Outbreak Reports

Epidemiological Investigation of a Tuberculosis Cluster Outbreak at a University — Changsha City, Hunan Province, China, September 2023–November 2025

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Summary

What is already known about this topic?

Tuberculosis (TB) is prone to cause clustered transmission in schools.

What is added by this report?

Following outbreak, the university conducted terminal disinfection of epidemic sites; however, *Mycobacterium tuberculosis* was detected (including air conditioner filters and air). Individuals with latent TB infection who receive preventive immunotherapy with Mycobacterium vaccae can develop active TB. Active cases were not identified promptly after preventive treatment, leading to renewed transmission.

What are the implications for public health practice?

Guidelines should add disinfection effectiveness evaluations and cover easily overlooked items, such as air conditioner filters. Follow-up examinations for individuals with LTBI who have completed preventive treatment remain necessary, as they still face a significant risk of developing active TB.

ABSTRACT

Introduction: From September 2023 to November 2025, a cluster outbreak of active tuberculosis (TB) was identified at a university in Changsha City, Hunan Province, China.

Methods: Contacts were screened, and patients with positive etiological results underwent sputum culture and drug susceptibility testing. Environmental samples (from air conditioners and air) were collected after terminal disinfection for polymerase chain reaction testing. A quantitative analysis of the infection risk was performed using linear regression models. Preventive intervention treatment effectiveness was evaluated using the log-rank test and Cox proportional hazards regression model.

Results: Of 671 contacts [110: latent tuberculosis infection (LTBI); 25: new active TB], all 26 cases, including the index case, were students. Whole-genome sequencing of five culture-positive cases showed high homology with ≤3 single nucleotide polymorphisms for four of them. For each additional hour of contact with the index patient, the prevalence of LTBI among contacts increased by 0.48%, and the TB incidence among individuals with LTBI increased by 0.20%. Developing active TB among individuals with LTBI who received Mycobacterium vaccae immunotherapy was 0.10 times that of the control group, the cumulative incidence within 2 years remained as high as 10.67%. Terminal disinfection of the epidemic sites was incomplete, and *M. tuberculosis* was detected in the air conditioner filters and air samples from the index case classroom and dormitory.

Conclusion: Contributing factors were failure to detect the index case during the new student entrance health examination, incomplete terminal disinfection of epidemic sites, and lack of follow-up monitoring of individuals with LTBI who received preventive immunotherapy.

Tuberculosis (TB) is a chronic infectious respiratory disease that poses a serious threat to public health. In 2024, the number of new TB cases worldwide reached 10.7 million, with 1.23 million deaths, ranking as the leading cause of death among infectious diseases (*1*). In crowded school settings with enclosed spaces, students have frequent close contact, which can facilitate the transmission of TB on campus (*2*). China has long attached great importance to TB prevention and control in schools. A series of documents have been issued to promote standardized and systematic prevention and control efforts to achieve significant results (*3*). However, several weaknesses remain in the current practice: first, accreditation standards and quality evaluation mechanisms for institutions conducting TB screening during new student entrance

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health examinations are not yet robust (*4*); second, there is a lack of scientific evaluation of the effectiveness of terminal disinfection at epidemic sites after an outbreak occurs (*5*); and third, requirements for long-term follow-up and effective monitoring for individuals with latent tuberculosis infection (LTBI) who have completed preventive treatment are not clearly defined (*6*). Evaluating the effectiveness of terminal disinfection is important because *M. tuberculosis* can persist at overlooked sites (e.g., air conditioner filters) and continue to pose infection risks in enclosed spaces if disinfection is incomplete (*7*). Likewise, evaluating the long-term outcomes of preventive immunotherapy is necessary as the durability of protection remains unclear and individuals who complete preventive treatment may still develop active TB without adequate follow-up (*8*). Between September 2023 and November 2025, a prolonged, large-scale cluster outbreak of TB was reported at a university in Changsha City, Hunan Province, China. Through an in-depth investigation of the outbreak, this study aimed to systematically describe its epidemiological characteristics, evaluate the effectiveness of terminal disinfection at epidemic sites and preventive treatment, analyze the relationship between infection/incidence risk and exposure duration, use empirical evidence to reveal key issues in current school TB prevention and control, and provide scientific evidence and management recommendations for optimizing prevention and control strategies.

