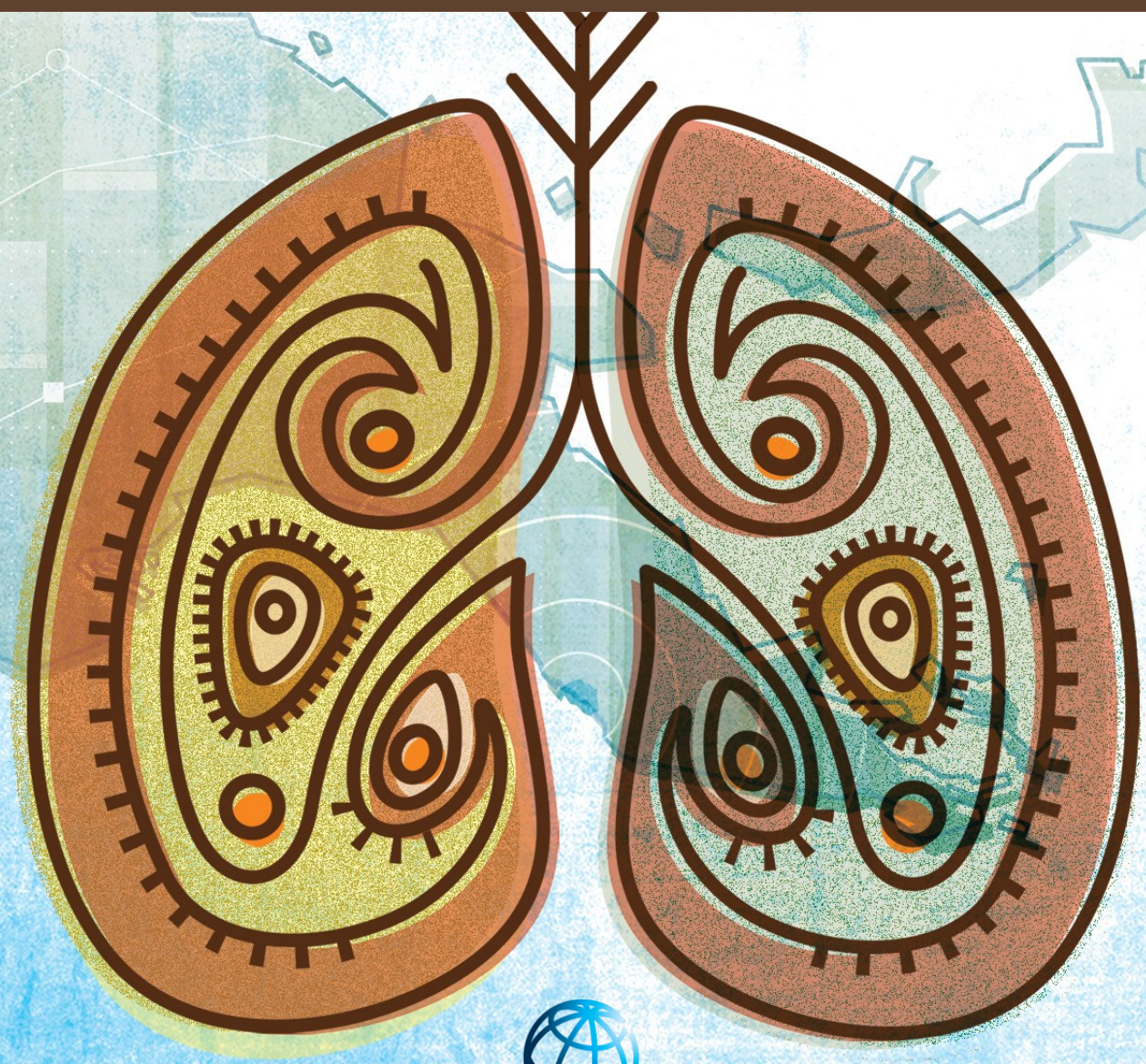
Evaluating Cost-effective Investments to Reduce the Burden of Tuberculosis in the National Capital District, Papua New Guinea

Findings from an Optima TB Analysis



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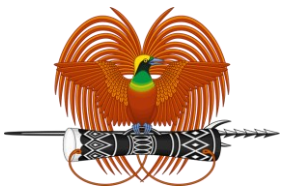
May 2023



Optima TB

Burnet

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† Paisson Dakulala passed away on March 1st, 2021.

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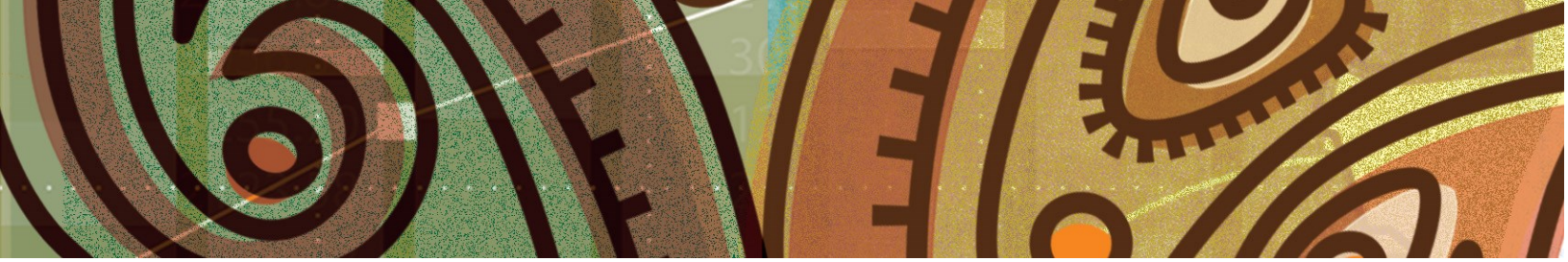


EXECUTIVE SUMMARY

Papua New Guinea (PNG) is one of the top 30 high burden countries for tuberculosis (TB) and drug-resistant (DR-TB), and National Capital District (NCD) accounts for 20% of total TB burden in PNG. Treatment success rates are relatively higher in NCD compared to national averages, yet key challenges persist leading to delayed diagnoses, low rates of bacteriological confirmation of TB and high treatment loss to follow-up.

NCD Public Health Authority (NCD-PHA) led Optima TB epidemiological modelling in partnership with the Burnet Institute, supported by the Emergency TB Project (World Bank) and Australian Government (DFAT), to (1) project progress towards NCD 2025 milestones as part of the End-TB strategy given status quo program coverage; (2) evaluate opportunities to prioritize population level screening (SSI) and TB Preventive therapy (TPT) by age group to inform TB strategy decision-making for the most efficient and effective response to the TB epidemic in NCD, and (3) evaluate the risks for the TB epidemic in the event of reduced future spending for prevention and screening. Four scenarios of TB prevention and screening coverage were modelled, assuming implementation changes would occur in 2023 and be sustained until at least 2030.

Key findings

A **Minimal resources:** If TB treatment continues but current contact tracing and community awareness is defunded, NCD risks a further loss of progress that would compound the impact of COVID-19 in 2020 and 2021, with a 39% increase in TB-related death by 2025 relative to 2020—a return to the number of deaths in 2015.

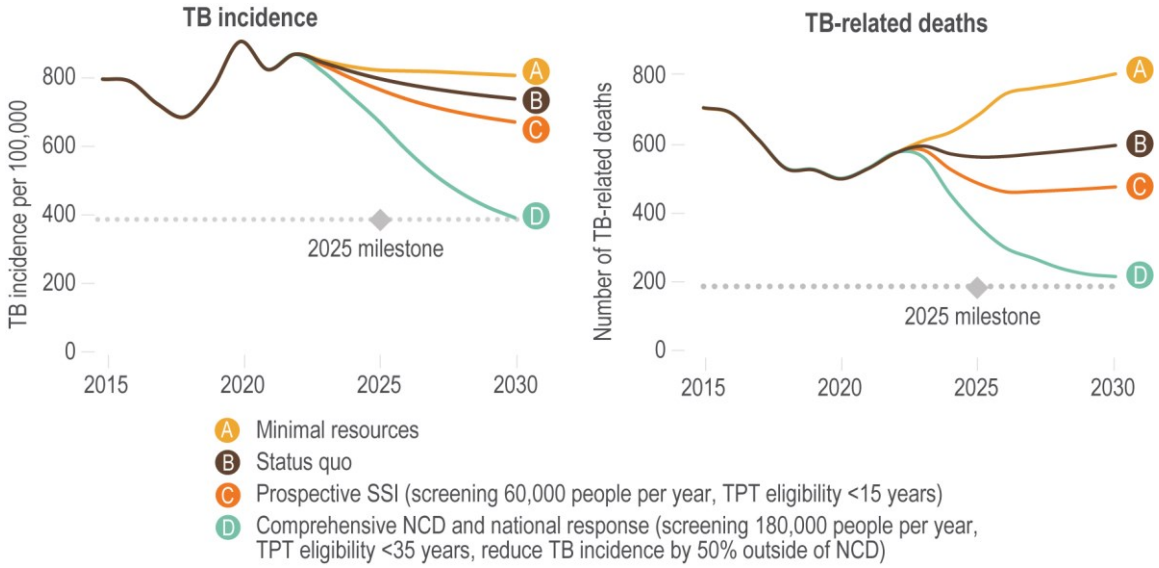
B **Status quo:** The NCD 2025 milestones are not on track under current spending and conditions. TB-related deaths may reduce by 21% between 2015 and 2025, while overall, TB incidence is projected to remain around 780 per 100,000 population. More than 50% of status quo active TB cases in NCD are estimated to originate outside of the official NCD health catchment area.

C **Prospective SSI:** Implementation of SSI to screen 60,000 people per year and expand TPT to TB contacts under age 15—under consideration for trialling in 2023—is not projected to be enough to reach the targeted reductions. However, if this program could be sustained annually, SSI implementation will have a significant impact on health outcomes, reducing

TB related deaths by 32% by 2025 relative to the 2015 baseline. The addition of TPT to SSI is necessary to have any further projected reduction of TB incidence over current conditions.

D **Comprehensive NCD and national response:** Reaching close to 75% reduction in number of TB-related deaths in NCD by 2030 (50% by 2025) and a 50% reduction in TB incidence within the NCD health catchment area by 2030 (15% by 2025) relative to the 2015 baseline may be possible with a comprehensive national response. This would entail widespread screening of estimated up to 180,000 people annually with SSI within NCD, expanded eligibility for TPT to TB contacts under age 35, and matching 50% reduction in the number of active TB cases that require treatment outside of the NCD. Implementation efficiencies may make this feasible at substantially lower cost or coverage levels.

Figure 0.1 Projected annual TB incidence per 100,000 and TB-related deaths under four scenarios of TB prevention and screening program implementation



Conclusions

Planned changes to implementation of TB screening in NCD could have a substantial impact on reducing TB-related deaths and TB incidence by 2030. However, even with extremely high programmatic coverage within NCD, achieving the NCD 2025 milestones will be extremely challenging without interventions to reach this mobile population. A coordinated response in NCD and other provinces, including widespread population screening, may bring the NCD TB milestones in reach by 2030.

Key recommendations

1. Focus on achieving earlier diagnosis of TB cases to reduce transmission and mortality, through a combination of:
    - 1.1 Implement SSI, including screening to up to 180,000 people annually within NCD
    - 1.2 Scale-up contact tracing, which is estimated to be reaching only 20% of households with a TB diagnosis, to increase case finding. The epidemic impacts of high SSI coverage may be achievable at a much lower cost through focusing on contact tracing first.
2. Expand eligibility for TPT to TB contacts under age 35 to reduce new active TB cases, a critical component of eliminating families facing catastrophic costs.
3. Meeting the NCD TB milestone for a reduction in new active TB infections will require an equivalent and well targeted response in other provinces.
4. Move from long course to short course MDR-TB treatment and reinvest savings (potential 40% reduction in costs based on regimen costing from an Indonesia study (1)) into TB prevention and testing.

