Tuberculosis Outbreaks in Schools

Experiences from the Western Pacific Region

World Health Organization
Western Pacific Region

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Abbreviations

BCG	bacille Calmette-Guerin
GDP	gross domestic product
IDCL	Infectious Diseases Control Law
IGRA	interferon-gamma release assay
LTBI	latent tuberculosis infection
MHLW	Ministry of Health, Labour and Welfare (Japan)
MIRU-VNTR	mycobacterial interspersed repetitive units-variable number of tandem repeats
NCCD	National Centre for Communicable Disease
TB	tuberculosis
TST	tuberculin skin test
VNTR	variable number of tandem repeats
WHO	World Health Organization

Introduction

Despite continued progress in reducing the burden of tuberculosis (TB) in the World Health Organization (WHO) Western Pacific Region, TB remains a major public health concern in the Region. An estimated 1.8 million people in the Region developed TB in 2018, 77% of whom were notified by TB programmes *(1)*. The TB burden varies widely across the 37 countries and areas in the Region, with some countries and areas in which TB has been eliminated as a public health concern and others with the highest TB burdens globally.

In recent years, there have been increased reports of TB outbreaks among schoolchildren in the Western Pacific Region. Mass settings, overcrowded classrooms and variable risk profiles among students may contribute to the rapid transmission of TB in school settings. Moreover, TB outbreaks in schools and among children can attract intense media and community attention and increase scrutiny of TB programmes. Unfortunately, there are limited international guidelines for a response to TB outbreaks in schools.

This document summarizes current evidence on TB outbreaks in schools and contextualizes the information within the Western Pacific Region. First, a structured review was conducted to summarize documented TB outbreaks in schools globally. Then, four country case studies were developed to highlight the diverse range of experiences in the Region. As many countries have minimal experience in preventing and responding to TB outbreaks in schools, evidence from past outbreaks and case studies from a few countries with experience in such outbreaks could inform future responses in other countries.

Summary of evidence

A structured literature search was conducted on 4 November 2019 using MESH heading and search terms including "tuberculosis" AND "school" or "tuberculosis" AND "outbreak", "investigation" or "control" on PubMed and Google Scholar. Title and abstracts of identified articles were reviewed. All primary observational studies in English that reported on TB outbreak investigations in a school or childcare setting were included.

The literature search identified 38 articles that met all our inclusion criteria. The majority (29; 76%) reported on one or more TB outbreaks that occurred in a high-income country; 13 in Western Europe *(2–14)*, eight in the Western Pacific Region *(15–21)*, seven in the United States of America *(22–26)* and one in Israel *(27)*. The rest reported on China *(28–34)*, Iran *(35)* and Serbia *(36)*. Only one high-burden TB country was featured (China) and none reported on lower-middle- or low-income countries. Key findings are summarized in Table 1.

Table 1. Summary of key findings at each phase of the TB investigation

Phase	Key findings
Index case	• This was a student at a middle/secondary school (22 studies), primary school (5), kindergarten or nursery school (2), technical school (1). • The reported source of infection was a family member or guardian (6), school teacher (2) or schoolmate (1). • It presented with typical TB symptoms but was rarely diagnosed within one month (3).
Investigation initiation	• Investigation was initiated after the first active TB case was diagnosed (25 studies). • Investigation was initiated after more than one case was identified over a set period of time (7); the number of cases and the period of time varied. • The first phase of contact screening included close contacts at school and in the household only (19), school-wide (6) and household contacts only (1).
Coordination	• Coordination by public health authorities varied from the county to state level. • Clinical teams of nurses and physicians were deployed in the effort.
Scale of investigation	• Employed a stone-in-the-pond approach (14 studies). • Expanded due to media and/or parental pressure (2). • Contact tracing of causal contacts were often not reported and/or missed.
Screening and testing methods	• Mantoux tuberculin skin test (TST) (27 studies), tine test (2), gamma-interferon T spot (1). • Interferon-gamma release assay (IGRA) as first line for all (4), first line for subgroups (4), to confirm a positive TST (2).
Treatment and prevention	• Poor latent tuberculosis infection (LTBI) treatment uptake (4 studies), did not report LTBI treatment provision (18).
Communications	• Intensified media coverage (8 studies). • Announcement of the first active TB case resulted in anxiety among parents (1), some reported psychological distress due to lack of TB knowledge and uncertainty (1).