INVESTIGATION AND RESULTS

Description of the Index Case

The index case was an 18-year-old male freshman majoring in physical education in class 2301, residing in room 419, Building 11 West. During his entrance health examination on September 10, 2023, the examination institution determined that his chest radiograph showed no abnormalities. However, upon re-reading by experts from the local municipal CDC and designated TB hospital, abnormal findings were identified on the chest radiographs.

He developed a productive cough on November 15, 2023, followed by progressive worsening of the cough and hemoptysis. From December 3 to December 18, 2023, he was treated for influenza A and pneumonia at two non-TB designated hospitals; however, his symptoms worsened. On December 19, 2023, he sought treatment at Hunan Provincial Chest Hospital and was diagnosed with cavitary pulmonary TB (sputum smear-positive 2+, rifampicin-susceptible), where his chest imaging findings revealed patchy high-density opacities in the dorsal segment of the right lower lobe, accompanied by a thick-walled cavity with smooth walls and no visible air-fluid level, surrounded by patchy satellite lesions. On December 22, 2023, the Centers for Disease Control and Prevention initiated an epidemiological investigation after receiving the report. The investigation revealed that he had classmates with TB in high school.

Distribution of Cases and LTBI

Among the 671 contacts, 110 individuals with LTBI were identified (Table 1), including 70 males, 40 females, 103 students, and seven staff members.

In total, 26 active TB cases (including the index case) were identified (13 confirmed pulmonary TB, 11 clinically diagnosed pulmonary TB, 2 extrapulmonary TB), all were students (18 males, 8 females), of whom 17 were asymptomatic (65.38%). The outbreak began with the first case identified in September 2023 and was followed by a gradual increase.

Two secondary case peaks occurred in January and April 2024. The outbreak subsided from August 2024 to July 2025 but resurged in August 2025, with a third peak in September 2025. The last case occurred in November 2025, with an outbreak duration of 28 months (Figure 1). The temporal distribution of cases was closely aligned with the timing of each screening round. Most individuals with LTBI and secondary cases were identified during the first and second rounds of screening, suggesting that contact identification was accurate. During the third round, the infection rate among contacts was only 6.96%, indicating that further expansion of screening is of limited necessity.

Evaluation of Preventive Treatment Effectiveness

Among individuals with LTBI, 35 did not receive preventive treatment (control group), with a 2-year cumulative incidence of 45.71%, which was concentrated in the early follow-up period. Seventy-five patients received Mycobacterium vaccae immunotherapy (intervention group), with a 2-year cumulative incidence rate of 10.67%. The intervention group had a lower risk in the early follow-up period; however, this risk increased significantly in the later period. log-Rank test results showed that the 2-year cumulative incidence in the intervention group was lower than that in the control group (χ^2=23.27,

TABLE 1. Details of contact screening.

Screening	Contact type	Number of contacts (*n*)	Number of LTBI (*n*)	Prevalence of LTBI among contacts (%)	Number of secondary cases (*n*)	TB incidence among individuals with LTBI (%)	Average exposure duration (hours)
First-round	Class 2301: Classmates of the index case	24	23	95.83	10	43.48	213.0
	Class 2301: Teachers of the index case	8	2	25.00	0	0.00	14.8
	Class 2302: Shared a classroom concurrently and self-study together	23	20	86.96	8	40.00	172.5
Second-round	Class 2307: Shared a classroom concurrently	24	18	75.00	3	16.67	100.5
	Class 2306: Shared a classroom concurrently	22	6	27.27	1	16.67	73.5
	Class 2303: Shared a classroom concurrently	24	3	12.50	0	0.00	73.5
Third-round	Same dormitory floor; Used the classroom later; Dormitory management staff	546	38	6.96	3	7.89	–
Total		671	110	16.4	25	22.7	–

Note: "–" means no direct contact with the index case.
Abbreviation: LTBI=latent tuberculosis infection; TB=tuberculosis.

