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Original Research

# Impact of age-stratified latent tuberculosis treatment on disease burden of active tuberculosis: A mathematical modeling study in an aging country with a high disease burden

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ABSTRACT

*Background:* The Republic of Korea has the highest tuberculosis (TB) incidence among OECD countries, with older adults at elevated risk of reactivation. However, latent TB infection (LTBI) control strategies often exclude individuals over 65 due to potential side effects, such as hepatotoxicity. Identifying optimal age groups for intervention is critical.
*Methods:* We developed an age-structured dynamic transmission model to simulate TB and LTBI progression in Korea. The model was calibrated using TB case data (2011-2018) from the Korea Disease Control and Prevention Agency and the Health Insurance Review and Assessment Service. We projected TB cases averted over 30 years by evaluating LTBI treatment strategies with varying coverage and success rates across age groups.
*Results:* Targeting LTBI treatment in adults aged 35-64 resulted in the greatest reduction in TB incidence. A fourfold increase in the LTBI treatment rate in this group averted 32,814 cases—compared to 11,564 and 5689 cases in the 19-34 and ≥65 age groups, respectively. Increasing the probability of treatment success had a smaller but similar effect.
*Conclusion:* Prioritizing LTBI treatment in the 35-64 age group may substantially reduce TB burden and supports age-stratified strategies for national TB control.


## Introduction

The Republic of Korea has had the highest tuberculosis (TB) incidence rate among OECD countries since 1996 [1]. Despite ongoing efforts to control TB, the burden remains substantial, particularly in the older population. According to the Korean Academy of Tuberculosis and Respiratory Diseases, the number of reported TB cases in individuals aged 65 years and older increased from 6547 in 2001 to 15,282 in 2018 [2]. During this period, the proportion of TB cases in this age group rose from 19.2% to 45.2%, indicating that nearly half of all TB cases now occurred in the older adults.

Latent TB infection (LTBI) is a condition in which individuals are infected with *Mycobacterium tuberculosis* but do not exhibit symptoms of active disease due to containment by the immune system [3]. In intermediate-burden countries like the Republic of Korea, reactivation of LTBI accounts for a substantial proportion of active TB cases [4]. Age is a significant factor influencing the risk of progression from LTBI to active TB. The prevalence of LTBI increases with age; data from the 2017 National LTBI Cohort Study in Korea showed an average LTBI positivity rate of 14.78%, with rates of 5.37% in individuals in their 20s and 12.45% in those in their 30s [5]. In contrast, the prevalence markedly increases to 43.19% in those in their 60s and 44.44% in individuals aged 70 years and older.

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The high prevalence of LTBI among older adults in Korea is partly attributed to historical TB outbreaks, particularly following the Korean War (1950-1953). Older adults may face a heightened risk of LTBI reactivation due to multifactorial influences, including immunosenescence and higher prevalence of comorbidities, though the exact mechanisms remain under investigation [6]. Consequently, TB incidence and mortality rates are substantially higher in older adults than those in the younger age groups [7]. Nevertheless, current LTBI screening and treatment efforts in Korea remain limited. The standard LTBI treatment regimens—9 months of isoniazid, 4 months of rifampin, or 3 months of isoniazid/rifampin—pose a risk of hepatotoxicity, which has led to restricting LTBI screening and treatment to individuals under 65 years of age.

Given the growing burden of TB in the older adults, there is an urgent need to evaluate age-stratified interventions for LTBI treatment to identify the most effective strategies for reducing TB incidence. In this study, we developed an age-structured epidemiological model to simulate the dynamics of TB transmission in Korea, with a focus on LTBI. By developing intervention scenarios of varying LTBI treatment rate and probability of treatment success across different age groups, we aimed to predict the number of active TB cases that could be prevented over the next 30 years. This study seeks to identify the age groups that would benefit the most from targeted LTBI interventions, thereby contributing to more effective TB control in Korea.

## Methods

In this study, we assessed the impact of LTBI treatment by developing various intervention scenarios and predicting the annual number of new active cases of TB and LTBI. We modified the susceptible-exposed-infectious-removed model into a susceptible-exposed-infectious-latent model to perform the analysis.

### *Study design and data sources*

The dataset included newly diagnosed active TB cases, patients who had completed or failed LTBI treatment, and patients who developed TB reactivation after successful LTBI treatment. The annual number of newly diagnosed active TB cases by age was reported by the Korea Disease Control and Prevention Agency in 2019 [8]. The model assumes that the TB notification data closely approximate true incidence, given the high case detection rate in Korea (estimated at over 90% by WHO). In Korea, the government provides free treatment for all patients with active TB until they are fully cured. Therefore, no explicit adjustment for underreporting was applied. Based on the proportion of new cases to cases of total active TB and the number of new cases by age group in annual reports (Table S1), the total number of patients with active TB for each age group by year was estimated. Details of the data preprocessing are provided in the Supplementary Appendix. Data on patients who had LTBI treatment and experienced reactivation were provided by the Health Insurance Review and Assessment Service in Korea.