Costs for a national TB response were not evaluated as part of this analysis, but investing in TB prevention has been estimated in 2017-18 to have an economic benefit of an estimated 2,643 PGK per new active TB infection averted, through reducing catastrophic costs faced by TB-affected families (2). This cost saving would significantly offset program implementation costs.

1 BACKGROUND

1.1 Epidemic overview

Papua New Guinea (PNG) is among the top 30 high burden countries for tuberculosis (TB) and drug-resistant (DR)-TB (3). In 2021 there were approximately 30,000 cases of TB notified in PNG (4), and TB is a leading cause of death (5). National Capital District (NCD) is one of three identified hotspots for TB in the country (6). It is one of 20 provinces in PNG and is characterized as an urban area spanning 240km^2. It has high population density, estimated at 1750 persons per km^2, and an average household size of 8.5, which is it highest in the country (7). Over the last decade there has been substantial internal migration from other provinces to NCD. This can include migration in the context of TB, with individuals often travelling from rural and remote areas with health facilities lacking to NCD for TB diagnosis and treatment. While the current official population size within the NCD health catchment area is estimated to be 0.5 million, the highly mobile population and increased number of settlements around the NCD mean that the real population has been estimated upwards of 0.8 million, with further growth projected (7).

NCD accounts for approximately 20% of total TB burden in PNG, 60% of all notified Rifampicin-resistant (RR)-TB, and the case notification rate is the highest in the country (7). In 2020, NCD notified 5,849 out of a total of 29,959 TB cases in PNG (7). Approximately 20% of total TB notifications in PNG and NCD are among children aged under 15 years (7, 8).The number of TB notifications in NCD has been largely stable since 2015 with the exception of a temporary decrease in notifications during 2020 and 2021 due to COVID-19 and pandemic response-related disruptions to health service delivery and supply chains (7). The estimated TB-related mortality rate per 100,000 has declined since 2015 due to progress in improving patient outcomes.

Dedicated TB services are delivered through decentralized basic management units (BMU), of which there are 15 in the NCD and 252 nationally, under the coordination of provincial and local governments. TB diagnostic services are more centralized, provided nationally through <100 functional smear microscopy centres and 64 GeneXpert testing sites (correct as of January 2023). Case report and notification data are collated nationally from localised data collected within BMU. Health system challenges in PNG include a shortage of healthcare workers, barriers to access due to remoteness, difficult terrain and lack of transportation, and

weak laboratory capacity for local diagnostics, and weak monitoring and evaluation (6). These lead to delayed diagnoses, low rates of bacteriological confirmation of TB and high treatment loss to follow-up.

Despite improvements in case finding and diagnostic capacity, there is still a high reliance on clinical diagnosis (6), and only 36% of national case notifications were bacteriologically confirmed in 2021 (8). Within NCD, clinical detection was reported in 18% of pulmonary TB (PTB) and 77% of extrapulmonary TB (EPTB) in 2020 (7). Further, there is a persistent gap in people with diagnosed TB who are not reported to be accessing care (6, 9, 10). Nationally, treatment success was around 65% in 2016, increasing to 74% in 2020 but remaining short of the 90% target (3, 4). NCD has the highest treatment success rate in the country, at 86% for drug susceptible (DS)-TB and 66% for DR-TB (7).

Among people living with HIV, antiretroviral therapy (ART) and TB preventative therapy (TBT) are provided through the national HIV and TB programmes. In 2020 89% of TB patients in NCD had their HIV status documented, among which 6% were co-infected with HIV and of these, and 89% of HIV-coinfected patients were started on ART, which were both higher than national averages (61% and 81% respectively).

TPT is provided in PNG for people living with HIV and at-risk children. Among diagnosed people living with HIV in NCD, in 2020 82% were treated with co-trimoxazole preventive therapy (7), which reduces mortality and improves treatment outcomes in HIV/TB co-infected patients. Isoniazid Preventive Therapy (IPT) is currently available for children under five years who are in contact with someone with bacteriologically-confirmed TB (11). Based on national reporting, 27% of children household contacts received TPT in 2021 (8). Current data from World Vision suggests that approximately 1500 confirmed TB cases are detected though contact tracing annually. In NCD, estimates suggest 20% of cases are currently contact traced (12).

The TB response in PNG is funded through strong government-donor partnerships in selected provinces (6). Since 2021, funding from external grants and domestic contributions have each decreased, broadening the estimating funding gap for TB programs, and long-term financing remains a concern (8). In particular, funding is lacking for programs for MDR-TB (6).

The NCD TB strategy for 201 to 2025 (draft) is aligned to the National TB Strategy, with the following milestones to reach by 2025 as part of a goal to end the TB epidemic in NCD (7):

1. Reduce number of TB deaths (compared to 2015) by 75%
2. Reduce TB incidence rate (compared to 2015) by 50%
3. No TB-affected families facing catastrophic costs.

1.2 Study objectives

The National Capital District Provincial Health Authority (NCD PHA) has led Optima TB epidemiological modelling in partnership with the Burnet Institute, supported by the Emergency TB Project (World Bank) and Australian Government (DFAT), to (1) project progress towards NCD 2025 milestones, given status quo program coverage, (2) evaluate opportunities to prioritize population level screening (SSI) and TB Preventive therapy (TPT) by age group as part of the TB strategy decision-making for the most efficient and effective response to the TB epidemic in NCD, and (3) evaluate the risks for the TB epidemic in the event of reduced future spending.

To support NCD in allocating TB resources for impact, this report presents results from four analyses to address key policy questions developed together with key stakeholders in the initial planning and methodology workshop. These are:

- Describe historical trends and project future trends of NCD's TB epidemic under status quo conditions;
- Describe the progress towards national and NCD 2025 milestones for reduction in TB deaths and TB incidence rate, given status quo program coverage;
- Estimate how population level screening and TPT by age group should be prioritized as part of the TB strategy; and
- Estimate the risks for the TB epidemic in the event of reduced future spending and priority programs to limit the negative impact of reduced spending.

2 METHODOLOGY

2.1 Overview

To carry out the analyses, the team used Optima TB, a mathematical optimization model applied to assess how to allocate the available resources across TB programs efficiently to maximize impact. Optima TB's scenario planning helps program managers answer "what-if" questions (for example, what would TB prevalence look like if current epidemiologic and spending remained the same or if we spent more; and what would we have to spend on TB if we wanted to reach national TB targets?). In contrast, the model's optimization function helps answer "how-to" questions (for example, how could we allocate (current, more, or less) resources more efficiently to optimize outcomes?). By comparing an infinite number of allocations to each other using a mathematical optimization algorithm, the model is able to optimize resource allocation among different programs to reach specific TB program objectives (for example, reducing new infections or disease-related deaths, increasing the number of patients on treatment, minimizing the costs required to achieve specific targets, or a combination thereof) within a given resource envelope.

Optima TB is a dynamic, population-based model that partitions the population by risk group including age, TB health state (for example, suspect, latent TB, active TB), diagnosis and drug resistant status, and tracks people's movement among health states. A detailed illustration of the compartmental model structure is included in Appendix A.

2.2 Collaboration and stakeholder involvement

The analysis was a collaboration between the NCD PHA, National Department of Health (NDoH), Burnet Institute, Emergency TB Project (World Bank) and the Australian Government (DFAT). Epidemiological, program and cost data (Table 2.1) were collated by the study team and collaborators using an adapted Excel-based Optima TB data entry spreadsheet. Input data, model calibration and cost-coverage-outcome relations were reviewed and validated by the in-country study group. In addition, in consultation with national TB experts, the Optima TB model was calibrated to match available epidemiologic data (Appendix C).

Table 2.1 Main sources of data used in the Optima TB Model, NCD-PNG

Data type	Source
Epidemiologic data	NCD population size and birth rate estimates, TB notifications, non-TB and TB-related deaths, estimated PLHIV and ART enrolment provided by National Capital District TB program 2014-2022; case detection rate (8)
Program coverage data	Treatment initiations and outcomes by bacterial confirmation status and strain, number of BCG vaccinations, TPT initiations, presumptive and confirmed active TB cases detected through community awareness and contact tracing, supplied by provincial TB Program, 2018-2021 and 2022 (partial).
Cost data	Lives Saved Tool (LiST) costing assumptions (13), Indonesia Optima TB analysis 2020 (proxy) (1), national report on TB patient costs (2)

2.3 Populations and TB program areas

Populations and TB programs considered in this analysis were:

Males 0–4 years
Males 5–14 years
Males 15–34 years
Males 35–64 years
Males 65+ years
Males living with HIV (untreated)
Males living with HIV (on ART)

Females 0–4 years
Females 5–14 years
Females 15–34 years
Females 35–64 years
Females 65+ years
Females living with HIV (untreated)
Females living with HIV (on ART)

Table 2.2 TB programs included in the analysis

Prevention		Diagnosis	Treatment
BCG vaccination		Passive case finding	DS-TB treatment (standard of care)
Preventive therapy for people living with HIV on ART		Active case finding (household contact tracing)	MDR-TB treatment: long-course oral regimen
Preventive therapy (DS only) for people with detected latent TB aged:	– 0–4 years – 5–14 years – 15–34 years – 35+ years	Active case finding (community awareness)	MDR-TB treatment: short-course oral regimen (prospective)
		Active case finding (population screening: SSI)*	XDR-TB treatment (standard of care)

Note: * = Prospective program, BCG = Bacille Calmette-Guérin.

To address the gap in diagnoses and support earlier diagnosis, systematic screening intervention (SSI) is planned to be introduced in NCD (expected to start by August 2023) as a form of population-level screening. A mobile clinic team will visit community localities and gatherings where community health-workers will administer a short TB symptom questionnaire

and brief physical examination to consenting people. Based on a screening algorithm, a digital chest X-ray may be performed, and individuals with a positive screening test or high clinical suspicion of TB will be referred for bacteriological testing (see Appendix 2).

TPT is currently available for people living with HIV and household contacts aged under five years of someone with bacteriologically-confirmed TB (11) but is under-review for expanding eligibility to contacts under 15 years old (7).

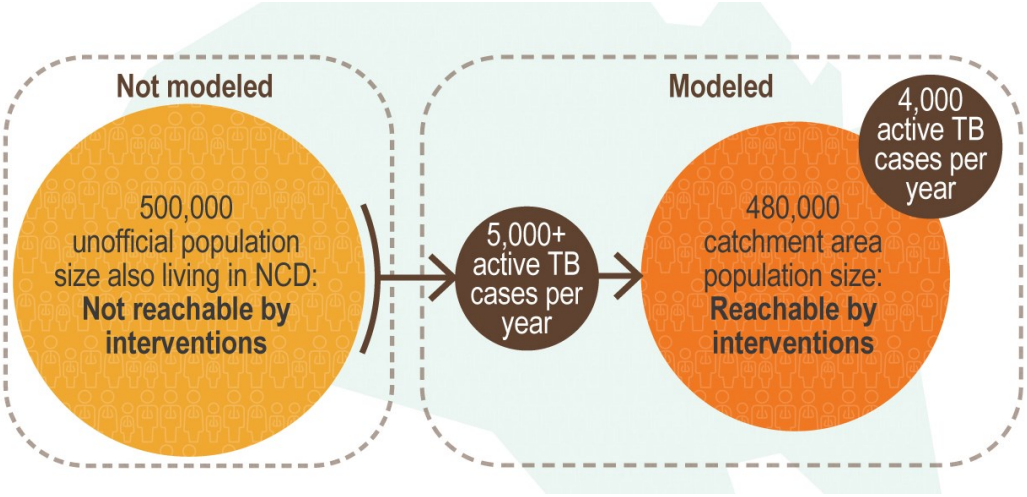
2.4 Scope of analysis

Based on input from stakeholders, a range of scenarios were identified for inclusion in the analysis (Table 2.3). These explore the projected impact on the TB epidemic of scaling up various interventions in NCD, as well as intervening outside of the NCD catchment area.