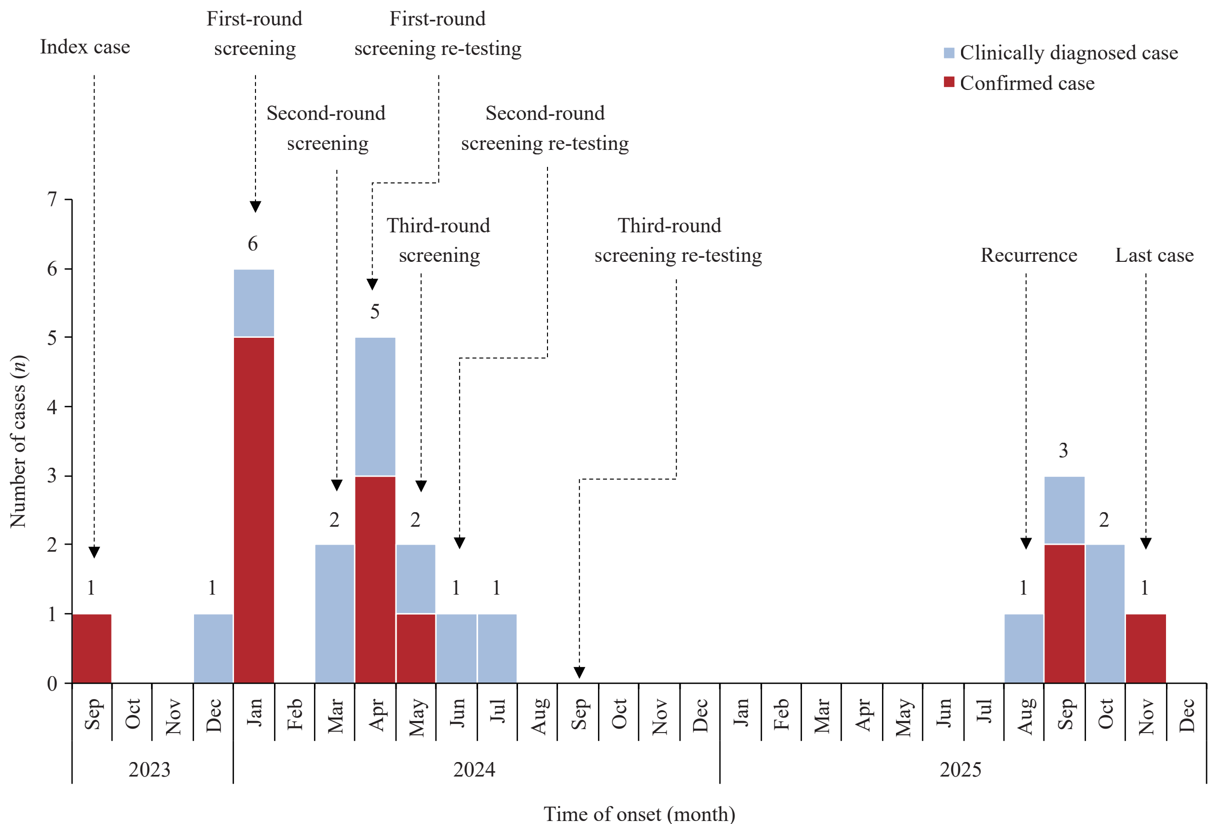

FIGURE 1. Epidemiological curve of a TB outbreak in Changsha City, Hunan Province, China, September 2023–November 2025.
Abbreviation: TB=tuberculosis.

P<0.01). The multivariable Cox proportional hazards regression model results, after adjusting for gender and age, showed that the hazard ratio (*HR*) in the intervention group was 0.10 [95% confidence interval

(*CI*): 0.04, 0.25] compared with the control group, indicating that the 2-year cumulative incidence risk in the intervention group was 0.10 times or 90.04% reduced risk that of the control group (Figure 2).

