Programmatic Efficiency and Optimizing TB Response

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Acronyms

AI	Artificial Intelligence
ACF	Active Case Finding
CAD	Computer Assisted Diagnostics
CCM	Country Coordinating Mechanism
CHW	Community Health Worker
CPR	Point-of-care C-reactive protein
DALY	Disability Adjusted Life Years
DR-TB	Drug-Resistant TB
DHIS	District Health Information System
DOTS	Directly Observed Treatment Short-Course
e-CBS	Electronic Case Based System
EID	Early Infant Diagnosis
GC	Grant Cycle
HEW	Health Extension Worker
HRH	Human Resources for Health
IC	Infection Control
ICER	Incremental Cost-Effective Ration
KII	Key Informant Interviews
LMIC	Low- and Middle-Income Countries
MCH	Maternal and Child Health
NCD	Noncommunicable Diseases
NTD	Neglected Tropical Disease
NSP	National Strategic Plan
NTP	National TB Control Program
PLHIV	People Living with HIV
TB	Tuberculosis
TST	Tuberculin Skin Test
TPT	TB Preventive Therapy
UQD	Unfunded Quality Demand
UNHLM	UN High-Level Meeting
VOT	Video Observed Therapy
WHO	World Health Organization

Executive Summary

The Global Fund has played a pivotal role in the global fight against HIV, tuberculosis (TB), and malaria, driving significant advancements and contributing to saving 65 million lives in the past two decades. Its investments in TB have spurred innovation, market shaping, and the adoption of advanced technologies, such as AI-powered screening tools and rapid molecular testing for both drug-susceptible (DS-TB) and drug-resistant TB (DR-TB) and shorter and more patient-friendly and effective treatment for TB, DR-TB and TB infection. By expanding access to sensitive screening methods and supporting the implementation of shorter, more effective treatment regimens, the partnership has made notable improvements in coverage and outcomes and increased the overall efficiency of TB care systems.

Despite these advancements, substantial challenges remain in the global TB response, including significant funding gap globally and in Grant Cycle 7 (GC7), and limited access to affordable health products. A funding gap of approximately US$1.35 billion in unfunded quality demand (UQD) for critical commodities and interventions in GC7 threatens to undermine the progress made, underscoring the need for strategic optimization of interventions and efficient use of resources to maintain the momentum, close funding gaps, and ensure access to essential health commodities.

This report is based on evidence and insights gathered on cost-effective, efficient, and scalable TB interventions that can optimize financial, programmatic, and technical resources to improve the overall TB response. It also aims to identify lessons learned and best practices in addressing funding shortfalls, inefficiencies in service delivery, and disparities in access to care. The findings from this assessment could inform development of key strategies and approaches to enhance the global TB response, ensuring sustainability and greater impact.

The following table presents the key themes, approaches, and best practices for optimizing the TB response and enhancing efficiency across the TB care cascade, as derived from the literature review and Key Informants Interview (KIIs). It emphasizes integrating all TB services into existing program, leveraging shared infrastructure for multi-disease integration, and optimizing utilization of cost-effective and efficient screening, diagnostic, treatment tools, algorithms and strategies.

Table 1: Key opportunities and evidence on optimizing TB response and gaining efficiency

S#	Themes (WHAT)	Approaches/Strategies (HOW)	Best Practices (Examples from countries)
1	**Integrating TB services within existing TB programs**	1.1 Combine contact examination, TB diagnosis and TPT provision, in one household visit. 1.2 Decentralize and integrate DS-TB and DR-TB services including logistics for anti-TB drugs, diagnostics, data systems in case management, and monitoring. 1.3 Integrating chest X-rays (CXR), CAD/AI and rapid molecular test 1.4 Expanding sample transport networks reduces logistical and catastrophic costs by centralizing testing efforts.	• **South Africa**: Routine TB screening with contact tracing and preventive treatment reduced costs (USD$9050/DALY averted). • **Ethiopia**: Patient-centered DR-TB treatment saved US$219–US$276 per patient. • **Philippines** – TB and DR-TB services are integrated at all levels (iDOTS). • **Zambia**: One-stop TB services integrating CXR, CAD, and Xpert improved affordability • **Pakistan & Philippines**: Sample transportation aids in timely treatment initiation and reduced the catastrophic cost faced by 42.4% of TB-affected households in Philippines.
2	**Efficient use of tools**	2.1 Maximize the use of new and existing screening and diagnostic tools like digital CXR, TB-LAMP, Truenat, antigen-based skin test (Cy-TB), GeneXpert and DAT. 2.2 Enhance the utilization of combination tests like Double X, pooled samples etc. 2.3 Use of potable digital CXR and mobile technology integrated with AI 2.4 Match screening and diagnostic methods to the population's TB yield.	• **Pakistan**: Increased access to molecular diagnostics in the private sector boost GeneXpert utilization. • **India**: Cy-Tb test for TBI is cost-effective with savings potential through bulk procurement. • **Vietnam**: Combining CXR with GeneXpert enhances early TB detection, improves radiograph interpretation, and increases eligibility for preventive treatment among household contacts. • **India**: Handheld CXR for TB screening is cost-effective in under-resourced areas. • **Global**: AI software for interpretation of CXR readings and sputum specimen pooling can reduce testing costs by up to 61.5%, potentially expanding diagnostic coverage significantly.
3	**Optimizing algorithms, approaches and interventions along cascade of care**	3.1 Optimize algorithms like conducting CXR prior to molecular testing, using TB-LAMP followed by Xpert MTB/RIF. 3.2 Combine symptom screening, digital CXR, and AI including for key populations like prisoners, children etc. 3.3 Leverage AI-powered tools for cost-efficient screening and diagnostics.	• **Global**: Conducting CXR prior to molecular testing can reduce GeneXpert testing by 31%-60%. • **Cameroon**: TB LAMP followed by GeneXpert reduced turnaround time by 74%. • **Pakistan**: CAD4TB/AI software reduces screening costs to US$0.25 with higher throughput. • **Ethiopia**: Community based active case finding is 43.4% more cost-

S#	Themes (WHAT)	Approaches/Strategies (HOW)	Best Practices (Examples from countries)
		3.4 Utilizing tools/applications for mapping and identifying high-risk areas, for targeted screening. 3.5 Use microscopy for follow-up only. 3.6 Enhance contact investigation strategies among household contacts. 3.7 Combine **CHWs** for active case finding and **mobile CXR screening and TPT provision.** 3.8 Shift to shorter treatment regimens (e.g., 3HP for TB prevention or 6-month BPaL/M for drug-resistant TB). 3.9 Streamline supervision, M&E activities, and review processes to reduce travel and logistical expenses. 3.10 Switch from classroom to online trainings of health care providers/blended trainings.	effective than passive case finding in detecting smear-positive TB. • **Global**: Truenat is battery-powered and designed to use in peripheral health centers, making it a more cost-effective option • **Pakistan**: Enhanced contact investigation detected 3.8 times more TB cases than passive methods at USD$120 per case detected. • **Vietnam**: Combining CHWs with mobile CXR screening boosted access to Xpert MTB/RIF and increased TB notifications. • **Global**: Transition to 6-month BPaL/M regimens for DR-TB improves outcome and saves health system up to US$3,596 to US$8,174 per patient cost. • **China**: The transition from face-to-face training to e-learning for TB health workers broadened access to high-quality continuing medical education resources while reducing costs
4	**Integrating and combining TB into other health care services**	4.1 Integrate TB with diabetes, hepatitis screening into routine TB contact tracing and nutrition programs. 4.2 Combine specimen transport for TB, HIV, EID, malaria, and other illnesses. 4.3 Incorporate TB screening into maternal and child health services. 4.4 Leverage active case-finding interventions for multi-disease screenings. 4.5 Use rapid molecular platforms for integrated testing for TB and HIV and other infections. 4.6 Use AI-integrated digital CXR to detect TB and other conditions like chronic lung diseases, cancer, musculoskeletal and cardiac issues. 4.7 Strengthen HRH (including CHWs) to support multi-disease and integrated services, including task-shifting. 4.8 Combine TB supervision with general health system supervision, case management and monitoring systems as well as finance and logistics for TB, HIV, and malaria to reduce on-site visits. 4.9 Integrate AI tools and teleconsultation with existing systems.	• **Ethiopia**: Integrated TB-diabetes screening detected TB at approximately three times the prevalence found in the general population. • **Zimbabwe**: Integrated specimen transport reduced costs by 44% per sample. • **Global**: Task shifting improved cost savings and efficiency in LMICs, especially at the community and primary health care levels. • **Global**: AI offers efficient, precise, and automated solutions for TB screening and reducing costs. • **Global**: People-centered treatment support is the most cost-effective approach, whether self-administered or supervised, with minimal cost differences between the two.

