

# Assessing the impact of the TB response in Taiwan – the journey towards ending TB

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## SUMMARY

The incidence of TB in Taiwan declined by 62% from 2005 to 2023 (i.e., from 73/100,000 to 28/100,000). Here we review the past two decades of TB epidemiology, policy implementation, and outcomes, identifying gaps and solutions for domestic and global responses. An external review in 2024 assessed National TB Program progress towards the End TB goal, integrating feedback from an International Review Panel and a 2023 expert questionnaire. The findings informed Phase III (2026–2030) of the ‘End TB by 2035 Project’. We present review materials, consensus recommendations, and follow-ups through 2024. In 2023, 64% of the TB cases were aged  $\geq 65$ . TB incidence among those  $< 60$  is projected to meet the End TB targets ( $< 10/100,000$ ) by 2035, while

elimination ( $< 1$  per million) is expected among 0–14-year-olds. During 2005–2024, Taiwan universally adopted new diagnostic tools for drug-resistant TB, shorter regimens and user-friendly platforms for reporting and case management. Nationwide policy innovations included active case finding, and TB infection (TBI) treatment. Taiwan’s consistent investment in TB reflects strong political commitment to End TB. Current challenges include aging, comorbidities, high TB/TBI among foreign migrant workers and societal disparities, and we suggest that future efforts must leverage artificial intelligence, universal genotyping and greater inter-departmental collaboration.

**KEY WORDS:** tuberculosis; End TB strategies; policy implementation; TB elimination

## INTRODUCTION

Elderly individuals consistently exhibit higher TB incidence rates than younger adults, primarily due to reactivations.<sup>1,2</sup> TB mortality remains disproportionately high in this age group; in the U.S., 7% of elderly patients died at diagnosis and 21% died during treatment, compared to 2% and 7%, respectively, among younger adults.<sup>2</sup> This poor prognosis results from non-specific symptoms, reduced drug tolerance, coexisting comorbidities, all contributing to TB transmission in medical institutes and long-term care facilities (LTCF), higher all-cause mortality and lower treatment success.<sup>1,3</sup> Additionally, increased population mobility from endemic countries represents challenges for TB elimination in low-incidence countries.<sup>4</sup> To optimize TB care and prevention in migrants, improved coordination is essential, ensuring a balance between individual rights and public health requirements. Strengthening migrant TB control strategies can contribute to Global End TB strategy by 2035.<sup>5</sup>

Taiwan’s unique demographic and public health infrastructure has strongly shaped its TB control efforts. Since the Japanese occupation in 1906, Taiwan

has maintained a household registration system, complemented by a national identification system established in 1947. Through such system information is constantly available. By the end of 2023, Taiwan’s population reached 23.4 million, with only 135,571 newborns, making it the lowest in its history.<sup>6</sup> Fertility rates have dropped from 7 births per woman in 1951 to 1.09 in 2023, making Taiwan one of the world’s lowest fertility-rate countries.<sup>7</sup> The aging population, accounting for 18% in 2023, is projected to reach 20% by 2025, classifying Taiwan as a super-aged society.<sup>8</sup>

Taiwan achieved a 62% reduction in TB incidence, dropping from 73 cases per 100,000 in 2005 to 28 in 2023, with an average annual decline of 6% (2016–2023).<sup>9</sup> TB mortality also declined, from 4.3 per 100,000 in 2005 to 1.9 in 2023. COVID-19 pandemic accelerated this decline, with annual reductions of 10.8% in 2020 compared to 2019, and 12.1% in 2021 compared to 2020. By 2022, the decline returned to the pre-COVID-19 trend (5.7%).

The aim of this report is to describe the epidemiological, response and policy context for TB control in Taiwan over the past two decades, to identify barriers

to achieving further TB reduction within the next 10 years and outlines strategies to overcome these issues.

## TB CONTROL IN TAIWAN

Since 2006, Taiwan's National TB Program (NTP) has implemented milestone initiatives, starting with the first National Strategic Plan (NSP) "Ten-Year Halving Tuberculosis Plan" (2006–2015), followed by Phase I (2016–2020) and Phase II (2021–2025) of the "Taiwan's End TB by 2035 Project", reflecting Taiwan's commitment to end TB.<sup>10,11</sup> Preparations for Phase III (2026–2030) are currently underway. In 2013, the Taiwan Centers for Disease Control (Taiwan CDC) conducted an external review of the NTP to assess the effectiveness of the 2006–2015 Plan.<sup>12</sup> Based on recommendations from the International Tuberculosis Review Panel (ITRP), Taiwan CDC developed Phase I (2016–2020) of the End TB project. A second review was planned for 2024.

To support the 2024 review, Taiwan CDC conducted an online questionnaire in late 2023, inviting input from TB experts across all levels. Between January and March 2024, detailed analyses of the collected data were prepared. A consensus meeting held on February 27, 2024, by the Ministry of Health and Welfare (MoHW), facilitated discussions on critical challenges and insights for Phase III development. The second external review was conducted in April 2024 to provide guidance for revising the program, addressing evolving epidemiological trends, demographic transitions, emerging technologies, and system and financial challenges.<sup>13</sup> The review consisted in the following activities: presentation by Taiwan CDC staff, followed by focused discussions; examination of data and re-evaluation; visit to a hospital for DR-TB care, a public health bureau, a district health center and meeting with staff; preparation of a consensus report and presentation to the MoHW.