### *Mathematical model and model parameters*

We developed a deterministic age-structured compartmental model to describe the person-to-person transmission of TB in the Republic of Korea, as illustrated in Figure 1. The population was classified into susceptible (S), exposed (E), infectious (I; active TB), latently infected (L; LTBI), successfully treated for LTBI (LT), and treatment was unsuccessful (LD). Each compartment was divided into four age groups: 0-18, 19-34, 35-64, and 65+. The age groups were selected based on clinical and public health considerations: those aged 0-18 years represent the pediatric population, who have distinct risk factors and immune responses to TB infection compared with adults. The cutoff at 35 years was chosen because, in Korea, LTBI screening for active TB contacts is generally limited to those under 35, given the potential hepatotoxicity of TB treatments and the increased risk of adverse effects in older populations. The 65+ age group was included as 65 is the current upper age limit for LTBI treatment in Korea.

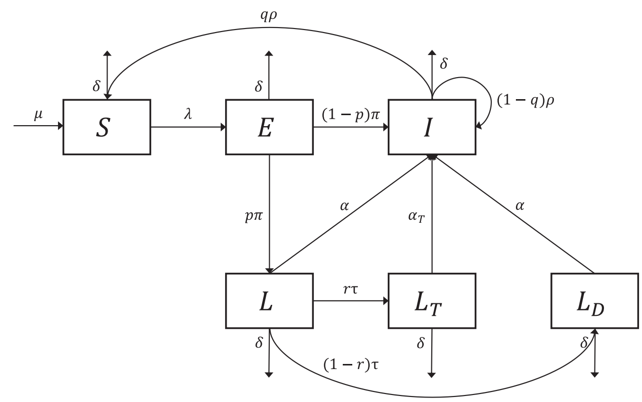

**Figure 1.** Mathematical model for tuberculosis in Republic of Korea.

The number of susceptible individuals ($S$) in the 0-18 age group increases by the number of newborns per unit time ($\mu$), whereas individuals in all compartments die of natural causes at the age-specific rate ($\delta$). Although the birth and death rates were assumed to be constant, the age-specific population for each year was adjusted during the model simulation to ensure that the projected population aligned with the actual demographic data reported by the Korean Statistical Information Service [9].

A susceptible individual ($S$) is infected by a person with active TB ($I$) at an infection rate $\lambda(t)$ at the time $t$. It is assumed that the proportion of exposed individuals ($E$) progressing to acute TB after the exposed period ($1/\pi$) is (1–$P$), whereas the remaining individuals enter a state where the bacteria in their bodies are suppressed by the immune system ($L$). Thus, individuals in the $E$ compartment either develop active TB ($I$) with probability $1-P$, a process known as the fast progression, or enter the latent compartment ($L$) with probability $P$, where they may develop active TB after several years or more—a process referred to as the slow progression. Individuals with active TB ($I$) are treated at a rate of $\rho$, where $1/\rho$ represents the infectious period. The probability of successful treatment for active TB is $q$, and those who complete the treatment become susceptible again. Those who failed the treatment completion remains in the infectious compartment. The individuals with LTBI ($L$) receive LTBI treatment at the rate of $\tau$, and the probability of treatment success is $r$. Reactivation occurred at a rate of $\alpha$ among individuals with LTBI and those whose treatment failed, whereas those who successfully completed treatment experienced reactivation at a rate of $\alpha_T$. Since the model spans a period longer than 5 years, age progression was incorporated into the simulation. The details for the parameter values and interpretations are summarized in Table S2.

The transmission rates ($\beta_{ij}$), treatment rates ($\tau_i$), and reactivation rates from LTBI ($\alpha_i$ and $\alpha_{T_i}$) are unknown, and other remaining parameters are given based on the references [9–15]. Although some studies have reported reactivation rates from untreated LTBI cases [16,17], these rates vary across countries [18], and the relevant data for Korea are lacking. Thus, we considered the reactivation rates to be unknown. The structure of the transmission matrix and the initial states are provided in the main text and Table S3 in the Supplementary Appendix.

The codes were generated to solve the ordinary differential equations in MATLAB. The "ode45" solver with the "NonNegative" option was used to solve the equations and ensure the positivity of the solutions. We implemented the simulation in MATLAB 2024a on Mac OSX. The code is available in a GitHub repository (https://github.com/YunjeongLee/tuberculosis_by_age.git).