A critical limitation in the NCD TB response is the highly mobile population, and the gap between the official population size of the health catchment area of NCD of approximately 490,000 people (7) and the estimated number of people who are unofficially living in proximity to NCD or who travel regularly from other provinces, including for TB treatment at NCD facilities, especially from the Central Province. This was captured in the model scenarios A-C by aligning the total modelled population that could be reached by NCD health interventions, including a prospective implementation of SSI, with the official health catchment area population (Figure 2.1).

The number of TB notifications per 100,000 official population was approximately 1,600 in 2018 and more than 1,100 in 2021 (10), compared to the national estimate of 420 per 100,000 (8). It is estimated that the number of people who may require treatment for active TB within the NCD is approximately double the number of official residents within the health catchment area, implying a local incidence rate of between 500 and 1,000 per 100,000 population. Because of wide uncertainty about the level of migration, the model was calibrated based on a net change in population size attributable to migration (not attributable to the birth rate within NCD). The proportion of people with active TB was calibrated within the “net migrants” to align with the total estimated number of prevalent TB cases in NCD indicated through the notification rate. The limitation of SSI in not being able to reach people outside of the official health catchment area is critical to the limited impact of scenario (C). Scenario D considers an increased scale-up of SSI and eligibility of TPT combined with the impact of reductions in TB outside of the NCD catchment area on epidemic outcomes within NCD. Each scenario assumes that changes in intervention coverage occur in 2023 and are sustained until 2030.

Figure 2.1 Modelled population in relation to the NCD catchment area estimated active TB cases



Note: NCD =National Capital District, TB = tuberculosis.

To evaluate the potential epidemic impact by target years of 2025 and 2030, a sensitivity analysis was conducted by running 136 scenarios with each combination of status quo or increased SSI coverage, TPT eligibility, TB migration, as well as the additional scenario (A) for reduced coverage of contact tracing and community awareness is minimal resources were available.

Table 2.3 Scenarios included in the Optima TB analysis, NCD

Scenario	Description
(A) Minimal resources	Considers the impact on active TB incidence and TB-related deaths if TB treatment continues at 2022 coverage but existing contact tracing and community awareness are defunded from 2023–2030.
(B) Status quo	2022 coverage of TB treatment, prevention and testing maintained over 2023-2030.
(C) Prospective SSI	Prospective scale-up of SSI to screen 60,000 people per year from 2023-2030 with expanded TPT eligibility to TB contacts under age 15.
(D) Comprehensive NCD and national response	Implementation of SSI to screen 180,000 people per year from 2023-2030 in addition to expanded TPT eligibility to TB contacts under age 35 and assuming a 50% reduction in the number of active TB cases outside of NCD official catchment area.

Table continued...

Table 2.3 Scenarios included in the Optima TB analysis, NCD (continued)

Scenario	Description
Sensitivity analyses:	
Impact of scaling up SSI	Prospective scale-up of SSI coverage at nine different annual coverage levels from 2023-2030: no coverage, 60k (proposed 2023 intervention), 120k, 180k, 240k, 300k, 360k, 420k, 480k (counterfactual where the entire health catchment area is screened annually)
Impact of expanding eligibility for TPT	Prospective expansion of TPT coverage was modelled at five different levels of TPT coverage from 2023-2030: no TPT, 0-4, 0-14, 0-35, all ages
Impact of reduced active infections originating outside of NCD health catchment area	Possible changes in the rate of new TB infections originating in other PNG provinces were modelled at three levels from 2023-2030 to capture the impact on NCD of a national response in line with national TB milestones: no change, 25% reduction, 50% reduction

3 FINDINGS

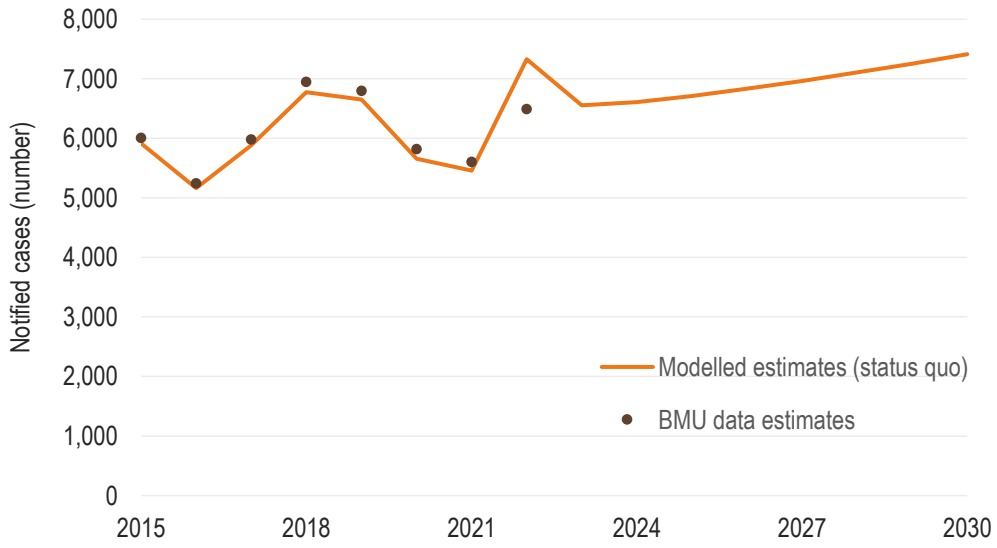
3.1 Epidemiological situation

Describe historical trends and project future trends of NCD's TB epidemic under status quo conditions

Case notifications

The number of notified cases has overall been increasing since 2016 in line with improvements to case finding and diagnostic capabilities. During 2020-2021 the number of notified cases decreased due to COVID-19-related disruptions, followed by a "catch-up" period of TB diagnoses seen as increase in notifications in 2022. The number of TB notifications is projected to increase in the future under current conditions in line with population growth (Figure 3.1).

Figure 3.1 Modelled number of notified TB cases from 2015 to 2030 in relation to provincial estimates, NCD



Source: Optima TB model for NCD-PNG, 2022 and BMU data, NCD TB program.
Note: BMU = basic management units; NCD = National Capital District, TB = tuberculosis.

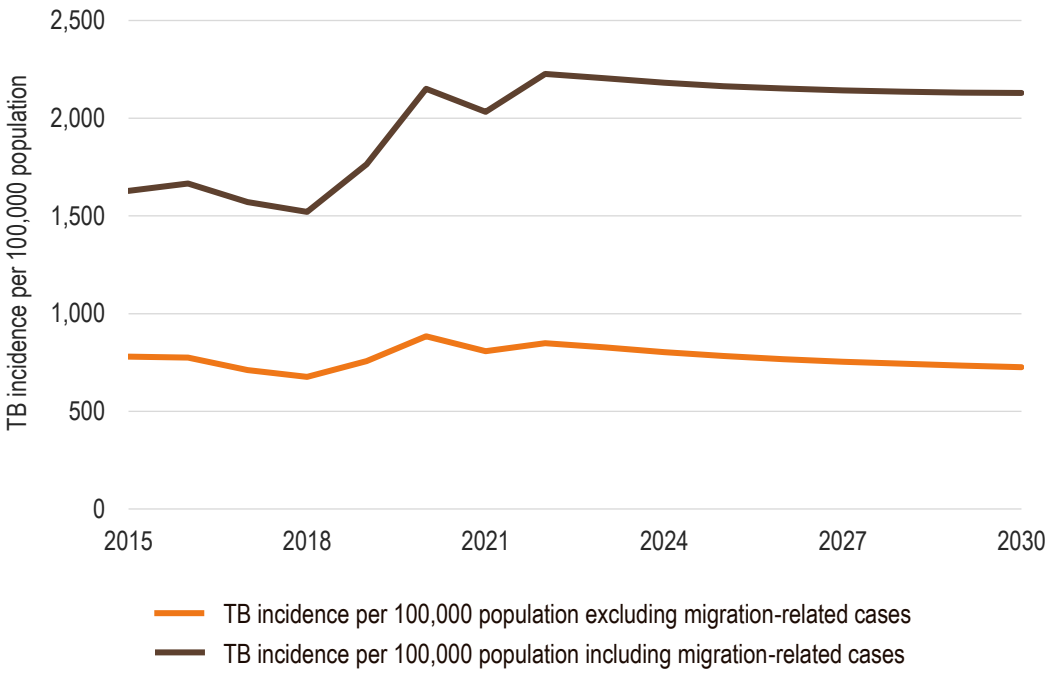
TB incidence

Historical and future projection of TB incidence were assessed both excluding and including migration-related cases (Figure 3.2). In 2022, estimated TB incidence was 849 per 100,000 population excluding migration-related cases, potentially increasing to 2,277 per 100,000 population when including migration-related cases and extrapulmonary TB. Considering migration-related cases puts the incidence more in line with the NCD TB notification rate in recent years. The incidence within the official NCD population is higher than the PNG national estimate of 420 per 100,000 population (8).

Box 1 Definition of migration-related cases

Migration-related cases represent a net change in active TB cases present in people who may access the NCD health system, among those who are not officially resident of the NCD health catchment area. This may include cases imported or externally activated from outside of the NCD health catchment area, as well as incident cases activated locally among people who are not official residents of NCD.

Figure 3.2 Modelled TB incidence from 2015 to 2030 including and excluding migration from outside of NCD in relation to provincial estimates, NCD

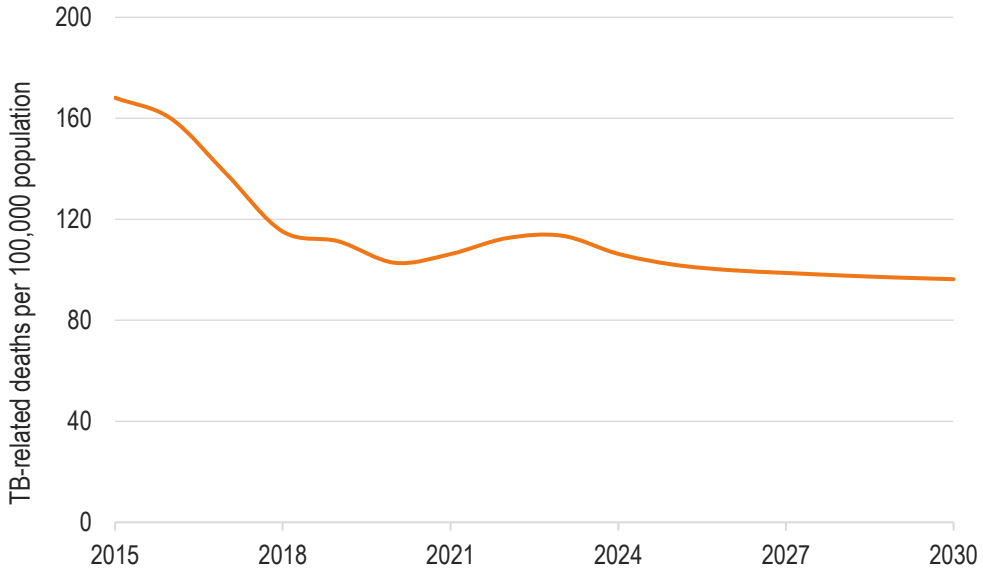


Source: Optima TB model for NCD-PNG, 2022.
Note: NCD = National Capital District, TB = tuberculosis.