Environmental Health Investigation

The ventilation conditions in the classrooms and dormitory where the cases occurred were poor, with no fans or air conditioners installed. In April 2024, the local CDC investigation found that the university had completed terminal disinfection of the epidemic sites but had missed air conditioner filters, suggesting that *M. tuberculosis* may persist in the environment. To test this hypothesis, laboratory staff collected environmental samples (air conditioner filters and air) from four of the nine classrooms and five of the 15 dormitory rooms involved in the outbreak. *M. tuberculosis* was detected in air conditioner filter samples from all 4 classrooms and 5 dormitory rooms, and in air samples from 2 dormitory rooms. Among the 25 secondary cases, all were contacts of the index case, sharing the same classroom, dormitory, or dormitory floor, or using the same classroom after the index case. Their environmental exposure settings were identical or similar to those of the index case; therefore, the environmental hygiene conditions were not described separately.

PUBLIC HEALTH RESPONSE

The ventilation conditions in the classrooms and dormitory where the cases occurred were poor, with no fans or air conditioners installed. In April 2024, the local CDC investigation found that the university had completed terminal disinfection of the epidemic sites but had missed the air conditioner filters, suggesting that M. tuberculosis may persist in the environment. To test this hypothesis, laboratory staff collected environmental samples (air conditioner filters and air) from four of the nine classrooms and five of the 15 dormitory rooms involved in the outbreak. *M. tuberculosis* was detected in air conditioner filter samples from all 4 classrooms and 5 dormitory rooms, and in air samples from 2 dormitory rooms. Among the 25 secondary cases, all were contacts of the index case, sharing the same classroom, dormitory, or dormitory floor, or using the same classroom after the index case. Their environmental exposure settings were identical or similar to those of the index case; therefore, the environmental hygiene conditions were not described separately.

DISCUSSION

The school TB outbreak involved 26 cases. After its occurrence, comprehensive prevention and control

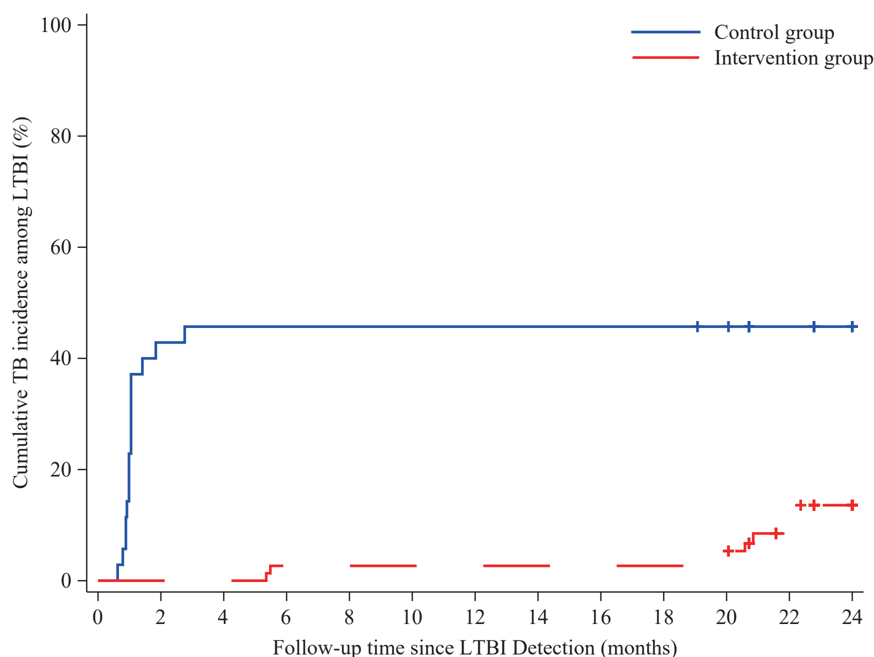

FIGURE 2. Survival analysis of preventive treatment in individuals with LTBI.
Abbreviation: LTBI=latent tuberculosis infection; TB=tuberculosis.

measures were implemented, resulting in no deaths or serious negative social impacts. According to the *Chinese School Tuberculosis Prevention and Control Guidelines (2020 Edition)* (*Guidelines 2020*) (*3*), this incident was determined to be a cluster outbreak of PTB in schools.

