Stop TB Partnership

Hosted by UNOPS

Digital TB Surviellance System Assessment Report

For 19 Global Fund TB Strategic Initiative (SI) Priority Countries

As part of The Global Fund Strategic Initiative (SI) for Data system, this report provides a rapid assessment of the digital TB surveillance systems in 19 TB SI countries and provide strategic recommendations and roadmap for the countries towards a comprehensive digital, case-based, real time, TB surveillance system.

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A partnership hosted by UNOPS

Digital TB Surviellance System Assessment Report

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FOREWORD

DR. LUCICA DITIU

Executive Director, Stop TB Partnership

The clock is ticking, and we are approaching the deadlines for the 2018 United Nations High-Level Meeting targets, the Sustainable Development Goals (SDGs) and End TB targets. The chaotic biennium of the COVID-19 pandemic has challenged the resilience of health systems since 2020 and has been partially responsible for slowing down the rapid progress in the TB response post-2015. However, the pandemic has also opened new doors in terms of the prevention of airborne infection, and peripheral availability of molecular diagnostics and facilities for differentiated care. It has also unveiled the highest political commitment of national governments and unprecedented global collaborations for health. I believe that the COVID-19 pandemic has demonstrated the power of the human race to conquer epidemics, and shown that funding can be made available and actions taken rapidly, if there is the will..

Since March 2020, we have had access like never before to data about the COVID-19 pandemic – people tested, diagnosed and cured, disaggregated by age, gender, small administrative units and so on. The daily reporting has been the most critical enabler of the global response to COVID-19.

For many years already, we at Stop TB Partnership have been of the strong belief that what we need to strengthen in our response is the availability of real-time temporospatial TB epidemiological information for precise, local rapid response with high-efficiency resource management and concurrent monitoring. It is encouraging to see that a small number of countries have started to report TB notification monthly and a few daily – we need many more.

Stop TB Partnership is working to contribute to and strengthen the TB response. One of the areas of interest is to strengthen the local TB surveillance systems to rapidly advance towards real-time, case-based and digital modes so that there is zero gap in timely information for action. The Global Fund, WHO and technical partners have been fortifying the Partnership's efforts. It is therefore an amazing step forward for all partners to have the current assessment of real-time digital case-based TB surveillance systems in 19 priority countries in order to support these systems to rapidly evolve into perfect response-drivers. To the best of my knowledge, this is the first assessment of its kind, and it is encouraging for all of us to see that the local digital systems are at various stages of evolution, set out for the final war-room.

I want to thank the national leaderships for their vision, work and commitment to make their digital TB surveillance systems more sensitive, timely, intelligent and responsive, and I am looking forward to working together to use the latest available data and information for action. It is 2022 – we need rapid action based on reliable and timely information. We saw it done for COVID-19; we need the same approach for TB (as an airborne disease) and all infectious diseases.

MESSAGE

MARIJKE WIJNROKS

Chief of Staff, Global Fund

Real-time digital case-based surveillance systems play a key role in the proper management of people with TB across the continuum of care. They also ensure the timely availability of people-centric data that supports the monitoring of notification results and treatment outcomes, and facilitates prompt decision-making. The Global Fund recognizes this importance and, together with other donors, technical partners and stakeholders, has continuously supported ministries of health and national disease programmes to build and strengthen in-country digital surveillance systems.

Through the Global Fund Strategic Initiative on Data and in synergy with the TB Strategic Initiative, the Stop TB Partnership has assessed the TB surveillance systems in 19 of the 20 Global Fund high-priority TB countries, with a special focus on the real-time digital TB surveillance systems. Understanding the digital case-based TB surveillance systems and challenges in these 19 countries is critical, as they account for 82% of the TB burden and about 66% of the TB funding in Global Fund-supported countries in the 2020–2022 cycle.

It is our hope that the findings and recommendations from this assessment facilitate knowledge transfer between country programmes on the health and TB data needs, inform stakeholder collaboration and help to catalyse the progressive transition from paper-based to functional digital case-based surveillance systems in countries. The Global Fund also acknowledges the valuable role of the World Health Organization, Stop TB Partnership, and other technical partners and donors in moving this priority forward.

ACKNOWLEDGEMENTS

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About the Global Fund Strategic Initiative:

The Global Fund Data Strategic Initiative (Data SI) aims to improve monitoring and evaluation systems in countries, and the collection, collation, analysis and use of such data for decision-making and quality improvement. The Stop TB Partnership (STBP) and World Health Organization (WHO) are among the implementers of this SI. As part of the first phase of this SI, STBP has assessed and reported on the availability, readiness and requirements for a real-time case-based tuberculosis (TB) surveillance system in the 19 TB SI countries, in consultation with national TB programmes/ministries of health, in-country stakeholders, WHO and other relevant technical partners. This assessment will be followed by the necessary facilitation to transition to real-time digital case-based surveillance systems in the TB SI countries.

About Stop TB Partnership:

The Stop TB Partnership is a unique United Nations-hosted entity based in Geneva, Switzerland, committed to revolutionizing the TB space to end the disease by 2030. The Stop TB Partnership's various teams and initiatives take bold but measured risks to identify, fund and support innovative approaches, ideas and solutions to ensure the TB community has a voice at the highest political levels and that all TB-affected people have access to affordable, high-quality and people-centred care. Learn more at www.stoptb.org.

DIGITAL TB SURVIELLANCE SYSTEM ASSESSMENT REPORT

EXECUTIVE SUMMARY

Tuberculosis (TB) is one of the world's leading infectious disease killers. The End TB Strategy aims to end the global TB epidemic and has a vision of a world free of TB, with no deaths, disease or suffering due to TB. A strong, responsive TB surveillance system that is digital, case-based and real-time, with data on the full cascade of care and necessary analytics for national TB programmes (NTPs), is critical in the global fight against TB. The COVID-19 pandemic has shown the importance of the availability of real-time data globally, nationally and locally to mount the necessary actions for prevention and care. Most high TB burden countries currently have digital case-based TB surveillance systems at various scales of implementation. While some countries use TB-specific and locally developed ICT systems, many others use platforms including DHIS2. However, there are challenges related to software, hardware, coverage, human resources, training, data regulations, data hosting and ownership, political and administrative will, and so on that need to be systematically identified and prioritized.

Part of the critical task of the Global Fund Data Strategic Initiative (Data SI) is to facilitate countries to rapidly adapt and scale up real-time digital case-based surveillance systems for TB. Stop TB Partnership, as a partner implementing the SI, has initiated this project to conduct a rapid assessment of the real-time digital case-based surveillance systems in TB SI priority countries virtually and to provide country-specific recommendations. Following this, the SI will provide the necessary support to implementers, including national governments, NTPs and partners, to strengthen countries' real-time TB surveillance systems. This assessment was done with the intention to understand the timeliness of data availability, use and coverage of digital tools, granularity of data, use of the information for surveillance and action, and the system to develop, maintain, integrate and innovate such tools with adequate data security measures.

The assessment was done virtually, primarily through a series of in-depth interviews with various stakeholders in the country, including NTPs and partners supporting TB surveillance, using structured questionnaires, online surveys, desktop review of published reports and other relevant documents. The assessment was done for 19 high TB burden SI priority countries.

The report consists of two parts: one multi-country systems analysis with the key findings and recommendations, and much more detailed information on the individual countries.

Key findings of the assessment:

All 19 NTPs have a digital TB surveillance platform. However, each country differs in terms of the maturity of its tools and the scale of implementation. The functional maturity of the digital TB surveillance platform to capture data at different stages of the continuum of care (screening, testing, treatment, treatment adherence, treatment outcome, etc.) varies with country programmes. Although some countries have progressed further in digital data on contact-tracing and preventive treatment, these have yet to be scaled up in most countries.

While all assessed countries have a digital TB surveillance system, 10/19 (53%) countries have a case-based system with at least diagnosis, treatment initiation and treatment outcome reported digitally; 5/19 (26%) countries have case-based systems, but with limited data variables; and 4/19 (21%) countries have yet to develop a case-based system. Countries use different digital platforms for TB surveillance. While many countries have transitioned to case-based digital data entry at facility level, others are still reporting aggregated data primarily from the district level, abstracted from paper-based line lists at the health facilities. The DHIS2 platform is used in 10 countries, whereas e-TB Manager is being leveraged in five countries. Some of the countries use a mix of different platforms, while other NTPs use their own in-house digital TB surveillance systems.

All surveyed countries, especially those with well-developed case-based TB surveillance systems, expressed the need to have an interoperable and integrated system that could allow data exchange between the different systems, such as diagnostic laboratory modules, digital adherence tools, and private sector notification tools. Apart from the core digital system available for TB surveillance and notification, countries have been implementing a range of other complementary digital innovations for their TB programme, including modules for digital adherence, private sector TB notification/monitoring, logistics management, laboratory information management, digital X-ray supported by artificial intelligence (AI), community-led monitoring (CLM), contact investigation/TB preventive treatment (TPT), pharmacovigilance, and so on.

EXECUTIVE SUMMARY

Key priority needs identified:

The key priority needs identified include in-house IT capacity, hardware for data entry, data servers, and software development for necessary linkages. NTPs often have limited in-house IT capacity and depend on external private or public IT service providers. This limits their flexibility and autonomy in upgrading and enhancing the system. The lack or limited availability of devices (mobile devices or laptops etc.) and the right infrastructure, such as servers, internet connectivity and a dedicated technical team at the central level, is a challenge in many countries.

Digital tools are most often used in addition to paper-based tools by the generally overburdened local health staff at the health facilities and outreach. Furthermore, the lack of a training mechanism limits operationalization of the digital tools and results in data quality issues.

Countries with case-based TB surveillance systems also have some form of data dashboard. However, there is a tangible need for advanced analytics and AI-based approaches to ensure real-time information for action. CLM is still a weak link in programme monitoring and surveillance systems.

Key recommendations:

Investment to enhance the hardware infrastructure: Most of the countries need devices for data entry at the peripheral level to ensure real-time TB surveillance and data use at the lowest level units. Providing mobile devices and securing Internet connectivity are crucial steps to ensure successful implementation of the digital case-based TB surveillance system.

Case-based monitoring across the continuum of care: While case-based TB notification is the most basic indicator for the digital TB surveillance system that all countries should strive to achieve, a comprehensive workflow-based system to monitor individual cases throughout the entire continuum of care – from client enrolment and risk assessment through to screening, referral, testing, treatment and follow-up – needs to be ensured.

Interoperability and system integration: The existing digital platform for TB surveillance should have the capacity to integrate and facilitate seamless data exchange between different data systems such as medicine inventory, laboratory information management systems, GeneXpert (GxAlert) system, CLM system, etc.

Advanced analytics for better data use: Real-time big data analytics that provide the right information for action need to be built into the digital TB surveillance architecture. Existing tools like DHIS2 have strong data analytics and dashboard functionality with robust indicator configuration. It is also recommended to explore the best-of-breed tools such as Tableau, Power BI and AI solutions for improved use.

e-Training: Developing a comprehensive e-Training/e-Learning platform is necessary to improve data collection and data use processes, and can also be used for continuing medical education.

Costed action plan for digital TB surveillance: An estimated budget has been recommended for each country to strengthen the digital TB surveillance system based on the current e-readiness and IT capacity, maturity of the existing platform (case-based vs. aggregated), number of facilities and users, and other parameters. However, countries need to develop a costed action plan for strengthening their digital TB surveillance system.

DIGITAL TB SURVIELLANCE SYSTEM ASSESSMENT REPORT

BACKGROUND

Tuberculosis (TB) is one of the leading infectious causes of death worldwide. Throughout human history, it is estimated that over 1 billion people have succumbed to TB. At the 2018 United Nations High-Level Meeting on TB, world leaders agreed to end TB by 2030. A robust TB surveillance system is the foundation on which to build and adapt locally appropriate strategies for ending TB. TB surveillance is the continuous and systematic collection, analysis and reporting of data related to TB infection and TB disease in the population [1]. While the coverage and quality of data are critical in making the surveillance system supportive for end-TB actions, the availability of real-time surveillance data helps in making timely decisions and taking proactive actions to meet the end-TB timelines. Real-time digital and case-based surveillance systems for TB have several advantages over paper-based reporting of aggregated data. Digital systems enable automated data quality checks, timely access to data and the availability of individual-level data on people with TB – from community level up to the national level. Strengthening the technology platforms to make the surveillance real-time is a key enabler in the global fight against TB. Such technology is also integral to the daily management of people with TB and provides critical data on the reach and efficacy of programmes.

Currently, there are many high TB burden countries with digital case-based TB surveillance systems at various scales of implementation. While some countries use TB-specific and locally developed ICT systems, many others use ICT tools including DHIS2. However, there are gaps and challenges that prevent uniform uptake of and benefit from such tools to establish a good TB surveillance system that is real-time and responsive. Challenges are related to software, hardware, coverage, human resources, training, data governance, policies and regulations, digital health architecture, data hosting and ownership, political and administrative will, and so on. These challenges need to be systematically identified, prioritized and addressed. There is also a need for smart analytics, including the potential scope of artificial intelligence (AI) in linking programme data with other ecological data to generate predictive models and other epidemiological information. Another challenge is data fragmentation; different tools are often used by public and private providers, or by different branches of a health department, even for managing comorbidities such as TB and HIV. There are also challenges in local implementation and timeliness of reporting; even the best tools need customization, maintenance and support, as well as strong local champions to ensure effective training, monitoring and ongoing use of new technologies.

The COVID-19 pandemic has shown the importance of the availability of real-time data globally, nationally, and locally to mount the necessary actions for prevention and care. This pandemic has also shown the power of digital data and the feasibility of quickly setting up information systems in almost every country [2]. The impact of COVID-19 disruptions on TB notification was first reported in India very early in the pandemic, thanks to the daily reporting of TB notification on a publicly available website [3] and data from the country programme's well-developed case-based TB surveillance system called 'Nikshay'. Later, countries were encouraged to report TB notification at least monthly, and more than 80 countries reported their TB notification data to WHO monthly to the end of 2021 [4]. Timely availability of data on TB notification and treatment outcomes at the national and subnational levels is critical for monitoring the results of TB catch-up plans and impact mitigation plans. There has recently been high demand for and political commitment to real-time data; therefore, it is the right time for further aggressive efforts in this area.

The Global Fund Data Strategic Initiative (Data SI) has the important task of facilitating countries to quickly adapt real-time TB notification systems. Stop TB Partnership, as a partner implementing the SI, has conducted an assessment of the TB surveillance systems virtually, with a special focus on the real-time digital TB surveillance systems in 19 SI countries, and provided necessary high-level advocacy support to implementers, including national governments, national TB programmes (NTPs) and partners, to enable the programmes to strengthen their real-time TB surveillance systems.

The assessment aimed to understand the timeliness of data availability, use and coverage of digital tools, granularity of data, use of the information for surveillance and action, and the system to develop, maintain, integrate and innovate such tools with adequate data security measures as a real-time digital case-based TB surveillance system.

- Data availability timelines are considered real-time when the relevant data on people with TB/cohorts are entered/reported immediately after diagnosis or initiation of treatment, or reported within a period of one month, since at least monthly notification is encouraged.
- Data are considered case-based when individual data are made available to the relevant levels of monitoring and decision-making units for validation, analysis and feedback.

BACKGROUND

- Data tools are considered digital when a digital application (web-based, mobile-based online or offline) is used to capture data, as opposed to the data being captured using pen and paper.
- Surveillance is when the gathered data are linked to epidemiological action beyond service delivery.
- A system implies that there is a systematic approach to the development/customization and maintenance of the tools used for recording, reporting, analysis and feedback.

Each of the components of the real-time digital case-based TB surveillance system are highly relevant in order to give the system the highest efficiency and have the desired impact on the country's TB burden. Real-time systems, for example, reduce the redundancy of information and time lag in decisions and actions. Digital systems enhance ease of operation in data entry, enhance the granularity of data, and facilitate the transmission, storage, validation and processing of data at multiple levels. Case-based systems improve the people-centric orientation and customization of the TB care continuum, and promote accountability of health programmes and individual care providers. Such systems also have the potential to evolve to accommodate treatment support, grievance redressal, adverse reaction management, differentiated TB care and access to low or no cost TB services. Although surveillance has been an integral part of disease programmes, provision of prompt feedback, linkage of surveillance to timely action, transparency and data accessibility improve with a well functioning and quality-controlled digital system.

Most country programmes currently use the relevant TB data and analytics for feedback to subnational levels, programme reviews and performance reports.

However, digital TB surveillance systems can make key programme performance indicators, such as TB notification and treatment outcomes, available in the public domain for necessary action by various key stakeholders. Access to real-time programme data by all stakeholders can also augment programme transparency.

The assessment also aimed to understand the challenges and gaps in political/administrative support, infrastructure, funding, human resources, system development, maintenance capacity and training.

The digital TB surveillance systems in the countries have developed over time and are continuously evolving with the addition of diverse features, supported by various technical and funding agencies including the World Health Organization (WHO), University of Oslo, United States Agency for International Development (USAID), Stop TB Partnership, KNCV Tuberculosis Foundation, the International Union Against Tuberculosis and Lung Disease (The Union), and the Global Fund to Fight AIDS, Tuberculosis and Malaria. The current assessment gained many insights from existing global guidance and reports, including WHO's Digital, case-based, real-time surveillance for TB: status of progress [1]; WHO Toolkit for routine health information systems data [5]; A new digital platform for timely analysis and use of TB data [6]; Microsoft Research, the Global Fund, Stop TB Partnership's Mapping the technology landscape of national TB programmes [7]; the Stop TB Partnership's field guide: Strengthening Information systems and linkages to care [8]; and USAID's TB DIAH Project.[9]

OBJECTIVES

The key objectives of the assessment were: :

- To describe the existing digital TB surveillance systems in the countries in terms of the systems and technologies, coverage, timeliness of reporting, data ownership and dissemination modalities, and hosting arrangements;
- To describe the e-readiness and capacity of the countries to implement a comprehensive digital case-based TB surveillance system;
- To describe the capacity at the national and subnational levels to analyse and use data for evidence-based decision- and policy-making and overall strengthening of programmatic monitoring and evaluation (M&E) efforts;
- To describe the challenges in implementing digital case-based TB surveillance systems in terms of software, hardware, human resources, training, connectivity, private sector involvement, political and administrative commitment, data housing and ownership, data through the entire cascade of care, and information dissemination with appropriate dashboards;
- To provide country-level recommendations for addressing identified challenges, including resource needs, to enable the NTP to implement a real-time digital case-based TB surveillance system and make the information accessible to all concerned at the appropriate levels for real-time actions;
- To share innovative solutions and success stories with the NTPs on real-time digital case-based TB surveillance systems.

APPROACH AND METHODOLOGY

The approach was devised for a rapid, remote assessment over a short study period, as time was of the essence, especially during the COVID-19 crisis. The assessment attempted to identify the digital TB surveillance systems operational at country level, relying mainly on the inputs from programme implementers, and to make recommendations based on country programme aspirations, system requirements and practical considerations including resource availability. The approach was to optimize the time and effort of the NTPs and other stakeholders yet assess key components that would help countries to better articulate their digital capacitation needs.

A structured process-led approach was designed to execute this assessment, which involved multistakeholder consultations and participation (see Figure 1). The assessment team tried to promote insight, introspection, and cross-learning as the core philosophy throughout the process of assessment and reporting.

The assessment was done primarily through a series of in-depth interviews with various stakeholders in the countries, including NTPs and partners supporting TB surveillance, along with structured questionnaires, online surveys, and desktop review of published reports and other relevant documents. Repeat interviews with probing questions were also conducted to gather more technical information, especially on the existing digital systems, fill information gaps and triangulate information from different stakeholders. Non-English-speaking countries were supported by interpreters and translated information was made available for cross-verification by the respective NTPs and stakeholders.

Following the data collection process, data gathered by the team from different sources (i.e. desktop research, online survey, introductory meetings, and detailed workshops) were curated to extract meaningful insights for country-wise compilation. Data analysis was done using the country assessment template. The analytical template consisted of the complete country assessment information put into a structured format. The framework enabled the team to convert subjective and unstructured information into more structured and analysed insights. It also enabled them to capture relevant recommendations from participants.