S#	Themes (WHAT)	Approaches/Strategies (HOW)	Best Practices (Examples from countries)
		4.10 Leverage public resources like free diagnostics and drugs in private facilities.	
5	Advocacy, innovative private sector engagement and community-based interventions	5.1 Collaborate with private providers such as pharmacies and GPs, to extend basic services like drug refills and patient referrals at a low cost. 5.2 Scale-up innovative private sector engagement approaches along the cascade of care, including performance-based incentives. 5.3 Engaging communities and Community-based interventions improve access along cascade of care and improve outcome.	• **Ethiopia:** Community-based TB treatment by HEWs/CHWs costs 39% less than facility-based treatment with similar outcomes. • **Nigeria:** Leveraging polio campaigns for screening reduces costs and increases community acceptance • **India:** Engaging TB survivors has improved care and addressed systemic issues, with plans to train 15,000 champions for sustainable community involvement. • **Pakistan:** PPM models have enhanced early diagnosis, improved treatment adherence, optimized resources, reduced diagnostic delays, and improved patient outcomes. • **India:** Scaling the private sector engagement, to reach 50% of privately treated TB patients would cost US$228 per DALY averted in Mumbai and USD$564 in Patna, with cost-effectiveness differing based on drug resistance levels. • **Global:** Effective screening tests improve cost-effectiveness in community-based TB case-finding if they are sensitive, specific, and affordable.

Key messages

While advocating for more resources for TB including from domestic, through innovative and blended financing and from external sources should be intensified, there are opportunities to gain efficiency and address urgent gaps in TB funding. This could be done through integration (within TB and beyond) and optimization of the use of existing and new tools, approaches and algorithms along the cascade of care. Evidence-based options could be adopted, streamlined and further optimized to align with the need, country contexts, capacity and resource availability. Below is a list of options on “how” to gain efficiency and sustain TB responses:

Enhancing efficiency in TB Programs	Integrating TB services with other programs and sector and contribute to RSSH
Combine contact screening as well as TB screening in other high-risk groups with TB diagnosis, treatment and provision of TPT.	Integrate disease screening (such as TB, HIV, diabetes, maternal health and nutrition) across health programs for comprehensive care.
Decentralize DR-TB and integrate it with DS-TB activities.	Strengthen and empower CHWs for disease detection, treatment adherence, and delivery of integrated health services across multiple conditions.
Promote cost-effective, shorter treatment regimens for DR-TB and TPT and children with DS-TB.	Expand and integrate sample transport networks constructed on national/local platforms and systems for TB and other diseases.
Optimize resources by combining screening using digital CXR with AI, sputum sample pooling and WRDs.	Promote multi-disease screening/testing platforms which could contribute to RSSH and pandemic preparedness and response.
Digitalize TB recording and reporting, enhance interoperability and strengthen surveillance system.	Utilize digital and online platforms for training and community engagement.
Invest in new low-cost and more sensitive and specific tools for screening/diagnosis when available and recommended.	Leveraging digital solutions for integrated health surveillance and reporting.
Scale up innovative and most efficient private provider engagement models in TB.	

Background[1]

The Global Fund has been instrumental in the global fight against HIV, tuberculosis (TB), and malaria, driving significant progress over the past two decades. By the end of 2023, countries supported by the Global Fund achieved a full recovery from the disruptions caused by the COVID-19 pandemic, marking a strong rebound in essential health programs.

Since its inception, the Global Fund partnership has demonstrated a consistent track record of success, achieving a remarkable 61% reduction in the combined death rate from AIDS, TB, and malaria. As of 2023, these efforts have resulted in saving an estimated 65 million lives, underscoring the transformative impact of the Global Fund's investments and collaborative approach. This progress highlights the Global Fund's pivotal role in advancing global health and strengthening health systems in the countries where it invests.

In 2023, the Global Fund reinforced its commitment to combating TB by supporting equitable, people-centered, and cost-effective interventions that address barriers to quality care and access. As the leading international funder for TB, providing 76% of all global

[1] The Global Fund Results Report 2024

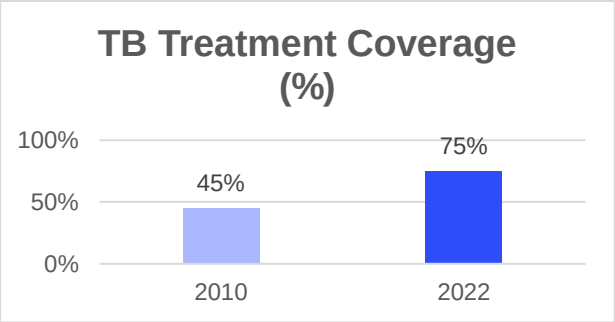
financing, the Global Fund had invested US$9.9 billion in TB programs and an additional US$1.9 billion in TB/HIV initiatives by mid-2024.

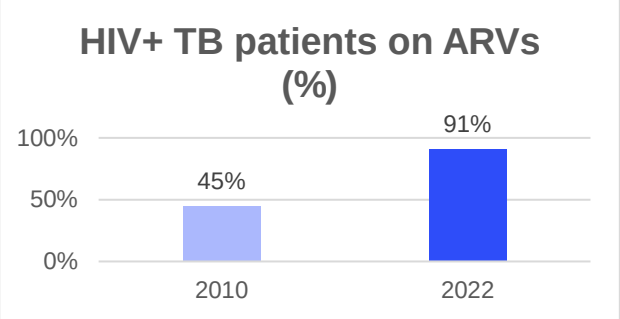
The Global Fund's investments also drive innovation, market shaping, and the adoption of advanced tools, including AI-powered diagnostic technologies and rapid molecular testing for drug-sensitive and drug-resistant TB. By widening access to more sensitive screening methods and supporting the rollout of shorter, more efficient treatment regimens, the partnership is improving patient outcomes while enhancing the overall efficiency and effectiveness of TB care systems.

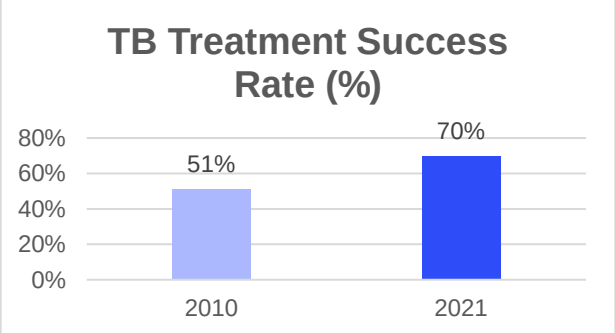
Contribution of the Global Fund to the Global TB Response

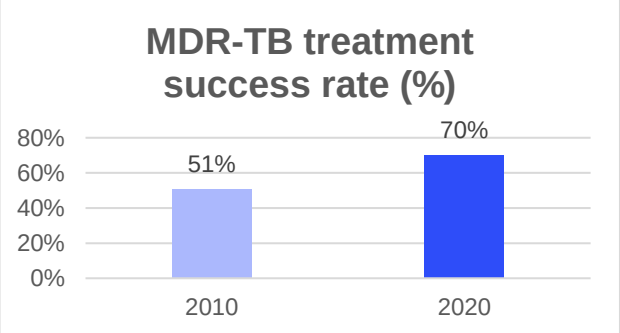
The Global Fund's investments in TB programs have delivered remarkable impact in countries where it operates. Between 2002 and 2023, the Global Fund allocated USD$10.6 billion to combat TB, contributing to a 36% reduction in TB deaths. In 2023 alone, over 7.1 million people received TB treatment, with 121,000 initiated on drug-resistant TB (DR-TB) treatment, and 2 million people were provided with TPT.

The graphs below illustrate the remarkable progress achieved in the global TB response, driven by investments and support from the Global Fund:[2]





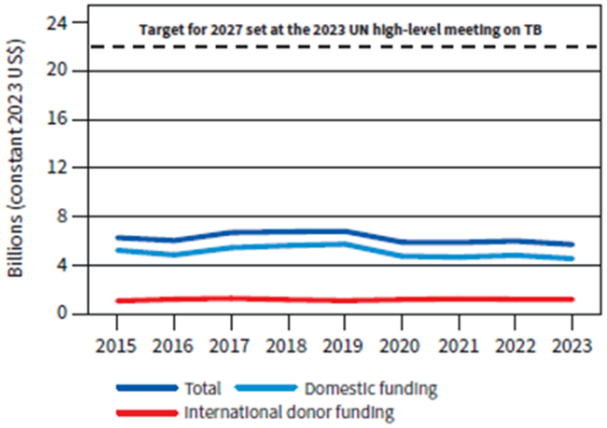




[2] The Global Fund Results Report 2024

Sustaining Momentum in the Global TB Response

Despite notable advancements in the global TB response, particularly through the support of the Global Fund, significant challenges persist. A critical funding gap, estimated at approximately US$1.35 billion in unfunded quality demand (UQD), is jeopardizing efforts to sustain the momentum during Grant Cycle 7. Moreover, the existing resources are not being utilized to their full potential, and access to affordable health products remains limited. These gaps threaten to stall or even reverse progress, highlighting the urgent need for strategic interventions to optimize resources, close funding deficits, and ensure the availability of essential health commodities.