This collaborative approach ensured that input from both local experts and national policymakers shaped the NSP's revisions. At the end of the review, the ITRP finalized strategic and technical recommendations to align the NSP with Taiwan's commitment to achieving the End TB 2035 target.

### *A brief history of TB control*

The Taiwan CDC, established in 1999, oversees TB control. In 2001, the Chronic Disease Control Bureau (CDCB), previously responsible for TB control in Taiwan, was merged into Taiwan CDC. Taiwan's NTP is funded entirely by the central government, which reflects the strong political commitment. Since 2003, TB diagnosis has required three sputum samples for smear microscopy and culture for *Mycobacterium tuberculosis complex* (MTBC), ensuring bacteriological confirmation. Under the Communicable Disease Control

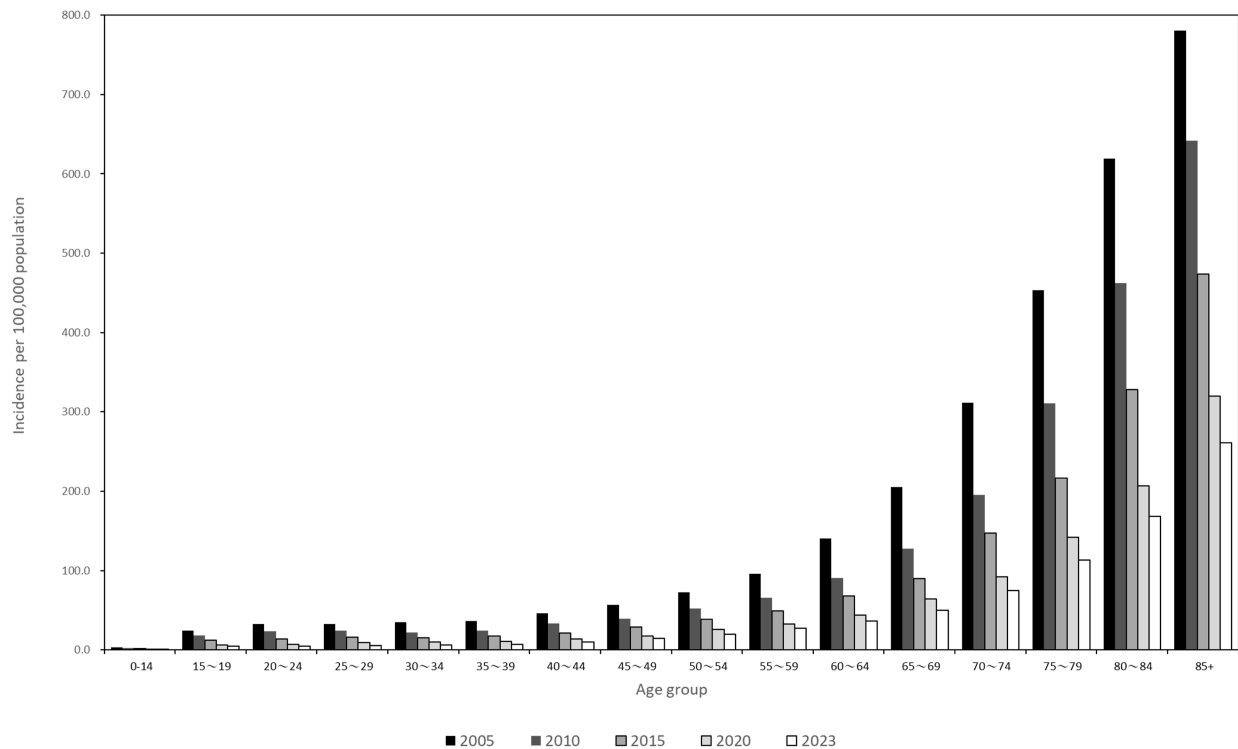
Act, physicians are mandated to report TB cases, with non-compliance penalties ranging from USD 3,000–15,000.<sup>14</sup> If a physician employed by a medical institution fails to report in a timely manner, the institution itself is also subject to fines ranging from USD 10,000–66,666.<sup>14</sup> To support timely notification, Taiwan CDC employs three integrated systems: Notifiable Infectious Disease Reporting System (NIDRS) for case reporting; Laboratory Automated Reporting System (LARS) for linking laboratory data; National TB Management System: a web-based registry connecting public health officials and healthcare providers to manage TB and TB infection (TBI) cases, is smart-card required, password protected and internet protocol (IP) address-sensitive. Taiwan's National Health Insurance (NHI) provides universal health coverage, ensuring care for 99% residents. To encourage comprehensive reporting, the 'No Reporting, No Reimbursement' policy, introduced in 1997, prevents reimbursement for anti-TB care without notification.<sup>15</sup>