The index case

In most studies, the index cases were one or more adolescent students attending a middle or secondary school. Index cases were attending primary school in five studies *(3,6,11,37,38)*, were attending kindergarten or nursery school in two *(7,8)*, and attended a technical school in one *(2)*. Although the children presented with typical TB symptoms (i.e. persisting cough, fever, weight loss), they were only correctly diagnosed with TB within one month of the onset of symptoms in three studies *(19,28,38)*. Some symptomatic patients continued to attend school while undiagnosed and untreated. One study reported patients possibly did not seek care and concealed their TB diagnosis from the school administration due to fear of missing school opportunities *(28)*. Of the studies that reported the source of infection, close contact with an adult family member or guardian was the most reported *(5,13,24,25,35,37)*, followed by schoolteachers *(2,7)* and students at the same school *(6)*. Many studies did not report information on the source of infection or the infection timeline.

In studies where adults were the cause for the outbreaks, the index cases were primary schoolteachers *(15,38)*, assistants at nursery schools or day-care centres *(9,39)*, bus drivers *(14,26)* or a nursing schoolteacher *(16)*. In one study, the TB outbreak was only identified after routine chest screening among students *(20)*.

TB investigation

Initiation

In 25 studies, a school-based contact investigation was initiated soon after the first case of active TB was diagnosed. In most instances, the first stage of TB screening was limited to close contacts (i.e. students and teachers in same class or grade, household members) *(6,7,10,13–16,18,19,22,24,25,27,29,30,33,37,40,41)*. In six studies, however, immediate school-wide screening (i.e. all students and teachers) was conducted *(3,8,9,17,31,39)*. In one study, where the index case was a 9-year-old male in primary school, a contact investigation was only initiated after all household members tested positive on the tuberculin skin test (TST) *(11)*. In seven outbreaks, contact investigation was not initiated until more than one TB cases was diagnosed over a period of time, though the number of cases (one to five cases) and the time period (two weeks to one year) differ *(2,4,5,21,23,26,36)*.

Coordination

Field investigations were coordinated by public health officials, although authority varied from county to state levels. Clinical teams were deployed to schools to conduct TB screening, and the majority consisted of nurses and physicians. Three studies deployed multidisciplinary teams with medical specialists (i.e. respiratory physicians, paediatricians, infectious disease specialists, mental health professionals) to facilitate with TB testing and to provide counselling to students, school staff and parents *(18,22,24)*. To overcome the large number of individuals needed to be screened quickly, off-campus clinics and community health teams were also recruited in three studies *(19,24,38)*. One study in the United States of America triggered an established rapid response system that mobilized resources and clinical staff from neighbouring counties and states to support the demand surge *(22)*.

Scale of investigation

As mentioned above, the first phase of contact tracing in most studies included only close contacts at home or at school. Some field investigations use the stone-in-the-pond approach (a contact investigation based on the risk of exposure and TB susceptibility) and expanded TB screening to all or lower-risk individuals after a high infection rate – active and/or latent tuberculosis infection (LTBI) – was detected from the initial round of screening *(6,7,10,11,13,15,18,19,22,23,27,29,30,41)*. However, these additional infectious cases were often not identified until follow-up TST screening two to three months after the initial screening. Additional cases were identified one year after diagnosis of the index case in two outbreaks *(27,41)*. Two studies, one in Australia and one in the United States of America, reported that TB screening was expanded due to parental pressure and media coverage of a school outbreak *(15,40)*.

Other than outbreaks that occurred in boarding schools, household contacts were soon screened after the index case was diagnosed. As most studies only investigated school contacts, school records or class schedules were used to identify eligible classmates or school-bus riders. Of the studies that identified active TB cases in high school students, only seven studies (25%) reported regular contacts outside of schools (e.g. friends, co-workers, shared extracurricular classes) were screened as part of the contact investigation *(2,5,18,22,23,35,40)*. The index case of one study in the United States of America did not disclose 20 social contacts until one year after TB diagnosis; one had active TB, two had LTBI and 11 could not be traced *(22)*.