This outbreak reflects three urgent issues that need to be addressed:

First, the accreditation standards and quality evaluation mechanisms for institutions conducting TB screening during new student entrance health examinations are not yet robust (*4*). Since 2017, TB screening has been included as a mandatory component of entrance health examinations in China for new students, and routine health examinations for faculty and staff in all types of schools, effectively preventing patients with TB from transmitting the disease on campus (*9*). However, it is noteworthy that the current accreditation standards for entrance health examination institutions are low, leading to uneven quality. TB cluster outbreaks caused by lax screening at entrance examination institutions are common. The health examination institution involved in this outbreak did not participate in the quality control training organized by the local CDC. It conducted TB screening for approximately 9,000 new students at this university but reported no abnormalities. This institution's failure to detect abnormalities in the index patient's chest radiograph was a key reason for the development of this cluster outbreak. Therefore, it is necessary to issue national or local regulations to raise the accreditation threshold for health examination institutions, clarify their capacity limits, participate in mandatory local CDC training for TB screening institutions, and establish penalty standards for missed diagnoses.

Second, there are no requirements for evaluating the effectiveness of terminal disinfection at epidemic sites (*5*). *M. tuberculosis* is resistant to acid, alkali, natural environments, and drying and can survive in dried sputum for 6 to 8 months. Failure to disinfect air conditioner filters during terminal disinfection at schools was a significant factor in the prolonged outbreak. When teachers and students at the epidemic sites turned on air conditioners and closed windows and doors, classrooms and dormitory spaces became enclosed, creating favorable conditions for disease transmission. Environmental sample testing results showed that *M. tuberculosis* was detected in air conditioner filters and air from classrooms and dormitories where cases occurred (*7*), indicating that individuals at these sites faced a continued risk of infection. Currently, the *Guidelines 2020* do not mention air conditioner filters in their list of disinfection targets and do not require an evaluation of terminal disinfection effectiveness (*5*).

Third, the follow-up monitoring requirements for individuals with LTBI who have completed preventive treatment require urgent revision. According to the *Guidelines 2020*, individuals with LTBI who refuse preventive treatment should undergo chest radiography examinations at 3, 6, and 12 months after screening. However, patients who complete preventive treatment are only required to undergo one chest radiography at the end of the treatment course (*3*). This outbreak investigation found that compared with the control group, the intervention group receiving preventive immunotherapy had a 90.04% reduced risk of developing active TB. However, the cumulative incidence within two years in the intervention group was still as high as 10.67%. The risk in the intervention group was low in the early intervention period, but rebounded significantly after one year. As an immunomodulator, the protective effect of Mycobacterium vaccae depends on the quantity and function of memory T cells in the body. In the absence of sustained stimulation by pathogens or antigens, memory T cells gradually undergo apoptosis (*8*). Therefore, it is necessary to increase the frequency of follow-up monitoring of individuals who have completed preventive immunotherapy to prevent renewed outbreaks due to delayed case detection.

Therefore, we propose: 1) Raise accreditation threshold for entrance screening institutions, enforce penalties for missed diagnoses, and strengthen quality control. 2) Require environmental sampling, including air conditioner filters, after terminal disinfection at outbreak sites to confirm *M. tuberculosis* elimination. 3) For LTBI individuals completing preventive immunotherapy, conduct chest imaging follow-ups (e.g., at 6, 12, and 24 months) to detect active TB cases that may arise due to waning immunity. 4) Tier contact management by exposure duration: longer exposure warrants more frequent screening and prioritization for preventive treatment, whereas shorter exposure allows a simplified protocol.

For details on Methods, Overview of the School, Spatial Distribution Description, Quantitative Analysis of Infection Risk and Disease Onset Risk, Laboratory Investigation, Supplementary Discussion, see the supplementary materials (available at https://weekly.chinacdc.cn).