The filled in country analytical frameworks with all findings and recommendations were sent to the participants (NTPs and partners) for validation. Further iterations were made following the feedback from the NTPs, and the draft reports were shared again with the NTPs and partners for further validation.

In addition to the individual country reports, the data were further analysed with characteristics such as types of digital platforms, timeliness, coverage and comprehensiveness, collated for multi-country analysis and presented in this report.

Some core principles were followed when designing the approach:

- Multistakeholder engagement and participation
- Open-minded discussion
- Proactive information collection
- Avoidance of any conflict of interest
- Validation of information at each stage
- Sign-off and approval by countries.

The methodology was formulated to conform to the above-mentioned principles. The detailed step-by-step process is further explained in Annex 2

Figure 1. The methodology was divided into five main steps, starting from collection through to curation, validation, analysis and recommendation

COUNTRIES ASSESSED

The 19 TB priority countries assessed were: Bangladesh, Cambodia, Cameroon, Democratic Republic of the Congo (DR Congo), Ethiopia, Ghana, India, Indonesia, Kenya, Mozambique, Nigeria, Pakistan, Philippines, South Africa, Ukraine, Uganda, United Republic of Tanzania, Viet Nam and Zambia.

Key findings of the assessment

MULTI COUNTRY COMPARISON AND ANALYSIS

STATUS OF DIGITAL TB SURVEILLANCE SYSTEMS – FUNCTIONAL MATURITY LEVEL

All NTPs across the 19 countries acknowledge the value of a real-time digital TB surveillance system. All 19 countries have created a TB surveillance platform to the best of their capacity. However, each country differs in terms of the maturity of these tools and scale of implementation, which is a function of resource availability, access to the existing digital ecosystem, political will and the presence of an enabling digital environment. Figure 2 and Table 1 show the level of maturity of the digital case-based TB surveillance systems in the 19 countries during the assessment period. The maturity level was assessed on a scale of 1 (basic) to 4 (full maturity) based on six parameters: 1) timeliness of data availability (score of 1 for quarterly reporting to a score of 4 for daily data entry and real-time analytics); 2) digital case-based (score of 1 for no case based systems to 4 for case-based for both drug-susceptible [DS-] and drug-resistant [DR-] TB); 3) coverage (score of 1 for pilot to 4 for full national coverage); 4) level of granularity and use of data for surveillance (score of 1 for national-level reporting only to 4 for dashboards, line lists, job aids and feedback, including publicly available key information); 5) IT systems, including human resources (score 1 for externally supported limited resources to 4 for full IT systems, a dedicated IT team and necessary data entry tools at all levels); and 6) cascade of care (score 1 for notification only to 4 for presumptive TB to outcome data). The assessment found that India and Philippines have fully mature digital case-based TB surveillance systems in operation. Bangladesh, Cambodia, Indonesia, Nigeria, South Africa, Ukraine and Viet Nam have fairly advanced systems, and, with some additional effort, these countries could quickly move to fully functional digital case-based TB surveillance systems. DR Congo, Kenya and the United Republic of Tanzania have digital case-based systems; with additional support for scale-up and IT support systems including data entry tools, these countries are on their way to achieving a mature system. Cameroon, Ethiopia, Ghana, Mozambique, Pakistan, Uganda and Zambia have a strong vision and political will to create a comprehensive digital case-based TB surveillance system, but need additional support in system development and scale-up.

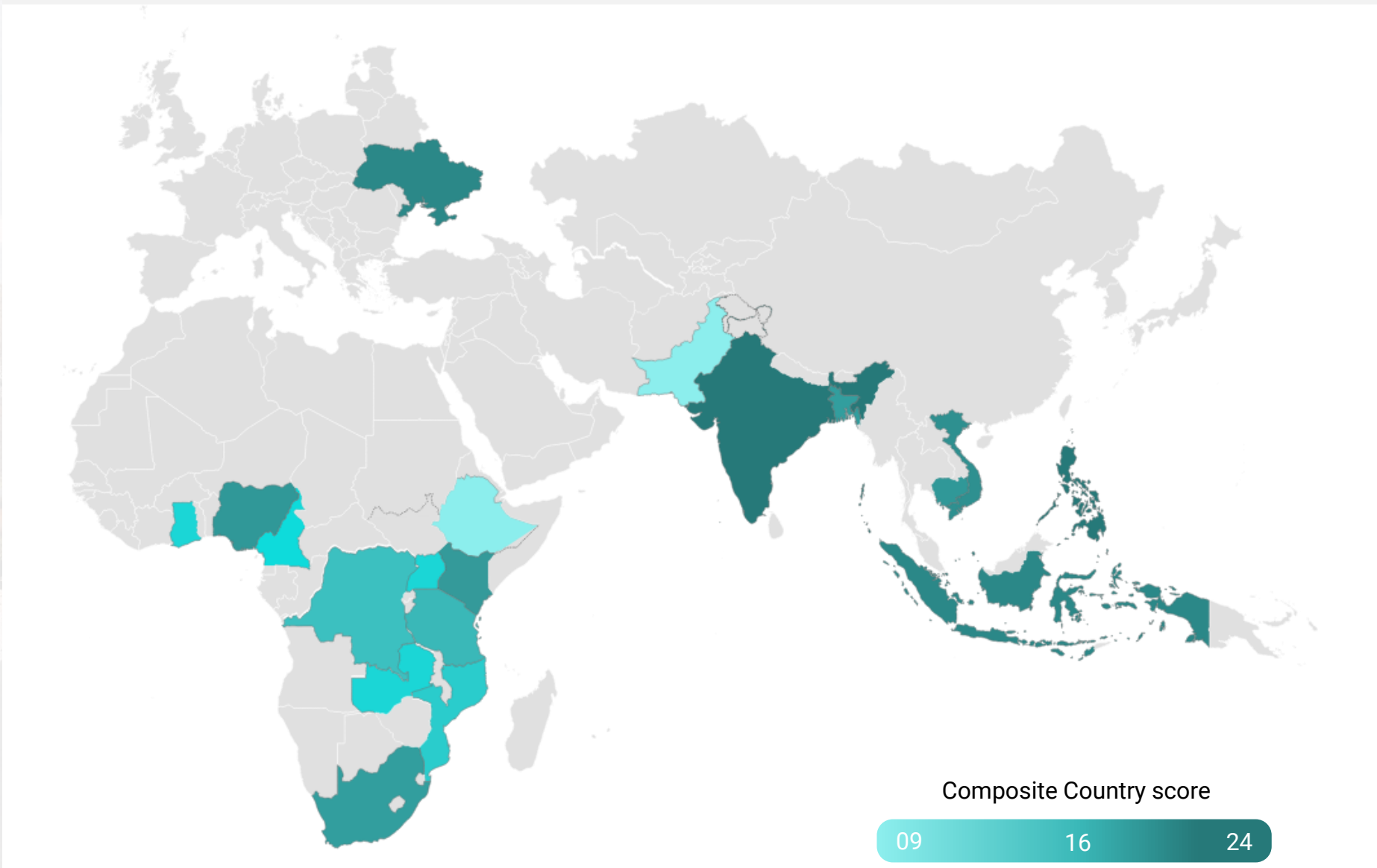

Figure 2. Countries' functional maturity in implementing digital case-based TB surveillance systems based on a composite score

Disclaimer

The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of the Stop TB Secretariat concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. White discontinuous lines are used to represent boundaries under dispute and to approximately show the line of control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. This map is based on UN Map No. 4170 Rev. 15 (July 2018). Every effort is made to ensure this map is free of errors but there is no warrant the map or its features are either spatially or temporally accurate or fit for a particular use. This map is provided without any warranty of any kind whatsoever, either express or implied.

	TIMELINESS OF DATA ENTRY	DIGITAL AND CASE-BASED	SCALE/ COVERAGE CASE-BASED	SURVEILLANCE LEVEL AND GRANULARITY	IT SYSTEM AND SUPPORT TEAM	CASCADE OF CARE	COMPOSITE COUNTRY SCORE
BANGLADESH	3	4	3	3	2	3	18
CAMBODIA	2	4	4	3	3	3	19
CAMEROON	1	1	1	2	3	2	10
DR CONGO	2	4	1	2	2	4	15
ETHIOPIA	1	1	1	2	2	2	09
GHANA	2	1	1	3	1	3	11
INDIA	4	4	4	4	4	4	24
INDONESIA	3	4	4	3	3	4	21
KENYA	2	4	3	3	2	3	17
MOZAMBIQUE	2	3	1	2	2	2	12
NIGERIA	3	4	3	3	3	3	19
PAKISTAN	1	1	1	2	2	2	09
PHILIPPINES	4	4	4	4	4	4	24
SOUTH AFRICA	3	4	3	3	2	3	18
UGANDA	3	1	1	2	2	2	11
UKRAINE	4	4	4	3	3	3	21
UNITED REPUBLIC OF TANZANIA	2	4	3	3	2	2	16
VIET NAM	3	4	4	3	2	4	20
ZAMBIA	2	1	1	2	2	3	11

Table 1. Digital TB surveillance systems – functional maturity level

VARIABLES	SCORE 1	SCORE 2	SCORE 3	SCORE 4
Timeliness of data entry	Quarterly	Monthly	Weekly	Daily
Digital and case-based	No case based system	Only DR TB case based	Only DS TB case based	Both DR TB and DS TB case based
Scale/ coverage case-based	No case based system functional at facilities or Pilot	DR TB full coverage	DS TB expanding (at least 25% national coverage)	Both DS TB and DR TB full national coverage
Surveillance level and granularity	Data use-blank (no evidence of any use)	Offline data analysis at national/sub national level	Dashboards, feedbacks -Data in programme domain	Publicly available data at all levels
IT system and support team	No, supported externally	Yes, IT system software available, more hardware needed, Team supported externally	Yes, inhouse team and software available, need more hardware support	Full IT system, inhouse team ready
Cascade of care	Notification only	Treatment initiation to outcome	Testing to outcome	Presumptive to outcome

STATUS OF DIGITAL TB SURVIELLANCE SYSTEMS – CONTINUUM OF CARE

It was encouraging to learn that all 19 TB priority countries have some form of digital tool for TB notification and surveillance. Although some countries are ahead of others in terms of the maturity of the tools, the vision for moving to a fully interoperable digital case-based TB surveillance system was clearly articulated by each NTP. The functional maturity of the digital TB surveillance platform in terms of its ability to capture data variables at the different stages of the continuum of care – from screening and TB testing through to treatment, treatment adherence and treatment outcome – varies with the respective country programmes (see Table 2). Although some countries have progressed further in digital data on contact-tracing and preventive treatment, this has yet to be scaled up in most countries.

	PRESUMPTIVE TB SCREENING	TB TESTING	TREATMENT INITIATION	TREATMENT ADHERENCE	TREATMENT OUTCOME	CONTACT TRACING
BANGLADESH	Manual	Case-based	Case-based	Case-based	Case-based	Manual
CAMBODIA	Manual	Case-based	Case-based	Case-based	Case-based	Case-based
CAMEROON	Manual	Manual	Aggregated	Manual	Aggregated	Manual
DR CONGO	Case-based	Case-based	Case-based	Manual	Case-based	Manual
ETHIOPIA	Manual	Manual	Aggregated	Manual	Aggregated	Manual
GHANA	Aggregated	Aggregated	Case-based	Case-based	Case-based	Aggregated
INDIA	Case-based	Case-based	Case-based	Case-based	Case-based	Case-based
INDONESIA	Manual	Case-based	Case-based	Case-based	Case-based	Case-based
KENYA	Aggregated	Case-based	Case-based	Case-based	Case-based	Case-based
MOZAMBIQUE	Manual	Case-based	Aggregated	Manual	Aggregated	Manual
NIGERIA	Manual	Case-based	Case-based	Case-based	Case-based	Manual
PAKISTAN	Manual	Manual	Aggregated	Manual	Aggregated	Manual
PHILIPPINES	Case-based	Case-based	Case-based	Case-based	Case-based	Case-based
SOUTH AFRICA	Aggregated	Aggregated	Case-based	Case-based	Case-based	Aggregated
UGANDA	Manual	Case-based	Aggregated	Manual	Manual	Manual
UKRAINE	Manual	Case-based	Case-based	Manual	Case-based	Manual
UNITED REPUBLIC OF TANZANIA	Manual	Manual	Case-based	Case-based	Case-based	Aggregated
VIET NAM	Case-based	Case-based	Case-based	Case-based	Case-based	Manual
ZAMBIA	Manual	Aggregated	Aggregated	Manual	Aggregated	Aggregated

Case-based Aggregated Manual

Table 2. Data systems for continuum of care

While all assessed countries have digital TB surveillance systems in their programmes, 10/19 countries (53%) have a case-based system reporting at least TB testing, treatment initiation and outcome digitally; 5/19 countries (26%) have case-based systems, but have data only for either notification or treatment initiation and outcome; 4/19 countries (21%) have yet to develop a case-based system. Countries such as Bangladesh, Cambodia, Kenya, India, Indonesia, Nigeria, Philippines and Viet Nam have fairly advanced systems. However, the national-level coverage and comprehensiveness vary.

DIGITAL TB SURVEILLANCE PLATFORMS

Countries use different digital platforms for TB surveillance. While many countries have transformed to case-based digital data entry at facility level, others are still reporting aggregated data primarily from the district level, abstracted from paper-based line lists at the health facilities.

Table 3 shows the different platforms used by the programmes, data types (case-based or aggregated) and point of data entry. (Note: The scale/coverage of the platform or data entry point is not depicted here. This can be seen in Table 1 describing the functional maturity.)

	NATIONAL DIGITAL TB SUVIELLANCE TB PLATFORM	DATA TYPE	POINT OF DATA ENTRY
BANGLADESH	e-TB Manager	Case-based	Facility level (Upazila Health Complex and other hospitals)
CAMBODIA	e-TB Manager (Cam TBMIS)	Case-based	Facility level (Treatment health centres)
CAMEROON	DHIS2	Aggregated	Regional level
DR CONGO	DHIS2	Case-based	Health zone level
ETHIOPIA	DHIS2	Aggregated	Facility level
GHANA	DHIS2, e-Tracker (high burden facilities)	Case-based + Aggregated (High burden facilities)	Facility level
INDIA	NIKSHAY	Case-based	Facility level
INDONESIA	SITB	Case-based	Facility level
KENYA	TIBU, KHIS 2	Case-based	Sub-county level (on behalf of health facilities)
MOZAMBIQUE	SIS-MA (DHIS2)	Aggregated	Facility level
NIGERIA	e-TB Manager, DHIS2	Case-based	High Burden facilities, District level
PAKISTAN	DHIS2, ENRS	Aggregated	DHIS2 - District level, ENRS - Facility level
PHILIPPINES	ITIS	Case-based	Facility level
SOUTH AFRICA	Tier.Net (DS TB), EDR web (DR TB)	Case-based	Facility level
UGANDA	DHIS2	Aggregated	Facility level
UKRAINE	e-TB Manager , MIS SSD	Case-based	Facility level (TB servicing units)
UNITED REPUBLIC OF TANZANIA	DHIS2	Case-based	Facility level
VIET NAM	VITIMES, e-TB Manager	Case-based	VITIMES - District level eTB manager - Facility level
ZAMBIA	DHIS2	Aggregated	District level

Table 3. Digital platforms

Case-based Aggregated

The DHIS2 platform is used in eight countries (Cameroon, DR Congo, Ethiopia, Ghana, Pakistan, Uganda, United Republic of Tanzania and Zambia), whereas e-TB Manager is being leveraged in five countries (Bangladesh, Cambodia, Nigeria, Ukraine and Viet Nam). Some of the countries in the list also use a mix of different platforms (Ghana, Nigeria and Viet Nam). For the remaining countries, the NTP has taken leadership to develop its own in-house TB surveillance system (Kenya, India, Indonesia, Mozambique, Philippines and South Africa).

COMPLEMENTARY DIGITAL INNOVATIONS, INTEROPERABILITY AND SYSTEM INTEGRATION

All surveyed countries, especially those with well developed case-based TB surveillance systems, expressed the need to have an interoperable and integrated system that could enable data exchange between different systems, such as diagnostic lab modules/GxAlert, digital adherence tools, private sector notification tools, etc. Countries have yet to implement comprehensive data warehouses and interoperable standards such as FHIR (Fast Healthcare Interoperability Resources) or HL7 (Health Level Seven International).

Apart from the core digital system available for TB surveillance and notification, countries have been implementing a range of other complementary digital innovations for the TB programme (see Table 4). Some of the key modules/platforms assessed include the following:

Digital adherence module/platform

This module/platform enables either adherence reporting by health workers/community/facility treatment supporters or self-reporting of adherence by the people on TB treatment themselves. The format can range from a software application to devices like a pill box integrated with an application to a 2G channel-based (USSD, Missed Call, IVRS, SMS) solution like 99DOTS.

Private sector TB notification/ monitoring module/platform

Many programmes use separate apps/modules for notification/monitoring from the private sector. While some mobile applications for this purpose are well integrated into the main digital TB surveillance platform, other standalone apps also exist.

Logistic management module/platform

This includes medicines/diagnostics reagents/commodities/consumables inventory and logistics management systems. Most often, these solutions cut across different health programmes and are not necessarily dedicated to one single programme like TB.

Laboratory information management module/platform

This includes different activities from test result updates – including for culture, drug susceptibility testing (DST) and line probe assay (LPA) – to sputum collection and transport systems, and integrated system/applications for GeneXpert/Truenat.

Digital X-ray supported by AI

Digital X-ray machines are being scaled up in many countries. Computer-aided detection (CAD) technology is also increasingly used to provide presumptive screening. However, these data often exist in silos and are not linked to laboratory diagnostic data, for example. Therefore, health care workers have to double-enter the X-ray screening data into the existing platforms. Interoperability solutions between X-ray/CAD databases and the main TB surveillance platform are crucial.

Community Led Monitoring module/ platform

This is a very essential yet new area of focus. Many countries realize the importance of community-centric approaches and the use of CLM systems and different digital innovations to facilitate community-based reporting, grievance redressal, access to information, community forums and discussion platforms.

Contact investigation/TB Preventive Treatment (TPT) module/platform

These apps/modules contain screening, contact investigation and TPT data. Most of the countries follow WHO's screening and contact investigation pathways to ensure access to TPT for eligible clients.

Pharmacovigilance module/platform

This involves systems or modules to report adverse events from TB medicines. In most of the countries, pharmacovigilance platforms cater to different programmes and medicines including TB medicines.

OTHER COMPLIMENTARY DIGITAL MODULES

As far as the integration of the complementary digital modules into the national digital TB surveillance system is concerned, three main categories were identified:

Module within the national TB surveillance platform: Some of the advanced systems have most of the complementary modules already built into the TB surveillance system. This means that the modules share a common code base and are deployed in the same data environment, which ensures complete harmonization and data exchange with the national TB surveillance platform.

External platform fully integrated into the national TB surveillance platform: Modules/platforms falling under this category are those that, despite using a different code base and having been developed as a separate platform, have all the necessary data exchange capabilities and integrations. Systems such as GxAlert or QureAI, WHO's Prevent TB platform, 99DOTS and OneImpact that are integrated into TB surveillance systems fall under this category.

External platform not integrated into the national TB surveillance platform: These are systems where a data exchange mechanism has yet to be put in place. These systems often have their own database and deployment in different environments.