Achieving the global TB targets by 2030 requires substantial financial investment, with an estimated US$22 billion needed in 2024 and US$35 billion by 2030. These resources are critical to fulfilling the commitments made during the 2023 UN High-Level Meeting (UNHLM) on TB, which aim to reach 45 million people with TB care and prevention services.[3] It is imperative to note that every US$1 invested in TB yields US$46 in economic and social benefits. Furthermore, sustained investments in TB programs can avert approximately 1 million deaths annually, underscoring their transformative impact on global health and economic development.[4]

In 2023, funding for TB fell significantly short of the US$22 billion target set at the UNHLM, reaching only a quarter of the required amount. This shortfall highlights the ongoing funding gap in TB control and prevention efforts. Since 2020, TB funding has remained relatively stagnant at approximately US$5.7 billion annually, failing to meet the escalating demands for TB treatment, research, and prevention programs. Domestic funding for TB has seen a concerning decline of US$1.2 billion from 2019 to 2023, signaling reduced national investments in combating the disease. While international funding saw a modest increase of US$0.1 billion over the same period, it remains insufficient to fill the gap left by the reduction in domestic contributions. This financial gap poses significant challenges to scaling up effective TB interventions, leaving millions without access to the necessary care and resources to fight the disease.

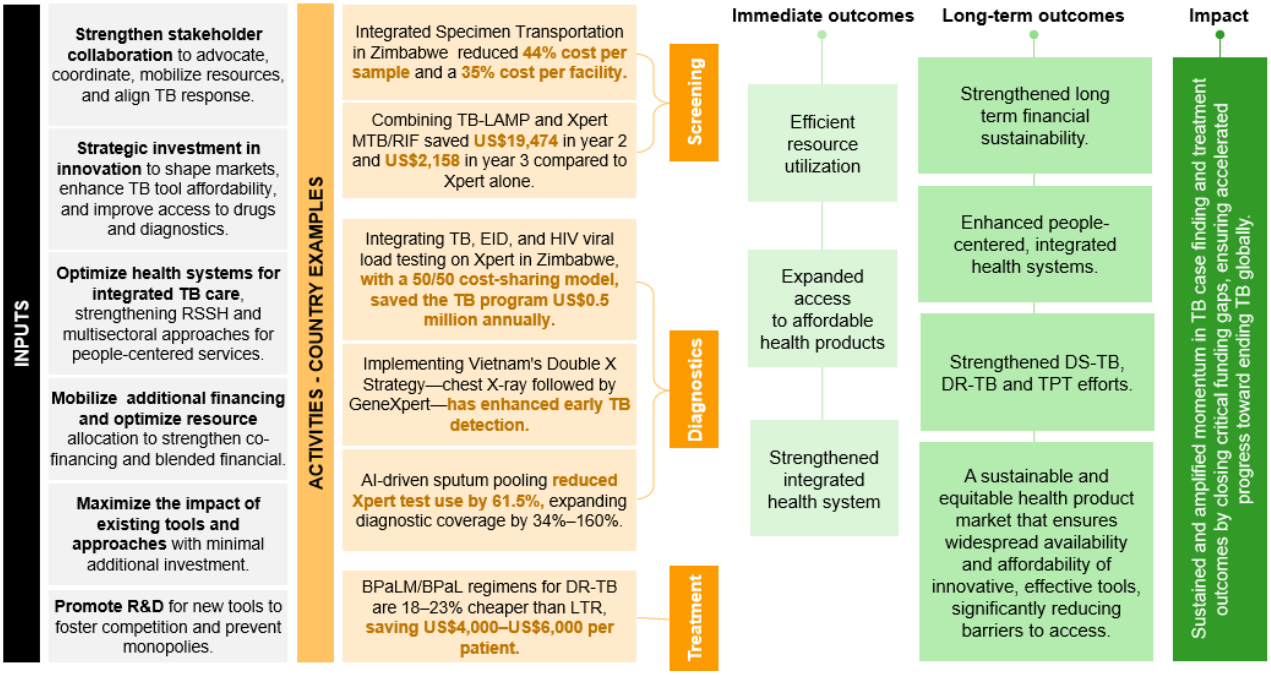
[3] WHO Global TB Report 2024
[4] One Million Lives Saved Per Year: A Cost-Benefit Analysis of the Global Plan to End Tuberculosis, 2023-2030 and Beyond

Theory of Change

By leveraging strategic approaches that maximize impact - through effective and efficient resource utilization, expanding access to affordable health products, enhanced financing mechanisms, strengthened integrated health systems, and innovative technologies - the urgent funding gaps could be minimized while ensuring uninterrupted access to critically important health products.

These measures not only sustain momentum in TB case finding and treatment outcomes but also strengthen DR-TB and TB prevention efforts and ensure a robust, equitable, sustainable TB response, and driving accelerated progress toward the global goal of ending TB.

Theory of Change Framework



Assumptions: 1. Govts, donors & stakeholders address funding gaps, 2. Govt. prioritize TB elimination as a health goal, 3. Pvt. Sector collaboration is strong and effective, 4. Cost-saving opportunities optimize resource use, 5. Integration across programs and sectors ensures efficiency and sustainability.

This analysis aims to identify cost-effective and scalable TB interventions that optimize resources, improve outcomes, and enhance cost-efficiency, addressing funding gaps and service delivery inefficiencies.

Specific Objectives

1. Gather information on interventions and solutions that are cost-effective, efficient, and scalable to improve TB management and treatment outcomes.
2. Identify key insights and successful strategies from lessons learned and best practices to improve future efforts.
3. Identify alternatives options for optimizing TB response, ensuring better use of available resources to sustain and accelerate ending TB.

Methodology

The methodology combines both desk review and KIIs to provide a well-rounded understanding of current challenges and innovative strategies in TB response. Through a review of existing literature and direct engagement with experts, the aim was to capture comprehensive insights on cost-effective, cost-efficient, scalable TB interventions and strategies, focusing on optimizing financial, human, and technical resources to improve efficiency, enhance program outcomes, and ensure scalability and sustainability, particularly in resource-limited settings. Additionally, lessons learned and best practices were identified, addressing challenges such as funding gaps, service delivery inefficiencies, and disparities in access to care, which will inform future strategies and actionable interventions to optimize the global TB response.

Desk Review

The desk review involved a thorough analysis of a range of sources, including published articles, research papers, commentaries, policy briefs, case studies, and reports from the Global Fund and the World Health Organization focusing on cost-effectiveness, efficiency, innovation and optimization and integration of services along cascade of TB care. This allowed for the identification of current trends, evidence-based practices, and gaps in TB control efforts.

Key Informant Interviews

To gather deeper insights and practical experiences, online interviews were conducted with six key stakeholders. These interviews aimed to explore challenges and opportunities related to TB funding, diagnostics, case finding, and access to care. The participants included representatives from international TB-focused organizations, academic and research institutions, national health ministry's/NTPs, and non-governmental organizations, offering diverse expertise across various aspects of TB response.

A standardized data collection tool was developed to ensure consistency across interviews. Validity was enhanced through the careful selection of informants based on their expertise and by cross-verifying the data with other sources.

All interviews were recorded with the prior consent of the interviewees. The interviews were then transcribed verbatim, with audio recordings converted into written text, capturing every word. The notes were shared with the key informants for their review to ensure that all their points were accurately covered and described. Similar patterns and themes within the interview data were identified.

The findings from literature review and KII were triangulated.

Key Findings from the Literature Review and KIIs

1. Key strategies for optimizing TB response and gaining efficiency

1.1 Integrating TB services within existing program and optimization

1.1.1 Combine contact examination, TB diagnosis and TPT provision, in one household visit: The findings from both literature review and KIIs highlight that community-based integrated approaches, are cost-effective by combining multiple TB services. These approaches significantly reduce child TB deaths, improve case detection, and enhance treatment adherence. Integrating TPT, contact screening, and follow-up into one single household visit maximizes efficiency and reduces costs.

a) **A modeling analysis of the custom randomized trial** in Cameron and Uganda demonstrated that Community-based household contact management approaches can significantly reduce child TB deaths. These approaches are considered cost-effective, with ICERs below US$1000 per DALY averted.[5]

b) People-centered treatment support is most cost-effective approach, whether self-administered (US$164 per cured patient) or supervised (US$172 per cured patient), with minimal cost differences between the two.[6]

c) **Community-based health workers can play a pivotal role in improving TB treatment adherence and outcomes. KII Pakistan**

d) **At the community level, TB prevention and care interventions are designed to be efficient and** integrated. For example, Community Health Promoters can simultaneously provide TPT to eligible household members, screen household

[5] Cost-effectiveness of community-based household tuberculosis contact management for children in Cameroon and Uganda: a modelling analysis of a cluster-randomized trial (https://www.thelancet.com/journals/langlo/article/PIIS2214-109X(23)00451-5/fulltext)
[6] The community as an active part in the implementation of interventions for the prevention and control of tuberculosis: a scoping review (https://pmc.ncbi.nlm.nih.gov/articles/PMC9882411/#R18)

members for potential TB disease, identify and bring back patients who have been lost to follow-up, and gather sputum or other diagnostic specimens from community members and transport them to health facilities for testing. **KII- Kenya**

1.1.2 Decentralize and integrate TB and DR-TB services including logistics for anti-TB drugs, diagnostics, data systems in case management, and monitoring: The findings from literature review and KIIs highlights that decentralizing DR-TB care and integrating it with routine DS-TB activities improves cost-effectiveness and access, saving substantial costs and enhancing patient outcomes. Community-based management and unified TB programming reduce inefficiencies, optimize resources, and facilitate integration, while critical cases may still require hospital care.

