1.46–3.33; *P* < 0.001) and CCI score (adjusted OR, 1.47; 95% CI, 1.21–1.78; *P* < 0.001) also remained statistically significant in the multivariable analysis.

Table 3. Age-based subgroup analysis investigating factors associated with mortality during anti-tuberculosis treatment among patients with pulmonary tuberculosis

Variables	Univariable logistic regression		Multivariable logistic regression	
	OR (95% CI)	P value	Adjusted OR (95% CI)	P value
Patients < 65 yr				
Age	1.01 (0.96–1.06)	0.619		
Positive sputum smear result	2.49 (0.77–8.01)	0.126	2.12 (0.49–9.16)	0.312
Presence of alarming symptoms	3.88 (1.21–12.43)	0.023*	3.86 (1.00–14.89)	0.049*
Nutrition risk score	3.31 (1.82–6.05)	< 0.001***	2.81 (1.38–5.69)	0.004**
CCI score	1.84 (1.36–2.48)	< 0.001***	2.13 (1.45–3.13)	< 0.001***
Initial treatment regimen				
HREZ	Reference		Reference	
Others	8.47 (0.91–78.69)	0.060	1.12 (0.04–31.03)	0.949
Patients ≥ 65 yr				
Age	1.11 (1.06–1.16)	< 0.001***	1.04 (0.98–1.09)	0.189
Positive sputum smear result	2.72 (1.42–5.21)	0.003**	1.75 (0.80–3.82)	0.160
Presence of alarming symptoms	1.92 (1.03–3.58)	0.039*	1.36 (0.68–2.73)	0.380
Nutrition risk score	2.76 (1.92–3.96)	< 0.001***	2.21 (1.46–3.33)	< 0.001***
CCI score	1.51 (1.27–1.79)	< 0.001***	1.47 (1.21–1.78)	< 0.001***
Initial treatment regimen				
HREZ	Reference			
Others	1.94 (0.69–5.46)	0.212		

OR = odds ratio, CI = confidence interval, CCI = Charlson Comorbidity Index, HREZ = isoniazid, rifampicin, ethambutol, and pyrazinamide.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$.

DISCUSSION

In this study, we analyzed the characteristics of patients who died during anti-TB treatment and identified factors associated with mortality. To objectively assess the nutritional status and comorbidities of the participants, we adopted previously validated tools: the NRS and CCI score. Our findings indicated that for each incremental increase in the NRS and CCI score, the odds of mortality were approximately 2.44 and 1.62 times higher, respectively. This trend was consistent with the results of age-stratified subgroup analysis. Accurately assessing the nutritional status and comorbidities of patients at the time of TB diagnosis and identifying reversible factors, such as nutritional status, body weight, and total cholesterol levels, are important to prevent TB mortality.

Risk factors for TB deaths vary according to human immunodeficiency virus (HIV) prevalence and regional conditions. In areas with high HIV rates, factors such as HIV positivity, advanced immunosuppression, and malnutrition increase the risk of TB mortality.¹¹ In regions with a low HIV prevalence, older age, male sex, comorbidities, and substance abuse were significant risk factors.^{11,12} Recently, Jeong et al.⁶ assessed the factors associated with mortality among patients with TB registered in the public-private mix TB control project in Korea. They found that older age, lower BMI, dyspnea, general weakness, and bilateral lesions were common risk factors for both TB- and non-TB-related deaths. TB-related deaths were linked to fever and smear positivity, whereas non-TB deaths were associated with the male sex and comorbidities such as heart or liver disease. Risk factors for TB-related mortality may vary depending on TB epidemiology, population structure, socioeconomic status, and healthcare system. Tailored public health strategies based on regional data are essential to reduce TB mortality.

Our study revealed that NRS had the highest odds of mortality, indicating that undernutrition plays a crucial role. However, assessment of the nutritional status of individuals with TB is not well established. Notably, BMI is a useful tool for evaluating nutritional status. Kim et al.¹⁰ developed and validated the NRS, demonstrating that nutritional deficits that are

assessed using the NRS are associated with poor outcomes in patients with miliary TB. A comprehensive assessment, incorporating simple physical examinations and laboratory tests, should be emphasized at the time of TB diagnosis. Further research is needed to formulate nutritional supplements based on the initial nutritional assessment. Recent clinical trials have indicated that nutritional support is associated with a substantial reduction in TB incidence among household contacts.¹³ This concept may also apply to individuals with active TB.