	DIGITAL ADHERENCE	LOGISTICS MANAGEMENT	LAB INFORMATION SYSTEMS	COMMUNITY LED MONITORING	CONTACT TRACING	PHARMACO-VIGILANCE
BANGLADESH	99DOTS	QuanTB	GxAlert, CAD4TB	mHealth, ConnecTB	e-TB manager	
CAMBODIA	Cam TBMIS		Cam TBMIS	OneImpact	Cam TBMIS	
CAMEROON		DHIS2	GxAlert, Data2Care		Household survey	
DR CONGO		QuanTB		OneImpact		
ETHIOPIA			GxAlert	eCHIS		VigiLyse, VigiBase
GHANA		QuanTB	GxAlert, ASPECT		DHIS2	
INDIA	NIKSHAY, 99DOTS, evriMED/ MERM box	NIKSHAY Aushadhi	LIPMS, Qure.ai	NIKSHAY Arogya Sathi, TB Mitra	Prevent TB	PVPI Pharmacovigilance system
INDONESIA	EMPATI	SITB, SITRUST	GxAlert, SITB	EMPATI	SITB, SITK	
KENYA		TBMeds, KEMSA LMIS	GxAlert, LabWare		TIBU	TIBU
MOZAMBIQUE	SIS-MA	Ferramenta Central	GxAlert, Disalink	OneImpact	DHIS2	
NIGERIA	99DOTS, VideoDOTS	LMIS	GxAlert, CAD4TB		EWORS, Commcare	e-TB manager
PAKISTAN		TB DMIS	GxAlert, CAD4TB	OneImpact		
PHILIPPINES	99DOTS, VideoDOTS, Smart Pillbox, ConnecTB, CareTB	QuanTB, PMIS	GxAlert, Data2Care, C360	OneImpact (CareTB)	CareTB, ITIS, ConnecTB	PVIMS
SOUTH AFRICA	Wisepill, PCAM	Stock Visibility System	GxAlert, Qure.ai	Ritshitze (SMS to patients)		EDR Web, PVIMS
UGANDA	VideoDOTS, 99DOTS	DHIS2	DHIS2, GxAlert	Toll Free call centre	DHIS2	
UKRAINE	VideoDOTS, evriMED pill box	e-TB manager, QuantTB	e-TB manager, LMIS	OneImpact		
UNITED REPUBLIC OF TANZANIA	99DOTS, TambuaTB	eLMIS	GxAlert	OneImpact		
VIET NAM	VITIMES, e-TB manager	VITIMES, e-TB manager	VITIMES, e-TB manager, GxAlert, PACS, Qure.ai, DrAids	ZeroTB Vietnam	ACIS	e-TB manager
ZAMBIA		eLMIS	GxAlert, DISA, Data2Care			

Table 4. Other complementary digital modules

KEY PRIORITY NEEDS IDENTIFIED

The following are some of the key priority needs identified. The specific needs and urgency assessed during the stakeholder discussions form the basis of the recommendations outlined in the next sections of this document.

IT capacity

Many countries highlighted that the in-house IT capacity of the NTP was limited, often dependent on external private or public IT service providers, thus limiting the flexibility and autonomy of upgrading and enhancing the system. There was a clear need to strengthen internal IT capacity. Doing so will not only provide autonomy to innovate, but also ensure sustainability and scalability in the long run in terms of expanding to different modules and different user groups. Lack of a dedicated technical team at the central level for digital TB surveillance is another challenge in many countries

Hardware and devices

One of the most common challenges faced by countries is the availability of devices (mobile devices, mobile Internet or laptops, etc.) and the right infrastructure such as Internet connectivity or even electricity. Providing the necessary devices to health functionaries at the lowest level units will help to optimize the work of health staff and ensure timely collection of data, which is crucial for the success of any digital TB surveillance system.

Double systems for data entry

Most often the health staff at the local levels are overburdened, and the digital entry tool is often being used in addition to the paper-based tools (rather than the digital tool as the only data collection tool). This duplication of data entry adds to the workloads of the health staff at the facilities or outreach.

Despite having advanced digital systems, most countries continue to rely on paper-based data entry at the periphery. The lack of complete coverage of digital systems, and thus the need to maintain paper-based systems, continues to present a challenge Data validation is another important issue, which is different when using a paper-based system. Digital systems can provide necessary quality checks/deduplication etc. and instil better confidence in programme managers to do away with paper-based systems

There have been concerns about transfer/migration of historical data from paper-based systems to the digital system and the availability and use of the historical data during the transition period. Countries that have fully transitioned to digital systems have made extra effort to enter the backlog of case-based data for the last few years.

Training and capacity-building

Training has multidimensional challenges. First, the ongoing COVID-19 pandemic has paused training to a considerable extent in most countries. Assessment of training needs and provision of fresh/update training on TB surveillance systems have been replaced by the more demanding need for COVID-19 infection prevention and control and impact mitigation. Virtual training/training with remote assistance are being promoted by many NTPs. Some national programmes, such as those in India and Philippines, have developed e-Learning platforms and self-learning modules with release alerts. Provision of self-learning and assisted learning opportunities to complement or reinforce physical learning has proven helpful. However, complete transition to remote or self-learning may not be an option for the most peripheral staff, especially general staff who additionally manage TB data. Furthermore, the lack of a scalable remote training mechanism limits the operationalization of digital tools and results in data quality issues at the source of collection during restricted access situations.

Cascade of care monitoring

Although many countries have case-based TB surveillance systems, many often lack a comprehensive workflow-based model to monitor a person with TB through the continuum of care – from risk assessment to screening and referral. However, all countries unequivocally expressed the importance of capturing real-time data across the entire cascade of care, as this has the potential to increase the yield and plug the leaks in the cascade.

KEY PRIORITY NEEDS IDENTIFIED

Community linkages/CLM

CLM is still a weak link in providing holistic TB care. Although many countries are implementing community screening/sputum collection and outreach work using community workers and volunteers, the countries have yet to implement standardized CLM frameworks or use the data to strengthen the TB response through community and civil society organization (CSO) participation. However, all NTPs recognize the importance and value of strengthening community and civil society engagement, and addressing community challenges such as social barriers to access, stigma, TB support services, and human rights challenges.

Data science, analytics and AI for a comprehensive TB surveillance system

Most of the countries with a case-based TB surveillance system also have some form of dashboard. Some countries are ahead of others, but the need to effectively analyse data for programmatic decision-making is acknowledged by all. Countries in advanced stages of digital platform implementation envision the use of advanced data science and AI-based approaches not only for analysing data, but also for predictive modelling to facilitate better resource planning and programme management, smart digital job aids powered by AI solutions, epidemiological intelligence, impact assessment, etc.

The use of AI enables reasoning with uncertainty in complex environments and helps find missing cases. Using survey or programme data at high resolution can help to predict risk of disease, health-seeking behaviour, vulnerabilities and treatment outcomes at the individual or population level. Predictive modelling approaches can be used to map at-risk population groups and support active case finding through the engagement of local stakeholders, including private health care providers.

RECOMMENDATIONS

KEY PRINCIPLES AND APPROACHES

Leveraging and maximizing existing IT infrastructure and capacity

One of the core principles considered in the country recommendations is to maximize the existing IT infrastructure and data ecosystems already in place, instead of creating a parallel system and “reinventing the wheel”. In general, the approach should be “build on what you have". The digital systems will keep on evolving and, at some point, every country programme will need to jump systems. For some, that shift might come sooner, while for others it might be a better option to shift at a later time. There should always be consideration of when it may make sense to change systems, followed by a full cost–benefit analysis, aligning with the country’s national HMIS/M&E plans and digital health national strategies.

In addition, if there is an opportunity to integrate the TB surveillance system into an existing sound general electronic medical records (EMR) system, it might be a better option, but without compromising the need for comprehensive TB surveillance. The recommendations aim to leverage the following key strengths of the countries.

Existing software/Data ecosystem

The assessment revealed that almost every country has some form of digital infrastructure and capacity in place. As indicated earlier, eight countries have DHIS2-based systems in different phases of implementation, and five countries are already using e-TB Manager-based systems. Kenya, India, Indonesia, Mozambique, Philippines and South Africa have systems developed by their internal IT teams.

This infrastructure provides the country with an excellent launchpad for creating a comprehensive digital TB surveillance system without much need to depend on external systems. However, while the existing platforms provide a core foundation, countries may use this assessment report to discover different functional and technical innovations and modules that other countries are implementing. There is also a great deal of scope to integrate external digital innovations into the core foundation countries already have in place.

This approach makes the digital roadmap not only cost-effective, but also sustainable in the long run, as it has the potential to integrate with the overall health system and help to reduce health data silos.

Human resource/IT capacity

In line with this core principle, countries should maximize and strengthen the human resources and IT capacity already available in countries. For example, one of the most common recommendations is to leverage the existing DHIS2 resources or other technical experts already in the countries. Capacitating and increasing existing resources will not only lead to a smooth transformation of the digital landscape in the country, but also ensure long-term sustainable growth. The recommendation is for these digital initiatives to be increasingly country-led, strengthening the country's in-house technical team and capacity.

Hosting and deployment environment

Like software applications, the recommendation ensures that countries' existing hosting and deployment environments, such as servers, clouds, data warehouses and repositories, are maximized.

Align recommendations with the country’s vision and challenges

One of the other core principles followed is to align the recommendations with the country's existing vision and priorities in order to address the key challenges faced by the country. These challenges can differ significantly from country to country based on different factors discussed below.

Stage and maturity of TB surveillance system

The recommendations vary from country to country based on the stage and maturity of the TB surveillance system. For example, for countries that have only an aggregated TB notification system, the typical recommendation is to first create a case-based TB surveillance system for the entire continuum of care, whereas for countries that already have a case-based TB surveillance system, the recommendation is to explore other advanced features/modules such as contact investigation, GxAlert integration, etc.

Alignment with roadmap and vision

The approach is also to keep the recommendations aligned with the country's existing vision and roadmap, shared as part of the assessment exercise.

RECOMMENDATIONS

Prioritization based on challenges

The recommendations also reflect the challenges highlighted by the countries as part of the assessment. While many of the basic challenges are similar across the countries, the countries also vary significantly in terms of how and when they can resolve the challenges.

Non-prescriptive

Another core principle of the recommendations is to keep them non-prescriptive. The idea is to share the best practices based on our combined understanding from multiple countries and stakeholders. However, the countries should evaluate these recommendations based on their country context, budget availability, priorities and mandates.

KEY GENERIC RECOMMENDATIONS

While the recommendations vary from country to country based on the principles indicated in the previous section, some of the common recommendations provided to achieve the ideal functional and technical architecture for a case-based TB surveillance system are as follows:

Interoperability and system integration

One of the biggest opportunities and enabling environments is the digital ecosystem that already exists within the national programme – whether fully owned and managed by the NTP or managed by an external private or public entity, including other programmes in the Ministry of Health, and across Ministries such as Information or Telecommunications.

These existing data ecosystems form a strong foundation for promoting interoperability, which would enable countries to integrate and facilitate seamless data exchange between different data systems such as medicine inventory, laboratory information management systems, GeneXpert (GxAlert) system, CLM and more. The idea is to create an integrated and harmonized data exchange system in which each part is complementary and duplication of effort is avoided. This ensures that existing efforts are better optimized and utilized, instead of introducing a new system.

As part of the assessment, we recommend that countries implement the following broad measures to ensure interoperability:

Leverage interoperability standards like FHIR: (Fast Healthcare Interoperability Resources). FHIR is a standard describing data formats and elements and an application programming interface for exchanging electronic health records. This would enable NTPs to exchange data with other health records or data systems such as diagnostic devices, logistics management systems and other data systems. It would also ensure high-level data security and privacy during the data exchange processes.

Recommended exchange/ETL tools: Tools like Talend or Informatica that include these features make data management and data governance tasks much easier.

Creation of a centralized data warehouse: A strong data warehouse, data governance and analytics framework are core to ensuring interoperability. These aspects will not only enable the sharing and reporting of TB data with other national health information systems, but also facilitate the consumption and triangulation of data from other data sources, including open data repositories.

Develop the necessary application program interface (API) and single sign-on: TB surveillance systems that have already been developed or are in the process of development should ensure development of the necessary APIs so that they can integrate with other systems.

Enhancing hardware infrastructure

All countries without exception expressed the need for and highlighted the importance of devices to ensure real-time TB surveillance and data use at the lowest levels. Providing mobile devices and mobile Internet could be a crucial and cost-effective way to ensure successful implementation and adoption of these tools, and investing in hardware as the backbone of the case-based TB surveillance system and other ancillary data systems. The investment made in devices can be optimized by maximizing their use in other health programmes, as most health functionaries at the lowest level units are often tasked with responsibilities from multiple programmes.

Hardware includes mobile devices/tablets/laptops for outreach/facility staff for real-time data entry and access to analytical dashboards/job aids, etc.

Although servers are also an important component of the hardware infrastructure, in most of the countries assessed, servers and deployment infrastructure are already available either directly within the TB programme or within the broader Ministry of Health or national government. Cloud-based hosting is generally recommended, as it offers appropriate security and ease of operation.

RECOMMENDATIONS

Case-based monitoring across the continuum of care

While digital case-based TB notification is the most basic and important data variable and early indicator for the development of a digital TB surveillance system that all countries should strive to achieve, one of the key processes and functional recommendations common to all countries is to achieve a comprehensive workflow-based system to monitor individual cases throughout the entire continuum of care – from client enrolment and risk assessment through to screening, referral, testing, treatment, treatment adherence, treatment outcome, comorbidity management and post-treatment follow-up. This should also ideally include the complete screening pathway for TB disease and infection for vulnerable groups such as HIV patients and contacts of people with TB in order to identify and refer clients for TPT.

Advanced analytics for better data use

One of the most crucial aspects of the assessment was to review the status of data use in the countries. Most country programme leaderships unequivocally consider this to be one of the most crucial areas. Although most countries have some form of data and data use tool, very few countries have a real-time dashboard with data at the lowest levels, not only for M&E purposes but also for better patient management and care. There are various innovations that can result in the most effective use of data for programmatic improvement. Some of the recommendations include:

- Enabling real-time monitoring of the cascade of care pathway;
- Big data analytics and AI-based predictive modelling, mapping, risk profiling and prioritization for actions of people with TB using appropriate machine learning and AI systems;
- Geospatial analytics;
- Integration of CLM indicators with programme indicators;
- Automated AI-based job aids for programme staff, etc.

Given that there are different data systems working in conjunction, it is also recommended to explore creation of a centralized data repository/data warehouse system, bringing data from multiple sources into one place.

Existing country tools like DHIS2 have strong data analytics and dashboard functionality with robust indicator configuration.

It is also recommended to explore best-of-breed tools such as Tableau and Power BI, which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework.

Community Led Monitoring (CLM)

Community-based monitoring (CBM)/CLM is one way of generating granular data to provide feedback to service providers and decision-makers in order to collaboratively solve barriers and bottlenecks to services and improve the quality of services. Examples of CBM models include community treatment observatories, human rights complaints mechanisms, and scorecards. Users and communities gather, analyse and use information to improve access to services, better target resources, and address human rights and gender barriers. This is crucial for the overall success of the programme. One of the key recommendations is to fully integrate CLM into the programmatic framework of the country. This can be achieved in different ways, as outlined below:

- Include CLM indicators among the core indicators of the NTP – mainly in terms of how different barriers to services reported by the community are impacting programmatic targets and outcomes.
- Promote CLM data collection by CSOs and other human rights organizations, or include key CLM data variables as part of the M&E of the national programme.

e-Training

Providing training to health staff at the lowest level units has always been a challenge. The COVID-19 crisis has only broadened the training gaps, resulting in huge data quality issues related to the completion of data, timeliness of data, and authenticity of data in the M&E process across the globe.

Developing comprehensive e-Training/e-Learning platforms to facilitate synchronous and asynchronous video and audio training sessions, dynamic training content management systems and the use of gamification has the potential to improve data collection and data use processes and contribute to CME and Manuals of Procedures for TB programmes.

RECOMMENDATIONS

A costed action plan for digital TB surveillance

An estimated budget has been recommended for each country for strengthening its digital TB surveillance system based on the country's current e-readiness and IT capacity, maturity of the existing platform (case-based vs. aggregated), number of facilities and users, and other parameters (see Figure 3). However, countries need to develop a costed action plan for strengthening their digital TB surveillance system.

The estimated budget is only designed to provide a rough estimate of the costing and should by no means be considered to be the final budget requirement. Each country is encouraged to evaluate its country-specific budget needs based on the current funding available and vision for creating a case-based TB surveillance system. Based on the NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements, supported by a detailed work plan with timelines.

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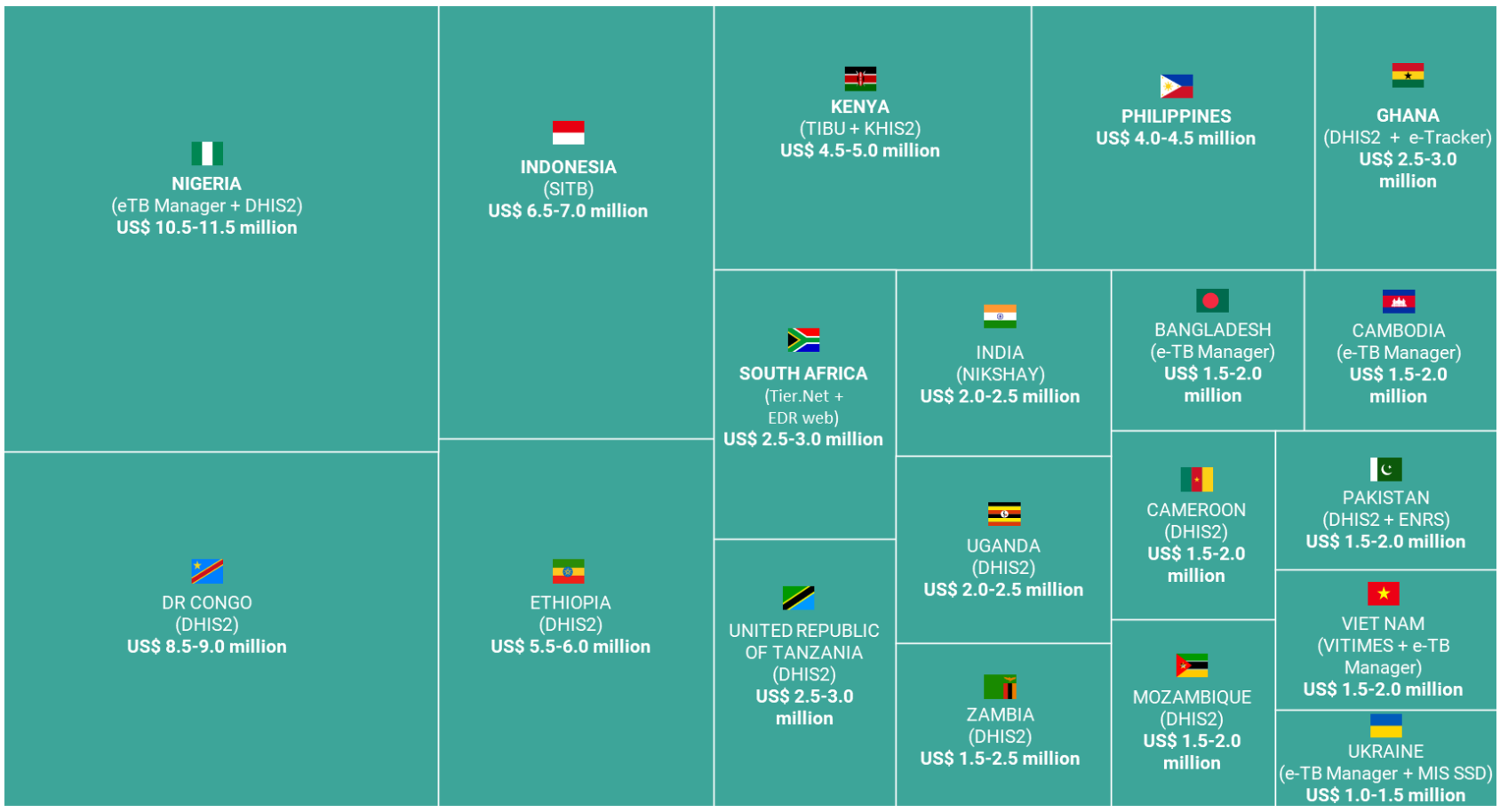
Figure 3 Estimated resource need for digital TB surveillance system



HOW TO READ THE COUNTRY REPORTS

AUDIENCE

The primary audience of the report is the NTP and IT cells within the Ministry of Health of each country. The assessment report also targets a broader audience that includes donor organizations, implementation organizations, NGOs and CSOs, among others. Table 5 shows the ways in which each stakeholder can benefit from this report.