Screening and testing methods

The Mantoux TST was the most commonly used screening method across all studies. One study *(11)* replaced it with gamma-interferon T spot due to logistic issues with the TST, and two older studies used the tine test (multiple-puncture TST) *(3,5)*. The induration size for positive TST varied depending on background vaccination of bacille Calmette-Guerin (BCG), and three studies reported larger induration criteria for individuals with limited or no exposure to diagnosed TB cases compared to close contacts *(18,27,37)*. In more recent investigations, interferon-gamma release assay (IGRA) was used as the first-line screening test for all individuals *(2,12,14,16)*, select individuals *(8,22,24,40)* (e.g. high risk, previous BCG vaccination, lived far from clinic) or to confirm a positive TST *(21,23)*. Approximately half of the studies did not report whether follow-up testing was conducted to rule out false-negative initial screening. In 20 studies, molecular tests – e.g. mycobacterial interspersed repetitive units-variable number of tandem repeats (MIRU-VNTR), DNA fingerprinting – were used to confirm genotype linkage to the index case or to identify outbreak clusters *(2,6–8,11–13,18–20,22,23,26,27,31,33,36,37,40,41)*.

Treatment and prevention

In all studies, individuals screened positive then underwent the age-appropriate TB testing procedure and were referred for TB treatment. However, treatment initiation or outcomes were seldom reported. Eighteen studies did not mention whether those diagnosed with LTBI were offered preventive treatment *(5,6,8–10,13,14,16,20,21,23,26,28,31,32,35,36,40)*. Four studies, including three in China *(29,30,33)*, reported that 40–100% of individuals diagnosed with LTBI declined preventive treatment.

Investigation interruptions

As TB screening may be expanded to lower-risk individuals and patients who often require continuous monitoring until treatment and/or testing completion, field investigations can extend beyond one year. In turn, four studies reported school breaks (e.g. major holidays, summer break, end of the school year) can result in the interruption of field investigations *(18,19,23,24)*. Five studies reported management by referring individuals to non-campus clinics during school breaks, repeating screening when school resumed, educating patients or parents to monitor TB treatment, and reminding students who graduated to another school to complete their assessment by mail or phone call *(18,19,23,25,28)*.

Communications

Eight studies reported intensified media coverage (e.g. social media, local or national news) and public interest during the TB outbreak *(4,15,18,19,22–24,40)*. During one outbreak in China *(40)*, the initial announcement of a TB case in school by the school administration resulted in anxiety in parents, and screening was expanded due to media attention. One study reported parents experiencing psychological pressure from limited TB knowledge and the uncertain prognosis for their children *(34)*. To prevent the spread of misinformation, past outbreaks have conducted initiatives such as: 1) designating a single contact person to coordinate media interest; 2) public health and school officials conducting regular briefings for the public (students, families) and news reporters; 3) developing multilingual media releases and fact sheets; and 4) sending informational pamphlets along with consent forms to parents at the start of the field investigation.

Country case studies

China

Population, 2019 *(42)*	Total: 1.40 billion Aged 0–14 years (%): 18%
TB incidence, 2018 (thousands) *(1)*	Total: 866 (740–1000) Children 0–14 years: 36 (30–41)
Life expectancy at birth, 2018 *(42)*	77 years
< 5 mortality rate, 2019 *(43)*	8 per 1000 live births
GDP* per capita, 2019 (US$) *(44)*	10 300
Health expenditure, 2017 (% GDP) *(45)*	5.2%

*gross domestic product

TB cases notified among students

Across China, there are approximately 496 000 schools attended by 250 million students *(46)*. There was a resurgence of TB incidence among students in recent years (2018: 18 cases per 100 000 students), after a steady decrease between 2008 and 2016 (2016: 14 cases per 100 000 students; 2008: 26 cases per 100 000 students)*(47,48)*. Among student TB cases reported in 2018, 44% were between 16 and 18 years old (high school), 31% between 19 and 22 years old (college), and 16% between 13 and 15 years old (middle school) *(48)*.

Notification among students peaks at two time points each year: from March to April and in September. This may be attributed to mandatory college entrance health checks and high school examinations. Some 43% of notified student cases originated from 10 provinces, which only account for 24% of all students in China. Higher incidence was also reported in the central (16 cases per 100 000 students) and western (29 cases per 100 000 students) regions, compared with the eastern region (12 cases per 100 000 students) *(47)*.

Past outbreaks in schools

China defines an outbreak as at least 10 TB cases with established epidemiological associations appearing in one school during one semester or if there have been TB-related deaths. Each outbreak is determined by local public health authorities, typically at the county level, based on public health risk assessments and on-site investigations *(49)*.