Consequently, TB detection peaked in 2004 with 16,784 cases (74.1/100,000).<sup>16</sup> The NHI reimburses medical services for active TB or TBI patients, ensuring timely access to care without financial hardship. Copayment fees for both TB and TBI patients are reimbursed by Taiwan CDC. For uninsured patients, Taiwan CDC covers all health care related expenditures of TB. Studies revealed relatively short patient delay and health system delay.<sup>17</sup> TB patients can access services at all hospitals and 89% of private clinics contracted under NHI.<sup>18</sup>

Diagnosis of TB typically begins with a Chest x-ray (CXR) followed by sputum examinations. Approximately 700 TB case managers under NHI through a Pay-for-Performance (P4P) program for TB and bridge clinical care and public health systems, coordinating care and managing challenging cases.<sup>19,20</sup> Once TB patients are notified, 2,500 public health nurses (PHNs) at 374 public health centers provide health education to TB patients, monitor treatment adherence, conduct contact and outbreak investigations. Regular training programs for clinicians ensure high-quality care by professional TB societies. Former TB supervisors of the CDCB continue to support monthly TB meetings at county and city level. A critical mass of clinicians and researchers committed to the fight against TB was in place, who collaborated with public health sectors in ensuring rational use of anti-TB medicines, especially fluoroquinolones,<sup>21</sup> which are further ensured through regularly updates of TB guidelines and collaboration between Taiwan CDC and the NHI Administration.<sup>22</sup>

### *Epidemiological characteristics of TB in Taiwan*

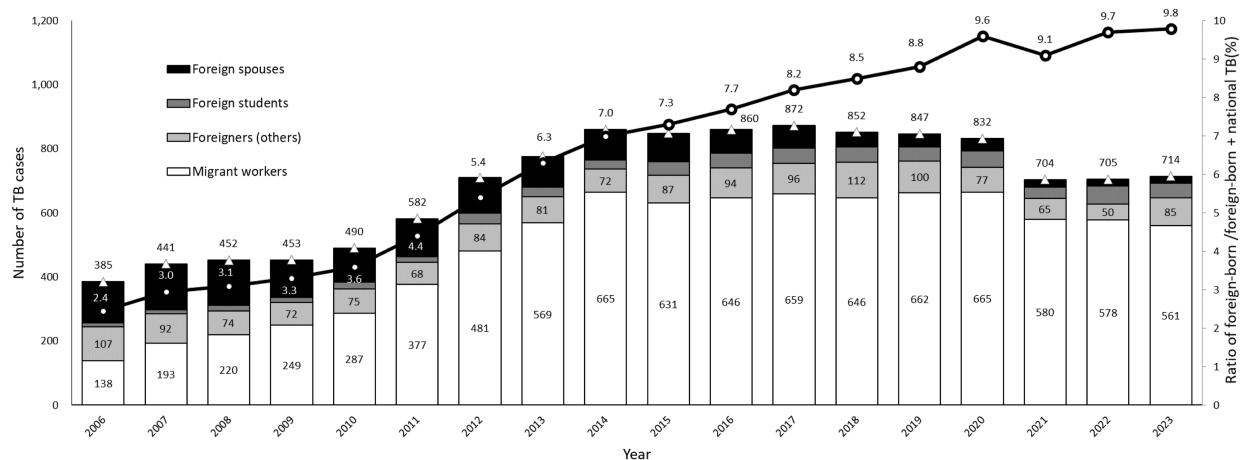
In 2023, for the first time, TB incidence remained unchanged for two consecutive years. This stabilization occurred as the number of medical visits and sputum examinations normalized to the pre-pandemic level,<sup>23</sup> with the 2024 mid-year TB notifications



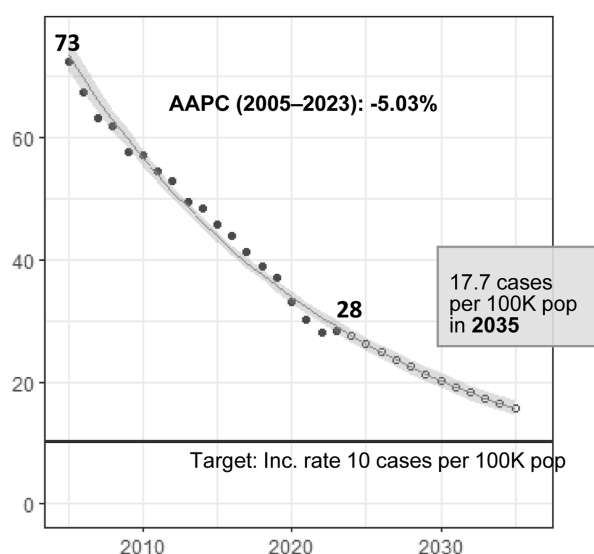
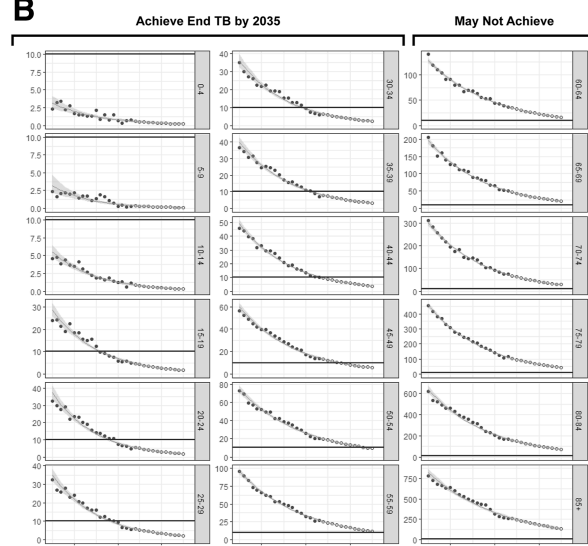
**Figure 1.** TB incidence rates stratified by age groups, 2005–2023.