Stakeholders	How it will benefit
National TB Program	Devise operational strategies to achieve real-time case-based surveillance and plan and advocate for resources.
Ministry of Health	Make policy decisions on integrated surveillance, data security, use of technologies and budgets.
Donors/Funding Organizations	Make high-impact investments for rapid transitions to real-time TB surveillance systems.
Country IT Teams/ Tech Solution Providers	Learn from best practices from all countries to further enhance existing digital offerings to countries.
Public Health Researchers	Better understand the data ecosystem in the countries that can be leveraged for epidemiological and other public health research.
Implementation Partners /NGOs	Converge different digital innovations being implemented by NGO partners to complement the existing national data ecosystem through integration and data harmonization.
Civil Society Partners/Advocacy / CLM partners	Promote evidence-based CLM and advocacy by harnessing and integrating with national data systems.

Table 5. How the assessment can benefit each stakeholder

KEY COMPONENTS OF THE COUNTRY FACT SHEET

Background

This provides a high-level overview of the country's TB programme, starting with the TB disease burden in the country using the latest data up to 2020 and other key indicators regarding TB care and prevention. This is then followed by the country's vision and commitments indicated in its latest National Strategic Plan (NSP). The background also gives a high-level overview of the enabling environment and digital ecosystem, which have a direct influence on the adaptation of digital TB surveillance tools and their scale-up within the country. This overview includes influencing factors such as a country's digital capacity, Internet penetration, mobile penetration, and so on.
The background also provides a brief summary of the current status of digital TB surveillance tools used in the country, whether these tools capture case-based or aggregated data, and the level of data collection (i.e. facility vs. district vs. provincial, etc.).

Brief of digital TB surveillance system

This section provides a comprehensive snapshot of the digital TB surveillance tool that is being used or scaled up to a national scale. It is important to keep in mind that many countries have multiple systems for capturing TB data that might be deployed at different scales (i.e. proof of concept or pilot stage); however, this section only considers the system that is used for national reporting of TB cases.
This section captures a narrative about the national system currently in place, the granularity of data collected (case-based or aggregated, the lowest level of data collection, country capacity, ownership of the platform and other related aspects).

Success stories

The success stories attempt to capture the most innovative components and major achievements in a country in terms of its conceptualization and development of a digital TB surveillance system. These stories can range from highlights of specific innovative modules such as contact-tracing modules, presumptive screening modules, or CLM modules that complement the main TB surveillance system to details of how countries have enabled integration of the digital TB surveillance system with external systems such as GeneXpert, laboratory information system or logistics management/medicine inventory systems.

Private sector

This section provides information on how countries are leveraging their digital TB surveillance systems to enable and improve private sector notification and the current private sector notification status.

Enabling environment

This section provides a narrative about the enabling environment and digital ecosystem, which have a direct influence on the adaptation of digital TB surveillance tools and their scale-up in the country. The narrative discusses influencing factors such as the country's digital capacity, Internet penetration, mobile penetration and so on.

Available resources

This section provides an overview of the current funding resources available to the country that can potentially be leveraged for digital case-based TB surveillance. However, this section by no means provides the entire NTP budget available or future funding expected. Therefore, this section should only be used as an additional piece of information and not for any future budget considerations.

Cascade of care

This section provides a snapshot of the different components of the entire continuum of TB care and a person's journey from presumptive TB screening and testing through to treatment, treatment support and adherence, treatment outcome, post-treatment follow-up and contact-tracing. This section also captures how data are captured at each stage along the continuum of care (digitally or manually and, if digitally, whether case-based or aggregated). It is important to note that this section captures whether the country has developed modules to capture data at each of these stages and not necessarily whether it has scaled these up to the national level.

Data variables

This section provides a high-level overview of what data variables are captured by the national programme and whether these variables are captured through a digital medium. The table is colour-coded for easy comprehension of whether the data captured are manual or digital and, if digital, whether they are case-based (indicated by a green tick mark) or aggregated (indicated by a yellow tick mark).

Indicators

Very similar to the data variable section, this provides a high-level overview of what indicators are reported by the national programme and whether these indicators are reported through a digital medium. The table is colour-coded for easy comprehension of whether the data reported are manual or digital and, if digital, whether they are case-based or aggregated.

Roadmap

This section provides a pictorial representation of the national programme's digital TB surveillance journey. It captures key milestones and achievements by the NTP from the inception of the digital TB notification tools to their current status and the programme's future vision and plans. This section tries to capture as concretely as possible specific modules or digital components that the NTP is planning to develop to further strengthen TB surveillance.

Ancillary systems

The table provides a compilation of various complementary digital tools (identified with the NTP) that are being used in the country to support TB treatment adherence, logistics management, laboratory record-keeping, result dissemination, CLM, pharmacovigilance and contact-tracing. These digital tools are further mapped with the primary channel of data inflow, details of the development and supporting agencies, and the scale of implementation for each of the identified technology solutions.

Challenges

Based on the country inputs, this section provides an account of the key challenges faced by the country in terms of planning, implementing, monitoring, integrating and/or scaling up the technology interventions. As a common indication, the challenges encountered by a country are most often dependent on the stage of development and implementation of the country's TB surveillance system.

Vision

These are a few key areas of focus for the country's NTP, as discussed in the various steps of this assessment. As a general practice, the points included here are further aligned with the suggested strategies and directives of the NSP and important milestones for establishing a case-based TB notification and surveillance system.

Budget requirement

Based on the country's feedback and recommendations, this section provides an estimate of the budget required to address the challenges and make progress towards the vision over the next three years. The budget is broken down to include specifics for hardware and infrastructure, software development, and capacity-building at various administrative levels of the health system.

Recommendation

To address the gaps and challenges identified through the assessment, this section provides a list of country-specific recommendations with timelines for execution over the next three years. These recommendation points have also been aligned with the system of choice and the suggested efforts of the TB programme (as per the NSP), and thus are projected to meet the broader vision for establishing a well functioning real-time digital case-based surveillance system for TB in the country.

DISCLAIMER

Some disclaimers need to be considered while reading this report.

Budget

The country snapshots provide information on the estimated budget required for each country. The numbers shared are only ballpark figures based on certain assumptions and standard budgeting principles designed for the purpose of this report based on guiding principles and typical budgeting components. Countries should independently evaluate their resource needs and budgets accurately based on the current maturity and e-readiness of the digital platforms, IT capacity and funding availability. We recommend countries to come up with a detailed budget plan for developing and scaling up a comprehensive digital TB surveillance and reporting system.

Recommendations

The recommendations in the country fact sheets provide a high-level plan that takes into consideration multiple factors, such as countries' future digital roadmap, challenges, vision and current status of the digital platform and capacity already available. Countries need to leverage the existing capacity and complement current efforts they are already making. The recommendations provide structured guidelines and best practices that could help countries to reach their digital goals and fulfil their vision. However, countries should independently evaluate each of the recommendations and timelines based on different factors such as budget availability, e-readiness, capacity and so on.

CONTINUITY

As many of the countries' vision and advancement in digital transformation are constantly evolving based on different programmatic and political needs, this assessment report should be a living document that is periodically and incrementally revised by countries once every six months in order to yield the most benefit from this report.

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ANNEX 2 – APPROACH AND METHODOLOGY

DATA COLLECTION

Country engagement process

As an initial introduction to the project and to seek the NTP's support, the Executive Director's Office of Stop TB Partnership shared an official letter in the month of July 2021 informing and inviting 20 NTP managers of high TB burden countries to participate in this assessment process. The countries were Bangladesh, Cambodia, Cameroon, DR Congo, Ethiopia, Ghana, Myanmar, India, Indonesia, Kenya, Mozambique, Nigeria, Pakistan, Philippines, South Africa, Ukraine, Uganda, United Republic of Tanzania, Viet Nam and Zambia. All countries responded except for Myanmar; it was decided to postpone the assessment of Myanmar. A series of follow-ups were done to seek a convenient time to organize the workshop from the office of Stop TB Partnership. The following were the areas for which countries' engagement and participation were requested:

- As a first step, all countries were invited for an introductory meeting wherein they were introduced to the project, objectives and expected outcome.
- Countries were also requested to complete the online questionnaire shared with them beforehand.
- Countries were also requested to appoint a point of contact who could lead the coordination on behalf of the NTP.

The list of NTPs who were contacted with dates can be found in Annex 1

Tools for data collection

Various tools and documentation templates were used as part of the data collection process. The following are some of the tools and templates used:

- Detailed survey questionnaire: A detailed questionnaire was administered during the assessment workshop calls with the national programme representatives. This involved real-time data transcription by the assessors using an Excel tool during the focus group discussions.
- Online survey: This online tool was developed to gather responses from the NTP team members in each country. The objective was to better optimize time during the assessment workshop calls.
- Desktop research data collection template: Detailed desktop research was done before the introductory workshop and assessment in order to optimize time during the calls and help with targeted and specific probing questions.
- Probing questionnaire: Based on the desktop research, specific and focused questions were asked and validated.
- Analytical framework/country assessment template: This was the most important and elaborate tool of the entire assessment. The analytical template consists of the complete country assessment information put into a structured format. The framework enabled subjective and unstructured information to be converted into more structured and analysed insights. This also enabled recommendations to be captured as one of the core components of the assessment report.
- Minutes of the meeting (MoM): There were primarily 3–4 calls (introductory call, detailed functional assessment, detailed technical and financial assessment call, follow-up call) per country as part of the core assessment process. Each call was recorded and detailed minutes were shared and re-captured with the country representatives. All video recordings have been archived and can be obtained upon request.
- Introductory PowerPoint: This was an anchor presentation that was used for the first introductory meeting with the NTP, highlighting the objectives and rationale for this assessment and seeking the representative's support for the entire assessment duration.

CURATION

Once the data collection process was complete, the data gathered by the team from different sources (i.e. desktop research, online survey, introductory meetings, and detailed workshops) were curated to extract meaningful insights for country-wise compilation of this report. The exercise was repeated periodically during the assessment, and a step-by-step process was followed to conduct the data curation:

Documenting the data

The first step in the process was to make sure that the data were adequately documented. A designated team worked on compiling all the data in country-specific folders and proofreading the first-version files to check for any inconsistencies or errors, which would help to identify areas requiring more information or clarification. The primary intention of this exercise was to assess and improve the intelligibility and ease of use of the collected information by putting it in a logical order.

ANNEX 2 – APPROACH AND METHODOLOGY

Asking questions

Based on the issues noted in the last step, the curator gathered more clarity around the identified inconsistencies or gaps in the documents. This was first done internally by either taking a further dive into desktop research or reviewing the meeting notes from other team members, or by asking questions of the documenter. In instances where the collected information was still insufficient to fill in the gaps, questions were shared with the country point of contact and follow-up meetings were convened if required.

Translating into standardized formats

With all the information in place, the data were translated and put together in standardized formats, mostly by standardizing the MoM document and further detailing the assessment template with the additional data. In doing so, the information was in a more usable format and presented logically for the country NTP teams and the report documenters in the next steps.

VALIDATION

A crucial step after each round of country engagement was to validate the findings internally, as well as with the country teams. The validation process for each country consisted of three steps:

1. After the initial introductory meetings, the MoM document (in a standardized format) was shared with the country NTP team. Their comments were sought to ensure that the understanding gathered from the discussions was correct. The feedback received was incorporated in the final versions of the country documentation.
2. The detailed assessment template for each country was pre-populated with basic findings from the desktop research and introductory meetings, and further filled out during the detailed functional and technical workshop in screen-sharing mode. The country NTP teams were encouraged to validate the data presented, provide more inputs to refine the recorded data and suggest corrections wherever required.
3. The compiled analytical frameworks (templates for country factsheets) were subject to the following process:
   - First, the frameworks were shared internally with the assessment team – Dure Technologies and Stop TB Partnership – for the first round of validation. The received feedback was incorporated.
   - The improved versions were sent to the country NTPs for their validation of the processes, challenges, vision and other components of the template. The final versions of the country factsheets were thus compiled by incorporating the country feedback received.

ANALYSIS

The collected data for each country was analysed using a standardized template that was designed specifically for this assessment project. The “Analytical Framework” template was designed at the onset of the assessment and was mapped to various data points in the other tools (like the assessment tool) used for engaging with the country teams. The data analysis process focused broadly on the following areas:

Technical feasibility analysis

- Technical/IT capacity analysis
- Information system architecture analysis
- Enabling environment and ecosystem analysis

Functional analysis

- Workflows and processes
- Functional modules analysis
- Data variables analysis
- Indicators and data use analysis

Policy and budget analysis

- o Political commitment and vision
- o Financial availability and commitment

ANNEX 2 – APPROACH AND METHODOLOGY

RECOMMENDATIONS

In line with the assessment objectives, the ultimate outcome of the country engagement and data analysis was to formulate specific recommendations for strengthening current systems and fast-tracking the plans envisioned by the NTPs. This final step of the broader exercise started with the preparation of a detailed master recommendation directory with inputs from internal and external stakeholders.

These recommendations were defined to match the country requirements identified in the desktop research, online survey responses, introductory meetings, and detailed workshops. These recommendations were classified in multiple groups and mapped against the general level of maturity of the national-level digital TB surveillance systems and country plans. Ultimately, the recommendations were customized for each country based on its specific needs. All country recommendations were drafted to address these fundamental questions:

- What can be done? The recommendations include steps that are needed to implement specific policies or actions that align with the country's interests, and the resources that would be required to take forward these initiatives.
- What benefits? Recommendations also comment on the feasibility of implementing the solutions and the adaptations induced by these actions. They talk further about the future of these enhancements and the related upgrades needed to bring the tools closer to the benchmarked standards for TB surveillance.
- What additional changes? Apart from the technical enhancements, the recommendations also point to policy-level interventions and strategic initiatives that should be practiced by countries to create a conducive ecosystem and sustain the solutions over time.

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ADDITIONAL RESOURCES

1. Guideline: Recommendations on Digital Interventions for Health System Strengthening
2. Classification of Digital Health Interventions
3. National eHealth Strategy Toolkit
4. https://www.digitalhealthindex.org/
5. Digital Implementation Investment Guide
6. Digital Health Platform: Building a Digital Information Infrastructure (Infostructure) for Health
7. https://www.who.int/data/data-collection-tools/health-service-data/toolkit-for-routine-health-information-system-data/modules
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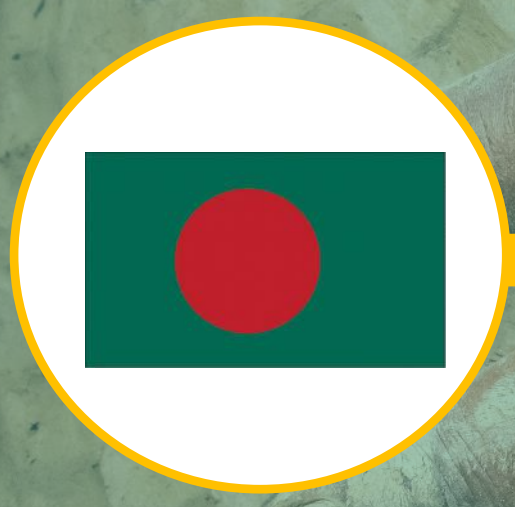
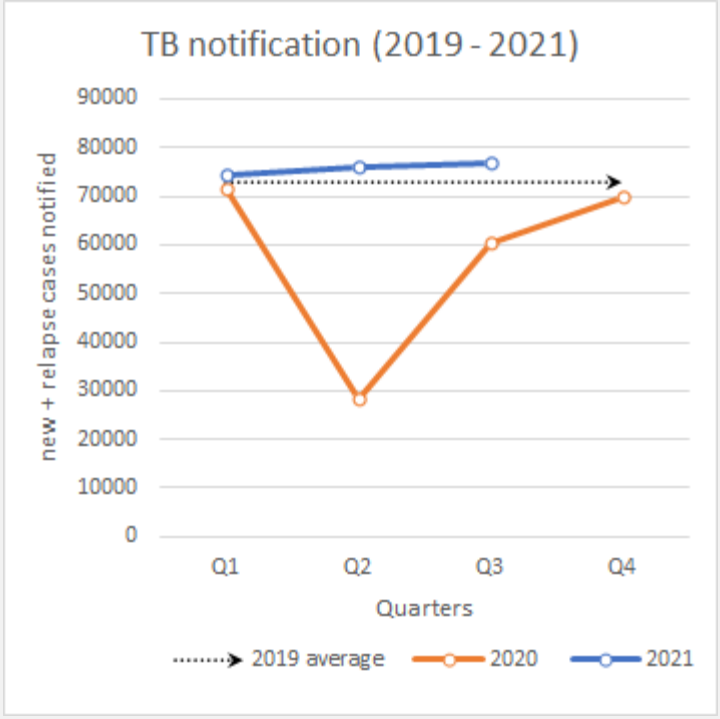


BANGLADESH

BANGLADESH

BACKGROUND

According to WHO estimates, of the 360,000 people with TB in Bangladesh in 2020, 230,880 got notified (Global TB report, 2021), and the drop was majorly attributed to the COVID19 pandemic in the country [1]. However, the country has revived its strong TB surveillance rapidly and TB notification has bounced back in 2021 to surpass the reporting rates in 2019. (refer the figure below).



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Bangladesh is also among the 30 High Burden countries for TB, as well as Rifampicin/Multi-drug (R + Isoniazid) Resistant TB.[1, 2] Around 1,113 laboratory confirmed MDR-TB and 67 XDR-TB (R + any fluoroquinolone) have been reported in 2020.

Approximately 49% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have been put on preventive treatment. [1]

In order to achieve the key milestones of reducing TB deaths by 75 percent and TB incidence rate by 50 percent by 2025, NTP's National Strategic Plan [3] outlines a set of key interventions for implementation, such as introduction of innovative active case finding approaches (with special attention to patients with DR-TB and comorbidities and pediatric TB); expansion of the diagnostic network; integration of TB services into the health service delivery system by using the existing health structure; improvement of clinical management systems for DS-TB and MDR-TB and an agile electronic TB surveillance system, in accordance with the 'Digital Bangladesh-Vision 2021' [4]

Bangladesh National TB Program has committed to build an advanced digital ecosystem to support TB surveillance. It is a priority to shift entirely to paperless recording and reporting, and to support the same, **eTB Manager** is being used at a national scale for case-based TB notification for a completely paper-less TB notification (already done at all DR-TB sites). Country's national HMIS (**DHIS2**) is used as the key platform for electronic data management, and it is fed with Tuberculosis data from eTB manager as a quarterly aggregate reporting of TB cases in a dedicated dataset from all facilities across the country. In the current phase of transitioning to eTB manager, NTP's traditional excel based reporting is also being practiced alongside. NTP has already directed and informed all the divisional and district managers to go paperless and use eTB manager for routine recording and reporting of TB patient data.

It is known that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. While about 104.2% of the population is using mobile phone (i.e., at least one device per individual), the popularity of smartphones remains relatively low (41%), where internet access is only with about 28.8% population. Further enhancing digital inclusion in Bangladesh with access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's developmental aspirations. [5,6,7]

Apart from implementing eTB manager and DHIS2 platforms, the NTP in Bangladesh has a vision to leverage other digital innovations for better data collection and data use for positive programmatic outcome. An icddr'b supported intervention, Janao mobile app has been implemented as the digital tool for receiving case-based data from private providers and has been made interoperable with eTB manager for directly feeding data in the national system. Other digital tools being used by NTP & partners are further listed in the document.

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and the identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based TB surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program has been implementing primarily two tools for TB surveillance:

eTB Manager is National TB Program's tool for collection of case-based data on a daily basis. The system is implemented at a national scale, and refresher trainings are being conducted in phases to strengthen and regularize the notification from all DS TB sites. All DR TB sites (9) have already established paperless reporting in eTB manager directly.