All TB outbreaks since 2006 were captured by National Public Health Emergency Reporting System, after the establishment of the *National Contingency Plan for Public Health Emergencies*. Approximately 80 outbreaks were reported nationally between 2006 and 2018. The number of cases involved varied, and the majority occurred in boarding schools (70% in high schools or secondary technical schools and 20% in private schools) *(47)*.

Below are few recent examples of TB outbreaks in schools.

Outbreak 1. Middle school in Hunan province

In August 2017, an emergency committee (consisting of local government and relevant departments) declared a Level IV Emergency Response to a Public Health Emergency. All students and staff were screened for TB four times. TB screening was repeated at regular intervals for asymptomatic close contacts and for classes with a high incidence of pulmonary TB. Treatment of infected students was a top priority, and a committee chaired by the county's top officials was established to facilitate treatment and to monitor the prognosis. Provincial- and municipal-level experts were invited to provide technical guidance on a regular basis. School infrastructure (e.g. classrooms, dorms, lavatories) were disinfected daily. Counselling via home visits or phone calls was offered to students and parents. Individually tailored study schemes were developed for infected students so that they could continue academic studies online and off-campus until medical clearance. Inpatient and outpatient costs incurred by students were fully covered by the county government and medical insurance.

By 16 November 2017, 29 pulmonary TB and five presumptive pulmonary TB cases were identified. Of the 72 students who began TB preventive therapy or TB treatment, 50 were medically cleared to resume schooling and the rest remained on treatment.

Outbreak 2. Medical college in Shanghai

The annual health check identified two presumptive pulmonary TB cases in November 2017. Screening of close contacts detected nine pulmonary TB cases in the same class and two from other classes.

The Shanghai Municipal Health Commission and the Commission of Education established a working group to monitor the outbreak investigation. Experts from municipal branches of the Chinese Center for Disease Control and Prevention and a TB-designated hospital were invited to conduct TB screening and an epidemiological investigation and to implement control measures, such as environmental disinfection and disseminating health promotion material to staff and students.

Outbreak 3. College in Zhejiang

After the index case was notified on 21 November 2017, the college immediately initiated its emergency contingency plan. The Hangzhou municipal Center for Disease Control and Prevention conducted TB screening for close contacts on campus and identified 13 pulmonary TB cases among 285 close contacts within three days. Two additional pulmonary TB cases were identified, but a plausible epidemiological connection could not be established and these cases were considered to be unrelated to the outbreak. The college ensured that TB patients were quarantined and were receiving proper treatment.

The college also designated quarantine areas for students with presumptive pulmonary TB and closely monitored asymptomatic students. Dorm rooms were thoroughly disinfected, and good ventilation was maintained throughout the investigation. The school also provided TB prevention material to all students.

TB control and management in schools

TB prevention and control standards in schools are detailed in three documents: *The National Tuberculosis Plan* under the *13th Five-year Plan*, the *Implementing Standards for Tuberculosis Prevention and Control in Schools,* and the *Tuberculosis Control Action Plan 2019–2022*. The 2019–2022 Action Plan was jointly issued by the National Health Commission and eight other national ministries and aims to increase the capacity of schools to detect TB cases early and to prevent public health emergencies. Recommended measures include incorporating TB screening in newly enrolled students and staff, monitoring students on sick leave, and ensuring school infrastructure meets environmental hygiene standards. Subnational TB prevention and control plans are recommended to be developed with a cross-departmental approach to guide TB control efforts at schools.

TB outbreak investigations are guided by *The Expert Consensus on Epidemiological Investigation and Onsite Disposition of Tuberculosis Outbreaks in Schools*. TB case reporting is mandated by the Interim Regulation on Public Health Emergencies.

Japan

Population, 2019 *(42)*	Total: 126.3 million Aged 0–14 years (%): 13%
TB incidence, 2018 *(1)*	Total: 18 000 (15 000–21 000) Children 0–14 years: 59 (50–67)
Life expectancy at birth, 2018 *(42)*	84 years
< 5 mortality rate, 2019 *(43)*	3 per 1000 live births
GDP per capita, 2019 (US$) *(44)*	40 200
Health expenditure, 2017 (% GDP) *(45)*	10.9%

*gross domestic product

Past outbreaks in schools

Japan's Ministry of Health, Labour and Welfare (MHLW) defines a TB outbreak as an event in which a single source case infects more than 20 people in more than two families.