*Model calibration*

Unknown parameters were estimated by fitting the model to four types of age group data: the annual number of active TB cases, the annual number of people who completed LTBI treatment or defaulted, and the annual number of reactivation cases after successful LTBI treatment. The model was calibrated using TB case data from 2011 to 2018. We selected 2019 as the starting year of intervention scenario simulations because it represents the last prepandemic year unaffected by COVID-19. Since 2020, TB notification trends in Korea have been affected by pandemic-related factors such as strain on the healthcare system, redistribution of healthcare resources, and enhanced infection control measures such as hand hygiene, mask-wearing, and social distancing. Therefore, using 2019 provides a stable baseline for evaluating intervention scenarios without confounding from the pandemic. The measurements were assumed to follow the Poisson distribution with mean values of model prediction, and the maximum likelihood estimation was employed to estimate parameters. The model fit to the annual number of active TB cases is shown in Figure S1. The larger LTBI treatment rate of 19-34 and 35-64 age groups were estimated and compared with those of other age groups (Table S4; 6.08-7.58 $\times$ $10^{-6}$/day vs 7.73 $\times$ $10^{-13}$-1.20 $\times$ $10^{-6}$/day for age groups 19-64 and 0-18, 65+ age groups, respectively). The estimated reactivation rates of untreated LTBI cases and those whose treatment failed were the smallest in the 0-18 years age group, whereas the age 65+ age group showed the largest rates. The reactivation rates of treated LTBI cases were in the range of 2.31-4.86 $\times$ $10^{-7}$/d in the 19-34 and 35-64 age groups. The annual ratio between acute infection and LTBI reactivation predicted by the model indicated that the 0-18 and 19-34 age groups would have a higher proportion of acute infection than LTBI reactivation (Figure S5). Conversely, the 35-64 and 65+ age groups showed a higher proportion of LTBI reactivation than acute infections. The detailed simulation results, including parameter estimates, confidence intervals, and fitting to other datasets, are illustrated in Table S4 and Figures S1-S4 in the Supplementary Appendix.

*Intervention scenarios*

To evaluate the effects of LTBI treatment, multiple intervention scenarios were simulated by varying the treatment rate ($\tau$) and the probability of treatment success ($r$) across different age groups. A total of eight scenarios were implemented: (1) $\tau$ multiplied by 0.3, 0.7, 1.3, 1.7, 2, 3, and 4 across all age groups; (2) the same $\tau$ scaling applied to only one age group at a time (19-34, 35-64, or 65+); (3) $r$ varied at 0%, 20%, 40%, 60%, 80%, and 100% for all age groups; and (4) the same r variation applied to only one age group at a time (19-34, 35-64, or 65+). The baseline scenario sets $r$ and $\tau$ to the values fixed or estimated during the model calibration process (for $\tau$, 19-34: $7.58\times10^{-6}$, 35-64: $6.08\times10^{-6}$, and 65+: $1.20\times10^{-6}$; for $r$, 19-34: 76%, 35-64: 78%, and 65+: 70%, as provided in Tables S2 and S4). We observed three types of model predictions: the annual number and incidence rates of (1) active TB cases, (2) acutely infected cases, and (3) LTBI for each scenario from 2019 to 2048 (a 30-year period). The incidence rates were represented by the number of cases per 100,000 person-years. Additionally, we compared the predicted TB burden across scenarios with that of the baseline scenario.

## Results

We generated eight scenarios by varying the LTBI treatment rate and the probability of LTBI treatment success, either across all age groups or by specific age groups. First, the LTBI treatment rate for all ages, $\tau_i$ ($i$ = 1, 2, 3, and 4) was fixed at 0, 0.3, 0.7, 1.3, 1.7, 2, 3, and 4 times the estimated values of $\tau_i$. The predicted number and incidence rates of active TB cases are presented in Figure 2, Table S5, Figures S6, and S7 (Supplementary Appendix). If LTBI treatment were not implemented for all age groups from 2019 to 2048,