resuming a 6% decline compared to 2023. The age-specific incidence trends (2005–2023) show the highest TB rates in individuals aged 85 and above, with a decline from 780.6 per 100,000 in 2005 to 261.0 in 2023 (Figure 1). Among those aged under 15, the TB incidence has been below 1 case per 100,000 since 2020, reaching 6 cases per million in 2023. The TB incidence among individuals under 40 years achieved the WHO End TB Strategy goal of  $<10/100,000$  cases in 2023. Migrant workers are the largest contributors to foreign-born TB notifications in Taiwan besides foreign spouses, students and foreigners (others) (Figure 2). With the

rising demands of labor, the total number of migrant workers exceeded 700,000 in 2023. Since 2020, the ratio of TB cases among foreign-born to those among foreign-born and citizens has exceeded 9%. Projections based on 2005–2023 data estimate Taiwan's TB incidence will decline to 17.7/100,000 by 2035 adjusted by 2035 predicted population without innovative tools or strategies (Figure 3A).<sup>8</sup> Although TB incidence among those below 60 is expected to meet End TB targets by 2035, it is unlikely for those aged over 60 (Figure 3B). TB elimination ( $<1$  case per million population) appears achievable for young age groups (0–14 years) by 2035.



**Figure 2.** Foreign-born TB in 2006–2023 stratified by 4 types of residence permits, including foreign workers, foreign spouses, foreign students and foreigners (others) and the ratio of foreign-born TB compared to foreign-born and Taiwanese national TB. Clear triangles = total number of foreign-born TB; clear circles = the proportion of foreign-born TB of foreign-born and Taiwanese national TB (%).

**A** Estimation of TB incidence rate**B**

**Figure 3. A:** The projected TB incidence towards 2035 with the trend fitting by TB incidence during 2005–2023. To predict TB incidence from 2024 to 2035, an interrupted time series model was used. A negative binomial distribution was assumed for annual number of newly confirmed TB. Due to the rapidly aging society in Taiwan, the prediction for crude TB incidence for all age in 2035 is further adjusted to account for the age distribution expected in that year and the adjusted TB incidence for all ages is therefore 17.7/100,000 population. **B:** The projected TB incidence towards 2035 with age stratifications during 2005–2023. Black circles = observed data 2005–2023; clear circles = estimation 2024–2035; shaded area = trend and 95% CI; AAPC = average annual percent change; Inc = incidence; pop = population.

## INTERVENTIONS FROM 2005–2024 AND THEIR IMPACT

### Laboratory services, reporting and recording and collaboration with universal health care

Taiwan's contracted and authorized laboratories, including all laboratories capable of performing MTBC culture and phenotypic drug-susceptibility

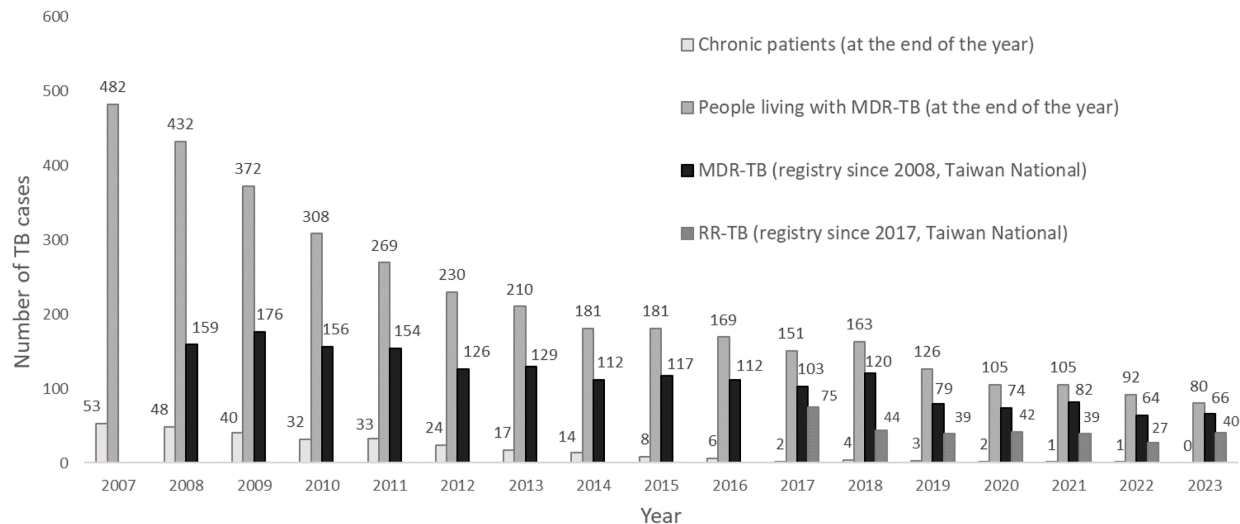
testing (DST), have been quality-assured through routine proficiency testing since 2007, with on-demand onsite visits by Taiwan CDC.<sup>24,25</sup> Since 2008, MDR-TB has been confirmed by the National Reference Laboratory (NRL), with genotypic DST routinely performed for rifampin resistant TB (RR-TB)/multi-drug resistant (MDR-TB) since 2017. Also, since 2014, Taiwan CDC required all TB laboratory testing data to be shared with the LARS. By 2018, automatic reporting and recording of TB cases were established through data exchange between LARS and the NIDRS. The auto-uploaded culture report coverage for new TB cases reached 98.2% in 2019 and 99.1% in 2023.