Between 2007 and 2017, 12% of all TB outbreaks occurred in schools, with Japanese-language schools reporting the most outbreaks in recent years.

Outbreak 1. Junior high and high school in Tokyo

The index case was a 13-year-old male student attending junior high school. He experienced intermittent fever, cough and sputum for six months before TB was diagnosed. Although the patient visited a few clinics two months prior to diagnosis, a chest X-ray was never taken. He was diagnosed with bacteriologically confirmed drug-susceptible TB in April 2009.

TB screening of family members identified one active TB and two LTBI cases. A school investigation was conducted using IGRA and chest X-rays for classmates and teachers. A high IGRA positivity rate was found among classmates, and TB prevention treatment was given to 50% of the classmates. Contact examination was expanded to all students and teachers across campus. The proportion of students with LTBI had increased due to additional exposure to the index case. A second case of pulmonary TB was identified in a first-year high school student in July 2009. VNTR (variable number tandem repeat) patterns between the index and second case were identical. Overall, 15 active TB cases were identified and 45 were diagnosed with LTBI.

Outbreak 2. Junior high school in Chiba

The index case was diagnosed in January 2010. Twenty-one LTBI cases were identified, but no active TB cases were found.

Outbreak 3. Primary school in Okinawa

The index case was a 12-year-old male student in primary school. The patient first experienced symptoms in June 2012 and was treated at a nearby clinic. Although an

abnormal chest X-ray was taken in October 2012, TB was not diagnosed at that time. Symptoms continued to worsen and he was hospitalized for mycoplasma pneumonia on 21 February 2013. The patient's mother was diagnosed with TB three days after the patient was hospitalized, and the patient was diagnosed with bacteriologically confirmed TB on 25 February.

Immediately after the index case was diagnosed, the public health centre initiated a contact investigation of classmates. A high infection rate (61%; two active TB and 17 LTBI) was found, and screening was expanded to all students in the same grade. The second round of screening detected 31 LTBI and no active cases (infection rate 32%). In turn, all 847 students in the school and the family members of the index case were screened. In total, five active TB and 63 LTBI cases were identified. VNTR patterns of the index case, his mother and one classmate were identical.

Outbreak 4. Junior high school in Hachioji

The index case was a 46 year-old male teacher at a junior high school. He was recommended for clinical evaluation after an abnormal chest X-ray during annual screening, but he failed to comply. He began experiencing a cough in April 2013 and was not diagnosed with pulmonary and bronchial TB until 29 August 2013. Meanwhile, he visited a few clinics, but TB was never diagnosed.

The public health centre immediately began a contact investigation, in cooperation with the school and education board of the city. Briefings for parents and students were held before the contact investigation was conducted. The public health centre provided medical and treatment counselling, and the school provided mental health support to students. A contact investigation of all students and staff members was conducted, which took a month. Parents were then notified of the results at briefings. After one LTBI case was identified among teachers who participated in training in August, a contact investigation was carried out in this subgroup and found no cases. A contact investigation was repeated two months after the initial screening. Of the 455 individuals tested, two active TB cases were found and 16 individuals had LTBI.

TB control and management in schools

The TB epidemiological surveys and contact investigations to be conducted during outbreaks are detailed in the Infectious Diseases Control Law (IDCL). The School Health and Safety Act prohibits students with infectious diseases from attending school, and the IDCL prohibits smear-positive cases from working until the sputum tests negative. Japan has a contact investigation guide that details criteria for expanding contact investigations. If a public health centre identifies an outbreak case, it must be reported to MHLW.

Public health centres have the primary responsibility to conduct contact investigations based on the ICDL. It is recommended that an outbreak investigation committee be convened. This committee should include school officials, local education committee officials, public health centre officials, local laboratory staff, TB experts and a local medical association representative, if needed. Parent association representatives are usually not invited due to confidentiality of the index case.

Mongolia

Population, 2019 *(42)*	Total: 3.2 million Aged 0–14 years (%): 31%
TB incidence, 2018 (thousands) *(1)*	Total: 14 (7–22) Children 0–14 years: 2.1 (0.7–3.5)
Life expectancy at birth, 2018 *(42)*	70 years
< 5 mortality rate, 2019 *(43)*	16 per 1000 live births
GDP per capita, 2019 (US$) *(44)*	4300
Health expenditure, 2017 (% GDP) *(45)*	4.0%

*gross domestic product

Past outbreaks in schools

A system for identifying TB outbreaks has not yet been well established in the country. Mongolia defines an outbreak based on the definition from the United States Centers for Disease Control and Prevention *(50)*. A major outbreak that occurred in one school between 2015 and 2017 is described below.