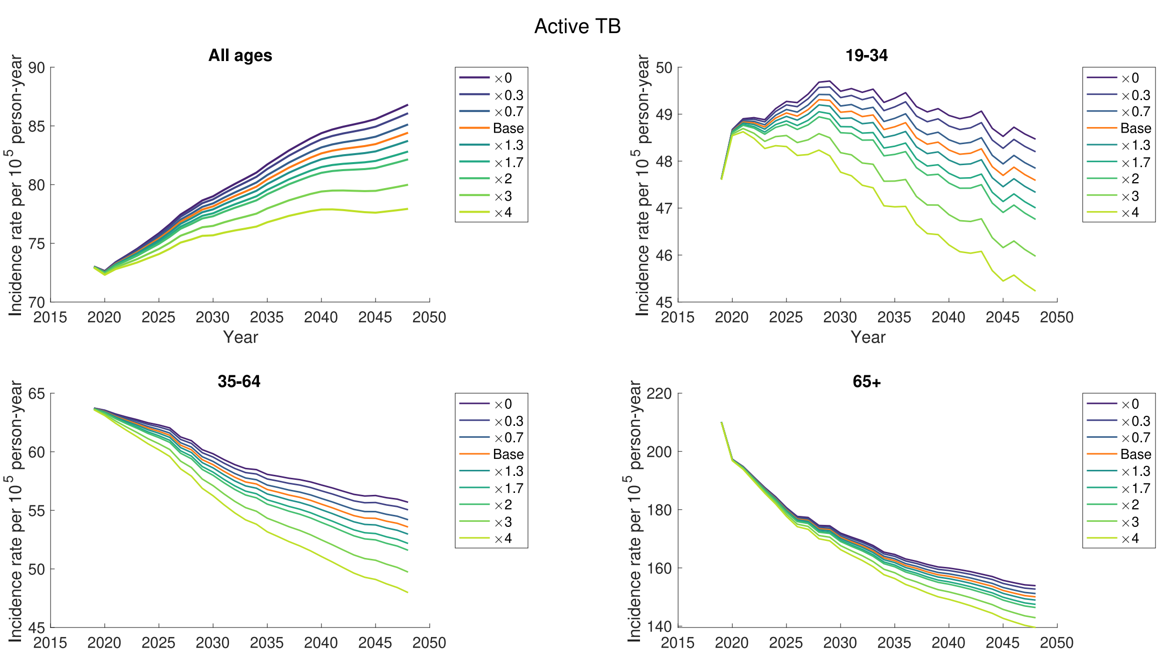


**Figure 2.** Incidence rates of active tuberculosis (TB) per 100,000 person-years were analyzed when the rates of treatment of latent tuberculosis infection (LTBI) for all age groups were adjusted to 0, 0.3, 0.7, 1.3, 1.7, 2, 3, and 4 times the baseline. The incidence rates are plotted for all ages (top left), 19-34 (top right), 35-64 (bottom left), and 65+ (bottom right) age groups.

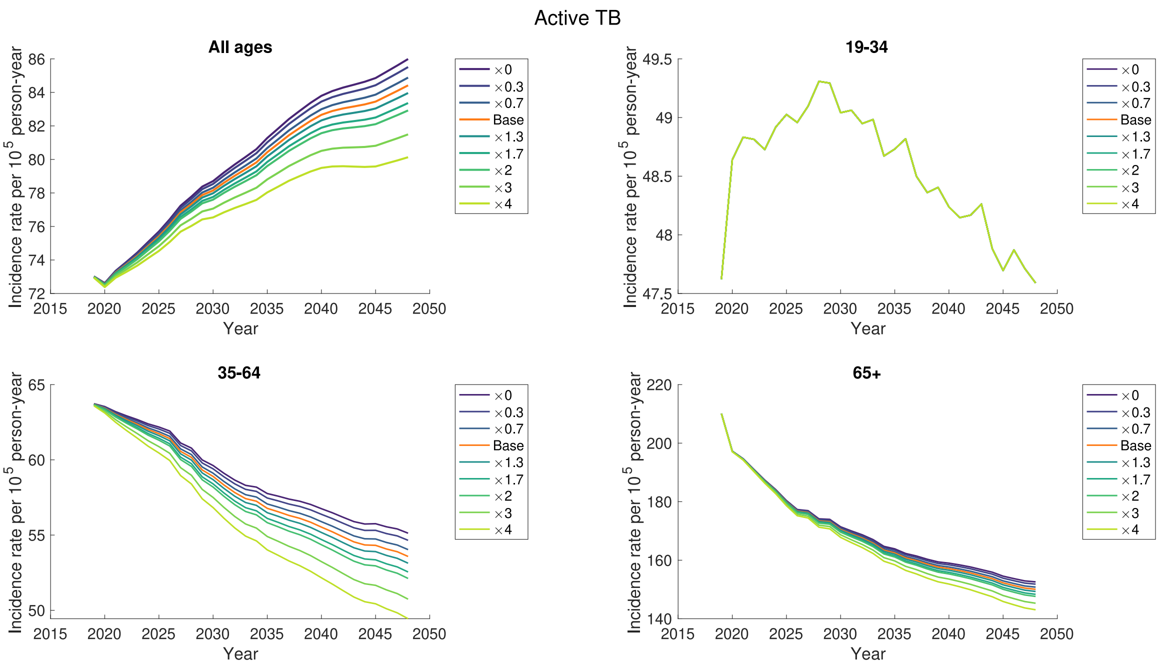


**Figure 3.** Incidence rates of active tuberculosis (TB) per 100,000 person-years were analyzed when the latent tuberculosis infection (LTBI) treatment rate for the 35-64 age group was adjusted to 0, 0.3, 0.7, 1.3, 1.7, 2, 3, and 4 times the baseline. The incidence rates are plotted for all ages (top left), 19-34 (top right), 35-64 (bottom left), and 65+ (bottom right) age groups. The graphs in the 19-34 age groups overlap due to the unaffected model outcomes by varying the LTBI treatment rate for the 35-64 age group.