a) Decentralized DR-TB care integrated with routine DOTS programs saves costs and improves patient outcomes (e.g., Ethiopia saved US$219–US$276 per patient). Similarly early treatment of DR-TB saved between **US$5,846 to US$25,575** per patient in India.[7]

b) The current shift toward community-based DR-TB management focuses on cost-saving and better integration. DR-TB drugs, such as the BPaL/M regimens, and services can be incorporated into routine TB programs with appropriate precautions, though exceptions apply for patients requiring critical care or hospital admission. This approach offers significant benefits, including reduced costs and easier implementation within existing health care frameworks. **KII -Ethiopia**

c) In some countries, separate funding and programming for drug-resistant TB have resulted in inefficiencies. A more unified approach to TB programming could optimize resources and reduce duplication. **KII – Global TB Partner**

1.1.3 Integrating chest X-rays (CXR), CAD and rapid molecular test: The findings highlight that integrating advanced diagnostic tools and mobile screening units enhances detection, particularly in high-risk areas. Digital CXR reduce costs, while AI integration improves screening outcomes, making these strategies effective in resource-limited settings.

a) The research in Zambia shows that “One-stop TB services” integrating X-ray, CAD, and Xpert improved affordability and multi-disease imaging.[8]

b) In Pakistan, the chest camps' average case detection is over 4 cases per camp with predictive analytics (and mapping of high-risk groups and geographic areas), with the potential for up to 8 cases per camp, showing significant improvement in

[7] Cost of inaction: a framework to estimate the economic cost of missing a patient with tuberculosis in the Indian context (https://bmjopen.bmj.com/content/13/12/e070717)

[8] Fast-track screening with One-Stop TB Service in a container in Zambia (https://www.checktb.com/one-stop-tb-service)

detection. The camps are conducted using mobile vans equipped with CAD4TB X-ray and Xpert machines for TB screening.[9]

c) In the Philippines, the innovative active case-finding strategy using mobile units significantly increased TB case detection and achieved high treatment success rates. Screening efforts targeting prisons, indigenous populations, and underserved urban and rural communities proved effective. The combined use of CXR and Xpert MTB/RIF played a key role in enhancing case identification. While CXR can be costly for initial screening, digital X-ray machines reduce expenses and streamline logistics, making them a feasible, cost-effective option for large-scale Active Case Finding (ACF) in resource-limited settings.[10]

1.1.4 Expanding sample transport networks reduces logistical and catastrophic costs by centralizing testing efforts: The triangulation of findings from the literature review and key informant interviews highlights that expanding sample transport networks significantly reduces logistical costs by centralizing testing efforts. Sputum transportation models in several countries have improved access to screening and diagnosis while minimizing logistical challenges and catastrophic costs. Transporting patient samples to diagnostic facilities, while allowing patients to remain in their communities, further increases access and reduces costs. Additionally, centralizing sample transport reduces reliance on multiple labs, streamlines the diagnostic process, and cuts transportation and overhead costs, ultimately improving the efficiency and quality of TB testing. Unified systems for sample transport also ensure the efficient use of existing resources and prevent duplication across disease programs.

a) Sputum transportation models in countries like Pakistan[11] and the Philippines[12] have not only enhanced access to screening and diagnosis but also minimized logistical challenges and catastrophic costs.

b) Transporting patient samples to diagnostic facilities while allowing patients to remain in their communities increases access and reduces costs. **Management Sciences for Health, Ethiopia**

c) The expansion of the Sample Transport system will also help reduce the reliance on a large number of labs across the country. This could cut down on transportation and logistics costs, streamlining the diagnostic process and improving the efficiency of TB testing. A centralized system could reduce overhead costs while improving the quality of care. **Mercy Corps, Pakistan**

[9] Economic analysis of different throughput scenarios and implementation strategies of computer-aided detection software as a screening and triage test for pulmonary TB (https://www.epcon.ai/post/finding-tb-cases-in-pakistan-using-ai-for-active-case-finding)
[10] Bringing state-of-the-art diagnostics to vulnerable populations: The use of a mobile screening unit in active case finding for tuberculosis in Palawan, the Philippines (https://pmc.ncbi.nlm.nih.gov/articles/PMC5289556/pdf/pone.0171310.pdf)
[11] Maximizing tuberculosis services through private provider engagement – A case study from Pakistan (https://pdf.sciencedirectassets.com/312438/AIP/1-s2.0-S2405579424000937/main.pdf)
[12] Connecting the dots: Optimizing TB diagnostics in the Philippines (https://devex.shorthandstories.com/connecting-the-dots-optimizing-tb-diagnostics-in-the-philippines/index.html)

d) Establishing unified systems for sample transport ensures efficient use of existing resources, avoiding duplication across disease programs. **NTP, Kenya**

1.2 Efficient use of existing and new tools

1.2.1 Maximize the use of new and existing screening and diagnostic tools: Evidence from both literature and KIIs demonstrates that maximizing the use of **new** TB screening and diagnostic tools improves efficiency, access, and reduces costs. AI-powered digital X-ray, stool-based GeneXpert and TrueNat testing, TB-LAMP, and Cy-TB testing have proven effective in diverse settings, particularly for pediatric TB, ACF, and peripheral health facilities. Strategic integration of these technologies enhances diagnostic capacity while optimizing resource allocation, making TB detection more accessible and cost-effective.

a) A comprehensive economic modeling analysis in India revealed that the Cy-Tb test for TBI is cost-effective, with significant savings potential through bulk procurement.[13]

b) A cost-benefit analysis for rapid tuberculosis diagnosis and rifampicin resistance detection during mass screening campaigns demonstrated that the combined use of TB-LAMP followed by Xpert MTB/RIF resulted in a 73.23% reduction in turnaround time (TAT) in prisons and a 74.92% reduction in TAT in refugee camps. The dual testing approach became more cost-effective from the second year of implementation, showing significant improvements in both efficiency and cost savings.[14]

c) Stool-based TrueNat testing in Nigeria demonstrated improved access to pediatric TB diagnosis, reduced direct health system costs, and proved to be a cost-effective alternative to Xpert testing.[15]

d) An economic analysis of various throughput scenarios and implementation strategies for the computer-aided detection software (CAD4TB) as a screening and triage test for pulmonary TB showed that per-screen costs drop to US$0.25 at higher throughputs, making it cost-effective in high-volume settings. Although costs can rise to US$2.28 at lower throughputs, it remains a scalable and economical alternative. Moreover, the studies shows that use of handheld X-ray for TB screening is cost-effective in under-resourced areas.[16]

[13] Evaluating the cost-effectiveness of Cy-Tb for LTBI in India: a comprehensive economic modelling analysis (https://doi.org/10.1093/inthealth/ihae048)
[14] A cost–benefit algorithm for rapid diagnosis of tuberculosis and rifampicin resistance detection during mass screening campaigns (https://doi.org/10.1186/s12879-022-07157-0)
[15] Evaluating the health impact, health-system costs and cost-effectiveness of using TrueNat on stool samples compared to usual care for the diagnosis of pediatric tuberculosis in primary care settings: a modelling analysis (https://www.medrxiv.org/content/10.1101/2024.11.19.24317558v1.full)
[16] Economic analysis of different throughput scenarios and implementation strategies of computer-aided detection software as a screening and triage test for pulmonary TB (https://pmc.ncbi.nlm.nih.gov/articles/PMC9803287/pdf/pone.0277393.pdf)

e) AI-powered X-ray technology offers significant potential to enhance TB screening, particularly in high-burden settings, by improving the efficiency of ACF and targeting individuals for screening. However, many programs are underutilizing X-rays, resulting in inefficient spending. **Stop TB Partnership/TB REACH**

f) AI-integrated digital X-ray systems, initially for TB detection, also identify other conditions like fractures, cardiac diseases (heart failure, hypertension), and chronic lung diseases (asthma, COPD, lung cancer). In Kenya, retrofitted X-ray machines enhanced multi-disease screening, improving diagnosis efficiency. **NTP Kenya**

g) Truenat machines, with longer battery life, are better suited for peripheral areas with limited power supply, complementing GeneXpert use. Moreover, Strategic placement and integration with existing tools (e.g., GeneXpert, Truenat) are critical for optimizing the TB response. **Management Sciences for Health, Ethiopia**

h) AI tools, such as computer-assisted diagnostics (CAD) for X-rays, have potential for cost reduction and improved accuracy in TB diagnosis. AI can also support diagnosis of non-TB conditions, increasing the utility of diagnostic platforms in high-burden areas. **Liverpool School of Tropical Medicine**

i) The CY-TB test offers a reliable, affordable TB infection diagnosis. AI-powered X-ray screening enhances mass detection. While TST reduced costs to US$1 per test in India, its accuracy dropped from 50% (IGRA) to 10% due to manual errors. Retraining improved results, but IGRA remains preferred for reliability, highlighting the balance between cost and quality. **KII India**