TB-related deaths

In 2022 it was estimated that there were approximately 560 TB-related deaths, or 110 TB-related deaths per 100,000 population, in NCD. This has decreased from approximately 670 deaths, or 170 deaths per 100,000 population, in 2015. While the absolute number of TB-related deaths are projected to slightly increase in the future under current conditions due to population growth, the number of TB-related deaths per 100,000 population is projected to decline (Figure 3.3)

Figure 3.3 Modelled number of TB-related death per 100,000 population from 2015 to 2030 in relation to provincial estimates, NCD



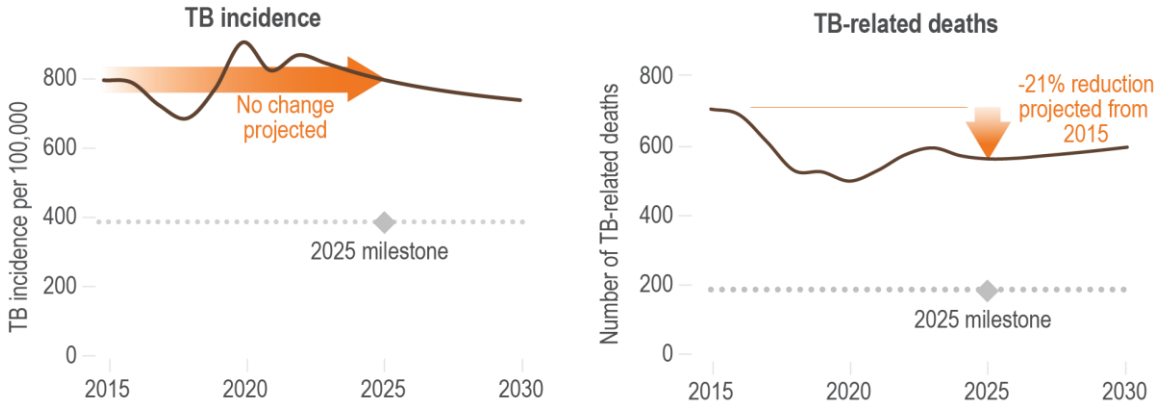
Source: Optima TB model for NCD-PNG, 2022
Note: TB = tuberculosis.

3.2 Progress made in the TB epidemic response in NCD

Describe the progress towards national and NCD 2025 milestones for reduction in TB deaths and TB incidence rate, given status quo program coverage

Based on current conditions and spending ("status quo"), NCD is not on track to achieve 2025 milestones to reduce the number of TB deaths by 75% from 2015 nor reduce TB incidence rate by 50% from 2015 baseline. It is projected that TB-related deaths may reduce by 21% from approximately 690 in 2015 to 550 in 2025, while TB incidence is projected to remain around 780 per 100,000 (Figure 3.4).

Figure 3.4 Progress towards NCD 2025 milestones for TB-related deaths and TB incidence



Source: Optima TB model for NCD-PNG, 2022.
Note: NCD = National Capital District, TB = tuberculosis.

Although not included in the TB modelling, out-of-pocket and indirect costs for TB treatment remain high, at 2,643 PGK (~US$ 829) in 2017-18 (2), thus hindering goals to eliminate catastrophic costs for TB-affected families.

3.3 Scenario comparison and priorities for the TB strategy in NCD

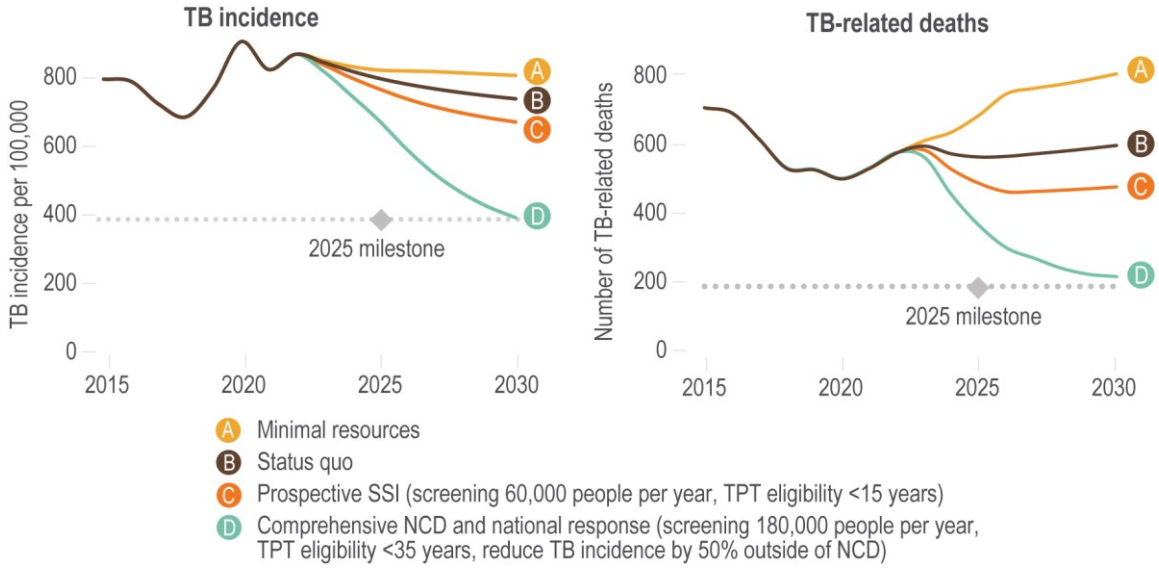
Estimate the risks for the TB epidemic in the event of reduced future spending and priority programs to limit the negative impact of reduced spending

In a scenario with **minimal resources** enabling the continuation of TB treatment but defunding of current contact tracing and community awareness, annual TB-related deaths may increase by 39% from 2020 to 2025 (from approximately 490 to 670 TB-related deaths), and 63% by 2030 (up to 800 TB-related deaths), thus exceeding 2015 levels (690 deaths) by 2030 (Figure 3.5). Under this scenario, TB incidence is expected to be approximately 810 per 100,000 population in 2025, representing a 9% decrease from 2020 values but an overall 3% increase from the 2015 baseline.

Prospective implementation of SSI to screen 60,000 people per year as well as expansion of TPT to TB contacts under age 15 could increase cumulative TB notifications by 12% over years 2015 to 2025 compared to status quo (approximately 117,000 versus 104,000). Improvements in detection and number on treatment could lead to a 32% reduction in annual TB-related deaths from 2015 to 2025, and 33% reduction by 2030, reaching 460 TB-related deaths in 2030. Over the same timeframe, TB incidence may reduce by 3% by 2025, increasing to a 15% reduction by 2030. Under these conditions, TB incidence is projected to reach 750 per 100,000 population in 2025 and 660 per 100,000 population in 2030.

A comprehensive NCD and national response incorporating SSI screening of up to 180,000 people, expanded eligibility of TBT to screen TB contacts under age 35, and 50% reduction in active TB cases from outside of NCD could increase cumulative TB notifications from 2015 to 2025 by 7% compared to status quo due to increased detection. Case notifications would be expected to be 5% lower than for implementation of SSI only due to more infections averted. Subsequent increases in the number eligible for treatment could lead to TB-related deaths reducing by 50% by 2025 and 72% by 2030 relative to the 2015 baseline, making the NCD target potentially in reach by 2030. The NCD milestone for TB incidence may also be possible by 2030, with a 49% reduction in TB incidence projected from 2015 to 2030, reaching 400 infections per 100,000 population. It is estimated that it could cost 8,235,594 PGK (~US$ 2.3M) per annum to screen 180,000 people.

Figure 3.5 Projected TB incidence and number of TB-related deaths from 2015 to 2030 under scenarios A–D.



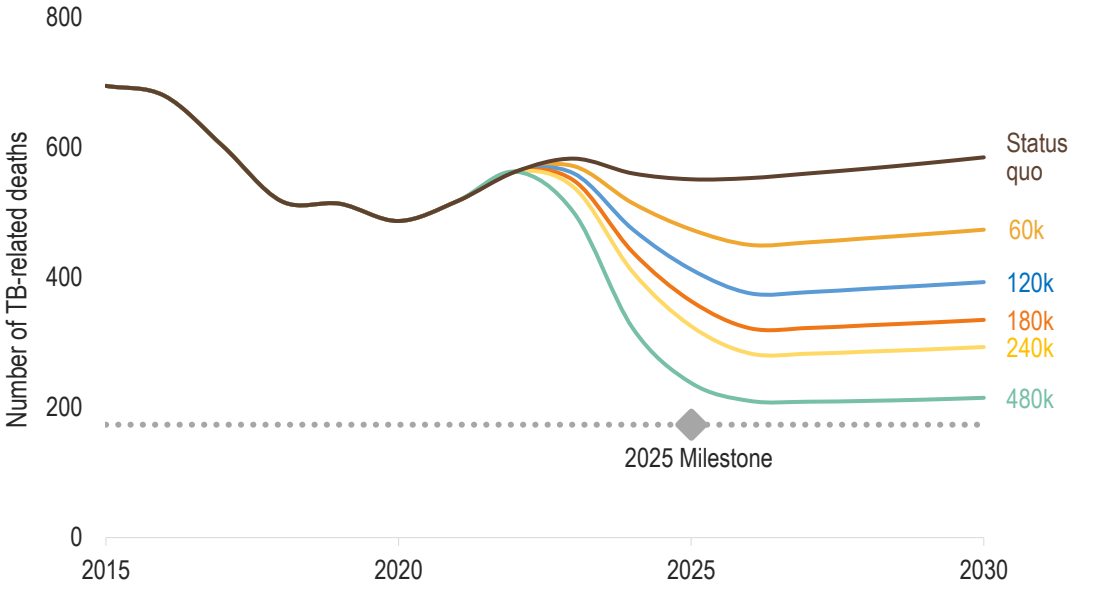
Source: Optima TB model for NCD-PNG, 2022
Notes:, NCD = National Capital District, TPT = TB preventive therapy, SSI = population-level screening.

Estimate how population level screening and TPT by age group should be prioritized as part of the TB strategy

Impact of scaling up SSI

Increasing coverage of SSI would enable earlier diagnosis of TB cases and improved treatment outcome, with the potential to rapidly reduce the number of TB-related deaths in NCD. Compared to the estimated number of TB-related deaths in 2015 (n=688), annual TB-related deaths may reduce by 20% with current conditions continued, 33% with 60,000 reached through SSI, 43% with 120,000 people reached, and 51 % with 180,000 people reached.

Figure 3.6. Number of TB-related deaths 2015–2030 with the introduction of sustained SSI to the health catchment area at different coverage levels



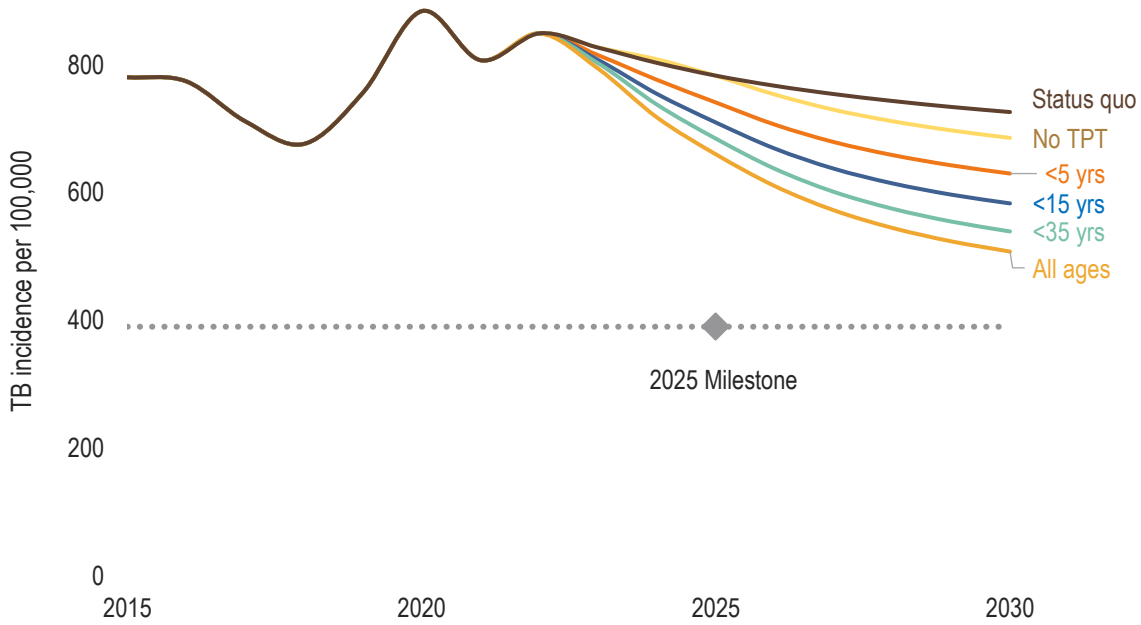
Source: Optima TB model for NCD-PNG, 2022
Note: k = thousands. Represents annual coverage of SSI, SSI = population-level screening, TB = tuberculosis.