the number of active patients with TB was predicted to increase by 17,792 over 30 years compared with the baseline scenario, which reflects the current situation. Over 30 years, the incidence rate of active TB in all age groups was projected to increase from 73 to 87 cases per 100,000 person-years (Figure 2). The number of acutely infected cases and LTBI reactivation cases was expected to increase by 2209 and 12,957, respectively, whereas the incidence rates were projected to decrease from 19 to 11 cases per 100,000 person-years for the former and increase from 43 to 63 cases per 100,000 person-years for the latter (Figures S6 and S7). Conversely, increasing the rates of LTBI treatment to four times the baseline for all age groups from 2019 to 2048 was predicted to reduce active cases of TB cases by 49,707 compared with the baseline scenario. By 2048, the incidence rate of active TB in the total population was projected to decrease by approximately 6 cases per 100,000 person-years compared with the baseline scenario. The impact of aggressive LTBI treatment on suppressing reactivation appeared to be stronger than its effect on acute infection.

In the subsequent scenarios, the rates of LTBI treatment for each age group were assumed to be 0, 0.3, 0.7, 1.3, 1.7, 2, 3, and 4 times the estimated values (Tables S6-S8; Figure 3 and Figures S8-S15). As the primary focus was on the treatment of LTBI in adults, intervention measures were evaluated for all age groups, except the 0-18 age group. Adjusting the treatment rate for individuals aged 35-64 years had the greatest impact on reducing the number of active TB cases compared with changes made for other age groups. Assuming no LTBI treatment was provided for the 35-64 age group starting in 2019, the number of active TB cases, acutely infected cases, and cases of LTBI reactivation was anticipated to increase by 11,706, 569, and 9409, respectively, over 30 years (Table S7). Similarly, the incidence rates of active TB, acute infections, and LTBI reactivation cases were projected to shift from 73 to 86, 19 to 10, and 43 to 63 cases per 100,000 person-years, respectively (Figure 3, Figures S11 and S12). Meanwhile, it was expected that the number of people with active TB was expected to decrease by 32,814 cases compared with the baseline scenario when LTBI treatment for adults aged 35-64 years was intensified fourfold. The incidence rate of active TB was also projected to decrease by 4 cases per 100,000 person-years compared with the baseline scenario. TB cases in the 19-34 age group were not significantly affected, as individuals in this group are primarily infected by others within the same age group, owing to low transmission rates from other age groups.

In the next scenarios, we varied the probabilities of successful LTBI treatment in all age groups from 0%, 20%, 40%, 60%, 80%, to 100% and compared the results with the baseline scenario (Table S9, Figure 4, Figures S16 and S17). If the probability of success of treatment success was 0%, the expected increase in the number of active TB was 17,792, and the incidence rate was projected to increase from 73 to 87 cases per 100,000 person-years (Figure 4). Conversely, if the treatment was always assumed to be successful, the number of active cases of TB was expected to decrease by 5320 over 30 years, and the incidence rate would decrease from 73 to 84 cases per 100,000 person-years. The general trends of the results were similar to the scenarios in which the rate of LTBI treatment was varied, but the impact on the number of active TB cases was smaller than in the scenarios that changed the treatment rate, $\tau$.

In the remaining intervention scenarios, the probability of treatment success for one age group varied from 0% to 100% in increments of 20% between 2019 and 2048. Changes in the probability of success of LTBI treatment in the 35-64-year age group were found to have the most significant impact on active TB cases compared with other age groups (Table S11 and Figure 5). The results for other age groups are presented in Tables S10 and S12 and in Figures S18-S25. For the 35-64-year age group, when it was assumed that LTBI treatment would always fail, the number of active TB cases was projected to increase by 11,720, and the incidence rate was expected to increase from 73 to 86 cases per 100,000 person-years. Conversely, in scenarios where the treatment was assumed to always succeed, the anticipated reduction in active TB cases was 3211 compared with the baseline scenario. Furthermore, the incidence rate of active TB cases was projected to increase slightly, from 73 to 84 cases per 100,000 person-years over