Using claimed data from the NHI (2005–2007), TB notification completeness and timeliness were 96.3%, with 80% of cases notified within 7 days of prescribing anti-TB medications, but only 77% of foreign TB patients were notified, of whom 92% were notified within 7 days.<sup>26</sup> Previously notified TB cases also had a lower re-notification rate (86%) and timeliness (71%) during the same period.<sup>26</sup> Performing three sets of sputum cultures routinely for presumptive TB patients increases bacteriological confirmation of TB or recurrent TB.<sup>27</sup> Additionally, molecular drug resistance diagnostics are provided for high-risk patients, including those with prior TB treatment, TB preventive therapy (TPT), or known DR-TB exposure.

According to the Department of Labor, migrant workers in Taiwan are required to undergo health examinations within three days of arrival, at the 6<sup>th</sup>, 18<sup>th</sup>, and 30<sup>th</sup> post-entry months, and annually thereafter. Prior to 2014, migrant workers diagnosed with TB were deemed unfit and repatriated.<sup>28</sup> Regulatory changes in 2014 allowed workers to stay for treatment if employers consented to Directly Observed Therapy (DOT) beyond the post-arrival health examinations. In 2015, further amendments permitted migrant workers with TB upon arrival to stay as long as their employers agreed. These changes improved TB notification among foreigners from 89% in 2016 to 97% in 2020, with 96.5% of cases notified within 7 days.<sup>29</sup> In 2022, further amendments allowed workers to stay for treatment based on their own consent, regardless of employer approval. As a result, the proportion of migrant workers staying for TB treatment increased from 10.6% in 2014 to 23.0% in 2015, 43.2% in 2016, and 88.8% in 2022.

### Patient support, contact tracing and examinations

Once a TB patient is diagnosed, treatment with support is essential to prevent further transmission and reduce mortality. In 2006, Taiwan CDC adopted a people-centered DOT program,<sup>30</sup> assigning each patient a government-employed DOT worker, alongside a PHN and TB case manager, to provide treatment support. Feedback from DOT workers enabled PHNs and other entities to assist patients and reduced treatment interruption due to socio-economic challenges or adverse effects (AEs), significantly reducing loss to follow-up and TB-specific mortality.<sup>30,31</sup> From 2008 to 2023, Taiwan



**Figure 4.** The trend number of multi-drug resistant TB (MDR-TB), rifampin resistant TB (RR-TB) without isoniazid resistance, chronic patients and people living with MDR-TB after implementation of patient-centered care, government-initiated hospital-based program for MDR-TB, the Taiwan MDR-TB Consortium, 2007–2023.

maintained a recurrent rate below 1% (0.56–0.97%) for DS-TB patients. The DOT program, covering 98% of TB patients, relied primarily on in-person community-based DOT. In 2015, electronic DOT (eDOT), an app for video DOT, was introduced to address mobility, lifestyle and privacy concerns, though usage remained below 5% until the COVID-19 pandemic (2021–2022), when adoption rose to 33.5% for DS-TB and 28.5% for TBI contacts.<sup>32</sup> Utilization reduced to 5–6% during mid-2023 but improved with the user-friendly eDOT version 2.0 launch in November 2023, reaching 16% usage by 2024.

To support low-income TB patients, the Taiwan Anti-Tuberculosis Association provides an annual USD 31,000 grant, aiding those without social welfare resources. In 2018, The 2018 National TB Patient Catastrophic Cost Survey revealed 22% of non-MDR-TB and 45% of MDR-TB households faced catastrophic costs due to TB (personal communication Lin HH), primarily due to non-medical expenses (49%), income loss (34%), and medical expenses (17%) before TB diagnosis. Contributing factors strongly associated with catastrophic costs, included low household income, TB stigma, and receiving inpatient treatment.