Impact of expanding eligibility for TPT

TPT eligibility supplements SSI and has the potential to substantially reduce the number of latent TB cases and new active TB infections originating within the NCD health catchment area. Limiting eligibility for younger age groups is more cost-effective as a larger proportion of contacts have recently acquired latent TB that may lead to active TB infections. However, expanding eligibility to older age groups can achieve higher reductions in active TB incidence and may be necessary to reach TB targets. By 2025, assuming 180,000 coverage of SSI, eligibility of TPT for contacts under 5 years old could achieve a 5% reduction in incidence compared to 2015 baseline, versus a 12% reduction with eligibility expanded to contacts under 35 years. These benefits could increase to a 19% and 31% reduction, respectively, by 2030 compared to baseline. Further trial data are needed to determine the prioritization of expanded eligibility for TPT compared with increased coverage of SSI based on feasibility and cost.

The combined impacts of SSI and TPT even at beyond-best-case coverage levels are still not projected to be enough to meet NCD targets due to the mobile population.

Figure 3.7 Active TB incidence per 100,000 within the health catchment area with the expansion of TPT eligibility to different age groups, assuming SSI for 60,000 people per year in NCD

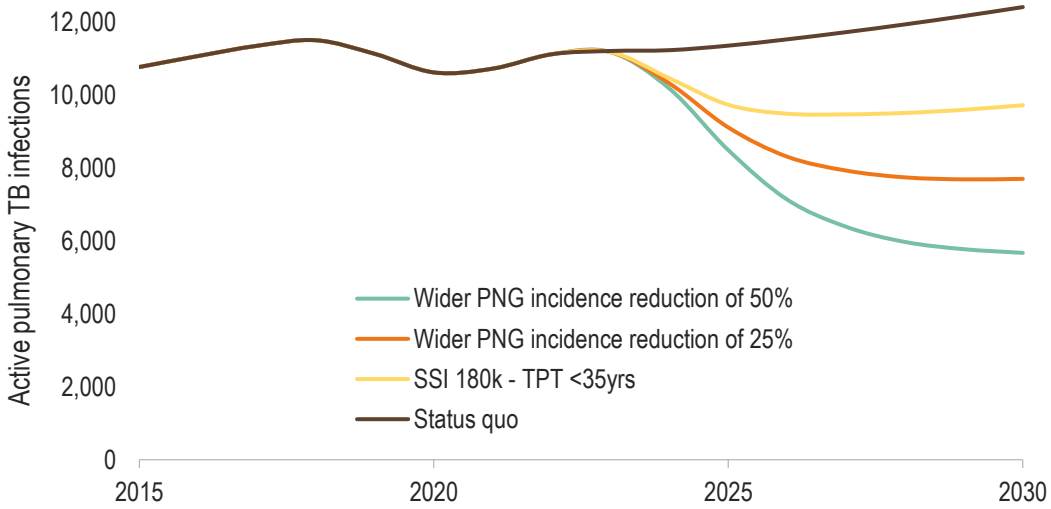


Source: Optima TB model for NCD-PNG, 2022.
Note: SSI = population-level screening, TB = tuberculosis, TPT = TB preventive therapy, yrs = years.

Impact of reduced active infections originating outside of NCD health catchment area

As more than 50% of status quo active TB cases in NCD are estimated to originate outside of the official NCD health catchment area, changes to TB service implementation in NCD may only limit epidemic gains in NCD. Implementing expanded SSI and TPT eligibility in NCD could lead to approximately 1000 (-10%) fewer active TB infections by 2025 compared to 2015 baseline. Achieving a 25% or 50% reduction in TB incidence outside of NCD on top of these implementation changes could increase this improvement to 1700 (-15%) and 2300 (-21%) fewer active TB infections, respectively, by 2025 compared to 2015 baseline.

Figure 3.8. Number of active TB cases within NCD, depending on changes to TB incidence originating outside of the NCD health catchment area



Source: Optima TB model for NCD-PNG, 2022
Note: NCD = National Capital District, PNG = Papua New Guinea, SSI = population-level screening, TB = tuberculosis.

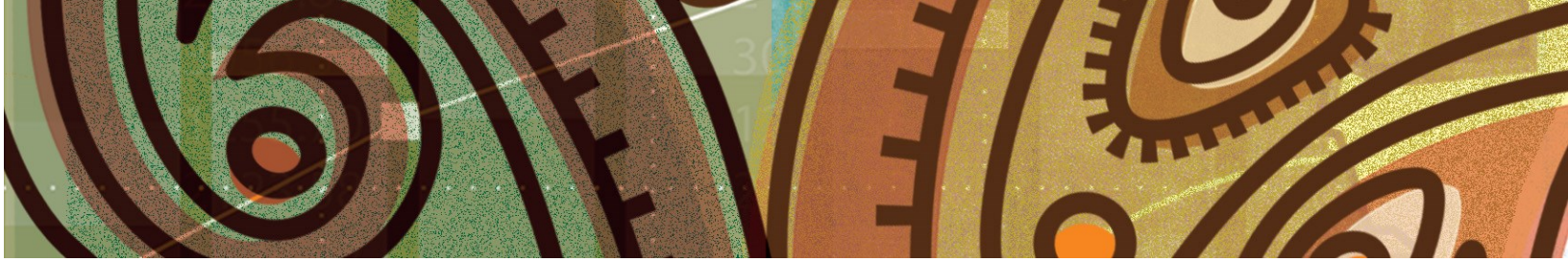
Implementation efficiencies

The estimated cost of SSI is 46 PGK per person screened, which given the estimated yield of testing based on the undiagnosed active TB prevalence gives an estimated price of 2900 PGK per person diagnosed, compared with 27 PGK per person diagnosed through household contact tracing.

Subsequently, although high SSI coverage is projected to have substantial impact on reducing TB epidemic impact, it has high associated costs, and scale-up may be difficult to achieve. The epidemic impacts of high SSI coverage may be achievable at a much lower cost through focusing on contact tracing first. Contact tracing is only estimated to reach 20% of households with a TB diagnosis, thus there is substantial opportunity to scale up this program.

Additional spending on TB prevention has economic benefits of an estimated 2,643 PGK per new active TB infection averted (2), which significantly offsets the costs of program implementation.

Moving from long course to short course MDR-TB treatment may lower the cost for MDR treatment up to 60%. Reinvesting these savings into TB prevention and testing could strengthen progress in reaching NCD 2025 milestones.



4 STUDY LIMITATIONS

As with any mathematical modelling analysis it is necessary to make assumptions about data that are not routinely collected or available, and about some of the expected relationships between variables. These assumptions necessarily imply certain limitations:

Population size: There is uncertainty in population size estimates due to a current review of population size in PNG, as well as uncertainty in NCD estimates due to migration.

TB incidence rates: TB incidence rates were calibrated to align to the WHO 75% case detection estimate and local notification data, but there is significant uncertainty in this estimate.

TB expenditure: There was very limited data on costs of TB interventions in NCD, and proxies from other settings were assumed for some intervention. Due to uncertainty in the capacity of the NCD health system to absorb large increases in spending and delivery services at large-scale with the estimated unit costs, an optimization analysis was not completed and the full cost of implementing the modelled scenarios was not evaluated.

Implementation efficiency: Detailed modelling of implementation efficiency was beyond the scope of the study, and this analysis only included considerations of implementation efficiency in a limited way. For instance, the feasibility and costs of scaling up case finding through contact tracing in place of SSI was not explored, and the efficiency and impact of reducing treatment duration was not modelled. Reduced drug prices (leading to lower unit costs, better efficiency and cost-effectiveness) were not modelled.

Non-TB benefits: Effects outside of TB indicators, such as the non-TB benefits of different TB treatment modalities, are not considered in these analyses. Given the range and complexity of interactions among interventions and their non-TB benefits, the model did not consider wider health, social, human rights, ethical, legal, employment-related or psychosocial implications; but acknowledges that they are important aspects to be considered in planning and evaluating TB responses.

This page is for collation purposes

5 CONCLUSION

Planned changes to implementation of TB screening in NCD could have a substantial impact on reducing TB-related deaths and TB incidence by 2030. However, even with extremely high programmatic coverage within NCD, achieving the NCD 2025 milestones will be extremely challenging. The NCD area has a highly mobile population, and it is estimated that half of TB cases come from outside of the health catchment area. A PNG-wide response that reaches mobile populations wider would have a very significant impact on the number of active TB cases in NCD and bring the NCD TB milestones for reduction in new active TB infections and TB-related deaths within reach. Costs for a national TB response were not evaluated as part of this analysis, but investing in TB prevention is estimated to have economic benefits of an estimated 2,643 PGK per new active TB infection averted. This cost saving would significantly offset program implementation costs.

Key Recommendations

1. Focus on achieving earlier diagnosis of TB cases to reduce transmission and mortality, through a combination of:
    - 1.1 Implementing SSI, including screening to up to 180,000 people annually within NCD
    - 1.2 Scaling-up case finding through contact tracing, which is estimated to be currently reaching only 20% of households with a TB diagnosis. The epidemic impacts of high SSI coverage may be achievable at a much lower cost through focusing on contact tracing first.
2. Expand eligibility for TPT to TB contacts under age 35 to reduce new active TB cases, a critical component of eliminating families facing catastrophic costs.
3. Meeting the NCD TB milestone for a reduction in new active TB infections will require an equivalent and well targeted response in other provinces
4. Move from long course to short course MDR-TB treatment and reinvest savings (estimated 60% reduction in costs) into TB prevention and testing.

This page is for collation purposes.

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7 APPENDICES

Appendix A Optima TB Model Overview

Tuberculosis model structure

The Optima TB tool is based on a dynamic, population-based TB model encapsulated within an intervention and costing framework (14). The model uses a linked system of ordinary differential equations to track the movement of people among health states (**Figure A1**). The overall population is partitioned in two ways: by population group and by TB health state. TB infections occur through the interactions among different populations. Each compartment in **Figure A1.** corresponds to a single differential equation in the model, and each rate (**Figure A1** arrows) corresponds to a single term in that equation. The analysis interprets empirical estimates for model parameter values in Bayesian terms as previous distributions. The model then must be calibrated: finding posterior distributions of the model parameter values so that the model generates accurate estimates of notified TB cases, TB incidence, TB prevalence, the number of people on treatment, and any other epidemiological data that are available (such as TB-related deaths). Model calibration and validation normally should be performed in consultation with governments in the countries, in which the model is being applied.