Outbreak 1. Secondary school in Khan-Uul district

Between 2015 and 2017, 60 active TB cases were reported from a secondary school in the Khan-Uul district of the capital of Ulaanbaatar. Active case finding was conducted in March 2017 and 49% of 889 students were TST positive. Isoniazid preventive therapy, however, was not offered to students due to insufficient stocks.

An outbreak investigation was conducted jointly between May and June 2017 by the Khan-Uul District Health Care Centre and the Tuberculosis Surveillance and Research Department and Diagnostics Division of the National Centre for Communicable Disease (NCCD). All school staff and eighth- to 12th-grade students were screened using chest X-rays. First- to seventh-grade students were screened using TST, followed by chest X-ray screening if induration was > 10mm. Sputum samples were collected from individuals with chest X-rays indicative of TB and were sent to the National Tuberculosis Reference Laboratory of NCCD for both mucus sputum tests and molecular biological studies. Of the 1618 students tested, two bacteriologically confirmed TB cases were detected.

A second field investigation was conducted in November 2017. Eighth- to 12th-grade students and students with negative TST from the first round of screening underwent further TST. TST conversion was detected in 91 students. Nine bacteriologically confirmed TB cases were identified, and another nine cases were clinically diagnosed by TB specialists and paediatricians.

A third field investigation took place in April 2018. TST was repeated among first- and second- grade students, 58 of whom converted to positive TST results. Symptom

screening and chest X-rays were conducted in 957 students, and one additional bacteriologically confirmed TB case was identified.

A fourth field investigation is currently ongoing. Two bacteriologically confirmed TB cases have been detected so far. Follow-up investigations were originally planned every six months for two years, until no new cases were detected. However, this was not implemented due to limited financial and human resource support.

TB control and management in schools

Currently, there are no established regulations and standards on TB management in schools in the Mongolia. A cross-ministry meeting (with the Ministry of Health; Ministry of Education, Culture and Sports; city governor's office; city's professional inspection agency; and others) was convened to develop plans for TB in schools and to report TB outbreaks. Draft guidelines on TB outbreaks are planned for approval by the Minister of Health.

Republic of Korea

Population, 2019 *(42)*	Total: 51.7 million Aged 0–14 years (%): 13%
TB incidence, 2018 *(1)*	Total: 34 000 (31 000–36 000) Children 0–14 years: 82 (77–88)
Life expectancy at birth, 2018 *(42)*	83 years
< 5 mortality rate, 2019 *(43)*	3 per 1000 live births
GDP per capita, 2019 (US$) *(44)*	31 800
Health expenditure, 2017 (% GDP) *(45)*	7.6%

*gross domestic product

Past outbreaks in schools

The Republic of Korea defines a TB outbreak as a situation where there are more TB cases detected than expected in a contact investigation in congregated settings.

In 2013, contact investigations in congregated settings, including schools, were introduced. Several TB outbreaks in schools have been identified since then. Consistent with the national trend of decreased case notification over time in the general population, the number of contact investigations in schools decreased from 192 in 2013 to 32 in 2018. The majority of the investigations occurred in universities or high schools. In 2018, 43% were in universities, 22% in high schools, 12% in primary schools, 11% in nursery schools and 9% in middle schools.

Outbreak 1. University

The index case was an 18-year-old male university student. He experienced a cough and fever for one week prior to being diagnosed with bacteriologically confirmed TB in September 2016. During the contact investigation of 48 close contacts, two active TB cases were identified. The contact investigation subsequently was expanded to all students and staff, and one active TB case was detected. Of the 569 individuals screened, 37 were diagnosed with LTBI.

Outbreak 2. University

In April 2015, the index case, a 19-year-old male university student, was diagnosed one week after symptom onset. A contact investigation was conducted for both casual and close contacts using chest X-rays. Active TB was found in four students in the same major subject field as the index case. The percentage diagnosed with LTBI was higher among close contacts (16; 22%) than among casual contacts (3; 3%)

Outbreak 3. High school

A 16-year-old female high school student was notified in June 2018, two weeks after symptom onset. A contact investigation was conducted among 250 individuals using

chest X-rays, and a female classmate was diagnosed with active TB. Of the 63 individuals tested for LTBI, 14 (seven close contacts, seven teachers) tested positive.