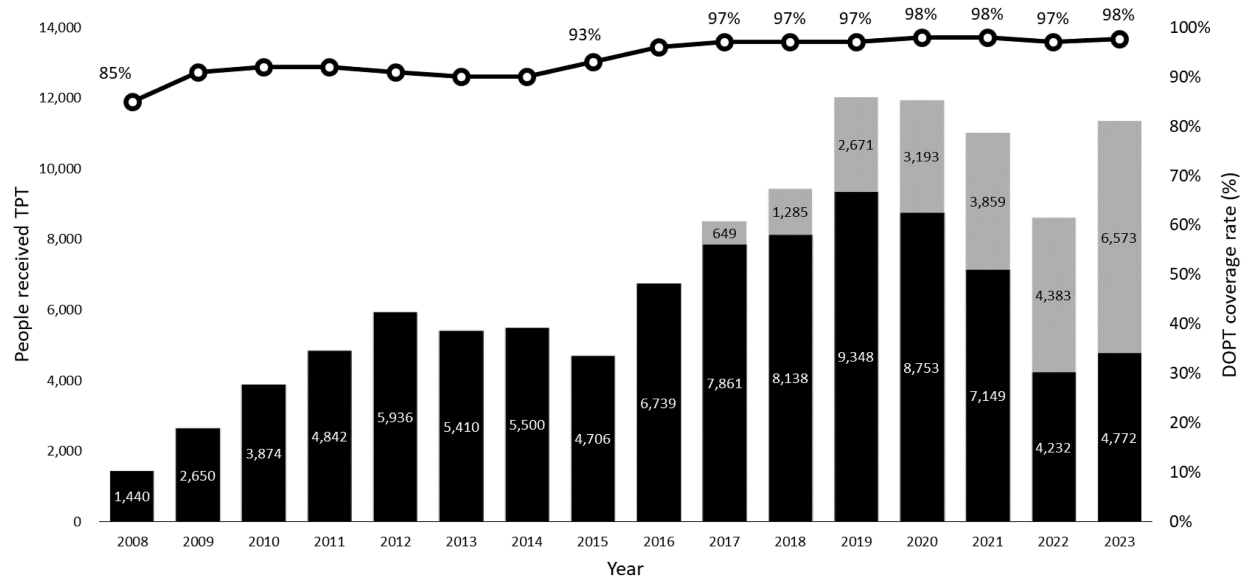
Following implementation of the DOTS program, efforts were intensified in contact investigation (CI), alongside the implementation of TPT. CI has long been part of TB control programs in Taiwan but registration of contacts only started after 2004.<sup>33,34</sup> The average number of contacts per people living with TB was 2.2 in 2006. With DOT workers assisting PHNs in administering care and enabling PHNs to focus on CI, in 2007, the introduction of referral forms for CI to alleviate co-payment burdens for contact examinations, standardized tracing procedures, and training in interviewing skills further boosted CI and investigating TB clusters.<sup>33</sup> By 2008, the average number of contacts per TB patients increased to 5.2, surpassing 10 by 2014 and reaching 14 in 2019.

Despite COVID-19 disruptions, averages remained stable, with 12 in 2020–2021, 11 in 2022 and 12.5 in 2023.

#### Program for DR-TB

The Taiwan MDR-TB Consortium (TMTC), established in 2007, was created to enhance person-centered care for DR-TB, addressing the challenge of the 29% loss-to-follow-up rate in the 1990s.<sup>35</sup> Approximately 25% of the NTP budget was allocated to TMTC, which supported individualized regimens for newly diagnosed MDR-TB cases and reevaluated ‘chronic-open’ patients, over 80% of whom lacked DST confirmation.<sup>27,35</sup> In 2007, while the prevalence of MDR-TB cases was 482 (figure 4), sputum samples were recollected for DST, and patient records were reviewed, enabling comprehensive treatment. Despite the absence of newer drugs initially, the program ensured molecular diagnostics for high-risk groups, uninterrupted second-line drug supplies (fluoroquinolones and aminoglycosides), managing AEs, and incentives to support adherence over 18–24 months. These efforts reduced the loss-to-follow-up rate to 2.9% and recurrence rate to 0.6 per 1,000 person-years.<sup>35–37</sup> In 2011, the program expanded to RR-TB and resistance to three first-line drugs other than rifampin, maintaining low recurrence rates of RR/MDR-TB at 0.34/0.35 per 1,000 person-years.<sup>38</sup>

Patients with fluoroquinolone resistance had poorer outcomes but better than those with both aminoglycoside and fluoroquinolone resistance (i.e., the old definition of XDR-TB).<sup>35,36,38</sup> The introduction of bedaquiline and delamanid in 2015–2016 improved outcomes for XDR-TB and pre-XDR-TB,<sup>39</sup> later expanding to MDR-TB/RR-TB patients in 2019 and to those intolerant to anti-TB treatment in 2022. In 2021, launch of the BPaLM/BPaL regimen shortened treatment to 6–9 months for XDR-TB and pre-XDR-TB and expanded to MDR-TB in 2023 and to RR-TB patients, as well as



**Figure 5.** Uptake of TB infection treatment and coverage rate of directly observed preventive therapy. Black bar = No. of contacts with TBI received TPT; gray bar = No. of high-risk populations with TBI received TPT; clear circles = DOPT coverage rate (%) for TPT. TBI = TB infection; No. = number; TPT = TB preventive therapy; DOPT = directly observed preventive therapy.

those intolerant to anti-TB treatment in 2024. By 2024, the BPaLM/BPaL regimen covered 89.7% of RR/MDR-TB patients receiving treatment. In 2017, additional advances included establishment of active TB drug safety monitoring and management (aDSM),<sup>40</sup> and therapeutic drug monitoring (TDM) for key drugs since 2020. Despite these improvements, a 20% all-cause mortality rate during MDR-TB management highlights the need to address comorbidities in an aging population.