Conflicts of interest: No conflicts of interest

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SUPPLEMENTARY MATERIALS

Methods

Contact screening was conducted as follows: simultaneous screening for tuberculosis (TB) symptoms, recombinant Mycobacterium tuberculosis fusion protein (EC) skin testing, and chest radiography; etiological examination of patients with abnormalities; and strain identification and drug susceptibility testing of etiologically positive cases. EC-negative individuals were retested after three months. EC-positive individuals receiving preventive treatment underwent chest radiography upon completion; those declining treatment were followed by chest radiography at 3, 6, and 12 months. Immunoprophylaxis with *Mycobacterium vaccae* (six doses) was administered.

Culture-positive strains underwent whole-genome sequencing. Using high-throughput next-generation sequencing technology, single nucleotide polymorphism (SNP) variation information of the target genome relative to the reference genome was obtained. Environmental samples (from air conditioners and air) were collected after terminal disinfection of epidemic sites for polymerase chain reaction (PCR) testing.

The data collection methods were as follows: contact information was provided by the school; the duration of exposure between contacts and the index case was calculated based on class schedules and evening self-study arrangements, with one class period equivalent to 45 minutes [The index case class (2301) shared a fixed classroom for evening self-study with class 2302 and shared classes to varying degrees with classes 2303, 2306, and 2307. Based on the course schedule and evening self-study duration assessment, the average exposure durations between the index case (from enrollment on September 10, 2023, to leaving school on December 8, 2023) and students from classes 2301, 2302, 2303, 2306, and 2307 were 213.00 hours, 172.50 hours, 73.50 hours, 73.50 hours, and 100.50 hours, respectively; for staff in class 2301, the average contact hours were 14.81 hours.]; information on latent tuberculosis infection (LTBI) was provided by the screening institutions; and case information was obtained from investigations by the Centers for Disease Control and Prevention, school follow-up, and case reports from medical institutions.

Data were processed and analyzed using SAS software (version 9.4, SAS Institute Inc., Cary, NC, USA). Quantitative analyses of the prevalence of LTBI among contacts (Y_1) and the incidence of TB among individuals with LTBI (Y_2) in relation to exposure duration (X) were performed using linear regression models, as defined below. The Shapiro–Wilk test was used to examine whether the residuals satisfied normality, and the White test was used to examine whether the residuals satisfied homoscedasticity. Survival analysis was conducted with the time of LTBI diagnosis as the starting point and the onset of active TB as the endpoint, with a follow-up period of 24 months. The log-rank test was used to compare the cumulative incidences between the intervention and control groups. The hazard ratios (HRs) between the groups were evaluated using the Cox proportional hazards regression model under the proportional hazards assumption.

$$Y_1 = \frac{\text{Number of individuals with LTBI}}{\text{Number of contacts}}$$

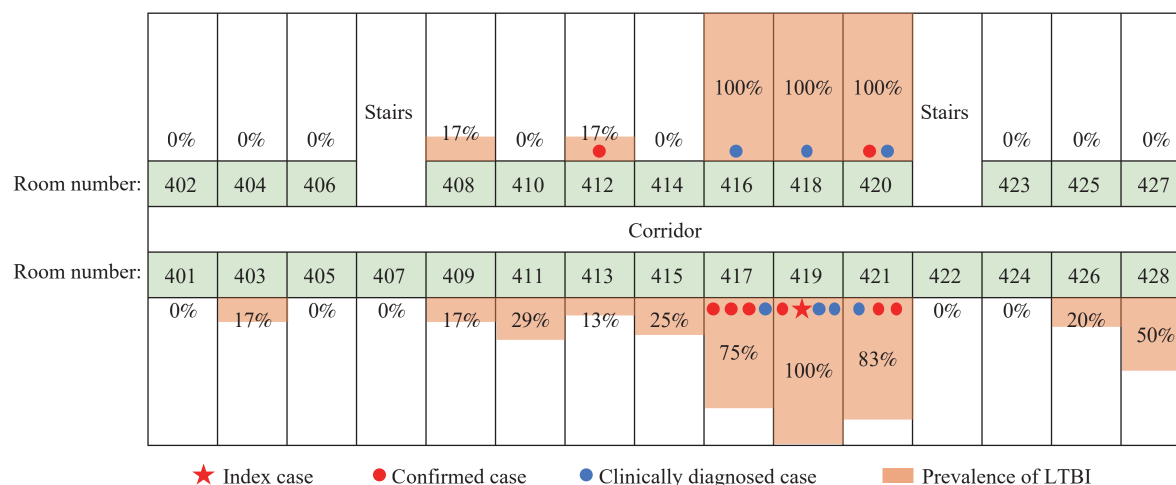
$$Y_2 = \frac{\text{Number of secondary TB cases}}{\text{Number of individuals with LTBI}}$$