DHIS2 based aggregated data collection system which is being used at all health facilities of Bangladesh. This is a component of the National HMIS platform and records quarterly aggregated data for the entire country.

NTP identifies eTB manager as a mandatory tool for case-based notification at all sites where it is functional, and with its national scale-up its integration with DHIS2 is further mandated to feed aggregate data to the national HMIS as per the MOHFW guidelines.

At the health facilities (Upazila Health Complex and Hospitals) with fully integrated eTB manager, the data is exported and added in DHIS2. While at other health facilities, data from compiled excel sheets is manually entered in DHIS2 directly.

In the present transition phase for eTB manager (i.e., until it is functional at all facilities), NTP's traditional excel based reporting system is also parallelly functional in the country and is considered as the most reliable source of TB data (98% accuracy).

SUCCESS STORIES

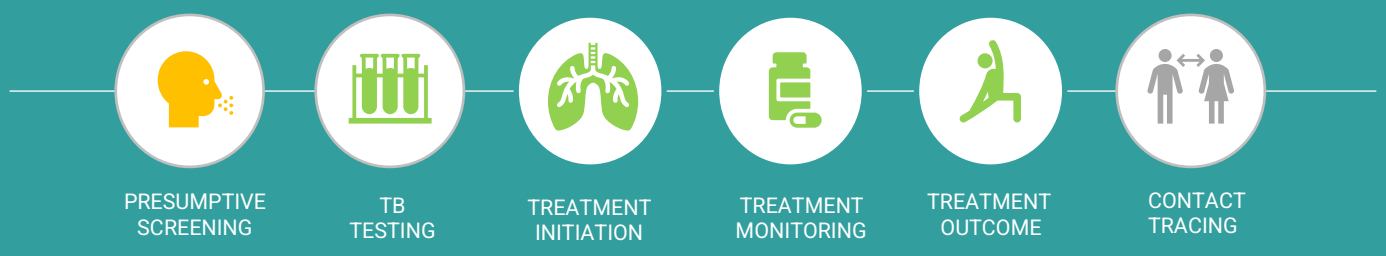
The implementation and establishment of eTB manager for case-based reporting from all health facilities across the country holds a special mention. Bangladesh is among the very few developing countries that have successfully rolled out a case-based surveillance system at national scale, which is directly integrated with country's national HMIS, i.e., the central server DHIS2 platform. With all Drug Resistant TB treatment centers digitizing the patient data in real time, and the strong commitment of the TB program to regularize DS-TB reporting by means of capacity building, the country will soon transition to a completely paperless reporting for all TB data.

Another notable success of the country TB program is the rapid recovery of TB notification during the COVID-19 pandemic. TB notification was majorly impacted by the first wave of COVID19 pandemic in 2020, but the country has has been able to bounce back the rates of TB notification and treatment initiation, reaching higher than the 2019 average.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				eTB manager reports, line lists DHIS2 dashboard
Divisional level	8	Data not collected from this level			eTB manager reports, line lists DHIS2 dashboard
District level	64	160	DHIS2 Web Application	Aggregate data	eTB manager reports, line lists DHIS2 dashboard
Reporting units (with more than 1 associated facilities)	858 (495 Upazila Health Complexes, and other hospitals)	DS TB – 858, DR TB - 9	eTB manager (80% DS sites, 100% DR TB sites) DHIS2 (non eTB manager sites) Excel (all facilities)	Case Based (Daily) Aggregated (quarterly) Case based	eTB manager reports, analyser, line lists DHIS2 dashboard
Community level	Data not collected from this level				No digital tool for data use

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Division, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	eTB Manager(80% DS sites, 100% DR TB sites), rest report aggregate data in excel/DHIS2
Lowest Unit for TB notification digitisation	Reporting centres (Upazila Health centres and other Hospitals)
Stage of notification	Diagnosis
Level of Access and Use of TB Notification data	Upazila Health center
Private sector notification	Manual notification process.
Frequency of digitization of TB notification	eTB manager- Daily DHIS2 - Quarterly
Mode of follow-up with notified cases	Manual follow-up- phone call, physical visit
Scale of implementation	DHIS2 aggregated system is scaled at National level, eTB manager – 80% DS facilities, 100% DR facilities
Contact tracing for TB notified cases	Module present in eTB manager, but not implemented yet
Multi-channel enablement	Private Providers & DOTS centres use a mobile application for notification
Govt. order for mandatory TB notification	Yes, Guideline issued in 2014

PRIVATE SECTOR NOTIFICATION

To ensure private sector notification, Janao mobile app was piloted in 2019 through a collaboration of NTP and icddr,b with financial support from USAID. After successful implementation in Dhaka metropolis, NTP has initiated the scale-up, starting from Rajshahi Division. Data for both Drug susceptible and Drug Resistant TB is entered in the application.

COUNTRY IT CAPACITY

Country Server
- Servers for DHIS2 are managed by the DGHS MIS, Ministry of Health, Bangladesh
- eTB manager hosted at MSH servers

Interoperability
Data export and import done between eTB manager and DHIS2.

Country IT team
DGHS MIS (and HISP Bangladesh) team manages the DHIS2 application; eTB manager is supported by a local IT firm, JANAO app supported by icddr'b

ENABLING ENVIRONMENT

100.2%
Mobile penetration (Jan 2021) [5]

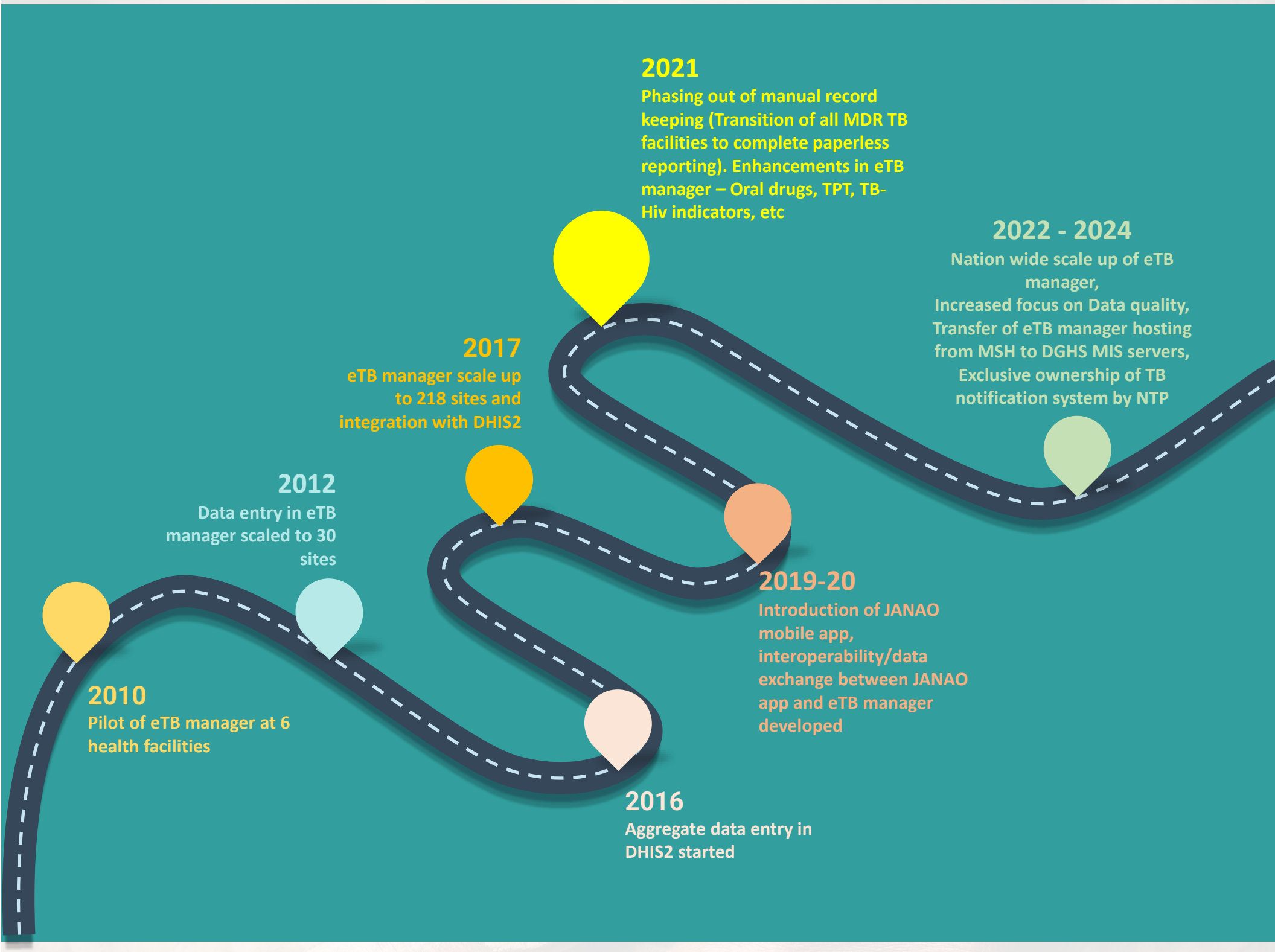
41%
Smartphone (Dec 2020) [6]

28.8%
Internet penetration (Jan 2021) [7]

CURRENT RESOURCES AVAILABLE

- Under the MTaPs grant from USAID, Bangladesh has received a 2-year long support for rolling out eTB manager country-wide (includes capacity building, logistics support, software development, upgradation, troubleshooting and system monitoring.
- USD 1.4 million has been granted for 2021-23 by The Global Fund for development of the TB module of eLMIS and its scale up.
- Additional funding of nearly USD 0.02 million has been granted by USAID to icddr'b for scale up of JANAO mobile app.
- Funding of USD 0.4 million (USAID, The Global Fund) is available for supporting the ongoing implementation, server cost, technical support other internet costs.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	99DOTS	Mobile application	Everwell	Icddr'b	Pilot
Logistic Management	Quant TB	Web Application	Ministry of Health	SIAPS	National
Laboratory Information Management	GxAlert	Web Application	Cepheid	USAID	39 GeneXpert sites
	Digital X-Ray (CAD4TB)	Web Application	DELFT CAD4TB	The Global Fund	Pilot
Community Led Monitoring (CLM)	mHealth, ConnecTB	Mobile App	National TB control Program	USAID	Pilot
Contact Tracing	eTB manager	Web application	NTP, Local IT firm	The Global Fund, USAID	Development completed, yet to be implemented

KEY CHALLENGES

- User training for all TB reporting units has already been done across the country, but the country has inconsistent digital infrastructure and logistics at DS TB sites. Inadequate logistic support at the remaining facilities is a major bottleneck for a country wide paperless reporting.
- TLCAs (TB Leprosy Control Assistants) are responsible for data entry to eTB manager, but they are heavily burdened (specially after COVID 19 pandemic). Also, the position is transferrable in nature, which causes a major scarcity of trained manpower.
- Refresher training is urgently required for streamlining the eTB manager data reporting and ensuring data quality, but the country faces a financial crunch to support this activity.
- DHIS2 being a common tool for all health programs and with it being owned by the MoH, any changes/ customizations in aggregate forms are to be routed through DGHS MIS, which causes significant delays.
- Without 100% transition to real-time case-based reporting in eTB manager, gaps will be encountered in access to real time data, its analysis and use for action.
- Inconsistency with electricity and internet connectivity, along with an inadequate maintenance/ on job facilitation support frequently causes reporting delays.

NTP VISION

- To ensure 100% scale up of e-TB Manager, completeness of data entry in e-TB Manager, in time reporting in online (e-TB Manager) and its interoperability with DHIS2.
- Further strengthen ON TIME reporting, realtime analysis of data within the platform of e-TB Manager and feedback.
- integration and sustainability of e-TB Manager within the National DG-MIS and adopting SERVER/ SOFTWARE -
- Continue the capacity (training) logistic support (computer, internet) and troubleshooting within GOB resources
- Improvement in data quality (accuracy, validity and precision) and reducing duplicity of effort in data entry.
- Real time dashboards for reviewing data against the targets from Strategic Plan.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Bangladesh has 858 TB reporting units and to provision mobile device for every facility for case-based TB surveillance, **USD 128,000** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Bangladesh has 495 upozila and 64 districts and 8 divisions and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 113,400** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 858,000** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Bangladesh would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Bangladesh already have a strong foundation for DHIS2 aggregated system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 495 districts, which could cost roughly USD 100 per district, amounting to **USD 49,500,** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 1.5 – 2.0 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Bangladesh

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step it is important for the country to create a comprehensive costed action plan for development, implementation and scale up of the TB case based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan with timelines. The plan will help the country to assess and monitor the progress and to mitigate risks

  Tentative timeline: Month 0-1

- **Device Procurement:** One of the limitations highlighted by NTP is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- **System Integration:** One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources (like GeneXpert) into the main eTB manager system as a central data repository for effective use.

  The current eTB Manager platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which would help in effective use of the data for the patient care continuum as highlighted by the NTP.

  Use of the recommended exchange / ETL tools like Talend and Informatica which include these features make the data management task much easier and simultaneously improve data warehousing needs to be considered. [8]

  The platform architecture of both the eTB manager and DHIS2 is highly compatible with these standard tools and processes making this an effective solution. [9]

  The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

  Tentative timeline: Month 0-6

- **Mobile app :** Implementation of data collection via mobile app to ensure ease of use and real time reporting

  One of the challenges reported by the NTP during the data collection processes is inconsistent data connectivity / network issues that delays reporting, and an inconsistent availability of hardware for data entry. One effective way to overcome this is to support the data collection processes by introducing a mobile application for the government facilities.

  Other advantages for a mobile application include better performance , effective use of device features like in house system updates , usage of location , security measures and tracking user patterns and issue log mechanisms and other analytics measures.

  Several mobile solutions for real time case-based notification can be explored for local adaption and building the mobile counterpart for eTB manager. Open source technologies like DHIS2 Mobile App, ODK and KOBO are some notable examples. [10]

  Enhancement of JANAO app based on the pilot findings and its expansion can also be a useful approach.

  Tentative timeline: Month 0-12

- **eLearning:** Packages to train health professionals on eTB manager use and workflows

  Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the eTB manager application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using eTB manager for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

RECOMMENDATIONS

Training tools like Moodle [11] built on standard LMS framework can be reviewed for application rollouts.

Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care, modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, especially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

❖ **Capacity building for application maintenance**

Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

Strengthening the NTP team with trained system administrators will help in reducing costs (in seeking technical support) and improving and expediting the planned implementations.

Tentative timeline: Month 6-24

❖ **Contact tracing application implementation**

To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

Tentative timeline: Month 6-12

❖ **Patient Interactive Systems :** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [12]

Tentative timeline: Month 6-24

❖ **Data Use :** The NTPs plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

Building on the current eTB manager and DHIS2 visualization modules that offer a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports and individual line lists are extremely useful.

Apart from the standard DHIS2 and eTB manager dashboard features (and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics) it is recommended to use best of the breed tools like Tableau , Power BI which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [13]

Tentative timeline: Month 6-12

Strategic Technical Recommendations

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan that would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for

RECOMMENDATIONS

data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption and exchange standards.

Additionally, the advance admin features offered by this version help the administrators to support the operational needs better for onboarding users , real time change in data variables and user management etc effectively.

Apart from this version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises. [14]

- ✓ **Performance Optimisation & Testing** : To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable a reliable platform and which also helps in architecture updates and augmentation.

  Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in database sizing and planning need to be adapted for effective planning . [15]

- ✓ **Application & System Security Audit**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[16] to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by DHIS2 [17] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [18]

ACKNOWLEDGMENT

We thank the Line Director National TB and Leprosy Program, ***Prof. Dr. Md. Shamiul Islam*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Rupali Sisir Banu*** for providing valuable insights into Bangladesh's vision for creating an advanced case-based TB surveillance and notification system.

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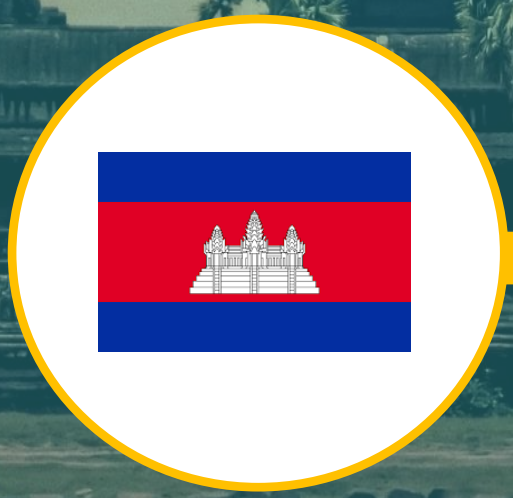


CAMBODIA

CAMBODIA

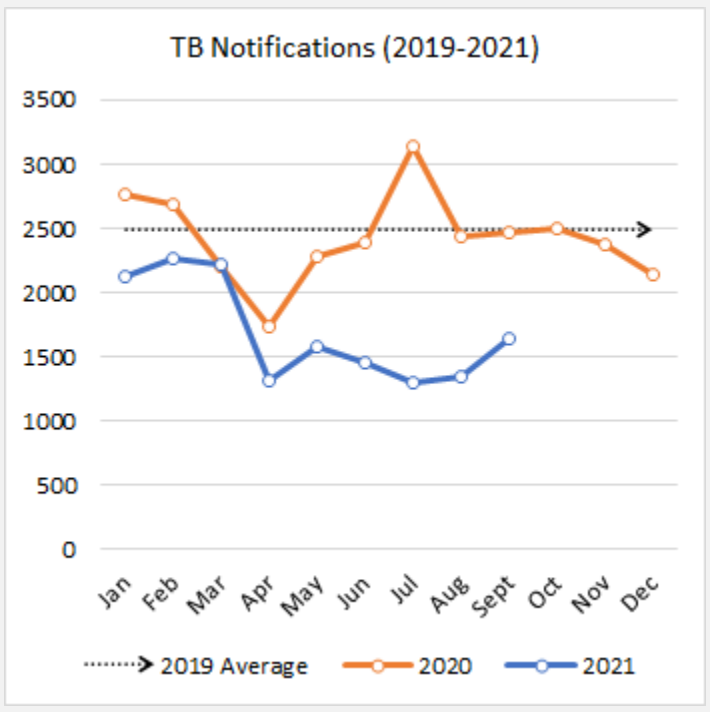
BACKGROUND

Cambodia is one of the 30 high burden TB countries, with an estimated incidence of 520,007 302 (95% CI: 169–473) per 100 000 population in 2020 of which the NTP notified 291,000.[1]

While there have been successes in the treatment of drug-susceptible TB (DS-TB) and multidrug-resistant TB (MDR-TB) in Cambodia, case detection of all types of TB remains a challenge, with more than 40 percent of estimated cases remaining undetected.[2] Prolonged delays to TB diagnosis and treatment, and the burden of undiagnosed cases in the community continue to perpetuate transmission of the infection.[3]

It was estimated that 60% of Cambodia's population were infected with TB [4] As the population ages, the prevalence of active TB is projected to increase to 33% in the next decade.[5] It is thus pertinent to reach TB affected individuals and ensure prompt linkage to diagnosis and effective treatment to break the cycle of TB transmission.[3]

During the COVID19 pandemic, country's TB case notification has remained broadly unimpacted in 2020, however, with the first wave hitting in later part of 2021, the TB case notification has been heavily impacted and the health system is now making efforts to revive its strong TB surveillance practices and reach back to the previous rates.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In 2015, through USAID TB care 1 Program, NTP introduced eTB manager as the MIS solution for recording and reporting of TB in the country commonly referred as Cam TBMIS.