Since 2009, MDR-TB contacts received CXR screenings every 6 months for two years, with timely referrals for presumptive cases.<sup>41</sup> A 9-month fluoroquinolone (9FQ) regimen, piloted in 2018 and expanded nationwide in 2021, faced 18.9% discontinuation due to AEs like joint pain. Greater access to TDM for levofloxacin adjustments and expanded care facilities is needed.<sup>42</sup> Newly-diagnosed MDR-TB cases dropped from over 150 (2008–2011) to fewer than 130 by 2012 (within five years) and since 2017 the figure has dropped below 100. Prevalent MDR-TB cases declined from 482 in 2007 to 80 in 2023, while chronic patients decreased from 53 in 2007 to fewer than 5 in 2017 and zero in 2023 (Figure 4). This demonstrates that once an MDR-TB program is initiated, significant progress can be observed within a decade.

#### *Active case finding, TBI diagnosis and preventive treatment*

The active case finding (ACF) program includes annual screening for healthcare workers (HCWs), employees and residents in LTCFs, and employees and inmates in correctional facilities. CXR screening is conducted for students entering high schools, colleges, and universities, as well as for newly onboarded employees and military personnel. Mobile CXR screening vans target

vulnerable populations, including economically disadvantaged groups, elderly individuals in communities, and those with household registration in mountainous aboriginal areas (MARs). Overall, 4.0 % of new TB cases are detected through ACF programs annually. For eligible contacts (such as child contacts aged under 13, household contacts, or contacts with comorbidities for all culture-proven index TB patients, or contacts who shared 8 hours per day or a cumulative 40 hours during contagiousness period with smear-positive, culture-proven index patients), TBI testing is conducted using Tuberculin Skin Test (TST) for children aged under 2 and interferon-gamma release assay (IGRA) for those aged 2 and above.<sup>43,44</sup> The overall number of people who received TPT and the proportion of DOPT they received are shown in Figure 5.

Since 2008, 9-month daily isoniazid (9H) was launched nationwide for contacts under 13 with positive TST.<sup>45</sup> In 2016, IGRA was endorsed nationwide for contacts aged 5 and above alongside the 12-dose weekly isoniazid and rifapentine (3HP) regimen. Both rifapentine and 300 mg isoniazid were imported for public health utilization by Taiwan CDC and a pre-licensure post-marketing surveillance collaborating with Taiwan Food and Drug Administration and Taiwan Drug Relief Foundation was implemented to ensure the safety.<sup>46</sup> By 2018, the TBI testing and treatment program expanded to LTCFs and MARs, complementary with pre-existing ACF program,<sup>47–49</sup> and in 2020, to people living with HIV and inmates,<sup>50,51</sup> alongside the endorsement of 4-month daily rifampin (4R) and 3-month daily isoniazid and rifampin (3HR).<sup>52</sup> In 2021, IGRA testing was extended to contacts aged 2 and above, with a fixed-dose combination of 3HP introduced. The program further expanded to foreign

spouses in 2022 and 1-month daily isoniazid and rifampentine (1HP) and 6-month daily isoniazid (6H) were adopted in 2023.<sup>42</sup> In the second half of 2023, TBI testing and treatment in LTCFs became part of the NHI pay-for-performance (P4P) program, under the NHI Long-term Care Plan. This inter-departmental collaboration incentivized medical facilities to deliver outreached ACF, TBI diagnosis and treatment in LTCFs, and provided P4P to TPT among contacts and high-risk populations mentioned above, including further expansion to individuals with chronic obstructive lung disease (aged 60 years and above), dialysis patients, and poor controlled diabetics (HbA1c higher than 9% and aged 45 years and above).

### CRITICAL REFLECTIONS

The ITRP has made recommendations to align Taiwan's NSP with evolving epidemiological trends, emerging technologies, and systemic challenges, reinforcing Taiwan's commitment to global TB elimination.<sup>13</sup> Nucleic acid amplification tests (NAATs) with higher sensitivity and shorter turnaround time than smear microscopy, differentiate MTBC and non-tuberculosis mycobacterium (NTM) and reduce treatment delays and pre-treatment death.<sup>53,54</sup> A recent study revealed that the incremental yield of the third sputum smear in Taiwan was negligible.<sup>55</sup> It may be reasonable to perform NAAT, smear and culture on the first specimen and culture alone on the second.<sup>55</sup> WHO targets universal NAAT for all presumptive TB cases by 2027.<sup>56</sup> Taiwan's 2023 NAAT coverage was 74% (92% for smear-positive and 60% for smear-negative cases). Taiwan CDC will launch universal NAATs in 2025. Universal NAATs are also vital for timely DR-TB detection.<sup>55</sup> Streamlined laboratory engagement has enhanced the information system's efficiency. Further automation of laboratory connection via a unified MoHW digital platform would accelerate reporting consistency and timeliness.