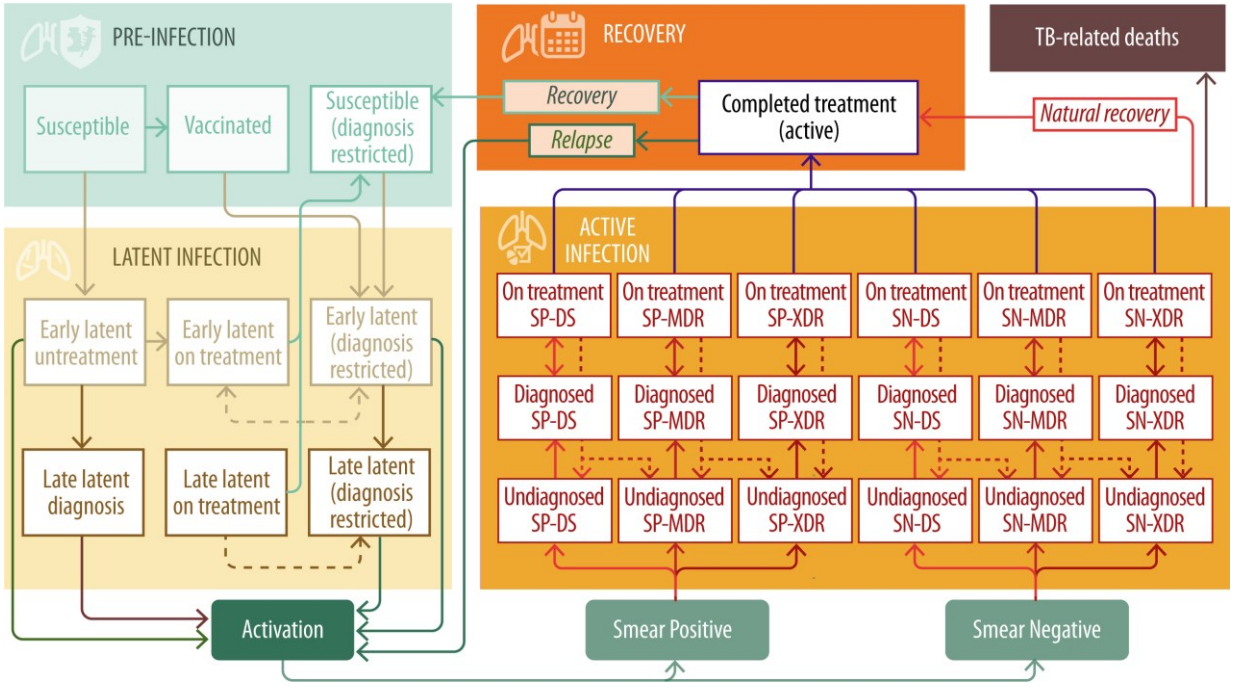
The WHO definition for incident TB cases includes both new and relapse cases. In the model, incident TB cases correspond to the following transitions between compartments (Table A.1):

- **New cases:** these are represented by the number of progressions to active TB from early and late latent-TB compartments. 'New' also includes recurring episodes of TB from the recovered compartment following re-infection
- **Relapse cases:** these correspond to all unsuccessful treatments in the model, which include failure, relapse, LTFU and re-treatments.

Treatment success includes 'cured' and 'treatment completion', as per the WHO definition:

- **Death during TB treatment** is not included in treatment failure, but is considered separately
- **Treatment failure and 'loss to follow-up'** during treatment are included as separate outcomes in the model.

Figure A.1 Optima Malaria model diagram



Source: Goscé (2021)
Note: Each compartment represents a single population group with the specified health state. Each arrow represents the movement of numbers of individuals between health states. All compartments except for "susceptible" and "vaccinated" represent individuals with either latent or active TB. Death can occur for any compartment, but TB related mortality varies between compartments; SN-DS = smear negative drug susceptible, SN-MDR =smear negative-multi-drug resistant, SN-XDR = smear negative-extensively drug-resistant, SP-DS = Smear-positive drug susceptible, SP-MDR =smear positive-multi-drug resistant, TB = tuberculosis.

Table A.1 Overview of key Optima TB Model features and definitions

TB parameters	Model features and definitions
Disaggregation by smear-status and drug-resistance	Both smear positive and negative; DS-TB, MDR-TB, XDR-TB
New vs. relapse cases	The WHO definition for incident TB cases includes both new and relapse cases. In the model, incident TB cases correspond to the following transitions between compartments: – **New cases:** these are represented by the number of progressions to active TB from early and late latent-TB compartments. 'New' also includes recurring episodes of TB from the recovered compartment following re-infection – **Relapse cases:** these correspond to all unsuccessful treatments in the model, which include failure, relapse, LTFU and re-treatments

Table continued...

Table A.2 Overview of key Optima TB Model features and definitions (continued)

TB parameters	Model features and definitions
Disaggregation by smear-status and drug-resistance	Both smear positive and negative; DS-TB, MDR-TB, XDR-TB
Latent TB	– Multiple compartments for latent TB infection (LTBI) – Cannot skip latent state for disease progression – States include undiagnosed, on treatment, and completed treatment – Accounts for re-infection and latent care-status using a secondary latent TB pathway. Cases previously treated for LTBI, or vaccinated individuals, can transition to the active TB pathway in the case of reinfection
Vaccination, immunity and resistance	– Vaccination explicitly included in model – Patients that spontaneously clear from infection
Treatment	– States for undiagnosed, diagnosed, diagnosed but not on-treatment, on-treatment, and recovered patients for different types of drug resistance – Failed or defaulted treatment can acquire drug resistance
Treatment outcomes	– Treatment success includes 'cured' and 'treatment completion', as per the WHO definitions – Treatment failure in the model includes 'loss to follow-up' during treatment, 'treatment failure', and 'not evaluated' – Death during TB treatment is not included in treatment failure, but is considered separately
Population structure, key populations and People living with HIV	– Age-structured populations can be user defined – Ability to specify additional key populations with defined transition rates to/from general population groups – People living with HIV represented as a separate key population disaggregated by HIV treatment status

TB resource optimization

Optima TB is able to calculate allocations of resources that optimally address one or more TB-related objectives (for example, impact-level targets in a country's TB national strategic plan). Because this model also calculates the coverage levels required to achieve these targets, Optima TB can be used to inform TB strategic planning and the determination of optimal program coverage levels. The key assumptions influencing resource optimization are the relationships among (1) the cost of TB interventions for specific target populations, (2) the resulting coverage levels of targeted populations with these TB programs, and (3) how these coverage levels of TB programs for targeted populations influence screening and treatment outcomes. Such relationships are required to understand how incremental changes in spending (marginal costs) affect TB epidemics. To perform the optimization, Optima uses a global parameter search algorithm, which is an adaptive stochastic descent algorithm (14).

Appendix B Model Inputs

Demographics

Table B.1 Demographics

Parameter	2015 (baseline year)	2021 (latest complete data)*	Source or assumption
Demographics			
Population size			
0-14	136,635	164,535	NCD PHA
15+	256,969	309,441	
15+ PLHIV	N/A	10,088	
Annual number of births	11,237	12,421	NCD PHA
Annual non-TB death rate**			
0-14	0.6%	0.5%	NCD PHA
15+	8.5%	8.7%	
15+ PLHIV	5.4%	5.5%	
Number of net new immigrants	4,030	4,725	NCD PHA

Note: * = Partial data for 2022 was also available and used; ** = Average across age and sex bands; NCD PHA = National Capital District Provincial Health Authority; PLHIV = people living with HIV.

Tuberculosis notifications

Table B2 Number of notified TB infections per population group (2021)

	Bacteriologically confirmed				Clinically diagnosed			
	DS-TB	MDR-TB	XDR-TB	Total notified	DS-TB	MDR-TB	XDR-TB	Total notified
0–14	219	11	<1	230	702	37	<1	739
15+ years	1,767	92	1	1,860	2,217	116	1	2,334
15+ years living with HIV	188	10	<1	198	229	12	<1	241
Total	**2,174**	**113**	**1**	**2,289**	**3,149**	**164**	**2**	**3,314**

Source: BMU data, NCD TB program.
Note: NCD-reported data provided total notifications by age group and HIV status. Disaggregation by strain was assumed to be the same proportion across all populations, based on rates of confirmed rifampicin resistance in GeneXpert testing and overall XDR treatment initiations. Disaggregation of notifications into DS, MDR and XDR is therefore considered estimates only. DS = drug susceptible; TB = tuberculosis; MDR = multi-drug resistant; XDR = extensively drug-resistant.

Epidemiological parameters

Table B.3 Epidemiological parameters

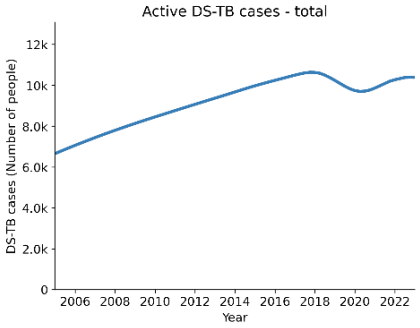
Description	Value	Population	Source or assumption
Vaccinations administered (/year)	12,713 (2021)	0-4	Country-provided program data, NCD BCG vaccination totals 2021-2022
Early Latency Departure Rate	0.2	All populations unless specified	
	0.4	65+	
	0.99	PLHIV unless female on treatment	
Late Latency Departure Rate*	0.003	All populations unless specified	Andrews (2012)- risk of progression to active.
	0.0037 (65+, PLHIV not on treatment)	65+, PLHIV unless female on treatment	
Probability of Early-Active vs. Early-Late LTBI Progression*	0.354	0-4	Andrews (2012)- risk of progression to active.
	0.177	5-64	
	0.531	65+	
	0.93	PLHIV unless female on treatment	
Infection Vulnerability Factor (Vaccinated vs. Susceptible)	0.5	0-14	Mangtani (2014) (protective efficacy of BCG found to range from 0-80%). A value of 0.5 was used for populations aged 0–14, and no protection (i.e., 1) was used for all populations older than 14 years old.
	1.0	15+	
Infection vulnerability factor (relative population susceptibility)	0.8-30	Varies by population	A value of '1' is the default, but this is likely to be significantly higher in vulnerable populations such people living with HIV. Values between 0.8 and 30 were used in calibrations
Smear positive (SP) TB Infectiousness*	1.0	All populations unless specified	A value of '1' is the default
	0.66	PLHIV not on treatment	
Smear negative (SN) TB Infectiousness (Compared to SP-TB)	0.22	All populations	Behr (1999)
Smear positive untreated-TB death rate	70%	All populations unless specified	WHO, Tiemersma (2011)
	80%	65+	
	83%	PLHIV not on treatment	
Smear negative untreated-TB death rate	20%	All populations unless specified	WHO, Tiemersma (2011)
	74%	PLHIV not on treatment	

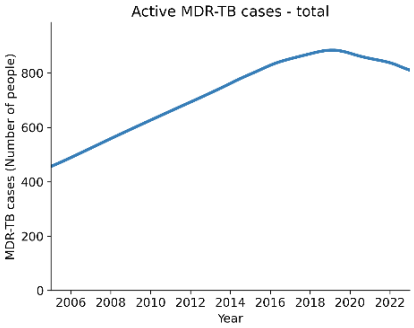
Table B4 Treatment outcomes, 2021

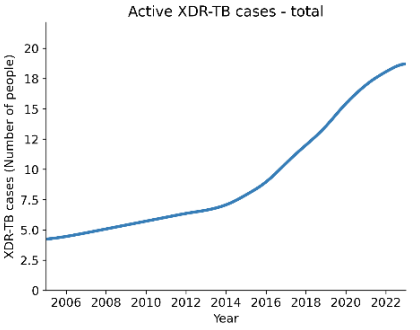
	Number of treatment initiations			Average treatment duration (days)			Treatment success			Treatment proportion of loss to follow up (require re-diagnosis)			Treatment proportion failed (no escalation, no need to re-diagnose)			Treatment proportion failed (escalation to MDR/XDR require re-diagnosis)			Proportion of deaths		
	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB	DS-TB	MDR-TB	XDR-TB
0–14	522	30	0	180	540	720	91.1%	90%	30%	5.8%	8%	21%	1.5%	7%	21%	0.2%	2%	N/A	1.0%	12%	28%
15+ years	2,658	128	0	180	540	720	89.6%	90%	30%	3.8%	8%	21%	1.3%	7%	21%	0.2%	2%	N/A	4.1%	12%	28%
15+ years living with HIV	380	10	0	180	540	720	80.1%	90%	30%	5.7%	8%	21%	0.6%	7%	21%	0.2%	2%	N/A	5.4%	12%	28%

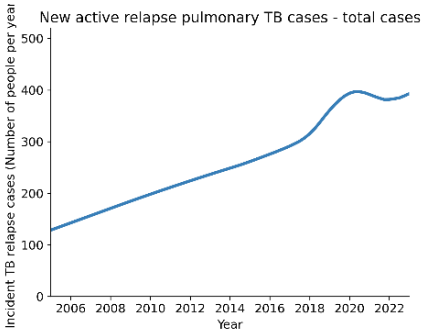
Source: NCD PHA.
Note: DS = drug susceptible; TB = tuberculosis; MDR = multi-drug resistant; XDR = extensively drug-resistant.