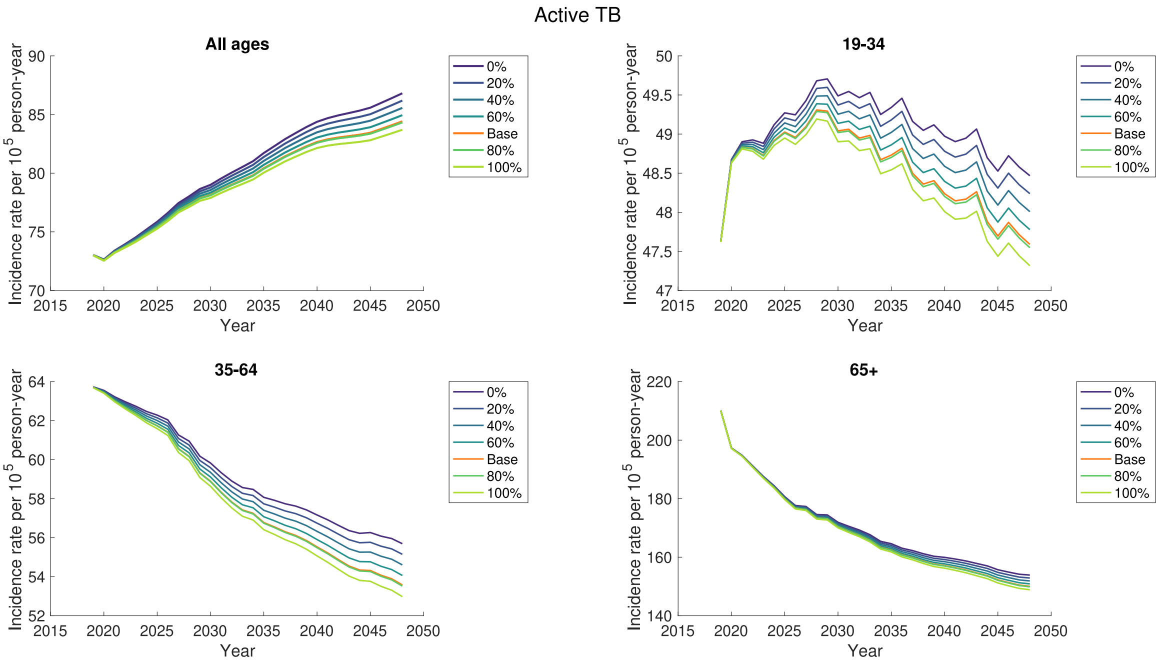


**Figure 4.** Predicted incidence rates of active tuberculosis (TB) per 100,000 person-years with different probabilities of success in treatment for latent tuberculosis infection (LTBI) in all age groups. The incidence rates are plotted for all ages (top left), 19-34 (top right), 35-64 (bottom left), and 65+ (bottom right) age groups.