In 2023, individuals aged over 65 accounted for 85% of deaths during TB treatment, with <60% treatment success. To address the challenge of a super-aged society, Taiwan must enhance screening, prompt diagnosis, aDSM and integrate TB management with geriatric care.<sup>1,2</sup> High TB mortality in the elderly stems from competing comorbidities and treatment discontinuation due to AEs.<sup>1-3</sup> Preventing TB with TPT is crucial to reducing mortality and transmission in LTCFs.<sup>57</sup> However, the elderly encountered 20% of permanent discontinuation due to AEs from TPT, leading to low treatment completion.<sup>58,59</sup> For those aged 65 and above, in-person DOPT delivering aDSM and support, supplemented by eDOT 2.0 ensures person-centered care without overburdening services. Analyses distinguishing TB-related deaths from deaths caused by comorbidities are essential, along with better tracking of diagnostic delays focusing on patient delays. The gaps in social protection and household TB-related costs need to be monitored to break the 'poverty-disease-poverty' cycle.

Sustaining centers of excellence is essential for TB control but best practices for maintaining human resources in TB low-burden countries have rarely been reported,<sup>60</sup> and it is challenging to attracting young physicians to focus on TB. Collaborating with the TMTC to create specialized centers for continued education, expert consultations, and addressing complex TB cases with comorbidities, AEs or drug-drug interactions, may help to maintain expertise. Regular refresher training for HCWs and exploring emerging technologies, such as clinical decision support systems powered by artificial intelligence (AI), may enhance TB care.

Pre-migration CXR screening of foreign workers need to be maintained, with TBI management strategies explored for this group.<sup>4,61,62</sup> Deportation policies for foreign-born MDR-TB patients should be reevaluated, as they can deter early consultation and increase community transmission.<sup>5</sup> Multilingual functionality in eDOT 2.0 could improve adherence among foreign-born TB patients. Addressing language barriers and strengthening education for migrants is critical for effective TB care.<sup>5</sup> Legal policies must not discourage symptomatic individuals from seeking diagnosis. Comprehensive, patient-centered approaches for migrants and vulnerable groups can sustain progress toward TB elimination.<sup>4,61,62</sup>

Regarding ACF, high-risk groups for TB need to be clearly defined. Geo-spatial mapping and genotyping (such as whole genome sequence) can pinpoint high-burden areas for more targeted ACF initiatives. Portable digital CXR and AI-powered computer-aided detection tools are recommended for remote areas like MARs. Pre-employment IGRA screening for HCWs could establish baselines for future CI in medical settings. Achieving the End TB goals by 2035 requires intensified ACF and large-scale TBI.<sup>63</sup> Current TBI programs remain limited, with a predictive model suggesting declines in TB incidence will primarily result from population aging without significant expansion.<sup>64</sup> Manpower shortages and high turnover rates need to be addressed and AI-based tools may assist PHNs and TB case managers in handling complex cases.

Since 2016, Taiwan's annual TB budget has remained steady at \$32–33 million. However, it is possible that budgets will be cut, as happened in 1970s in the U.S.A., resulting in a resurgence of TB.<sup>65</sup> Other challenges include the impacts of immigration, global epidemics like HIV/AIDS and COVID-19,<sup>66</sup> and the severe public health disruptions that result from military conflict.<sup>67,68</sup> Experiences from other countries demonstrate that TB elimination can be planned programmatically, with regional efforts playing a crucial role, supporting national and global elimination goals.<sup>4,61,62,69,70</sup> To safeguard progress in TB control, Taiwan must maintain steady funding, invest in innovative tools, and implement strategies to retain expertise in TB care while also adapting to emerging challenges.

## CONCLUSION

The Taiwan NTP frequently draws on the experiences of other countries to avoid complacency regarding its moderate TB incidence rate. Taiwan has significantly improved early diagnosis and treatment by continually adopting new tools and medications, providing user-friendly platforms and implementing diverse policy interventions supported by operational research and incentives for targeted populations. Over the past two decades, free TB care has been provided universally, ACF and TBI treatment among contacts and high-risk groups have been expanded, and DR-TB cases have been properly managed. This approach has helped reduce TB incidence and mortality.

For future challenges we recommend utilizing comprehensive approaches (including AI tools) to deal with increasingly complex TB cases (due to aging and comorbidities), to address TB/TBI among foreign workers, to mitigate the impact of an M-shaped society, to identify hot spots of ongoing transmission and drug resistance by universal genotyping, and to enhance information exchange and utilization through inter-departmental collaborations. Taiwan's consistent investment in TB control and prevention reflects the strong political commitment to addressing this long-standing public health issue. This commitment will likely be the most crucial factor in achieving the goal of ending TB in the coming decade. With the support of resilient healthcare and public health systems, led by the Taiwan MoHW, we are well-positioned to combat TB effectively.

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