Overview of the School

The outbreak occurred at a private undergraduate university (three-year academic system and open management model), comprising 1,800 faculty and staff and 31,200 students, with the majority from Hunan Province. Infirmary included three doctors, six nurses, and one staff. In 2023, a new student entrance health examination was contracted to a local hospital through university bidding. Approximately 9,000 new students underwent the examination; however, no abnormalities were reported. The investigation revealed that this hospital did not participate in the quality control training organized by the local CDC.

Spatial Distribution Description

Spatial clustering was observed in the dormitory, with higher infection and progression risks closer to those of the index case (Supplementary Figure S1).



SUPPLEMENTARY FIGURE S1. Screening results on the same floor of the male dormitory where the index case resided.
Abbreviation: LTBI=latent tuberculosis infection.

Quantitative Analysis of Infection Risk and Disease Onset Risk

Scatter plots showed that the prevalence of LTBI among contacts (Y_1) in each class was linearly distributed with exposure duration (X). Linear regression analysis revealed that the linear regression equation was Y_1=0.48%X, which was statistically significant (F=79.46, P<0.01). For each additional hour of exposure, the prevalence of LTBI among contacts increased by 0.48% (Supplementary Figure S2).

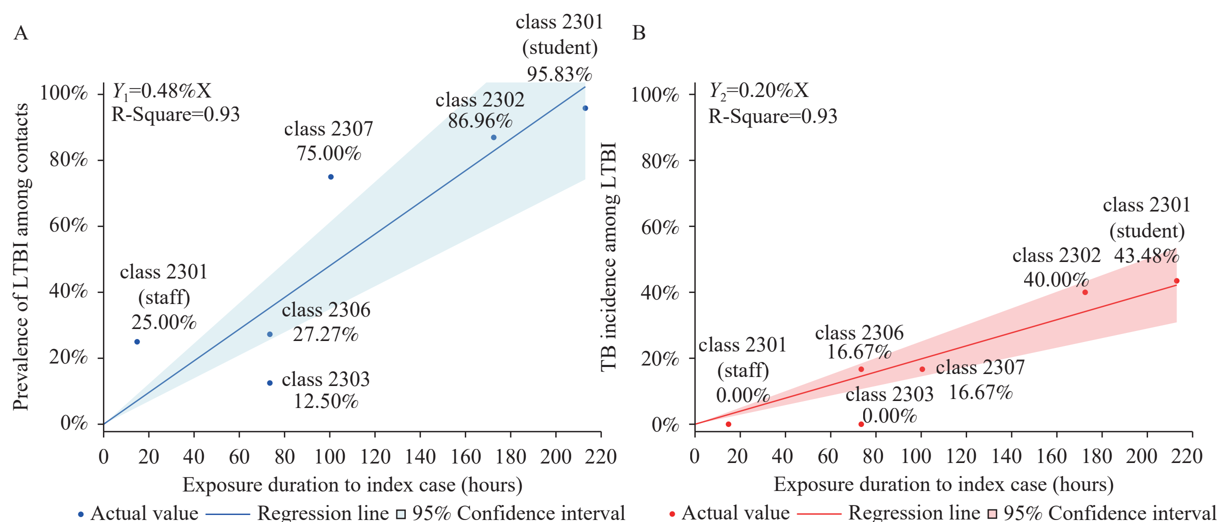
Scatter plots showed that the secondary incidence rate (Y_2) among individuals with LTBI in each class was linearly distributed with exposure duration (X). Linear regression analysis revealed that the linear regression equation was Y_2=0.20%X, which was statistically significant (F=83.53, P<0.01). For each additional hour of exposure, the incidence of TB among individuals with LTBI increased by 0.20% (Supplementary Figure S2).