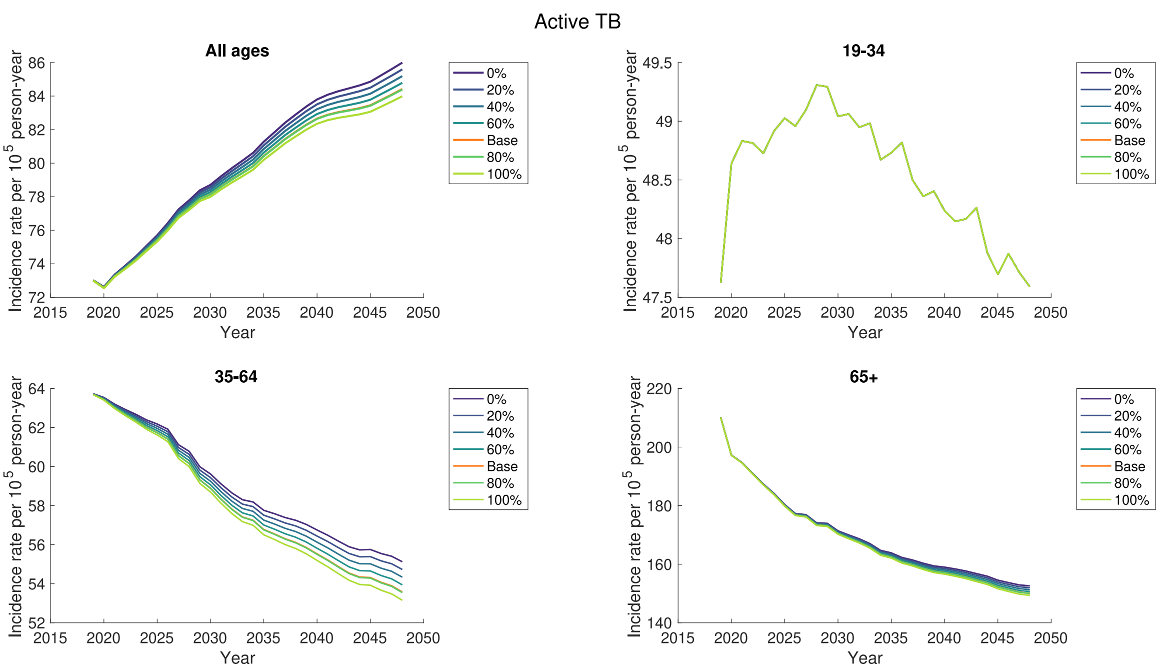


**Figure 5.** Incidence rates of active tuberculosis (TB) per 100,000 person-years with different probabilities of treatment success for latent tuberculosis infection (LTBI) for the 35-64 age group. Incidence rates are plotted for all age groups (top left), 19-34 (top right), 35-64 (bottom left), and 65+ (bottom right). The graphs in the 19-34 age groups overlap due to the unaffected model outcomes by varying the LTBI treatment success probability for the 35-64 age group.

30 years. As mentioned above, unaffected TB cases in the 19-34 age group were attributed to the low transmission rates from other age groups.

Based on predictions for 2019-2048, age-specific incidence rates of active TB and LTBI reactivation cases were expected to decrease. However, overall incidence rates across all age groups were projected to increase over 30 years. This can be attributed to the growing proportion of individuals aged 65 years and older as Korea transitions to an aging society (Table S13). To verify the demographic effect, we fixed population data to the population in 2018 and predicted incidence rates per 100,000 patients in the same scenarios. Figures S26 and S27 illustrate that the incidence rates of active TB at all ages decreased when it was assumed that the population remained unchanged. The predicted incidence rates in the other scenarios showed similar trends. These findings highlight the significant impact of population aging on TB in Korea.

## Discussion

This study used an age-structured dynamic model to demonstrate that age-specific and proactive interventions in LTBI treatment can significantly reduce the incidence of active TB in the

Republic of Korea. The model suggests that increasing LTBI treatment rates and the probability of treatment success, particularly in the 35-64-age group, produces a much greater reduction in active TB cases than interventions targeting other age groups. These findings are especially relevant given the limitations of current LTBI treatment practices, which typically restrict treatment to individuals aged under 65 years due to concerns about side effects like hepatotoxicity [19].

It is well established that the likelihood of LTBI progressing to active TB can be markedly reduced through appropriate treatment [20]. In the Republic of Korea, the proportion of newly diagnosed TB cases among individuals aged 65 years and older has been increasing, rising from 20.2% in 2001 to 41.9% in 2017. Moreover, the percentage of TB-related deaths in this age group increased significantly from 58.0% in 2001 to 81.7% in 2016 [2]. Despite the recognized benefits of LTBI treatment, its application in the older population is often constrained due to several challenges, indicating an urgent need for alternative intervention strategies that do not solely rely on direct treatment in individuals aged over 65 years.

Although the burden of TB in older populations is well documented, research focusing on age-specific modeling of LTBI remains scarce. For example, Lee et al. introduced a mathematical framework to investigate the transmission dynamics of TB with an emphasis on age-related factors, highlighting the pivotal role of age-targeted LTBI screening and treatment in reducing the incidence of TB in the Republic of Korea. The simplistic division of the population into only two categories, nonolder and older, in their model limits its practical applicability for developing customized treatment strategies and prioritizes strategies that promote direct LTBI treatment in the older population [21]. Cho et al. also evaluated the cost-effectiveness of LTBI treatment using an age-structured TB model. Instead of segmenting the population into distinct age groups, their approach incrementally broadened the age range from infancy, which limited its applicability to formulating effective age-specific intervention policies [22].

The strength of our study lies in demonstrating that implementing active treatment interventions in individuals aged 35-64 years, rather than directly targeting the older population over 65 years—where treatment interventions face significant limitations—can lead to greater overall benefits in reducing TB prevalence and incidence. One key reason for this effectiveness is that individuals in this age group represent a critical transmission link in the population. They are more likely to be in active social and occupational settings, which facilitates the spread of TB more significantly than older adults. Furthermore, the 35-64 age group is expected to remain the largest demographic until 2046, after which the 65 and older will become the majority. This demographic trend further supports the rationale for prioritizing interventions in the 35-64 age group. By targeting this demographic, intervention strategies can interrupt transmission chains more effectively, ultimately contributing to a larger reduction in TB incidence. Targeting the 35-64 age group with more intensive treatment for LTBI could serve as a critical buffer against the increasing number of active TB cases, highlighting the need for national TB control policies to incorporate more flexible strategies that include all ages. This approach underscores the potential effectiveness of indirect intervention strategies that focus on younger age groups to achieve broader public health impacts. These findings align with existing evidence that indicates that age-specific interventions can be highly effective, particularly in high-burden countries [21,23].