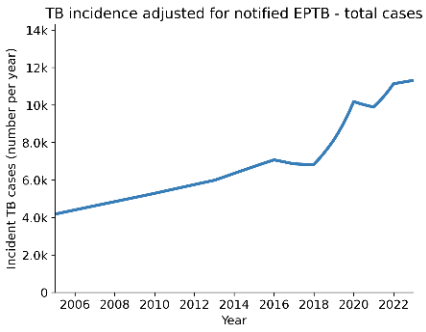
Appendix C Calibration

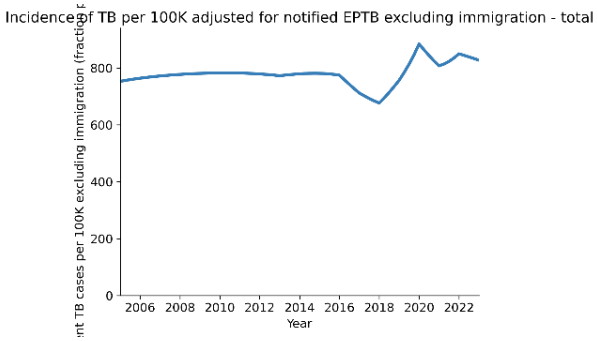


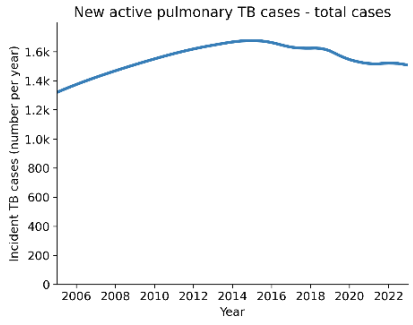


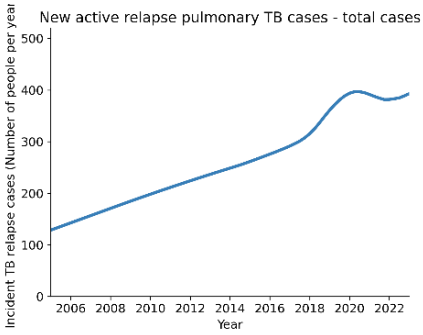


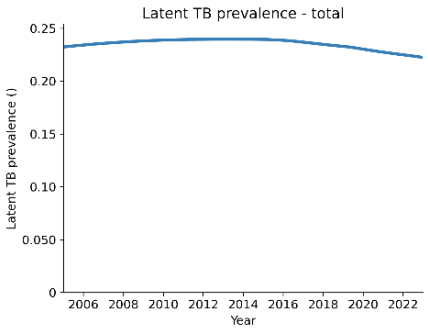


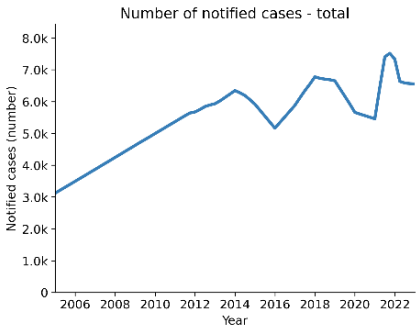


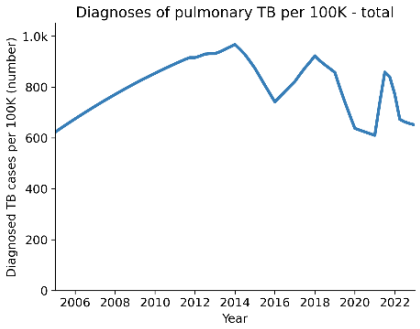


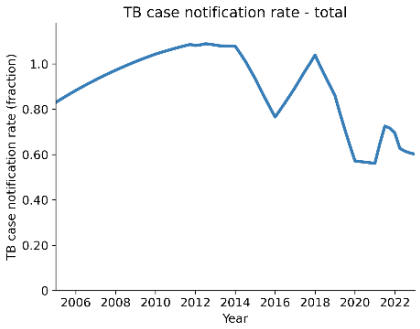


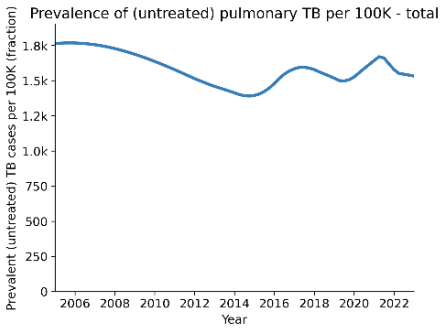


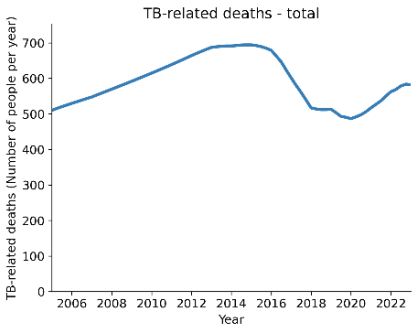

Latent TB prevalence - total
Latent TB prevalence (-)
0.25
0.20
0.15
0.10
0.050
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year

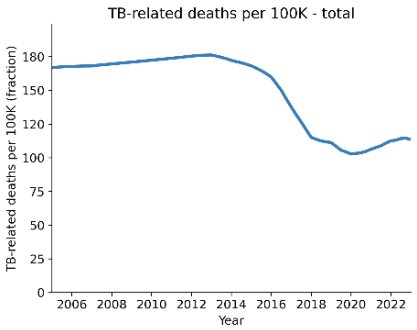

Number of notified cases - total
Notified cases (number)
8.0k
7.0k
6.0k
5.0k
4.0k
3.0k
2.0k
1.0k
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year

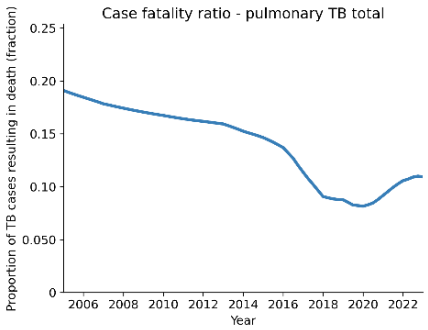

Diagnoses of pulmonary TB per 100K - total
Diagnosed TB cases per 100K (number)
1.0k
800
600
400
200
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year

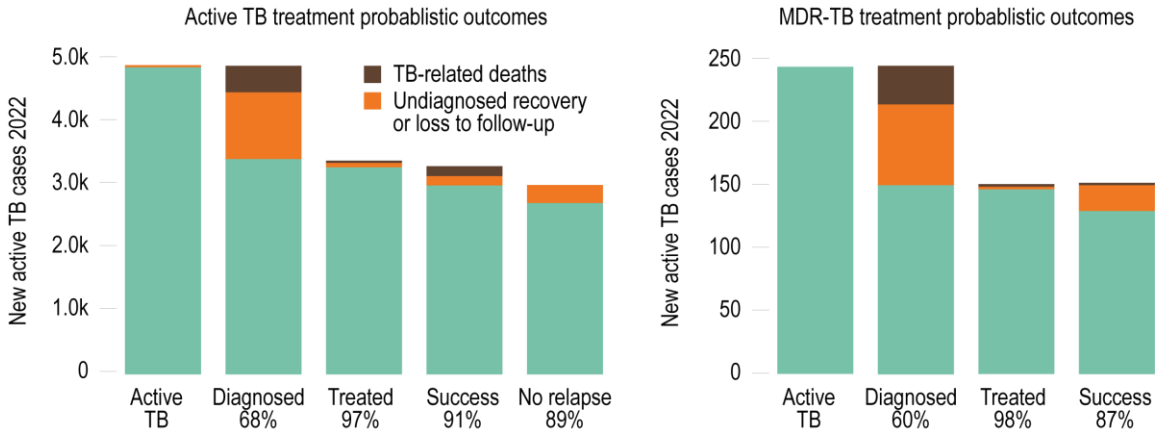

TB case notification rate - total
TB case notification rate (fraction)
1.0
0.80
0.60
0.40
0.20
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


Prevalence of (untreated) pulmonary TB per 100K - total
Prevalent (untreated) TB cases per 100K (fraction)
1.8k
1.5k
1.2k
1.0k
750
500
250
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


TB-related deaths - total
TB-related deaths (Number of people per year)
700
600
500
400
300
200
100
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


TB-related deaths per 100K - total
TB-related deaths per 100K (fraction)
180
150
120
100
75
50
25
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year


Case fatality ratio - pulmonary TB total
Proportion of TB cases resulting in death (fraction)
0.25
0.20
0.15
0.10
0.050
0
2006 2008 2010 2012 2014 2016 2018 2020 2022
Year



Note: DS = drug susceptible; TB = tuberculosis; MDR = multi-drug resistant; XDR = extensively drug-resistant, EPTB = extrapulmonary tuberculosis. TB case notification rate = the number of new and relapse tuberculosis cases notified in a given year, divided by number of modelled incident tuberculosis cases for the same year.
Case fatality ratio = the number TB-related deaths in a given year, divided by number of modelled incident tuberculosis cases for the same year.

Appendix D Program Definitions

Program details

Table D1 Program details and estimated unit costs for TB interventions in NCD, PNG

		Unit	Unit cost (PGK)	Assumptions
TB Prevention programs				
BCG vaccination		Cost per infant vaccinated	0.6 PGK *	
Preventive therapy for people living with HIV on ART		Cost per person on ART per year	36.03 PGK *	Sulfamethoxazole + trimethropin, tablet 400 mg + 80 mg; Isoniazid 300 mg; Vitamine B6, 15 mg; Isoniazid 100 mg
Preventive therapy (DS only) for people with detected latent TB aged	0–4 years 5–14 years 15–34 years 35+ years	Cost per person who is a contact of active TB, per preventive therapy initiation	36.03 PGK *	Sulfamethoxazole + trimethropin, tablet 400 mg + 80 mg; Isoniazid 300 mg; Vitamine B6, 15 mg; Isoniazid 100 mg
Screening And Diagnosis programs				
Passive case finding		Per person diagnosed	5.26 PGK *	Based on 3.65 per test and 70% yield^ over 5,574 people tested
Active case finding (household contact tracing)		Per person diagnosed	27.13 PGK *	Based on 20,000 extra fixed costs over 3,001 people tested and 1,145 diagnoses, at 38% yield^
Active case finding (community awareness)		Per person diagnosed	43.46 PGK *	Based on 17,500 extra fixed costs over 3,061 people tested and 624 diagnoses, at 20% yield^
Active case finding (population screening: SSI)		Per person screened	45.75 PGK*	Based on total SSI package of 2,745,198 PGK divide by 60,000 reached
TB Treatment programs				
DS-TB treatment		Per person initiating treatment	479.8 PGK †	All scenarios assumed proportion of notified cases treated remained constant at 2021 levels, at XX%
MDR-TB treatment (long oral course)		Per person initiating treatment	7,441 PGK †	All scenarios assumed proportion of notified cases treated remained constant at 2021 levels, at XX%
MDR-TB treatment (short oral course)		Per person initiating treatment	4,550 PGK †	All scenarios assumed proportion of notified cases treated remained constant at 2021 levels, at XX%
XDR-TB treatment		Per person initiating treatment	14,882 PGK †	All scenarios assumed proportion of notified cases treated remained constant at 2021 levels, at XX%
Out-of-pocket costs (average)		Per new active TB infection	2,643 PGK §	Average across both DS and DR TB