Laboratory Investigation

Whole-genome sequencing was performed on five culture-positive strains. Testing revealed that all five strains belonged to the Beijing genotype (rifampicin-susceptible). Among them, four exhibited high homology (SNPs≤3), while the remaining one showed significant SNP divergence from the other four (SNPs from 450 to 452), suggesting the possible presence of two different sources of infection in this outbreak. For the four cases with high genomic homology, epidemiological investigation confirmed that they shared classroom and evening self-study sessions with the index case, with cumulative exposure durations ranging from 172.50 to 213.00 hours, and no other identifiable sources of infection, establishing a clear epidemiological link. The case with the non-homologous strain was in the same class as the index case, resided in a dormitory adjacent to that of the index case, and shared the same contact population as the index case.

Supplementary Discussion

The outbreak exhibited three key characteristics, including high transmissibility. The infection rate among the contacts identified in the first round of screening was 81.8%, which is extremely rare in other school TB outbreaks (*1*–*2*). This was primarily because the index case was sputum smear-positive 2+ with cavitary lesions, presenting obvious symptoms of cough and hemoptysis, and was highly infectious, transmitting the disease on campus for nearly three months from September 10 to December 8, 2023. Simultaneously, genotypic homology analysis results indicated the presence of two sources of infection in this outbreak, which suggests the possible presence of other sources of infection, in addition to the index case, contributing to transmission within the school. Second, the strains were highly pathogenic. The incidence of TB among 110 individuals with LTBI was 22.73% during the 2-year follow-up period. The incidence of TB among individuals with LTBI in classes 2301 and 2302 was even higher, reaching 43.48% and 40.00%, respectively, significantly exceeding the previously understood lifetime risk of 5%–10% for individuals with LTBI to develop active disease (*3*). Whole-genome sequencing results revealed that



SUPPLEMENTARY FIGURE S2. Linear regression analysis of the prevalence of LTBI among contacts and incidence of TB among individuals in relation to exposure duration. (A) Linear regression analysis of the prevalence of LTBI among contacts in relation to exposure duration. (B) Linear regression analysis of the incidence of TB among individuals with LTBI in relation to exposure duration.
Abbreviation: LTBI=latent tuberculosis infection; TB=tuberculosis.

the strain responsible for this outbreak was the Beijing genotype, providing laboratory evidence supporting its high pathogenicity and transmissibility (*4*). Third, there was a wide range of impacts, with 671 contacts identified. Owing to the index case-sharing classes and evening self-study sessions with other classes, and not using a fixed classroom, the outbreak spread across multiple classes.

Notably, there was a one-year period with no new cases between the early and late stages of this outbreak. There are two possible reasons for this finding. Preventive treatment reduces the risk of disease progression in patients with LTBI. In this study, immunoprophylaxis with Mycobacterium vaccae (6 doses) was used in individuals with LTBI, and Cox regression analysis showed a protective efficacy of 90.04%. Among the 110 patients with LTBI, 75 (68.18%) received preventive treatment, representing a high coverage rate that enhanced their short-term immunity and lowered their risk of developing active disease. Second, case detection may have been delayed. The individuals involved in this outbreak were primarily sports-related majors in good physical condition, and their symptoms at disease onset were often subtle. Of the 26 patients with TB, 17 presented with no obvious symptoms. Moreover, individuals with LTBI who received preventive treatment were not subjected to additional follow-up examinations, which may have led to subsequent cases being detected only when symptoms appeared. Therefore, the actual period without new cases may be shorter than one year.

Limitations include, regular immunological monitoring (e.g., T-cell responses) in individuals with LTBI who received Mycobacterium vaccae immunization was not performed. As environmental samples were tested using PCR without concurrent culture, the viability of the detected *M. tuberculosis* could not be determined. Finally, linear regression analysis included only six data points, resulting in limited statistical power.

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