It was one of the initial efforts by NTP to change user behavior for improved data completeness and accuracy.[6] Over the years the platform has been matured, stabilized and is nationally scaled. Other important health information system in Cambodia is SMS system for TB, a web-based text messaging system used to relay sputum smear test results on time. This helps in reducing the delay in treatment initiation and thereby achieving better treatment results and preventing further spread of the TB infection.[7]

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As per 2021 figures, about 125.8% of the population has a cell phone, and about 63.7% (2020) use smartphones. Internet penetration stands at 52.6% in the country. Enhancing digital inclusion in Cambodia is essential, given that access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's development aspirations.[8,9]

Under its National strategic plan (NSP) 2021-2030, NTP envisions early TB detection and treatment initiation by using more sensitive screening and diagnostic algorithms with an emphasis on reaching missing cases. Improving community and people-centered care and treatment approaches, public-private mix (PPM) MDR-TB, and TB in vulnerable populations (e.g., prisons, migrants, children, patients with comorbidities like diabetes or HIV co-infection). Based on these objectives, NTP has carved out strategic plan with series of new interventions to Strengthen NTP monitoring and evaluation (M&E) systems. Improving the quality of TB laboratory and diagnostic services at health facilities; strengthening active case finding (ACF) approaches; improving community TB care; strengthening the implementation of TB services in prisons and correction centers; and improving overall TB M&E and surveillance systems.[5]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based TB surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program has been implementing the following tool for TB surveillance:

Version 2 of e-TB Manager, commonly referred as **Cam TBMIS** is National TB Program's tool for collection of case-based data. All DR-TB data is entered directly into this system, while the records of DS-TB are maintained in manual TB registers at the TB centers/ hospitals, and further reported (case based) from the facilities (where functional) or district level, on a quarterly/monthly basis. The platform is envisioned for a national scale up and use in real time across all DS TB sites too, in a phased manner.

NTP identifies Cam TBMIS as a mandatory tool for TB notification at all sites where it is functional and with its national scale up and is aiming to enhance this to a more comprehensive record keeping system, which would be interoperable with national HMIS.

NTP is seeking help in building a TB MIS app which is embedded with the national TB MIS system and has an enhanced UI and dashboard features that will improve data entry at facility level. Starting from next year, the TB MIS app will be rolled out in 10 operational districts for case-based data reporting from each TB facility.

In the present transition phase for Cam TBMIS (i.e., until it is functional at all facilities), NTP's traditional excel based reporting system is also parallelly functional in the country. NTP wants to eventually phase out the paper based records and wants to move to real-time case-based data entry.

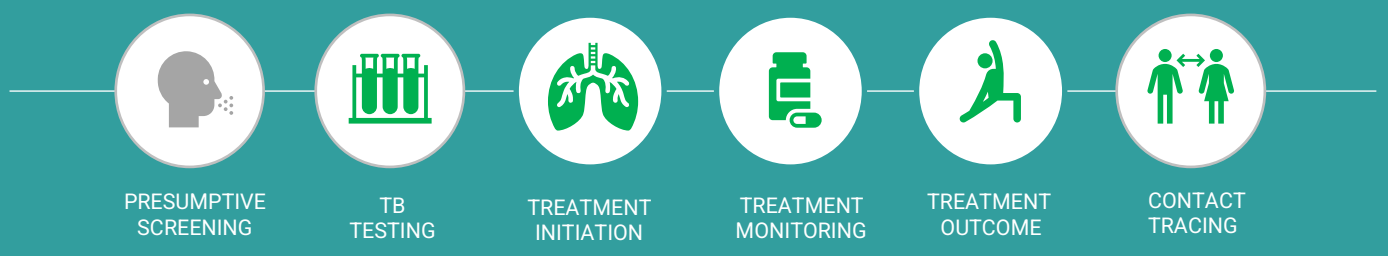
SUCCESS STORIES

In 2018-19, based on the Community, Rights and Gender Assessment (CRG) report, KHANA and the NTP introduced **OneImpact community-led monitoring (CLM) platform.** OneImpact empowers people affected by TB to access health and support services, claim their human rights, and identify and reduce stigma. Through an innovative mobile application, OneImpact CLM encourages and facilitates the participation of people affected by TB in all aspects of TB programming to activate a human rights-based, people-centered response. In doing so, OneImpact CLM supports people affected by TB to successfully complete their TB journey, while strengthening accountability and responsiveness in TB programs, with special attention to gender-related barriers to services and the experiences of key and vulnerable populations.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				Cam TBMIS dashboard and line lists, Quarterly Reports
Provincial level	25	Data not collected from this level			Cam TBMIS dashboard and line lists, Quarterly Reports
Operational District level	103	103	CAM TBMIS	Case Based	Cam TBMIS dashboard and line lists, Quarterly Reports
Facilities	1400 (treatment centers, including referral hospital)	100 health centers (own computer provided Ministry of Health)	CAM TBMIS	Case Based	Cam TBMIS dashboard and line lists, Quarterly Reports
Community level	Data not collected from this level				Data not used at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	
Comorbidity disaggregated treatment outcomes (proportions)	
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	eTB Manager – Cam TBMIS
Lowest Unit for TB notification digitisation	Treatment health centres
Stage of notification	Treatment Initiation
Level of Access and Use of TB Notification data	District level
Private sector notification	Private sector can only refer suspected cases to public facilities. No treatment provided
Frequency of digitization of TB notification	MDR-TB : Daily DS-TB : Monthly/Quarterly
Mode of follow-up with notified cases	Manual follow-up- phone call, physical visit
Scale of implementation	National roll out
Contact tracing for TB notified cases	Cam TB MIS – TPT module
Multi-channel enablement	Mobile app usage for data entry being piloted (USAID commit project)
Govt. order for mandatory TB notification	None

PRIVATE SECTOR NOTIFICATION

Even though Private providers are sometimes the first point of contact for treatment, they are not yet treating the TB cases. As per NTP directives, they can only refer cases to public facilities. However, realizing this gap, NTP has now planned interventions under its NSP 2021-2030 to engage private providers in TB notification and treatment.

COUNTRY IT CAPACITY

Country Server
Platform is hosted at CENAT (National Center for Tuberculosis and Leprosy Control) servers

Interoperability
Data export functionality is available, but yet to be used for any integrations

Country IT team
MoH and CENAT has developed the system with an external consultant, and is managed by in-house IT team

ENABLING ENVIRONMENT

125.8%
Mobile penetration (Jan 2021) [8]

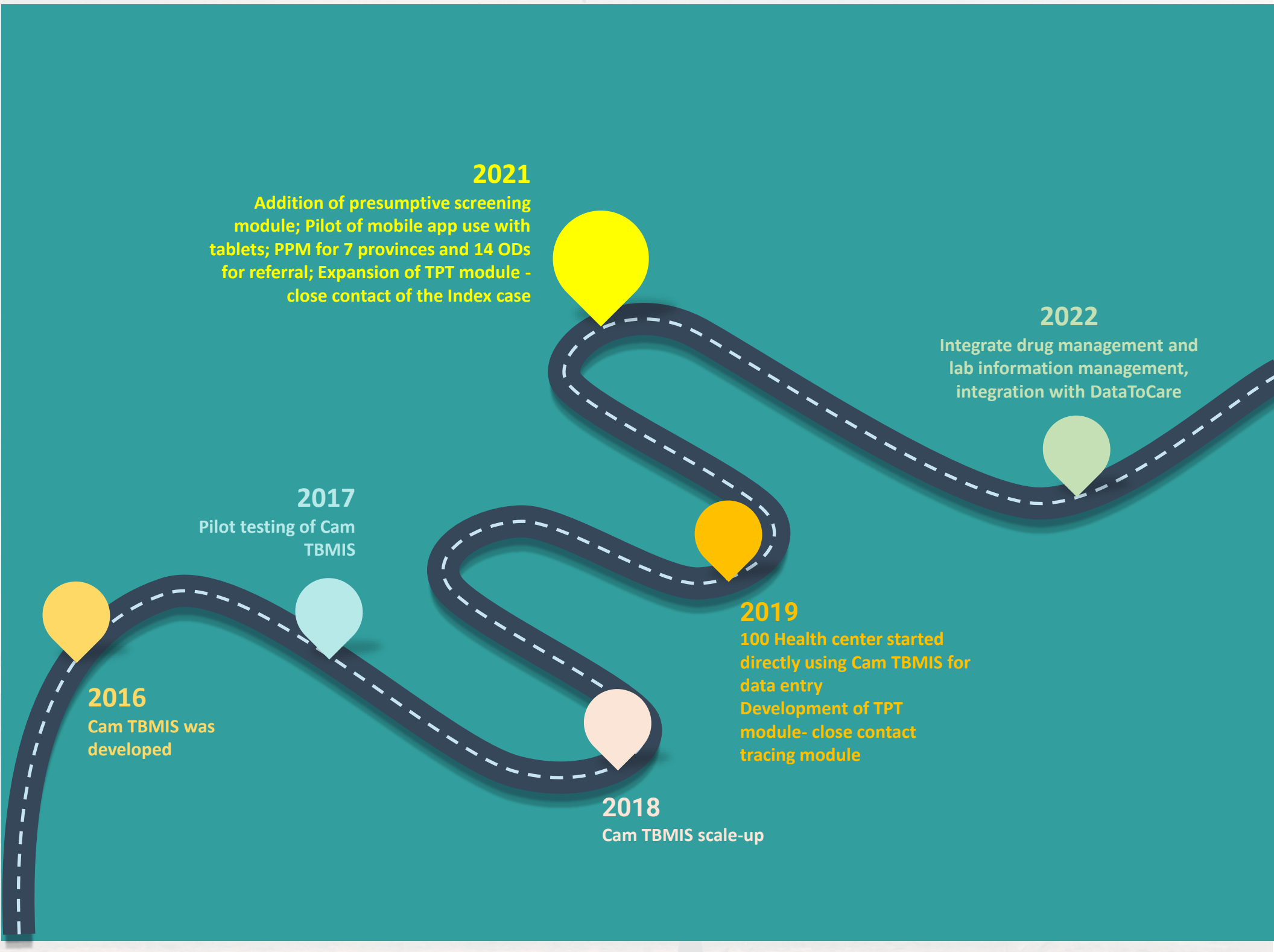
63.7%
Smartphone (2020) [9]

52.6%
Internet penetration (Jan 2021) [8]

CURRENT RESOURCES AVAILABLE

- Under USAID TB care program 1, NTP introduced e-TB manager for TB recording and reporting. USAID roughly invested USD 1 Million in piloting e-TB manager in MDR–TB facilities and providing hardware support to facilities. USAID funded for 11 desktop computers, 11 uninterrupted power supply units, 10 printers, and 12 internet modems were distributed to 9 health facilities and 3 laboratories that were piloting e-TB Manager.[6]
- NTP Cambodia expanded eTB manager to DS-TB under USAID funded HIPA project. MSH facilitated its official's knowledge exchange visits to Bangladesh to improve and strengthen the overall systems. HIPA project supported the system uptil 2018. [6]
- USD 12,000 (only the server) and 3 IT people currently available for managing the software- USD 50,000 per annum.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Cam TBMIS	Web application	Palladium	USAID	Pilot
Logistic Management	Nil	NA			
Laboratory Information Management	Cam TBMIS	Web Application	Palladium	USAID	To be rolled out soon
Community Led Monitoring (CLM)	OneImpact	Mobile App	Dure Technologies	Stop TB Partnership	Pilot
Contact Tracing	Cam TBMIS	Web application	Palladium	USAID	Pilot (Being scaled up)

KEY CHALLENGES

- **Shared Hardware:** NTP is using shared laptops/ desktops across the multiple programs which hampers timely data entry and hence it is usually delayed by a week or 10 days.
- **Data entry burden:** Maintaining Parallel data entry manual records and digital records (for multiple programs), increases the workload on facility staff.
- **Lack of trainer manpower:** With high attrition rate at the data reporting rates and inadequate training, there is a gap in manpower availability for entering data in TBMIS.
- **Data quality and Data Duplication:** Currently, data entry points are limited (only OD TB supervisors and Hospital DEOs), and duplication of data is solely dependent on either the system prompts or manual audit of the data against aggregate data. NTP would like to link unique identifiers would help in patient tracking & monitoring.
- **Timeliness of Data availability:** Majority of TB centers enter data on quarterly basis, very few centers enter data monthly or bi-monthly, or weekly basis. With such inconsistencies in frequency of data entry, data is not available real time for stakeholder use.
- Maintaining uninterrupted **internet availability** at a few facilities is challenging.

NTP VISION

- Transition to a real time case-based data entry. A comprehensive record keeping system TB MIS which is interoperable with national HMIS
- Improving the cascade of care by adding new modules (presumptive TB, Screening) and scale e-reporting of TB cases throughout the country using e- TB manager (TB MIS), aiming to make it functional by end of this year.
- NTP is seeking help in building a TB MIS app which is embedded with the national TB MIS system and has an enhanced UI and dashboard features that will improve data entry at facility level.
- Enhanced TB MIS application pilot roll-out in 10 operational districts for real-time case-based data reporting from each TB facility.
- Improving hardware support (with CSR engagements by computer companies) i.e., using multifunctional mobile tablets will be useful for taking forward field reporting.
- Building internal capacity of human resources for ensuring sustainability of software, system management and troubleshooting.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

Hardware and Infrastructure:

- Mobile Devices (for data collection): Cambodia has 1200 TB Treatment units and to provision mobile device for every facility for case-based TB surveillance, **USD 1,80,000** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): Cambodia has 1200 treatment facilities and 103 districts and 25 provisions and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 2,65,600** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 132,800** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
- Server: Based on the current volumes of new cases, Cambodia would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

Software Development:

- Based on various multi-stakeholder meetings and given the fact Cambodia already have a strong foundation for e-TB manager aggregated system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 103 districts, which could cost roughly USD 100 per district, amounting to **USD 10,300** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 1.5 – 2.0 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Cambodia

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the data collection processes for direct data entry from the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-3

- **Enhancement of Case Based Notification systems :** The NTP has already established Cam TBMIS as the national notification platform and has the required infrastructure in terms of database and deployment. It has also built the eTB manager expertise and capacity which acts as a strong foundation for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the Cam TBMIS app (in the enhanced version). The application should be further expanded to include monitoring of the entire continuum of care for both DR and DS TB, including presumptive screening, referral, treatment initiation, treatment adherence & outcome, and contact tracing in real-time.

  The solution architecture should support adding the additional components in phases, supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing program templates being used by other countries such as WHO's prevent TB tool or other tracker-based systems can be explored for fast-tracking the software development processes.

  Tentative timeline: Month 0-12

- **Data Integration:** The NSP (2021-2030) clearly highlights the importance of strengthening the TB Notification information system for improving all the TB service provisions

  Cambodia is using version 2 of e-TB manager for TB notification commonly referred as Cam TBMIS. To ensure that there is a seamless integration of data with Cam TBMIS, from multiple data sources like Lab information systems, CLM platform and other data sources like excel files maintained at facilities without any data loss, the data upload / export API should be explored.

  There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central database.

  While transformation and data export options offered by the current systems can be used for this other source ETL tools over Postgres DB and/or WHO powered XMart[10] which can be installed within the current environment can also be considered.

  Tentative timeline: Month 6-12

- **Mobile app :** Implementation of data collection via mobile app to ensure ease of use and real time reporting

RECOMMENDATIONS

NTP is seeking help in building a TB MIS app which is embedded with the national TB MIS system and has an enhanced UI and dashboard features that will improve data entry at facility level. This would help in tackling challenges like inconsistent data connectivity/network issues which delays reporting of cases, and an inconsistent availability of hardware for data entry. One effective way to overcome this is to support the current data collection processes by introducing a mobile application for the health facilities.

As is already envisioned by the NTP, a pilot on using android technology (mobile app) to encourage real time data entry and its further scale-up is required for mitigating the infrastructure and internet challenges at the facility level.

Other advantages of a mobile application include better performance, effective use of device features like in house system updates, offline data entry, usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

Several mobile solutions for real time case-based notification can be explored for local adaption and building the mobile counterpart for eTB manager/ Cam TBMIS. Open-source technologies like Android Capture app (DHIS2), ODK & KOBO are some notable examples. [11]

Tentative timeline: Month 0-12

- **eLearning:** Packages to train health professionals on Cam TBMIS use and workflows

  Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the Cam TBMIS application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff, i.e., to orient them on using Cam TBMIS for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  Training tools like Moodle [12] built on standard Learning Management System (LMS) framework can be reviewed for application rollouts.

  Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care, modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- **Capacity building for application maintenance**

  Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

  Strengthening the NTP team with trained system administrators will help in reducing costs (in seeking technical support) and improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- **Contact tracing application scale-up**

  To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated in the current module of the national TB notification tool, and be scaled up to fast track the country's efforts to eliminate TB and target the

RECOMMENDATIONS

initiation of preventive treatment for all TB contacts.

Tentative timeline: Month 6-12

- **Patient Interactive Systems :** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

  Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [13]

  Tentative timeline: Month 6-24

- **Data Use :** The NTPs plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

  Building on the current Cam TBMIS modules that offer a dashboard and linelist for reviewing program and data indicators, additional features of pivot table, event reports which support dimensions, data aggregation reports. etc are extremely useful.

  To strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics, it is recommended to use best of the breed tools like Tableau , Power BI which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [14]

  Tentative timeline: Month 6-12

- **Data Quality** :

  As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

  UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

  This should be generated automatically through the new case-based TB surveillance system that is already being planned.

  Data access control is one such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

  Tentative timeline: Month 6-18

RECOMMENDATIONS

Strategic Technical Recommendations

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Additionally, the advance admin features offered by the version 2 of eTB manager help the administrators to support the operational needs better for onboarding users, real time change in data variables and user management etc effectively.

Apart from this, version 2 of eTB manager also supports compliance to GDPR standards and offers more controlled data encryption practises. [15]

✓ **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in database sizing and planning need to be adapted for effective planning . [16]

✓ **Application & System Security Audit**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[17] to cover

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by eTB manager/ Cam TBMIS for patient data security, hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting.[18]

ACKNOWLEDGMENT

We thank the Line Director National TB and Leprosy Program, **Dr. Huot Chan Yuda** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Tieng Sivanna*** for providing valuable insights into Cambodia's vision for creating an advanced case-based TB surveillance and notification system.

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12. Application Training Tool : https://moodle.org/
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14. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
15. DHIS Security : https://dhis2.org/security/
16. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
17. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
18. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

CAMEROON

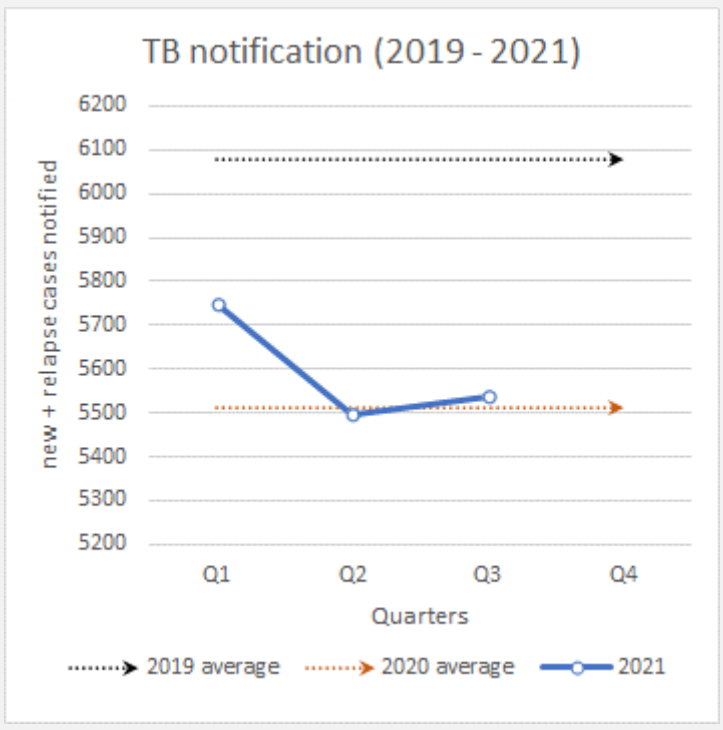
CAMEROON

BACKGROUND

According to WHO estimates, 46,000 people in Cameroon newly developed TB in 2020 (Global TB report, 2021), out of which 22,492 cases were notified. [1] With over 11,000 of all people with TB- are also infected with HIV, Cameroon is included in the list for the top 30 TB/HIV high burden countries. [2] Children account for nearly 5% of all cases, and many also suffer from TB-HIV coinfection.