In 2021, the proportion of patients with TB aged ≥ 65 years among all notified cases reached 51.1%, signifying an inevitable increase in TB burden among older individuals in an aging population in Korea.⁴ Older patients are often frail and have significant comorbidities that contribute to adverse drug reactions and poor medication adherence during anti-TB treatment. The effect of comorbidities on mortality is likely attributable to non-TB-related causes of death. A recent nationwide Korean study revealed that comorbidities, particularly heart, liver, and kidney diseases, were associated with non-TB-related death.⁶ Lin et al.¹⁴ found that a significant proportion of deaths were attributed to underlying comorbidities, particularly liver cirrhosis. Patients with TB and chronic liver disease have a higher risk of drug-induced liver injury.¹⁵ Elevation of hepatic enzymes is one of the most common adverse drug reactions during anti-TB treatment with first-line drugs.^{16,17} The synergistic effect of aging and underlying liver disease may increase the likelihood of adverse drug reactions, such as drug-induced liver injury, posing a potential threat to treatment outcomes. Metabolic disorders are associated with drug-induced liver injury during anti-TB treatment.¹⁸ Untreated and complicated diabetes increases the risk of unfavorable outcome and mortality.¹⁹ Understanding the impact of comorbidities on TB and its treatment outcomes can assist physicians in preparing proactive interventions.

Despite a notable proportion of TB-related deaths among older patients in Korea,²⁰ age did not emerge as a significant factor associated with mortality in the multivariate analysis conducted in the current study. Initially, we hypothesized that the effects of nutritional status and comorbidities would vary with age, prompting further subgroup analyses. The impact on mortality was similar between older patients aged ≥ 65 years and those aged < 65 years. A recent cluster analysis²¹ revealed that older patient comorbidities and who were underweight were more likely to exhibit dyspnea, positive smear results, and bilateral disease on chest radiography among individuals with pulmonary TB, regardless of sex. These clinical characteristics have been recognized as factors associated with mortality. For patients aged < 65 years, alarming symptoms indicative of severe lung parenchymal destruction and heightened disease severity emerged as significant factors associated with mortality in the subgroup analysis. An individualized approach is warranted for younger patients with alarming symptoms to strengthen patient-centered care and improve survival. However, the presence of alarming symptoms was not significant in patients aged ≥ 65 years. This might be ascribed to chronic symptoms similar to those of TB in older patients with multi-morbidities. This indicates that, in older patients, TB severity cannot be determined based on symptoms alone. In addition, distinguishing the causes of symptoms when treating older patients is crucial to prevent delays in TB diagnosis.

TB mortality is a crucial indicator for national TB control programs aligned with the 'End TB Strategy' of the WHO, which aims to reduce the number of TB-related deaths by 95% between 2015 and 2035. Despite being a preventable and curable disease, TB was the world's second leading cause of death from a single infectious agent after COVID-19 in 2022.

Globally, an estimated 1.3 million deaths were attributed to TB in 2022.²² Pandemic-related disruptions are projected to have led to nearly half a million excess TB deaths between 2020 and 2022, compared to the anticipated numbers. The global trend showed a decline in the absolute number of TB deaths until 2019, followed by an increase between 2020 and 2021 and then a reversal in 2022. To address potential delays in TB diagnosis and treatment due to the impact of COVID-19, the Korea Disease Control and Prevention Agency plans to strengthen public-private partnerships for TB care and prevention in Korea.²³ The agency aims to provide systematic management for patients with TB from diagnosis to completion of anti-TB treatment. In the third National Strategic Plan for TB control announced in 2023, efforts will be intensified across government agencies to reduce mortality rates. This involves improving treatment accessibility and success rates, particularly for patients aged ≥ 65 years and those facing economic vulnerabilities, by integrating various health programs. Our study highlights that controlling comorbidities and improving nutritional status are important for reducing mortality in patients with TB and that public health programs should address these factors through a multidisciplinary approach. For example, we recently found that untreated and complicated diabetes at the time of TB diagnosis increases the risk of TB mortality.¹⁹ Policymakers must revise medical policies to screen for diabetes status and complications at baseline and incorporate proactive management.

The strength of our study is that data were extracted from a nationwide multi-center prospective cohort study. However, this study has several limitations. First, a convenience sampling strategy was employed for participant enrollment, which, owing to its non-probabilistic nature, limited the generalizability of the study. Second, there may have been selection bias, as only patients who provided informed consent were enrolled. Individuals with a severe clinical presentation who were unable to provide informed consent were excluded from the study. Third, because our study was conducted from 2019 to 2021, which was during the COVID-19 pandemic, there may be confounding bias due to COVID-19. Fourth, although other well-known covariables, such as positive sputum smear results, presence of alarming symptoms, and initial treatment regimen, were not statistically significant, this does not mean that these were not important factors associated with TB mortality. This could be ascribed to the small sample size of our study. Notably, the NRS and CCI score remained statistically significant despite the small sample size. Fifth, specific comorbidities were not included in this analysis. If each comorbidity was added as a variable in the current statistical analysis, the number of variables required to minimize bias would be exceeded. Therefore, we attempted to avoid this problem. Additional research is needed to determine how chronic diseases, such as hypertension or cardiovascular disease, affect TB treatment prognosis.

In conclusion, our findings highlight a significant association between nutritional status and comorbidities at the time of TB diagnosis and mortality during anti-TB treatment. There is a compelling need for a comprehensive assessment of patients with pulmonary TB to identify and address the reversible factors that ultimately enhance survival of patients with TB.

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