Expanding the coverage of LTBI treatment among older adults presents certain challenges. Safety concerns, particularly regarding hepatotoxicity and other side effects, have historically led to the exclusion of people over 65 years of age from routine LTBI treatment. Exploring safer alternative regimens, such as intermittent 12-dose isoniazid-rifapentine therapy, is crucial for making LTBI treatment more accessible and safer for older individuals. Furthermore, refining screening protocols to accurately identify people at the highest risk of LTBI progression and transition from LTBI to active TB could further optimize treatment outcomes and minimize the likelihood of adverse effects [24].

A practical strategy to increase LTBI treatment coverage could involve incorporating LTBI screening into Korea's existing national health screening program, which already offers biennial check-ups for adults aged 40 years and older. While our model applies a simplified treatment rate among individuals with LTBI, in practice, achieving such coverage would require a combination of population-level screening, LTBI test positivity, treatment initiation, and successful completion. Although our model does not explicitly simulate each of these steps, the assumed treatment rates conceptually reflect what could be achieved through systematic screening and follow-up within an established public health infrastructure. This interpretation provides a bridge between the model's assumptions and feasible implementation pathways in the Korean healthcare context.

Despite the potential benefits in reducing TB incidence rates within individual age groups, the overall TB burden is projected to increase due to demographic shifts in the Republic of Korea. As the population continues to age, the proportion of people at a high risk for LTBI reactivation will increase, leading to more active cases of TB. Therefore, age-specific strategies, along with broader healthcare policies that integrate LTBI screening and treatment into routine medical check-ups, could help improve treatment uptake and adherence among middle-aged and older populations. Expanding public health messages and awareness campaigns tailored to different age groups may further enhance the effectiveness of such interventions. These steps are crucial in addressing the challenges faced by an aging society.

This study has several limitations that should be acknowledged. First, our mathematical model relies on simplifying assumptions regarding the natural history of TB. Specifically, we assumed individuals with active TB return to the susceptible compartment after successful treatment, consistent with previous modeling studies [25,26]. Although this assumption may raise concerns about relapse or reinfection, prior studies suggest that the post-treatment risk is comparable to that of individuals with remote infection [27]. Additionally, Korean surveillance data indicate a decline in relapse rates from 4.8% to 1.0% between 2006 and 2010 [28]. Our model structure, which assumes that individuals must progress to active TB in order to transition from LTBI back to susceptibility, may raise concerns that a short-term increase in active cases could reduce long-term incidence. However, our simulations clearly demonstrate that decreasing LTBI treatment rates or success probabilities leads to increased long-term TB burden, encompassing both latent and active infections. Second, the model relies on assumptions regarding LTBI treatment success, patient adherence, and progression rates, which may oversimplify the complexities of real-world scenarios. Factors such as healthcare access, comorbidities, and individual behaviors could substantially influence the outcomes. Moreover, as model parameters were calibrated specifically for the Korean context, generalizability to other epidemiological contexts may be limited. Thus, further research is needed to refine parameters and validate findings across diverse settings. Third, although our findings strongly support expanding LTBI treatment in the 35-64 age group, the feasibility and cost-effectiveness of such interventions require further evaluation through pilot studies and longitudinal assessments. Finally, the model does not account for anti-TB drug resistance, including multidrug-resistant TB, which could significantly affect intervention effectiveness.

## Conclusion

In conclusion, this study emphasizes the importance of age-specific interventions in LTBI treatment for effective TB control in Korea. It highlights that successful TB control strategies should be adapted to the country's shifting demographics, with a particular focus on the adults aged 35-64 years, by addressing transmission dynamics across a broader population spectrum. A tailored approach to TB control would be crucial to mitigate the impact of population aging and ensure a sustainable future in the fight against TB.

## Author contributions

HS, JL, and JYS conceived the study and contributed to project administration. HS, JS, and YL designed the study; and YL and JS developed the model and performed the primary analysis. HS, YL, and JS contributed to data collection; and HS and YL wrote the first draft of the manuscript. All authors contributed to data interpretation, revision of the manuscript, and approved the final version of the manuscript.

## Declarations of competing interest

The authors declare that they have no competing interests.

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## Data sharing

All data used in this study are publicly available. Detailed information regarding the data sources and access methods can be found in the referenced literature. All codes for the model simulation were provided in the GitHub Repository (https://github.com/YunjeongLee/tuberculosis_by_age.git).

## Ethical approval

Patient consent for publication was not required as no identifiable personal data are included in this study.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.ijid.2025.108003.

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