These numbers have been on the decline for the last decade (Global TB report, 2021) [1]. In line with WHO's End TB strategy, Cameroon has achieved a treatment coverage of 48% of all people living with TB in 2020 (for reference, the target is 90% by 2030) and the TB case fatality ratio stands at 37%. 43% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have been put on preventive treatment.

Under the COVID19 pandemic, the TB case notification in Cameroon was impacted and the numbers reduced to lower than 2019, however, the country is now reviving its surveillance practices and the overall notification trend shows a steady improvement in 2021.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

While case-based TB data is currently managed in excel sheets and only aggregate data is fed into the TB component of the national HMIS (**DHIS2**), the NTP is developing an implementation plan for a DHIS2-tracker model that can integrate multi-facility data to enable a versatile and interoperable data management system.

With close support from University of Oslo and WHO, Cameroon has been working on adapting the standard DHIS2 TB Tracker reporting module according to the local treatment guidelines and is soon planning to pilot the system in 180 facilities.

While funding continues to be supported through the Global Fund (as well through GAVI and WHO for associated immunization programs, and through PEPFAR for HIV/AIDS), HISP Central Africa, the University of Oslo and the WHO continue to offer technical guidance for building and customization of the system.

Leadership of the in-house technical team at the Ministry of Public Health has made feasible an implementation plan for scale up of the proposed DHIS2 tracker model for case-based TB surveillance at all facilities. This would further enable the use of advanced DHIS2 data analytics, starting right at the facility level. Additionally , to complement the existing national HMIS data systems , the TB Data from DHIS2 can easily be integrated as indicators which enable comprehensive data review and analysis of TB data nationally. The application is currently owned by the Ministry of Public Health and hosted at the Health Information Center (MoH), but NTP expects more system ownership and to maintain it in-house, for which their staff would require relevant training.

It is known that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. In Cameroon, while 95% of the population has a cell phone, the smartphone use is still about 40% and internet penetrance is close to 34%. It thus becomes crucial for the country to augment this infrastructure and technologies which support online / offline data capture mechanisms for improving the digital literacy and at the same time creating a strong ground to implement advanced solutions and ensuring their adequate uptake.

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report attempts to produce clear recommendations and way forward towards developing a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program uses DHIS2 used for aggregate TB notification, for both DR TB and DS TB. Paper-based data is collected at facilities and transferred to the regional level to be entered into DHIS2 on a quarterly basis. This data reporting is only in the aggregated form currently.

In line with country's vision outlined in the NSP 2020-24 to establish an electronic case-based data recording system, the HMIS is undergoing a transition to integrate the complete cascade of care by using a DHIS2 tracker data model. Currently, aggregated TB datasets only capture cases initiated on treatment. The tracker model will expand this to register all patients, including presumptive TB cases.

SUCCESS STORIES

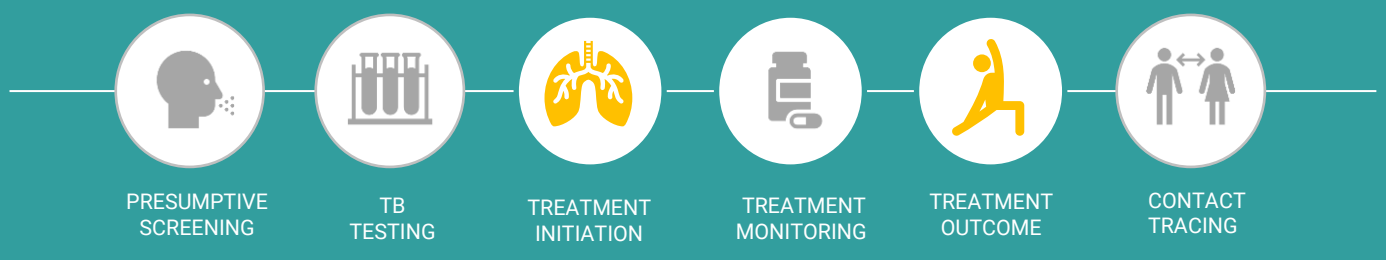
Implementation of the current aggregated model across all the regions through standard data collection tools across 261 facilities and receiving 100% data reporting from the private sector as well.

In efforts to strengthen MDR-TB management, GeneXpert has become progressively more available throughout the entire country, allowing an increase in the number of re-treatment cases tested from 17 percent in 2010 to 81 percent in 2017. GeneXpert sites are connected through a server at the NTP, and data is transmitted in real time to clinicians. It is further supported by a sample transport system; training of nurses; supervision of sites by doctors; and the transfer of skills to lower-level cadres. Results have shown a success rate of about 82 percent in the 425 cases treated overall since then.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				DHIS2 Dashboard
Regional level	10	10	DHIS2 (National HMIS) and Excel	Aggregate	DHIS2 Dashboard
District level	197	Data not collected from this level			DHIS2 Dashboard
Facility Level	307 (261 effective facility reporting)	307	Paper based	Aggregate	No Data usage at this level
Community level	Data not collected from this level				No Data usage at this level

CASCADE OF CARE MONITORING



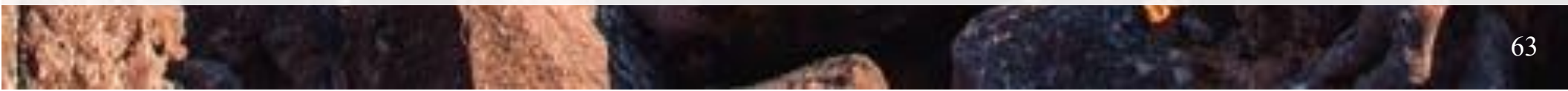
KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNat, CXR, etc.)	✓
Date of test result	
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	
Key-population wise aggregate numbers and proportions notified	
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)



STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	None. DHIS2 used for aggregate reporting
Lowest Unit for TB notification digitisation	Regional level
Stage of notification	Treatment initiation stage
Level of Access and Use of TB Notification data	District level
Private sector notification	Manual notification process
Frequency of digitization of TB notification	Quarterly
Mode of follow-up with notified cases	Manual follow-up: phone calls, physical visits
Scale of implementation	DHIS2: national rollout
Contact tracing for TB notified cases	CETA project – regions covered under pilot
Muti – Channel Enablement	None
Govt. order for mandatory TB notification	None

PRIVATE SECTOR ENGAGEMENT

With the private sector being governed by the same rules as public facilities (falls under the MoPH structure), private providers provide 100% data on TB notification to the public system through manual route, and will also have a direct access to the system when the DHIS2 tracker model is adopted.

COUNTRY IT CAPACITY

Country Server
National DHIS2 platform is managed centrally by the Health Information Center at MoPH.

Interoperability
DHIS2 as a platform provides APIs for interoperability, but yet to be integrated with other tools

Country IT team
Ministry of Health has a Health Information Center unit that hosts and manages the application centrally.

ENABLING ENVIRONMENT

95.1%
Mobile penetration (2020) [3]

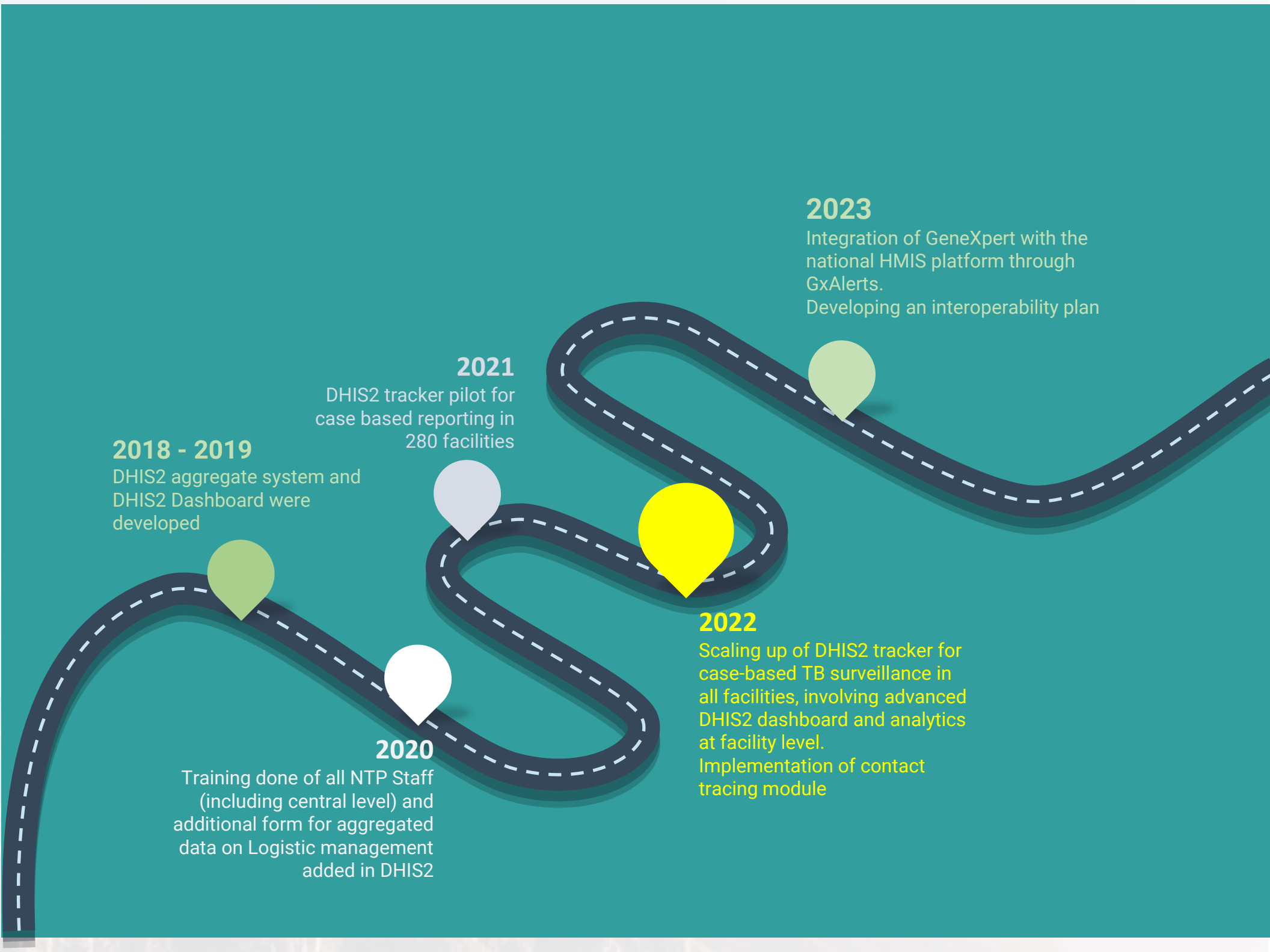
40%
Smartphone (2021) [4]

34%
Internet penetration (Jan 2021) [5]

CURRENT RESOURCES AVAILABLE

- The National TB Program's primary source of funding is through the Global Fund grant (support available till 2023). This totals to USD 11.9 million as in 2018-20, when TB programs were supported through HIV/AIDS funding from PEPFAR and PMI.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nil	NA	NA	NA	NA
Logistic Management	DHIS2 dataset	Web Application	Ministry of Health	The Global Fund	National
Laboratory Information Management	GxAlert	Web Application	Aspect	Stop TB Partnership	National
	DataToCare	Web Application	Savics	The Global Fund	National
Community Led Monitoring (CLM)	Nil	NA	NA	NA	NA
Contact Tracing	Household Survey	NA	NA	CETA Project	6 out of 10 Regions

KEY CHALLENGES

- NTP currently relies on the Health Information Unit of the Ministry of Health for system hosting and maintenance. The in-house IT team's capacity is inadequate to manage DHIS2 customization at their end.
- DHIS2 dashboards are available and accessible from the national to regional level, however the use for program monitoring by health professionals remains very low. Excel data is considered more reliable, and hence used it routinely.
- Current programme M&E practices are significantly inadequate to execute the plan of implementing a case-based system.
- Internet availability is a major concern. Its unreliability affects data entry and analysis.
- With the current data collection only limited to the cases put on treatment, crucial data points like screening, specimen transport and testing get missed out in the data outputs, producing limited knowledge to improve service provision.
- Moving to a direct digital reporting from facility level would be a shift in the mode of work for the TB staff, and hence requires a sustained availability of funds to support both the hardware availability and capacity building for using digital tools.

NTP VISION

- As part of the National Strategic Plan for 2020-24, the NTP plans to develop and implement a DHIS2 case based tracker system for TB notification.
- Strengthening the IT system administrator at NTP and training health facility staff to shift data entry from the level of the region to the facility.
- Improving the vigilance on data quality in TB reporting
- Ensuring internet and other IT infrastructure availability at all health facilities to enable real time data entry.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

❖ Hardware and Infrastructure:

- Mobile Devices (for data collection): Cameroon has 307 TB facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 46,050** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): Cameroon has 197 districts and 10 regions. To promote active data use, each district and region should be given a tablet which would cost roughly around **USD 41,400** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **US 154,200** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
- Server: Based on the current volumes of new cases, Cameroon would need an investment of **USD 30,000-40,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

❖ Software Development:

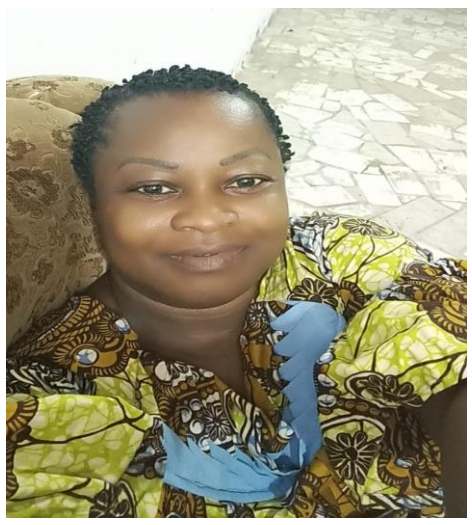
- Based on various multi-stakeholder meetings and given the fact Cameroon already have a foundation for DHIS2 aggregate system for TB, around **USD 50,0000-1,000,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

❖ Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each 197 districts over a period of 3 years which could cost roughly USD 100 per training amounting to **USD 19,700.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 1.5 - 2 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Cameroon .

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.



"The NTP goal is to use data for effective decision making. Digital data surveillance is the gate way in closing the gaps in our patient care pathway for an efficient and effective health system."

Dr. BISSO NGONO ANNIE PRUDENCE
NTP Manager
Cameroon

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step it is important for the country to create a comprehensive costed action plan for development, implementation and scale up of the TB case-based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan with timelines. The plan will help the country to assess and monitor the progress and to mitigate risks

  Tentative timeline: Month 0-1

- **Mobile App** : One of the challenges reported by the NTP during the assessment is inconsistent internet connectivity/network issues and the lack of availability of real time data for stakeholders. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, which is in line with the country's efforts of improving the overall digital ecosystem.

  One effective way to overcome this is to support the current data collection processes by introducing a mobile application which will help the data entry process easier and also has feature to store data offline which can then later be synched with the central systems .

  The advantages for a mobile application include better performance, effective use of device features like in house system updates, usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

  In line with with the current system design and NTP's ongoing procurement of *Compbook* laptops (with SIM cards) , the latest DHIS2 mobile app version should be evaluated. This app also has additional features on data collection , security ,offline data collection , encryption ,version management etc should be evaluated which would easily extend to the current systems.

  This would also ensure that the data structures are consistent. Also, the app is supported with a configurable set up to support any updates / changes to the program.

  Additionally, the DHIS2 mobile framework uses open-source technologies like Java, Postgre, React and Android, there are easily supported by country IT teams also the standard best practices of mobile development like version management , data encryption etc which make this as more robust solution. [6]

  Tentative timeline: Month 0-6

- **Implementation of TB Case-based notification system :**

  In line with country's vision outlined in the NSP 2020-24 ,Cameroon has already developed core infrastructure in terms of database and deployment environment for DHIS2 in form of the country HMIS, which lays a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for developing DHIS2 tracker for creating case-based notification system which accommodate monitoring of entire continuum of care for both DS TB and DR TB patients starting from presumptive screening, referral, testing, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes . [7]

  Tentative timeline: Month 0-12

- **Data Integration** : Another key area highlighted by NTP is the leveraging of data collected from the multiple sources like the excel files maintained at the

facilities without any data loss.

There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central repository.

This DHIS2 data transformation API feature also offers creation of standard templates which can be easily mapped with external data collection tools. [8] Apart from this it also supports batch upload for historical data for large volumes to ensure minimum disruption to the live systems.

Other source ETL tools over Postgres DB and / or WHO powered XMart [9] which can be installed within the current environment can also be considered.

Tentative timeline: Month 0-6

- **Data Use**: Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports and individual line lists and with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current DHIS2 and other systems then a more advanced analytical dashboard should be designed linked to the new case based TB surveillance system that is already being planned.

  To achieve this , apart from the standard DHIS2 dashboard features and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features.

  The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [10]

  Tentative timeline: Month 6-12

System Integration : As visioned by the national TB program with the concept of an integrated Health Information Management System (HMIS) , leveraging the current platform and foundation , basic integration and data exchange mechanisms should be worked out to avoid duplication of efforts and complement the existing data systems.

The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in use the data effectively for the patient care continuum as highlighted by the National program.

Recommended exchange / ETL tools like Talend and Informatica which include these features make the data management task much easier and simultaneously improve data warehousing. [11]

The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [12]

The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

Tentative timeline: Month 6-18

- **Data Quality :** NTP clearly emphasizes on the importance and need to introduce improved data collection practices and validations to avoid data duplicity and redundancy for better data quality.

  Some standard recommendations include

  - ✓ UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records. This should be generated automatically through the new case-based TB surveillance system that is already being planned.
  - ✓ DHIS2 data de-duplication feature should also be explored which would enable restriction of multiple case data entries based on patient profile and other variables configuration.

Additionally , as part of standard practices, the application(s) / solutions should follow the data quality mechanisms or the Data Quality Assurance (DQA) framework. [13] Some recommendations include:

RECOMMENDATIONS

- ✓ Data Validations for data inputs at every level
- ✓ Retrieval of existing user driven values / attributes to avoid data discrepancy
- ✓ Smart follow up questions to validate previously entered data.

These standard practices are configurable using the DHIS2 ruleset feature which is applicable to both web / mobile app interfaces. This will ensure that the data collected from multiple sources is in a standard structure and format.

Data access control is another DQA measure that will regulate user's access to meta-data. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access. [14]

This can be implemented using the DHIS user access and data management feature for restricted data access and control. Apart from this DHIS2 admin also has privileged access to configure the user data roles.

Tentative timeline: Month 3-6

- ❖ **e-Learning**: Digital training packages to train health professionals on DHIS2 data entry, information use, M&E and workflows:

  To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While DHIS2 offers standard training modules on the application , training tools like Moodle [15] built om standard LMS framework can be reviewed for application rollouts.

  Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers , administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, especially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- ❖ **Capacity building for application upgrade and server maintenance**

  One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires trained personnel on DHIS.

  Strengthening the NTP team with DHIS2 trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- ❖ **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- ❖ **Contact tracing application implementation :**

  To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

  Tentative timeline: Month 6-12

RECOMMENDATIONS

Strategic Technical Recommendations

Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan that would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- ✓ **Technical Upgrades:** Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data

  exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better and data exchange standards.

  Additionally, the advance admin features offered by this version help the administrators to support the operational needs better for onboarding users , real time change in data variables and user management etc effectively.

  Apart from version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises. [16]

- ✓ **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable a reliable platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning . [17]

- ✓ **Application & System Security Audit**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[18] / to country specific policies over

- Patient Data Management
- Server & Infra guidelines

  Apart from application measures offered by DHIS2 [19] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [20]

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr. Bisso Ngono Annie Prudence*** *and* ***Dr. Mbassa Vincent*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to **Mr.** ***Titahong Nosoh Collins*** for providing valuable insights into Cameroon's vision for creating a comprehensive case-based TB surveillance and notification system.