Outbreak 4. University

The index case was a 21-year-old female university student, who experienced cough for eight weeks prior to diagnosis in December 2017. A contact investigation was initiated among students, and two active TB cases were found among her close contacts. Another seven close contacts were diagnosed with LTBI. LTBI was not tested among the 123 casual contacts.

TB control and management in schools

The Infectious Diseases Prevention and Control Act describes the legal responsibility of the central and local government (Article 4) and of the epidemiological investigation (Article 18). The Tuberculosis Prevention Act details measures to be taken against outbreaks (Article 10) and to manage contacts of infectious TB (Article 19).

After a school reports a TB case to a health centre, the head of the health centre should notify provincial TB officials, the Korea Centers for Disease Control and Prevention, and the electronic TB surveillance system. The health centre should organize an investigation team composed of a physician and TB nurse from the health centre, a member of Korea Tuberculosis Epidemic Investigation Service from the Korea Centers for Disease Control and Prevention, a principal and health teacher from the school, and a focal person from the provincial Department of Education. The health centre is responsible for conducting case and contact investigations, treating patients, and inputting the results of contact investigation into the TB surveillance system. The health centre also should provide briefing sessions with parents and students, when necessary. The provincial department of health is in charge of the administrative measures of the contact investigation, including supporting and supervising the respective health centre's activities during the contact investigation.

Conclusions

The four country experiences demonstrate the range of challenges faced by countries in the Western Pacific Region. Moreover, these experiences echo many of the issues that were identified in the literature review from past outbreaks globally. The challenges and lessons learnt from each country are summarized in Table 2, along with potential solutions from published guidelines and past outbreaks.

Table 2. Key challenges and lessons learnt

Challenges	Lessons learnt and solutions
Delayed TB diagnosis	• Empower students to proactively identify and manage their health issues through TB-related health promotion in schools and by reducing stigma. • Outbreaks could be an opportunity to educate health-care professionals and the general public that TB still exists in their communities. • Improve the capacity of schools to detect TB cases.
Low LTBI treatment uptake	• Educate students, teachers and parents about the importance of LTBI treatment. • Offer LTBI treatment at the site of the outbreak. • Create a treatment monitoring system to ensure patients initiate and complete the full course of treatment.
Lack of financial support and human resource capacity	• Recruit staff (e.g. nurses, laboratory staff) and resources from neighbouring cities or from outside the TB teams. • Assessment of resources available should be conducted at the start of a field investigation to ensure continuity in services.
Poor coordination among stakeholders	• Establish national policies and local plans to coordinate the outbreak response. • Health and education authorities, at all levels, should support schools to implement prevention and control activities. • Clarify the role of each organization to ensure harmony and complementarity.
Media and community attention interfering with outbreak response	• Outbreak communications should focus on: 1) clear and early announcements; 2) building and maintaining trust; 3) transparency; and 4) understanding the public. • Designate a communications staff member to coordinate media requests and to provide public briefings. • Provide information and counselling to parents and students starting from the beginning of the outbreak.

In majority of past outbreaks, the index case has been a high-school or university student. As young adults and older children are more likely to have more casual contacts, this could increase the size and complexity of field investigation. Guidelines (from the Public Health Agency of Canada, the European Centre for Disease Control and Prevention, the National Institute for Health and Care Excellence in United Kingdom of Great Britain and Northern Ireland, and the United States Centers for Disease Control and Prevention) suggest a stone-in-the-pond approach to field investigations, where contacts are prioritized based on the risk of exposure and TB susceptibility *(51–54)*. After screening those considered to be of the highest risk, the investigation would only be expanded if the infection rate

is higher than expected. One guideline noted that this systematic and cost-effective screening approach is rarely implemented if the index case is a child *(54)*.