1.2.2 Enhance the utilization of combination tests: Triangulated findings confirm that combining AI-assisted chest X-ray interpretation with molecular testing and sputum pooling enhances TB detection while optimizing resource use. These approaches reduce testing costs, expand diagnostic coverage, and improve efficiency, particularly in settings with limited GeneXpert cartridge availability.

a) A modeling study across four high-burden countries showed that AI software for chest X-ray interpretation and sputum specimen pooling can reduce testing costs. A cumulative savings in Xpert tests ranging from 50.8% in Zambia to 61.5% in Bangladesh and Vietnam, with Nigeria at 57.5% was observed. These savings could expand diagnostic coverage by 34% to 160%, depending on the country and approach. Leveraging AI for a differentiated pooled testing strategy can optimize TB diagnostic use and extend molecular tests to more individuals.[17]

[17] Expanding molecular diagnostic coverage
for tuberculosis by combining computer-aided chest radiography and sputum specimen pooling: a modeling study from four high-burden countries (https://bmcglobalpublichealth.biomedcentral.com/articles/10.1186/s44263-024-00081-2)

b) Combining chest radiography with GeneXpert enhances early TB detection, improves radiograph interpretation, and increases eligibility for preventive treatment as seen in Vietnam.[18]

c) Sputum pooling is an efficient strategy for settings with low TB positivity rates, conserving GeneXpert cartridges and increasing testing capacity. Despite a slight loss in sensitivity, it offers significant benefits, especially in countries facing severe cartridge shortages like Nigeria. **KII Global TB Partner**

d) Utilizing low-cost, rapid screening tools could ensure that diagnostic tests are reserved for people with a high pre-test probability of TB, optimizing resource use. Examples include pooling sputum samples, especially in low- to moderate-prevalence settings, which reduces the cost per diagnosis. **KII UK**

1.3 Optimizing algorithms, approaches and interventions along cascade of care

Triangulating KIIs and literature review highlights cost-effective strategies to optimize TB care, including reducing Xpert MTB/RIF testing with pre-screening chest X-rays, using AI-driven digital X-rays, and implementing shorter MDR-TB regimens. Mobile screening with CHWs and CAD4TB also increases detection and reduces costs, improving overall efficiency in TB care.

a) A global study revealed that conducting CXR prior to molecular testing can reduced Xpert MTB/RIF testing by 31%-60%.[19]

b) In Cameron, the TB LAMP followed by Xpert MTB/RIF reduced turnaround time by 73%-74% and became cost-effective by the second year. About US$16,934 and US$19,474 are saved for years 2 and 3, respectively in prison and US$1877 and USD$2158 are saved for years 2 and 3, respectively in village, respectively.[20]

c) CAD4TB software reduced screening costs to US$0.25 with higher throughput as concluded by a study in Pakistan.[21]

d) Truenat is battery-powered and designed to use in peripheral health centers, making it a more cost-effective option compared to other molecular tests.[22]

e) In Ethiopia, community based active case finding is 43.4% more cost-effective than passive case finding in detecting smear-positive TB.[23]

[18] An Effective Health System Approach to End TB: Implementing the Double X Strategy in Vietnam (https://www.ghspjournal.org/content/12/3/e2400024)
[19] The performance and yield of tuberculosis testing algorithms using T microscopy, chest x-ray, and Xpert MTB/RIF (https://www.sciencedirect.com/science/article/pii/S2405579418300482)
[20] A cost–benefit algorithm for rapid diagnosis of tuberculosis and rifampicin resistance detection during mass screening campaigns (https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-022-07157-0#:~:text=The%20aim%20of%20this%20study,in%20prisons%20and%20refugee%20camps)
[21] Economic analysis of different throughput scenarios and implementation strategies of computer-aided detection software as a screening and triage test for pulmonary TB (https://pmc.ncbi.nlm.nih.gov/articles/PMC9803287/pdf/pone.0277393.pdf)
[22] Treatment Action Group Applauds Price Reduction of Molbio's Truenat Diagnostics for Tuberculosis (https://www.treatmentactiongroup.org/statement/tag-applauds-price-reduction-of-molbios-truenat-diagnostics-for-tuberculosis/)
[23] Cost-Effectiveness of Follow-Up of Chronic Coughers in Detecting Smear-Positive Tuberculosis in South Ethiopia (https://doi.org/10.2147/CEOR.S319588)

f) Enhanced contact investigation detected 3.8 times more TB cases than passive methods at US$120 per case in Pakistan.[24]

g) **In Belarus, Georgia, Kazakhstan and Moldova**, modified Shorter Treatment Regimen for DR-TB saved US$3,596 to US$8,174 per patient.[25]

h) **In Brazil and South Africa,** an analysis of costs and cost- effectiveness showed that scaling up shorter TPT regimens, among PLHIV on ARV, meeting minimal or optimal criteria significantly reduces TB cases, deaths, and DALYs.[26]

i) **In China**, the transition from face-to-face training to e-learning for TB health workers broadened access to high-quality continuing medical education resources while reducing costs.[27]

j) The choice of TB screening tools varies by target population. In settings like prisons or large-scale community screenings, combining symptom history, digital X-rays with AI, and molecular testing improves efficiency by reducing unnecessary tests and identifying high-risk cases. For children, screening is more complex due to reliance on caregivers for history and difficulties in obtaining specimens, with AI solutions not validated for pediatric X-rays. In these cases, emphasizing symptom screening and contact history is crucial. **KII Kenya**

k) For prisoner's symptom history, digital X-rays with AI, and molecular testing offer a comprehensive screening approach. Whereas for children, screening is more complex due to reliance on caregivers for history and the difficulty of obtaining diagnostic specimens. AI solutions are typically not validated for pediatric X-rays, necessitating radiologist interpretation. Emphasizing symptom screening and contact history is particularly valuable in these cases. **KII Kenya**

l) Facility-based screening (beyond verbal screening) using X-ray could help detect more cases. However, there will always be a segment of the population that cannot access health care, necessitating active outreach efforts. **KII Global TB Partner**

m) Use pre-completed online modules for foundational knowledge, followed by shorter in-person practical sessions, reduces travel, accommodation costs, and the time health workers spend away from their duties. **KII Ethiopia**

n) AI is a valuable tool for TB screening, particularly for reading chest X-rays and conducting mass screenings with handheld X-ray machines equipped with AI. **KII India**

[24] Cost-effectiveness of household contact investigation for detection of tuberculosis in Pakistan (https://pmc.ncbi.nlm.nih.gov/articles/PMC8543626/)
[25] Cost, cost-effectiveness and efficiency gains of introducing modified short treatment for multidrug or rifampicin-resistance TB in Belarus, Georgia, Kazakhstan and Moldova (The TB Quarterly Update | November/December 2024, The Global Fund)
[26] Scaling up target regimens for tuberculosis preventive treatment in Brazil and South Africa: An analysis of costs and cost-effectiveness (https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1004032)
[27] Process evaluation of E-learning in continuing medical education: evidence from the China-Gates Foundation Tuberculosis Control Program (file:///Users/rashidkureshi/Downloads/s40249-021-00810-x.pdf)

o) AI reduces the number of patients needing GeneXpert testing by pre-screening with X-rays and identifying presumptive cases. This approach optimizes the use of resources, conserving cartridges for confirmed TB cases. **KII Ethiopia**

p) Shorter drug regimens, while not yet transformative in cost savings, have the potential to reduce overall health care costs and improve patient adherence. **KII U**

q) Implementation of shorter TPT regimens increased patient compliance and easier service delivery in decentralized settings. **KII Ethiopia**

1.4 Integrating and combining TB into other health care services and sectors

Integrating TB with HIV, diabetes, hepatitis, into routine TB contact tracing and nutrition programs can lower costs and enhance case notification: Both literature review and KIIs revealed that integrating TB screening with other health services, such as HIV, diabetes, hepatitis, and nutrition programs, offers significant cost savings and improves case detection. Additionally, integrated approaches in high HIV/TB burden settings, including expanded ART coverage and infection control, are found to be cost-effective in preventing TB cases. This holistic approach reduces duplication of services, optimizes resource use, and enhances the efficiency of health care delivery.

a) The project in Ethiopia demonstrated that integrating TB and diabetes screening tripled the TB yield among diabetes patients.[28]

b) A study in Zimbabwe assessed the feasibility of delivering 3HP through the Fast Track (FT) model, aligning TPT with HIV care and using phone-based adherence support. Among 50 PLHIV in FT, 96% completed 3HP in 13 weeks, with 94% adhering consistently. Participants were highly satisfied, with minimal challenges (pill burden 12%, tolerability 24%). Phone support was effective, and 98% would recommend the model. The findings suggest FT-based 3HP delivery is feasible, efficient, and scalable for expanding TPT coverage in Zimbabwe.[29]

c) Community-level strategies may need to prioritize more prevalent conditions like diabetes or undernutrition depending on local epidemiological data. **KII-UK**

d) Contacts of TB patients and individuals with HIV or diabetes are prioritized for integrated TB screening and testing services. These groups yield the maximum TB cases and justify the use of more advanced diagnostic tools. **KII, Ethiopia**

e) Diabetes and Hepatitis C testing can also be incorporated at the community level, as many private doctors are already offering these services. This holistic approach will not only improve disease detection but also reduce the cost and duplication of services, making health care delivery more efficient. **KII, Pakistan**