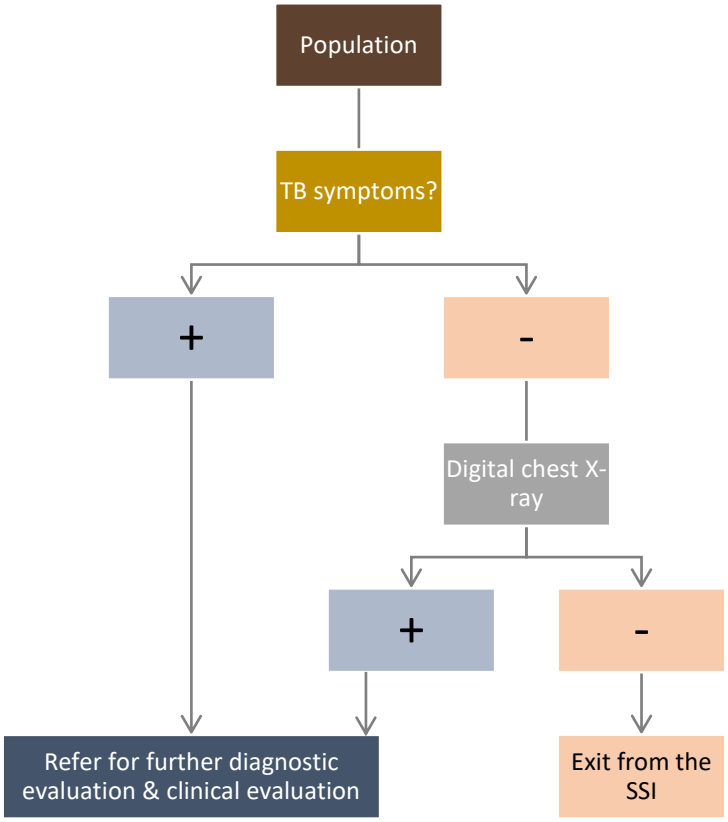
Source: * = LiST unit costs (13); † = Indonesia proxy (1); § = Report on the national tuberculosis patient cost survey in Papua New Guinea: 2017–2018 (2); ^ = NCD TB Program data

Note: DS = drug susceptible; TB = tuberculosis; MDR = multi-drug resistant; XDR = extensively drug-resistant.

SSI Protocol

The planned SSI protocol uses a sequential negative serial screening algorithm to detect active TB

Figure D1 Proposed SSI screening algorithm, NCD



Appendix E Detailed Model Findings

Table E1 Projected TB-related deaths by scenario from 2020 to 2030

	TB-related deaths															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
(A) Minimal resources	694	679	602	517	513	487	517	562	599	624	674	736	752	764	778	795
(B) Status quo	694	679	602	517	513	487	517	562	582	560	551	553	560	567	575	584
(C) Prospective SSI	694	679	602	517	513	487	517	562	571	514	473	449	450	453	458	463
(D) Comprehensive NCD and national response	694	679	602	517	513	487	517	562	549	437	347	281	251	221	203	197

Table E 2 Projected TB incidence per 100,000 people by scenario from 2020 to 2030

	Incidence per 100,000 people excluding immigration															
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
(A) Minimal resources	780	774	712	676	756	884	807	849	832	816	806	803	801	798	794	791
(B) Status quo	780	774	712	676	756	884	807	849	827	803	783	767	754	743	734	726
(C) Prospective SSI	780	774	712	676	756	884	807	849	820	785	754	727	705	688	674	663
(D) Comprehensive NCD and national response	780	774	712	676	756	884	807	849	802	736	667	589	521	467	427	397

Appendix F Additional Analyses

Outcome matrix of TB-related deaths

The following matrices show the projected reduction of TB-related deaths from 2015 levels with different combinations of PPT eligibility, SSI coverage, and reduction of TB incidence outside of the NCD health catchment area. These show a direct relationship between proportion screened through SSI and a reduction in TB-related deaths. There is less relative impact in achievable impact through changes in PNG-wide incidence.

Reduction of TB-related deaths from 2015 levels

PNG-wide incidence:	Status quo			Year:	2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	31.8%	31.8%	31.9%	31.9%	32.2%
120k	40.6%	40.7%	40.8%	40.9%	41.4%
180k	47.7%	47.8%	47.8%	48.0%	48.7%
240k	53.2%	53.4%	53.4%	53.6%	54.4%
300k	57.6%	57.8%	57.9%	58.1%	59.0%
360k	61.0%	61.2%	61.4%	61.7%	62.7%
420k	63.7%	64.0%	64.1%	64.4%	65.5%
480k	65.8%	66.1%	66.3%	66.7%	67.8%

PNG-wide incidence:	Status quo			Year:	2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	31.8%	32.7%	33.3%	33.7%	34.2%
120k	43.4%	44.6%	45.5%	46.1%	46.9%
180k	51.8%	53.0%	54.0%	54.7%	55.8%
240k	57.8%	59.0%	60.0%	60.8%	62.1%
300k	62.1%	63.2%	64.2%	65.1%	66.5%
360k	65.2%	66.3%	67.2%	68.2%	69.6%
420k	67.4%	68.4%	69.3%	70.4%	71.9%
480k	69.1%	70.0%	70.9%	71.9%	73.5%

PNG-wide incidence:	25% reduction			Year:	2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	32.8%	48.6%	48.6%	48.6%	48.9%
120k	55.4%	55.4%	55.4%	55.5%	55.9%
180k	60.7%	60.8%	60.9%	61.0%	61.5%
240k	65.0%	65.1%	65.2%	65.3%	66.0%
300k	68.4%	68.5%	68.6%	68.8%	69.5%
360k	71.0%	71.2%	71.3%	71.5%	72.3%
420k	73.1%	73.3%	73.4%	73.7%	74.5%
480k	74.7%	74.9%	75.1%	75.4%	76.2%

PNG-wide incidence:	25% reduction			Year:	2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	43.4%	44.2%	44.9%	45.3%	45.8%
120k	53.2%	54.3%	55.2%	55.8%	56.6%
180k	60.2%	61.3%	62.4%	63.1%	64.2%
240k	65.2%	66.4%	67.4%	68.3%	69.4%
300k	68.9%	70.0%	70.9%	71.9%	73.2%
360k	71.5%	72.5%	73.4%	74.4%	75.8%
420k	73.4%	74.4%	75.2%	76.3%	77.7%
480k	74.8%	75.7%	76.5%	77.6%	79.1%

PNG-wide incidence:	50% reduction			Year:	2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	33.7%	33.7%	33.8%	33.8%	34.1%
120k	42.6%	42.7%	42.7%	42.8%	43.3%
180k	49.7%	49.8%	49.8%	50.0%	50.7%
240k	55.3%	55.4%	55.5%	55.7%	56.5%
300k	59.7%	59.9%	60.0%	60.2%	61.1%
360k	63.1%	63.4%	63.5%	63.8%	64.8%
420k	65.9%	66.1%	66.3%	66.6%	67.7%
480k	68.0%	68.3%	68.5%	68.9%	70.0%

PNG-wide incidence:	50% reduction			Year:	2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	55.2%	56.0%	56.6%	57.0%	57.5%
120k	63.0%	64.1%	65.0%	65.7%	66.5%
180k	68.7%	69.8%	70.8%	71.7%	72.6%
240k	72.8%	73.9%	74.9%	75.8%	76.9%
300k	75.7%	76.8%	77.7%	78.7%	79.9%
360k	77.9%	78.8%	79.8%	80.8%	82.1%
420k	79.4%	80.3%	81.2%	82.3%	83.6%
480k	80.5%	81.4%	82.3%	83.4%	84.7%

Note: k = thousand – referring to coverage of SSI; TPT = TB preventative therapy. Immigration refers to the change in TB incidence.

Outcome matrix of TB infections

The following matrices show the projected reduction of TB incidence from 2015 levels with different combinations of PPT eligibility, SSI coverage, and reduction of TB incidence outside of the NCD health catchment area. These project that it will be challenging to have long-term impact on TB incidence without very high levels of screening and TPT. Reduction in new infections from other parts of PNG will be critical to reaching incidence targets.

Reduction of new active TB infections from 2015 levels

PNG-wide incidence:	Status quo				Year: 2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	-0.3%	1.8%	3.3%	4.5%	5.6%
120k	-0.3%	3.6%	6.4%	8.7%	10.8%
180k	-0.3%	5.1%	9.1%	12.3%	15.4%
240k	-0.2%	6.3%	11.3%	15.5%	19.5%
300k	-0.1%	7.4%	13.2%	18.3%	23.2%
360k	0.0%	8.3%	14.9%	20.7%	26.4%
420k	0.1%	9.1%	16.3%	22.9%	29.3%
480k	0.2%	9.8%	17.5%	24.9%	31.9%

PNG-wide incidence:	Status quo				Year: 2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	8.9%	12.2%	15.1%	17.4%	19.0%
120keE	10.6%	16.2%	21.0%	25.1%	28.0%
180k	12.2%	19.3%	25.3%	30.9%	34.9%
240k	13.5%	21.8%	28.6%	35.4%	40.4%
300k	14.7%	23.8%	31.1%	39.0%	44.8%
360k	15.8%	25.4%	33.2%	41.8%	48.4%
420k	16.7%	26.8%	34.8%	44.2%	51.4%
480k	17.5%	28.0%	36.2%	46.1%	53.9%

PNG-wide incidence:	25% reduction				Year: 2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	0.7%	2.9%	4.4%	5.6%	6.7%
120k	0.8%	4.7%	7.5%	9.8%	11.9%
180k	0.8%	6.2%	10.2%	13.4%	16.5%
240k	0.9%	7.4%	12.4%	16.6%	20.6%
300k	1.0%	8.5%	14.3%	19.4%	24.3%
360k	1.1%	9.4%	16.0%	21.8%	27.5%
420k	1.2%	10.2%	17.4%	24.0%	30.4%
480k	1.3%	10.9%	18.7%	26.0%	33.0%

PNG-wide incidence:	25% reduction				Year: 2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	18.7%	21.8%	24.6%	26.9%	28.4%
120k	20.3%	25.5%	30.2%	34.3%	37.1%
180k	21.8%	28.4%	34.3%	39.8%	43.7%
240k	23.1%	30.7%	37.4%	44.1%	48.9%
300k	24.2%	32.6%	39.7%	47.5%	53.1%
360k	25.2%	34.1%	41.6%	50.2%	56.5%
420k	26.1%	35.3%	43.1%	52.4%	59.2%
480k	26.9%	36.4%	44.4%	54.2%	61.6%

PNG-wide incidence:	50% reduction				Year: 2025
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	1.8%	4.0%	5.5%	6.7%	7.8%
120k	1.9%	5.8%	8.6%	10.8%	13.0%
180k	1.9%	7.2%	11.3%	14.5%	17.6%
240k	2.0%	8.5%	13.5%	17.7%	21.7%
300k	2.1%	9.6%	15.4%	20.5%	25.3%
360k	2.2%	10.5%	17.1%	23.0%	28.6%
420k	2.4%	11.3%	18.5%	25.1%	31.5%
480k	2.5%	12.0%	19.8%	27.1%	34.1%

PNG-wide incidence:	50% reduction				Year: 2030
	no TPT	TPT <5yrs	TPT <15yrs	TPT <35yrs	TPT all ages
60k	28.9%	31.8%	34.6%	36.8%	38.3%
120k	30.4%	35.3%	39.8%	43.9%	46.6%
180k	31.8%	37.9%	43.7%	49.2%	52.9%
240k	33.0%	40.0%	46.5%	53.2%	57.8%
300k	34.1%	41.7%	48.7%	56.3%	61.7%
360k	35.0%	43.1%	50.4%	58.8%	64.8%
420k	35.9%	44.2%	51.8%	60.9%	67.3%
480k	36.6%	45.2%	52.9%	62.6%	69.5%

Note: k = thousand – referring to coverage of SSI; TPT = TB preventative therapy. Immigration refers to the change in TB incidence.