Delayed in TB diagnoses were repeatedly reported. In countries with low TB incidence, clinicians may be less conscious of TB symptoms and therefore misdiagnose patients. Delayed diagnosis may also be attributed to low TB knowledge among students and teachers, as well as poor health seeking-behaviour among students. In many instances, health promotion material was distributed during outbreaks to increase TB awareness and reduce stigma. China developed online modules for students to decrease school interruptions during TB treatment, which may further reduce hesitancy to seek care. China also recommends routine symptom monitoring by head teachers and monitoring of student absences in order to identify presumptive TB cases early on. Once the index case is identified, guidelines suggest that an alert system should be in place to notify the responsible public health authority *(51–54)*. Japan reported that a TB alert system for health-care workers and the general public may be important.

As field investigations should begin soon after identifying an outbreak, there is a surge in demand for human resources (e.g. clinicians, nurses) and medical supplies (e.g. test kits, drugs). Mongolia, for example, could not treat patients with LTBI due to drug shortages and had to limit the number of follow-up investigations due to financial constraints. Japan also reported a lack of paediatricians with experience in TB to facilitate screening. Past outbreaks were managed by recruiting assistance from neighbouring districts or by spacing out screening over a longer period of time. Guidelines suggest that an assessment of required resources should be conducted at the beginning of the investigation and staff from outside the TB teams could be recruited to facilitate the response *(51,54)*. Sustained financial and human resources support are crucial as investigations could be prolonged. The Republic of Korea reported that high turnover of nurses may disrupt patient monitoring and noted that during past outbreaks school breaks interrupted field investigations. Guidelines indicate that a vigilant TB surveillance system is needed to monitor patients' prognosis and TB epidemiology over time *(51–54)*.

The importance of communications was also emphasized, as TB outbreaks in schools often resulted in increased attention from the media and the community. Designating communications personnel to coordinate media requests and to regularly update the public and media was useful in the past. Guidelines state that proactive communication with parents, school administrators, students, health practitioners and the general public is always needed *(51–54)*. The *WHO Outbreak Communication Guidelines* detail best practices to effectively communicate with the public during an outbreak *(55)*.

Cooperation with relevant organizations, particularly between public health authorities and school officials, was commonly reported. In some instances, the burden of coordinating TB screening and monitoring students over time was shared between the school and public health centre. Although local public health centres were primarily responsible for the outbreak response, external experts were often sought to guide implementation. This is consistent with published guidelines that suggest that the core TB management team (consisting of individuals specializing in public health, paediatrics and TB) should keep key experts informed and seek consultations when necessary *(54)*. Notably, there were differences in the level of public health authorities involved (i.e. from

municipal to national level) in past outbreak responses across countries. There were also country-to-country variations in the involvement of ministries outside of health care (e.g. education) and local organizations (e.g. professional medical associations, parent associations). Japan reported that parent associations were typically not included in outbreak coordination in order to maintain confidentiality of the index case. As ministry jurisdictions and public health administrative structures likely differ from country to country, there may not be a universal coordination mechanism. Nevertheless, there were key cross-sector collaborations in outbreak preparedness (e.g. established resource mobilization schemes) and field investigations (e.g. assembling an inclusive oversight committee at initiation) that could be adapted to local policies.

From the four country experiences, policies related to TB in schools were either covered by the general national TB strategy or were in development. This summary of past outbreaks, however, identified contributions from government bodies other than the national TB programme. There were also limited published guidelines on TB outbreaks in schools internationally for countries to draw upon. In particular, there were no guidelines published from a lower-middle- or low-income country or a country with high burden of TB. In resource-limited settings, health-care programmes may be supplemented by external sources (e.g. nongovernmental organizations, faith-based organizations) and the most effective way to coordinate all groups is unclear. As large-scale outbreaks could greatly deplete available resources in such settings, the need for informed outbreak prevention and control efforts is critical. In settings with a high burden of TB, where outbreaks are likely to occur, there is limited guidance on how to best integrate outbreak response as part of the national TB programme. As such, there are gaps in the current knowledge base, particularly in settings most impacted by TB outbreaks in schools.

This report summarized challenges and lessons learnt from past TB outbreaks in schools within the Western Pacific Region and globally. Despite great variations in TB burden and outbreak preparedness across the Region, countries faced similar challenges. There was a noted lack of guidelines or published outbreak reports from countries with a high-burden of TB or with limited resources. Successful past outbreak responses highlight the necessity of vigilant outbreak detection, established resource mobilization networks, coordinated efforts shared across parties and proactive communications. Countries could adapt such practices to their local context when developing prevention and control protocols on TB outbreaks in schools.

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