[28] Integrating Service Delivery for TB and Diabetes Mellitus – An Innovative and Scalable Approach in Ethiopia (https://msh.org/wp-content/uploads/2017/10/ctb_brief_ethiopia_on_tb-dm_100317ms.pdf)

[29] https://onlinelibrary.wiley.com/doi/full/10.1002/jia2.26105#:~:text=Benefits%20highlighted%20by%20both%20clients,with%20TB%20as%20another%20challenge

f) The integration of TB programs with broader disease control and health system initiatives ensures efficient resource utilization. For example, platforms for TB services could also support interventions for other diseases, reducing overall costs and improving health care delivery. **KII, Global TB Partner**

g) Collaboration with other health programs, such as those for Hepatitis C and HIV, can enhance TB screening efforts. By identifying overlapping high-risk areas for multiple diseases, targeted screening initiatives can be integrated to reach the most vulnerable populations. This collaboration allows for joint screening efforts, reducing costs and improving service delivery. **KII, Pakistan**

1.4.1 Integrated sample transportation models reduce costs: Integrated sample transportation models have demonstrated significant cost reductions and efficiency improvements. Evidence shows that combining transportation systems for TB, HIV, and other diseases can lower costs per sample, reduce turnaround times, and enhance sample tracking. These models streamline logistics, reduce duplication, and improve overall coordination, making them a highly effective strategy for strengthening health systems and ensuring timely care.

a) An integrated specimen transportation model in Zimbabwe for TB, HIV, and EID reduced turnaround time dramatically, achieving an 8-day TAT for CD4 and TB sputum testing. Annual sample volume increased from 400,000 in 2021 to over 1 million This has contributed to 44% cost reduction per sample and a 35% per facility. The project helps in strengthening the care for infants born with or exposed to HIV, TB patients, and other vulnerable groups. Improved sample tracking and reduced specimen rejection rates, ensuring higher-quality results.[30]

b) An integrated sample transport system covering TB, HIV, malaria, and cancer samples can streamline logistics and reduce costs. **KII Kenya**

c) The integration of sample transportation systems for diseases like HIV, along with TB, can improve efficiency and reduce duplication of efforts. Currently, sample transportation is managed separately for different diseases, leading to higher costs and inefficiencies. By creating a unified system for transporting samples across different diseases, the country can reduce costs and improve overall coordination. **KII Pakistan**

1.4.2 Incorporating TB screening into maternal and child health services: Integrating TB screening into maternal and child health (MCH) services proves effective in improving early detection and reducing complications. Evidence from various settings indicates that combining TB screening with routine maternal and pediatric services, such as ANC visits and child health care, enhances accessibility and outcomes. These efforts not only improve maternal and neonatal

[30] Integrated Sample Transportation and Optimization in Zimbabwe: The lessons (https://www.youtube.com/watch?v=TwP7SooOOYc)

health but also reduce the risk of TB transmission in the communities, making them a cost-effective strategy for ending TB.

a) The integration of COVID-19 into HIV, TB, and MCH Clinics reduced client wait times by integrating COVID-19 screening and testing within the same clinic space. Same-day test results enable timely decision-making for both clients and health officials. Moreover, integrated COVID-19 testing into existing service platforms, ensuring continued access to services beyond donor funding.[31]

b) A modeling analysis of a cluster-randomized trial integrating pediatric TB services into child health care in Africa estimated that 350 (95% UI −31 to 2204) deaths would be prevented in Cameroon, while 3 (95% UI −22 to 48) deaths would be prevented in Kenya. The incremental cost-effectiveness ratio (ICER) for the intervention was US$506 per DALY averted in Cameroon and US$1299 per DALY averted in Kenya.[32]

c) Similarly, the results from a pilot project in Pakistan revealed TB screening during routine ANC visits is feasible in high-TB-burden settings. A multi-faceted approach, including clinical examination and chest X-rays, is recommended for better TB diagnosis in pregnant women.[33] Although the TB yield was low, the cost of failing to detect TB in pregnant women is very high as it can lead to significant maternal and neonatal complications. Integrating TB screening into routine ANC visits will improve maternal and neonatal outcomes and reduce community transmission.

d) For example, in MCH clinics, health care workers are encouraged to screen children for TB during routine visits, such as growth monitoring or when they present with other illnesses. This ensures early detection and management of TB cases among pediatric patients. **KII Kenya**

e) Leverage activities such as immunization campaigns, maternal health programs, and polio eradication initiatives to integrate TB awareness, screening, and diagnosis. **KII Ethiopia**

1.4.3 Leverage active case-finding interventions and molecular diagnostic devices for multi-disease screenings: Task shifting, particularly through community health workers (CHWs), enhances health care access, reduces costs, and improves efficiency in TB and other disease programs Systematic reviews highlight its effectiveness in managing TB, HIV, and other conditions, while country experiences demonstrate that training non-specialist workers for tasks

[31] COVID-19 Integration Model into HIV, TB, and MCH Clinics (https://www.pedaids.org/wp-content/uploads/2022/09/cca-project-integrationmodel_0929.pdf)
[32] Cost-effectiveness of integrating pediatric tuberculosis services into child health care services in Africa: a modelling analysis of a cluster-randomized trial (https://gh.bmj.com/content/bmjgh/9/12/e016416.full.pdf)
[33] Integrating tuberculosis screening into antenatal visits to improve tuberculosis diagnosis and care: Results from a pilot project in Pakistan (https://www.ijidonline.com/action/showPdf?pii=S1201-9712%2821%2900475-6)

like TB screening, diagnosis, and treatment support strengthens health systems and optimizes resource use.[34]

a) Integrating TB and COVID-19 screening during community-based ACF using point-of-care molecular and radiological tools is feasible, demonstrates a high diagnostic yield, and effectively identifies potentially infectious individuals.[35]

b) A case study demonstrated that integrating HIV and TB testing led to reduced turnaround times for HIV diagnosis. Shared operational costs, including maintenance and staff salaries, resulted in projected annual savings of US$0.5M, cutting total TB testing costs by 16%. Utilizing existing GeneXpert devices for multi-disease testing minimized the need for additional infrastructure, making it a cost-efficient and scalable solution.[36]

c) The systematic review concluded task shifting, particularly involving community health workers has become an effective strategy to improve access to health care in low- and middle-income countries (LMICs). Research indicates that task shifting not only enhances population health outcomes but also leads to cost savings and efficiency improvements, especially in managing tuberculosis, HIV/AIDS, malaria, Noncommunicable Diseases (NCDs), Neglected Tropical Disease (NTDs), and childhood illnesses. This systematic review confirms that task shifting at the primary health care and community levels results in substantial cost savings and efficiency gains.[37]

d) Another systematic review conducted on the effectiveness and cost implications of task-shifting in the delivery of antiretroviral therapy to HIV-infected patients, revealed that task-shifting can potentially reduce ART provision costs without compromising patient health outcomes. It is a promising and cost-effective approach to overcoming human resource limitations.[38]

e) In Nigeria, leveraging house-to-house visits for immunization campaigns to identify presumptive TB cases resulted in reduced costs and increased community acceptance.[39]

f) Currently, mobile vans are used solely for TB screening, but these could be expanded to screen for other diseases, such as HIV, diabetes, and Hepatitis C. This would significantly reduce the cost of mobile chest camps, improving both

[34] Does task shifting yield cost savings and improve efficiency for health systems? A systematic review of evidence from low-income and middle-income countries (https://pmc.ncbi.nlm.nih.gov/articles/PMC5390445/)
[35] Integrating molecular and radiological screening tools during community-based active case-finding for tuberculosis and COVID-19 in southern Africa (https://pdf.sciencedirectassets.com/272991/1-s2.0-S1201971224X00089/1-s2.0-S1201971224001528/main.pdf?)
[36] Integrated Testing for TB and HIV Using Gene Xpert Devices expand access to near-point-of-care testing (https://aslm.org/resource/integrated-testing-for-tb-and-hiv-using-genexpert-devices-expands-access-to-near-point-of-care-testing/)
[37] Does task shifting yield cost savings and improve efficiency for health systems? A systematic review of evidence from low-income and middle-income countries (https://pmc.ncbi.nlm.nih.gov/articles/PMC5390445/)
[38] The effectiveness and cost implications of task-shifting in the delivery of antiretroviral therapy to HIV-infected patients: A systematic review (https://human-resources-health.biomedcentral.com/articles/10.1186/1478-4491-8-8#:~:text=Conclusions,than%20a%20physician%2Dcentered%20model)
[39] Integrating TB screening into house-to-house polio vaccination campaigns (https://pmc.ncbi.nlm.nih.gov/articles/PMC10162365/)

efficiency and cost-effectiveness by utilizing the same infrastructure for multiple disease screenings. **KII Pakistan**

g) Given TB's status as the leading comorbidity among people living with HIV (PLHIV), integrating management processes for TB within HIV services can reduce duplication and enhance resource utilization**. KII Kenya**

h) Diagnostic platforms, such as GeneXpert and Truenat, have the capability to diagnose multiple conditions beyond TB. These platforms do not always need to be procured solely by the TB program. If other health departments have the resources to acquire such equipment, the TB program can focus on covering the cost of consumables and tests specific to TB. This approach significantly reduces the financial burden on TB programs by eliminating the need for new equipment or additional staff, as existing infrastructure and personnel can be utilized. **KII Kenya**

i) CHWs play a critical role in TB case-finding and treatment support but are also engaged in HIV, malaria, and immunization programs. Task shifting, such as training non-radiographers to take basic chest X-rays, can improve efficiency. **KII Global TB Partner**

j) Community-level health workers can be engaged not only for TB screening but also for testing other diseases such as HIV, diabetes, and Hepatitis C. **KII Pakistan**

k) Training community workers (e.g., health extension workers) to deliver basic TB services, including awareness, diagnostics, treatment, and prevention have significantly improved TB case finding, treatment success rates, and community-level prevention. **KII Ethiopia**

1.5 Advocacy, innovative private sector engagement approaches along the cascade of care and community-based interventions

Triangulated findings confirm that community-based interventions effectively improve TB detection, treatment initiation, and patient retention while reducing costs and overcoming barriers such as stigma, financial constraints, and low awareness. The findings also highlight the importance of scaling private sector engagement (PSE) in the TB care cascade. Both sources stress that integrating private providers—such as pharmacies, labs, and practitioners—enhances access to quality diagnostics and treatment. Tailored models like Public-Private Interface Agencies (PPIAs) and Public-Private Mix (PPM) strategies improve efficiency, particularly in high-resistance settings, and are crucial for accelerating progress toward End TB targets.

a) A community randomized trial in Ethiopia showed that community-based treatment by HEWs costs only 39% of health facility treatment for similar outcomes**.** Involving HEWs in TB treatment is a cost-effective alternative for both

health services and families. There is both an economic and public health rationale to involve HEWs in TB treatment in Ethiopia.[40]

b) In India, TB survivors' engagement significantly impacted the TB program and the lives of people with TB, improving both individual care and systemic challenges. TB champions have become integral to India's TB response, with the national program aiming to train 15,000 champions and engage at least two per health center. Several states have allocated funds for training and engaging TB champions, signaling the potential for sustainable community involvement in TB management.[41]

c) A cross-sectional study, in Pakistan, demonstrated that the engagement of Lady Health Workers can significantly reduce the delay in diagnosis of TB patients. Through LHW intervention, people with TB signs or symptoms were diagnosed 47 days earlier as compared to patients diagnosed through PPM intervention. The LHW intervention significantly reduced diagnostic delays, encouraged earlier health care-seeking behavior, and expedited treatment initiation compared to the PPM intervention, demonstrating its effectiveness in improving TB detection and care.[42]

d) The results of the evaluation on the Impact of community referral for Chest X-ray Screening and Xpert Testing on case notifications, showed that the combination of **CHWs** for ACF and **mobile CXR screening** increased access to Xpert MTB/RIF testing, leading to a significant rise in TB notifications in Vietnam.[43]

e) Community-based approaches help overcome barriers such as lack of awareness – patients do not perceive themselves as sick enough, social and cultural constraints – patients may lack agency to seek care, financial barriers – cost of care is prohibitive and stigma – TB diagnosis may lead to social exclusion. **KII Global TB Partner**

f) CHWs and volunteers play a critical role in ACF and patient follow-up. Moreover, leveraging community leaders, celebrities, or local elders for health promotion can drive engagement without significant financial outlays. **KII UK**

g) Initiative for promoting affordable and Quality TB tests (IPAQT) in India aimed to transform a high-price, low-volume market into a low-price, high-volume market for better uptake of TB tests like Xpert MTB/RIF. IPAQT membership grew from 56 laboratories in 2013 to 211 in 2018. A 10-fold increase in the uptake of Xpert

[40] Cost and Cost-Effectiveness of Smear-Positive Tuberculosis Treatment by Health Extension Workers in Southern Ethiopia: A Community Randomized Trial (https://pmc.ncbi.nlm.nih.gov/articles/PMC2822844/)
[41] Community engagement and accountability at scale in India (https://iris.who.int/bitstream/handle/10665/379229/9789240099890-eng.pdf)
[42] ENGAGEMENT OF LADY HEALTH WORKERS LEADING TO EARLY DIAGNOSIS (https://www.mercycorps.org/sites/default/files/2020-01/Diagnosis_delay_LHW_Intervention_June2018_Final.pdf)
[43] Optimizing Active Tuberculosis Case Finding: Evaluating the Impact of Community Referral for Chest X-ray Screening and Xpert Testing on Case Notifications in Two Cities in Vietnam (https://pmc.ncbi.nlm.nih.gov/articles/PMC7709663/)

tests was observed. Price reductions of 30%-50% were achieved for these tests.[44]

h) Effective private sector engagement through tailored Public-Private Interface Agency (PPIA) models is key to accelerating TB incidence decline in India. Scaling a PPIA to reach 50% of privately treated TB patients would cost US$228 per DALY averted in Mumbai and USD$564 in Patna. In Mumbai, it is cost-effective across all thresholds, while in Patna, focusing on adherence support rather than diagnosis improves cost-effectiveness. These differences stem from varying drug resistance burdens, with improved diagnosis being more valuable in high-resistance settings like Mumbai.[45]

i) PPM models have improved efficiency in Pakistan's TB response by enhancing early diagnosis, increasing case notifications, and strengthening treatment adherence. By integrating private providers, these models optimize resource use, reduce delays in diagnosis, and improve patient outcomes, demonstrating a scalable approach to achieving End TB targets.[46]

j) Pharmacists have traditionally dispensed TB medications, but their role can be expanded to support early diagnosis and treatment. Key actions include providing evidence-based management guidance, integrating digital systems for reporting and referrals, and engaging in sputum collection and CXR referrals. Strengthening pharmacist involvement in TB testing and notification requires collaboration with TB programs and pharmacy associations, along with sustainable funding models to reach undiagnosed TB cases effectively.[47]

k) Many patients, based on care-seeking behavior analyses, initially access health services through private providers rather than public facilities. By collaborating with private providers such as pharmacies, TB programs can extend basic services like drug refills and patient referrals. For instance, if a patient with recurrent respiratory tract infections seeks care in a pharmacy, the pharmacist can identify them as a potential TB case and refer them for further screening and testing. This approach improves access to care while leveraging existing private health care infrastructure, thereby enhancing program efficiency. A robust model was introduced that allowed private sector patients to access government resources while receiving care in the private sector. This approach improved case detection and reduced costs for patients. **KII India**

l) If the Mandatory Case Notification law is implemented, there will be no need for financial incentives to encourage private providers and labs to report cases. The

[44] Initiative for promoting affordable and Quality TB tests (IPAQT): A market shaping intervention in India (https://gh.bmj.com/content/4/6/e001539)
[45] Engaging with the private health care sector for the control of tuberculosis in India: cost and cost-effectiveness (https://pmc.ncbi.nlm.nih.gov/articles/PMC8493898/pdf/bmjgh-2021-006114.pdf)
[46] Maximizing tuberculosis services through private provider engagement – A case study from Pakistan (https://pdf.sciencedirectassets.com/312438/AIP/1-s2.0-S2405579424000937/main.pdf)
[47] Pharmacy engagement in TB prevention and care: not if, but how? (https://gh.bmj.com/content/bmjgh/8/7/e013104.full.pdf)

MCN law will ensure that all TB cases are reported, and this regulatory framework can reduce the financial burden on the program by eliminating unnecessary costs associated with incentivizing private sector participation. **KII Pakistan**

m) Introduction of negotiated payment systems for services like GeneXpert testing in private facilities helps recover costs. Supporting private providers through capacity building, supervision, and program linkages serves as indirect motivation. **KII Ethiopia**

n) Effective two-way communication between public and private providers can help reduce diagnostic delays, ultimately benefiting both patients and health systems. **KII UK**

2. Innovative financing for TB response - examples

2.1 Mobilize resources for TB programs:

- Leverage local fundraising, philanthropy, and community trust through awareness campaigns.
- Explore community-based and social health insurance models to cover TB costs.

2.2 Improve access and coordination:

- Establish TB clinics within private health care facilities for better accessibility.
- Promote inter-ministerial coordination to integrate TB services into insurance programs.

2.3 Innovative funding streams:

- Introduce TB-specific taxes (e.g., tobacco excise) and performance-based budgeting.
- Implement district-level self-financing.
- Blended financing – with World Bank, Asian Development B, African Development Bank, Islamic Bank, Gates Foundation, Global Financing Facility.
- Debt Swap, D4H.

2.4 Financial assistance and performance-based payment models:

- Expand financial assistance for TB patients and families through local initiatives.
- Introduce performance-based financing to incentivize implementation of efficient interventions.

By diversifying financing strategies, integrating TB into existing insurance schemes, and leveraging public-private partnerships, TB programs can achieve financial sustainability and reduce dependency on external donors.

3. Recommendations based on literature review and KIIs to optimize TB response and programmatic efficiency and sustainability

3.1 Enhancing efficiency in TB programs

a) **Expand Community-Based Integrated Models and Active Case Finding**: Scale up community-based approaches integrating multiple TB services, including ACF and TB screening by CHWs. This will enhance case detection, reduce treatment delays, and improve treatment adherence, especially in rural and underserved communities.

b) **Decentralize DR-TB Care and Integrate with DS-TB activities**: Governments should prioritize decentralizing DR-TB care, integrating it into routine **DS-TB services** for cost savings and improved access, particularly in underserved areas. This includes integrating innovative diagnostics into community-based care.

c) **Leverage Shorter Treatment Regimens for DR-TB and TPT**: Promote the use of shorter, cost-effective regimens for DR-TB, children with non-severe DS-TB and TPT, which have shown substantial cost savings and improved patient adherence, especially in decentralized settings.

d) **Maximize Resource Use with AI and Molecular Testing**: Integrate AI-assisted chest X-ray interpretation with molecular tests like GeneXpert and implement sputum pooling strategies. This combination can significantly enhance diagnostic efficiency, especially in high-burden settings.

e) **Utilize Innovative Diagnostic Tools**: Invest in scalable, cost-effective screening and diagnostic tools, such as AI-powered chest X-rays, mobile screening units, and TrueNat, to improve TB detection, particularly in high-risk populations and remote areas. These technologies can be used in combination with molecular testing platforms like GeneXpert to streamline diagnostics and reduce costs.

f) **Strengthen TB Surveillance and Reporting Systems**: Advocate for the adoption and enforcement of MCN laws to ensure all TB cases, including those detected by private providers, are reported. This will improve surveillance data and reduce unnecessary program costs.

g) **Expand PPM Models**: Scale up innovative and most efficient PPM models to improve TB case detection, treatment adherence, and efficiency by engaging private providers in TB care. This includes incentivizing private laboratories for diagnostic testing and integrating them with national TB programs.

3.2 Integrating TB services with other programs/sectors and contribute to RSSH/PPP

a) **Integrate TB Screening with Other Health Services**: Integrate TB screening into existing health care services such as HIV, diabetes, and maternal health programs. Targeted screening for high-risk populations will reduce duplication and improve case detection and resource utilization.

b) **Strengthen and empower Community Health Worker Capacities**: Train and equip CHWs diseases detection, treatment adherence, and delivery of integrated health services across multiple conditions.

c) **Expand and Optimize Sample Transport Networks**: Expand and integrated sample transport networks constructed on national/local platforms and systems for TB and other diseases. Integrated transportation models for multiple diseases (TB, HIV, malaria) can further improve efficiency.

d) **Promote multi-disease screening and Diagnostic Platforms**: Expand the use of diagnostic platforms that can detect multiple diseases, such as GeneXpert and Truenat, to reduce financial and operational burdens while maximizing existing infrastructure.

e) **Incorporate Digital Platforms for Health Worker Training and Community Engagement**: Utilize digital platforms to provide cost-effective training for health workers and engage communities in TB prevention, screening, and treatment. These platforms can improve follow-up care and enhance coordination between health care providers and the community.

f) **Leveraging digital solutions for integrated health surveillance and reporting**: Implement integrated digital tools for real-time disease tracking, case management, and reporting. These solutions enhance data accuracy, streamline processes, and improve coordination across TB and other health programs.

4. Other opportunities to ensure sustainability and leverage additional resources and tools for TB

4.1 Cost reduction and access:

- Promote **local production** of TB medicines and diagnostics to lower procurement costs.
- Integrate TB into **social health insurance and protection** schemes to reduce financial barriers.

4.2 Advocacy and policy:

- **CSO Engagement:** Collaborate with CSOs to lobby for reduced costs, improved access, and inclusive policies for marginalized populations.
- **Private Sector Legislation:** Implement laws for TB mandatory reporting by private providers.

4.3 Research and sharing evidence/lessons learned:

- Invest in **R&D/operational research** to identify cost-effective TB interventions and inform policy.
- Learn from innovative TB models in other countries to optimize costs without compromising quality.
- Support global efforts to accelerate **TB vaccine development and rollout** for enhanced efficiency.

4.4 Sustainability and long-term impact:

- Address sustainability gaps, improve patient retention, and integrate programs into health systems.
- Link TB services with programs addressing poverty, malnutrition, and housing for long-term cost-efficiency.

Annex 1: Addressing the Persistent Funding Gap in TB Programs Based on KIIs

1.1 Role of International Donors and Strengthening Domestic Resources

Historically, many countries have relied on funding from international donors such as the Global Fund. However, as donor contributions become increasingly constrained and priorities evolve, it is crucial for countries to diversify their funding sources. Engaging potential donors like USAID, TB Reach, the Bill & Melinda Gates Foundation and others can help bridge this gap and support the scaling of TB programs. This can be achieved through advocacy efforts directed at international donors, ensuring alignment with their funding strategies. Moreover, the countries need to prioritize domestic resource mobilization. This can be achieved through advocacy efforts to secure additional domestic funding from the Ministry of Health and the Country Coordinating Mechanism (CCM). Highlighting unfunded activities in the National Strategic Plan (NSP) can attract alternative funding to strengthen the country's TB program.

1.2 Health Systems Strengthening and Efficiency Gains

Integrating TB-related supervision into general health system oversight and establishing unified sample referral systems can reduce logistical challenges, streamline operations, and improve health system efficiency. Strengthening health workforce capacity and minimizing reliance on additional HR are key strategies for sustaining TB program delivery at a lower cost.

1.3 Efficient Utilization and Local Production of Drugs and Diagnostics

A significant portion of TB funding is allocated to the procurement of drugs and diagnostic tools. Countries can reduce costs by focusing on the local production of these products, ensuring they meet WHO prequalification standards. This not only lowers procurement costs but also enhances the sustainability of TB programs.

1.4 Proposed Solutions for Resource Optimization

Integrating TB services into existing TB program and other health programs, such as HIV care and maternal and child health services, can reduce duplication and enhance resource utilization. The use of shared diagnostic tools like GeneXpert and AI technologies for multiple diseases, as well as developing integrated sample transport

systems for TB, HIV, malaria, and cancer, can streamline logistics, reduce costs, and optimize resources.

1.5 Maximizing Resource Efficiency in Case Finding and Service Delivery

Improving case detection is crucial to closing the treatment gap. Countries should focus on strengthening case finding, expanding community-based interventions, and leveraging existing resources, such as health system personnel and facilities, to reduce the need for additional human resources. Integrating TB care into broader health initiatives and focusing on cost-effective interventions will maximize the impact of TB programs.

Annex 2: Key Cost Drivers Affecting Program Efficiency Based on KIIs

2.1 Human Resources

Human resources remain one of the largest cost drivers in the TB care cascade. The high dependency on temporary or additional staff for specific interventions significantly increases costs and creates inefficiencies when donor funding ends. In many cases, new staff are added without fully utilizing existing health system personnel, leading to unnecessary cost increases. Optimizing HR use by reducing task duplication and leveraging digital tools such as electronic patient records and remote monitoring systems can streamline operations and improve efficiency. Strengthening the capacity of the existing health workforce is essential to mitigating HR-related costs and improving service delivery.

2.2 Diagnostics, Drugs and other Commodities

Diagnostic tools, anti-TB drugs, and related commodities are significant cost drivers in TB care. Accurate diagnostics and continuous drug supply are essential for effective TB management, but they require substantial investments. To reduce these costs, exploring local manufacturing of diagnostic tools and drugs, as well as negotiating better terms with suppliers, should be prioritized. Expanding the use of diagnostic tools like Xpert for screening other diseases (e.g., HIV and Hepatitis C) can optimize resource use and further reduce costs. Additionally, improving procurement strategies and leveraging local production can help ease financial pressures while ensuring timely and accurate disease identification and uninterrupted treatment regimens.

2.3 Optimizing Monitoring and Training Through Digital Solutions

Efficient planning of monitoring visits and leveraging digital systems such as DHIS II, e-CBS, and remote monitoring tools can significantly reduce on-site visits and travel-related expenses. Similarly, shifting from traditional, resource-intensive classroom training to online platforms eliminates costs associated with travel, accommodation, and logistics. These digital approaches enhance resource efficiency, ensure broader

access to training and monitoring tools, and yield long-term cost savings while improving overall program effectiveness.

2.4 Innovations

New diagnostic platforms or screening methods, often funded by external donors, can be costly. If not integrated into existing health systems, these innovations may not achieve long-term cost-effectiveness. Therefore, integrating new tools and technologies into the broader health system is essential for maximizing their impact without driving up costs.

2.5 Dynamic Nature of the TB Program

The evolving nature of the TB program, including frequent updates to treatment regimens and diagnostic algorithms, necessitates continuous investments in capacity building and policy implementation. Scaling up programmatic changes or expanding coverage further increases program costs, presenting ongoing financial challenges.

2.6 Underfunded Research Needs

Research into new technologies, diagnostic tools, and treatments for TB remains underfunded, limiting innovation and progress. Increased funding for research is essential to improving the efficiency and effectiveness of TB care, enabling the development of more cost-effective solutions.