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10. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
11. System Integration Tools (Talend , Informatica) : https://www.talend.com/index.php , https://www.informatica.com/
12. DHIS2 Communities on DHIS2 using GDPR guidelines : https://community.dhis2.org/t/how-does-dhis2-protect-personal-information-the-tech-details/5335
13. DQA Guidelines : https://www.who.int/data/data-collection-tools/health-service-data/data-quality-assurance-dqa
14. DHIS2 & DQA : https://dhis2.org/who-dq/
15. Application Training Tool : https://moodle.org/
16. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/
17. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
18. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
19. DHIS Security : https://dhis2.org/security/
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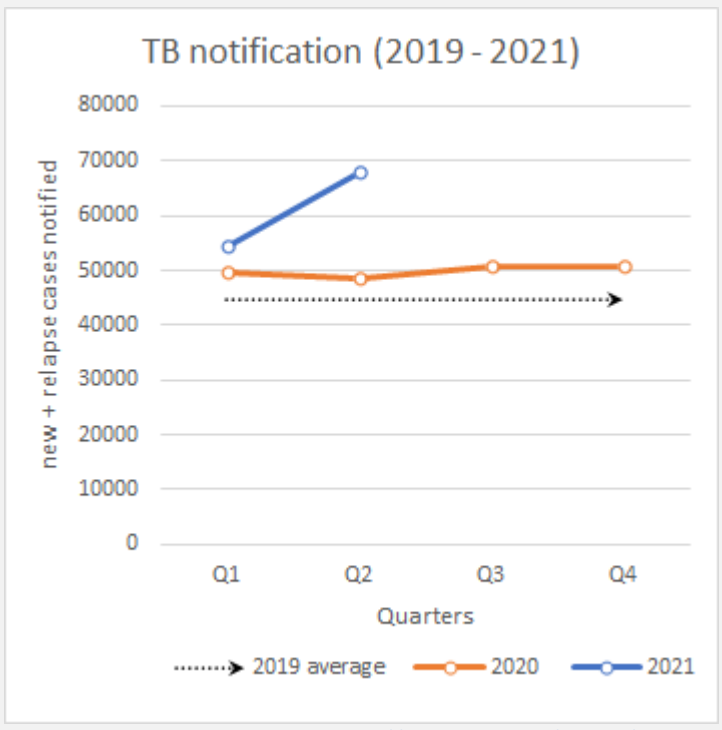
DEMOCRATIC REPUBLIC OF CONGO

DEMOCRATIC REPUBLIC OF CONGO

BACKGROUND

The Democratic Republic of Congo (DRC) is considered a 'high burden' country for Tuberculosis and HIV infection.[1] The estimated incidence of tuberculosis in the Democratic Republic of the Congo (DRC) is 319/100.000 according to WHO 2021 global tuberculosis report. Although there has been an increase in TB cases, challenges persist in closing the gap in case reporting and estimated TB incidence.[2]

DRC is one of the few countries which have shown an increase in overall TB notification in 2020 (against 2019), which indicates that the DRC's TB surveillance system is quite robust to even stand strong amidst such a large-scale pandemic. Country's TB notification trends continue to further improve through 2021 as well.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

DRC's National Tuberculosis Control Program (PNLT), in the current National Tuberculosis Strategic Plan 2021-2023, prioritizes improving tuberculosis detection, effective tuberculosis prevention activities, Strengthening community ownership in TB control and promoting the inclusion of human rights and sustainability in TB programming. It further emphasizes improving the TB supply chain system and strengthening the diagnostic network, expanding treatment access to increase treatment coverage, ensuring a reliable access to second line drugs for Tuberculosis and strengthening of programmatic management of tuberculosis by implementing effective monitoring of treatment adherence and appropriate treatment of patients followed-up. To achieve its objectives and rationalizing its activities, the PNLT is committed to developing the internal capacities of national resources for tuberculosis control services.[3]

In the Republic of Congo, the management of patients co-infected with TB and HIV co-infection is subject to several diagnostic and therapeutic challenges. There is a lack of coordination between the TB and HIV programs and there is no common database or reporting system, leading to separate reporting and monitoring.[1] The limited laboratory infrastructure for MTB cultures and drug susceptibility testing (DST) makes it difficult to determine the true MDR-TB burden and treatment outcome.[4]

The Ministry of Health of the Democratic Republic of Congo (DRC) has adopted DHIS2 as the country's national health information system. The government began piloting and deploying the system at the sub-national level in 2014, expanding it nationwide over next three years. [5] The national HMIS has a TB module which is used to record data on TB cases. Tuberculosis control activities in the DRC are integrated into all levels of the health systems at the national level and are implemented in 26 provinces and 519 health zones.[3]

In 2015, DRC Congo adopted an electronic tool known as QuanTB to ensure that no patient is interrupted due to a lack of medication. The QuanTB program creates a dashboard for managers to monitor drug stocks and drug orders that need to be placed to support the procurement, and distribution planning of TB drugs and consumables. QuanTB provides early alerts for stockouts and helps program managers make timely decisions.[6]

Digital connectivity is the cornerstone of economic growth and prosperity. The DRC lags in mobile connectivity compared to almost all other countries in sub-Saharan Africa. The high costs of connectivity and the lack of affordable options are significant challenges. According to 2021 figures, around 88.7% of the population owns a cell phone. Internet penetration is only 32.3%. Improving digital inclusion in the DRC is essential, as access to reliable and affordable connectivity is a fundamental step in maximizing the impact of the deployment of digital technologies on the government's development aspirations.[8]

Based on multi-stakeholder discussions, interviews and independent research, and advice from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based TB surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE-BASED TB NOTIFICATION

The Ministry of Health (MoH) of the country uses a National HMIS which is based on **DHIS2.** The government began to pilot and roll out the system sub nationally in 2014, scaling it up countrywide over next three years. In collaboration with many partners, the MSP rolled out DHIS2 across all 516 health zones in 2016. The zones have moved from paper-based reporting at all levels to electronic reporting at the health zone level. [5]

The national HMIS has a TB module which is used to record the data related TB cases. It is used for both DS-TB & DR –TB cases. The type of data entered in the DHIS2 is Case based. However, data is captured at the treatment center and the notification of cases is done in a hard copy report sent to the Health Zone level where the data is entered in DHIS2. The data reporting frequency is monthly.

Data for drug-resistant TB is entered in Excel files and compiled at each level. They will soon be entered in Tier.Net.

At the end of 2017, there were 17,859 facilities registered in DHIS2 across the DRC. Facilities in DHIS2 are categorized as public, FBO, or private. Of all facilities registered in DHIS2, 20 percent (3,501) are categorized as private, 10 percent (1,872) as FBO, and 53 percent (9,493) as public.[5]

SUCCESS STORIES

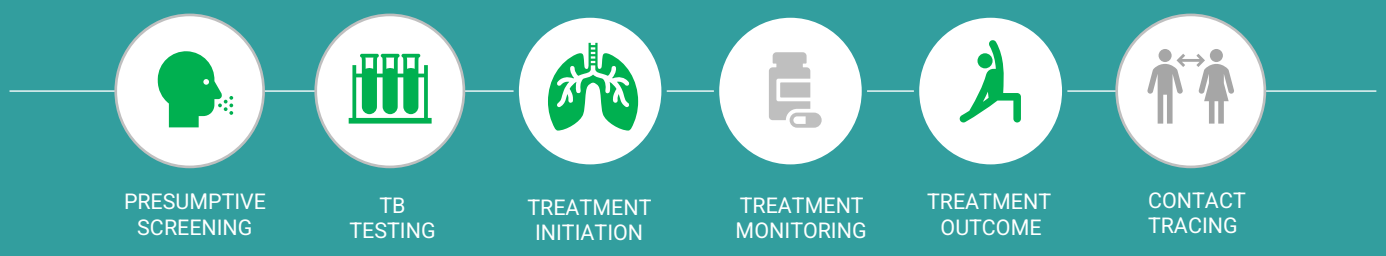
Democratic Republic of Congo adopted DHIS2 as the national health management information system (HMIS) for collection and analysis of health data. Within the national HMIS, a TB module was added to monitor TB related services and information in the country. The PNLT is working towards building an effective and comprehensive case-based TB notification system and case management system.

PNLT is proposing to expand to scale the existing HIV system called TIER.Net to collect and track clinical patient TB data and transition from paper-based to digital systems at the point of care. Integration of facility-based electronic patient management systems will allow for improved sub-national TB surveillance and facility-level monitoring.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				DHIS2 Dashboard
Provincial level	26	Data not collected from this level			DHIS2 Dashboard
Health Zones level	519	519	DHIS2	Case Based	DHIS2 Dashboard
Facilities	17859	17859	Paper Based/ Excel	Case Based	Hard copy submitted to Health zones
Community level	Data not collected from this level				No tools used

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	
Provider source-wise aggregate numbers and proportions notified	
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	DHIS2 system
Lowest Unit for TB notification digitisation	Tuberculosis screening and treatment health center (CSDT)
Stage of notification	Reporting at Health zone level
Level of Access and Use of TB Notification data	Health Zone level
Private sector notification	At the community level, the NTP collects data on suspected TB patients referred using existing community tools
Frequency of digitization of TB notification	Monthly -quarterly reporting
Mode of follow-up with notified cases	Manual follow-up- phone call, physical visit
Scale of implementation	National roll out
Contact tracing for TB notified cases	Not yet developed
Multi-channel enablement	None
Govt. order for mandatory TB notification	None

PRIVATE SECTOR NOTIFICATION

Facilities in DHIS2 are categorized as public, FBO, or private. Of all facilities registered in DHIS2 30 percent (5,373) of all registered facilities across DRC are in the private sector (FBO and private). Over half (53 percent or 2,848) of these are private health centers, 26 percent (1,414) are private health posts, and 14 percent (771) are private hospitals.[8] Private facilities report aggregated figures only.

COUNTRY IT CAPACITY

Country Server
Data is hosted in Norway / OSLOW University

Interoperability
Data export functionality is available and Used

Country IT team
Country has a in-house IT team supported by external IT team

ENABLING ENVIRONMENT

88.7%
Mobile penetration (Jan 2021) [8]

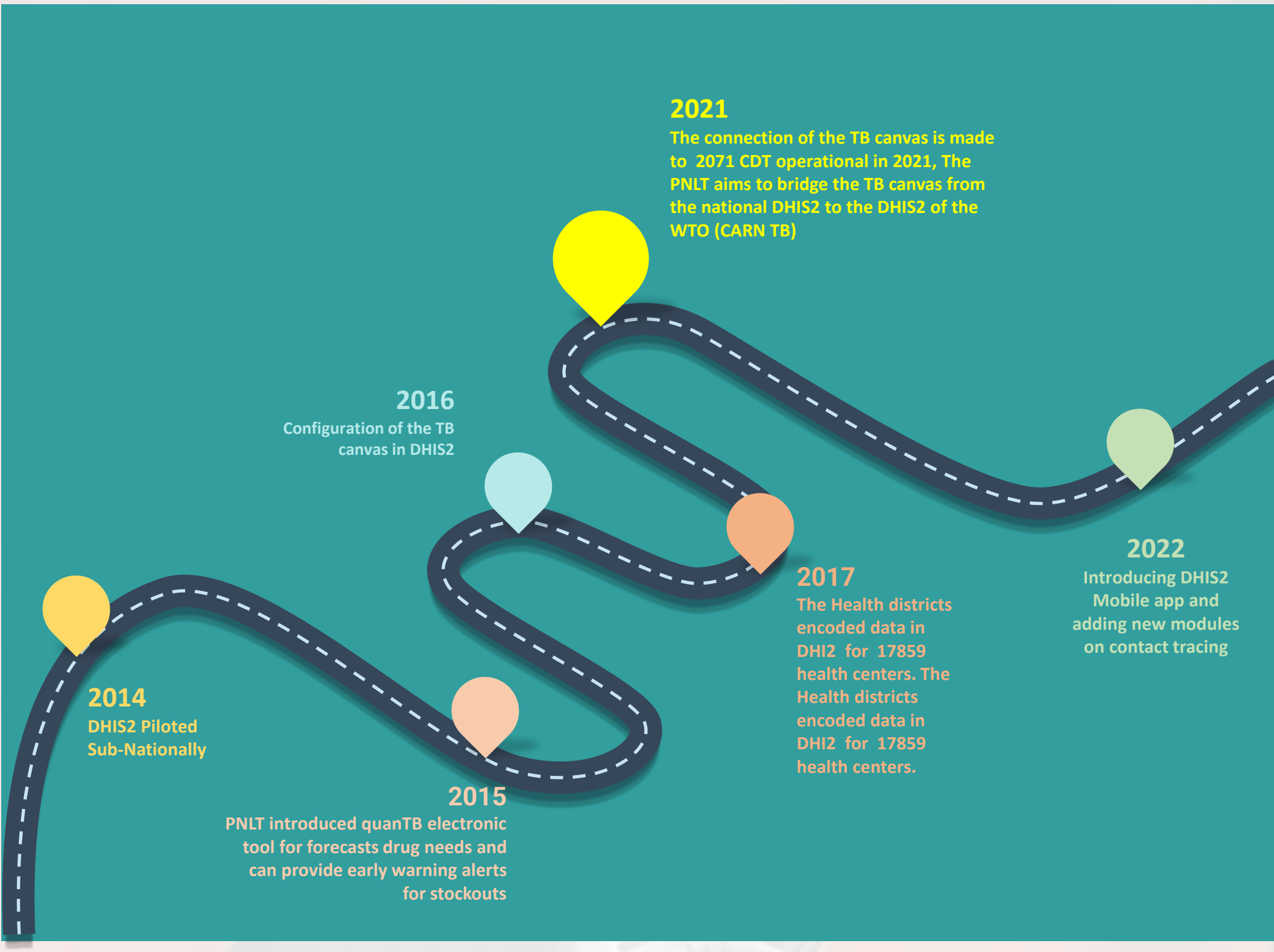
88.5%
Smartphone (2020) [9]

32.3%
Internet penetration (Jan 2021) [8]

CURRENT RESOURCES AVAILABLE

- USAID invested $13 million annually (2015-2019) through its Challenge TB program and the Integrated Health Project Plus activity (IHP+) over a period of 5 years. Under Challenge TB program, activities focused on TB efforts (coordination, outreach, detection, treatment, tracking) at all levels of the health system were implemented. While IHP+ operates primarily at the provincial and health zone level and focuses on multi-disease, integrated primary health care. [10]
- The proposed FY 2020 USAID TB budget for the Democratic Republic of Congo is $14 million [3]
- Fund pledged by Global Fund for 2020-2022 is USD 6million as the sixth replenishment[11]

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	NIL				
Logistic Management	QuanTB	Web Application	MOH	USAID	National Roll Out
Laboratory Information Management	NIL				
Community Led Monitoring (CLM)	One Impact	Mobile App	Dure Technologies	Stop TB Partnership	Pilot
Contact Tracing	NIL				

KEY CHALLENGES

- **Limited digital infrastructure results in technological limitations** i.e., using shared laptops/ desktops across the multiple programs causes delays in data entry.
- **Parallel Data entry:** Maintaining Parallel data entry manual records and digital records, increases the task of facility staff and delays data entry.
- **Data quality :** Currently, only the data manager of each health zone enters the data in DHIS2 for all the programs. Due to lack of tuberculosis background at times of data manager is unable to encode the accurate data.
- **Data Duplication:** Duplication of data is another challenge faced by the PNLT. It is reported that due to the unavailability of unique identifiers, data duplication is a challenge at CSDT level.
- **Data Adequacy :** Most health centers transmit data on a monthly or quarterly basis but the data on Tuberculosis are transmitted quarterly according to the directives of the PNLT. All the CDTs do not transmit the report on time. This causes a delay in data entry at the Health Zone level; therefore, the data is not available in real time.
- **Poor internet connectivity** hinders timely data entry, further delaying the availability of real-time data.

PNLT VISION

- PNLT wants to eventually phase out the paper based records and wants to move to real-time case-based data entry. A comprehensive record keeping National HMIS which is interoperable with other programs.
- Improving data capturing by introducing DHIS 2 Mobile app for ease of data collection and reporting.
- Improving the cascade of care by adding new modules (contact tracing) and scale e-reporting of TB cases throughout the country using DHIS2.
- Improving hardware support (with CSR engagements by computer companies) i.e., using multifunctional mobile tablets will be useful for taking forward field reporting.
- Building internal capacity of human resources for ensuring sustainability of software, system management and troubleshooting.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): DRC Congo has 17859 TB Treatment units and to provision mobile device for every facility for case-based TB surveillance, **USD 26,78,850** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): DRC Congo has 519 health zones and 26 provisions and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 109,800** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 5,357,700** should be considered (assuming USD 100 mobile data cost for the entire 3 years per facility, district and regional user)
  - Server: Based on the current volumes of new cases, DRC Congo would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact DRC Congo already have a strong foundation for DHIS2 System aggregated system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 516 health zones, which could cost roughly USD 100 per district, amounting to **USD 51,600** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

Total investment of around **USD 8.5 - 9 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for DRC Congo

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on PNLT's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Device Procurement:** One of the limitation highlighted by PNLT is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-3

- **Data Integration:** The NSP (2021-2023) clearly highlights the importance of strengthening the TB Notification information system for improving all the TB service provisions[3]

  DRC Congo has nationally rolled out DHIS 2 for TB notification. Both DS-TB and DR-TB are reported from the treatment health facilities to the Health zones in hard copies and from here post verification case-based data is entered in DHIS2 system. However, for DR-TB data is maintained in excel files at the TB centers/ hospitals. TB treatment health centers enter data in DHIS2 on monthly or quarterly basis. The data is reviewed nationally through quarterly reports.

  To ensure that there is a seamless integration of data from multiple data systems like National HMIS, and other data sources like excel files maintained at facilities without any data loss, the data upload / export API should be explored.

  There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central database.

  While transformation and data export options offered by the current systems can be used for this other source ETL tools over Postgres DB and / or WHO powered XMart[12] which can be installed within the current environment can also be considered.

  Tentative timeline: Month 6-12

- **Mobile app :** Implementation of data collection via mobile app to ensure ease of use and real time reporting

  PNLT is seeking help in building a TB MIS app which is embedded with the national TB MIS system and has an enhanced UI and dashboard features that will improve data entry at facility level. This would help in tackling challenges like inconsistent data connectivity/network issues which delays reporting of cases, and an inconsistent availability of hardware for data entry. One effective way to overcome this is to support the current data collection processes by introducing a mobile application for the health facilities.

  Other advantages for a mobile application include better performance, effective use of device features like in house system updates, usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

  Several mobile solutions for real time case-based notification can be explored for local adaption and building the mobile counterpart for DHIS2. Open source technologies like DHIS2 Mobile App, ODK and KOBO are some notable examples. [13]

  Tentative timeline: Month 0-12

RECOMMENDATIONS

- **eLearning:** Packages to train health professionals on DHIS 2 use and workflows

  Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the National HMIS, DHIS2 application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using DHIS2 System for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  Training tools like Moodle [14] built on standard Learning Management System (LMS) framework can be reviewed for application rollouts.

  Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care, modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- **Capacity building for application maintenance**

  Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

  Strengthening the PNLT team with trained system administrators will help in reducing costs (in seeking technical support) and improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- **Contact tracing application implementation**

  To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

  Tentative timeline: Month 6-12

- **Patient Interactive Systems :** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

  Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [15]

  Tentative timeline: Month 6-24

- **Data Use :** The PNLTs plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

  Building on the current DHIS2 System and DHIS2 visualization modules that offer a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table, event reports which support dimensions, data aggregation reports and individual line lists are extremely useful.

  To strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics it is recommended to use best of the breed tools like Tableau , Power BI which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [16]

  Tentative timeline: Month 6-12

RECOMMENDATIONS

❖ **Unique Identifiers:** Duplication of data due to multiple systems are used for data entering. This results in missing out some of crucial information as a result patients are often not followed-up or tracked.

It is recommended while capturing the information of the TB cases they should be linked with unique identifiers like national Id, to ensure de-duplication of the patient is avoided and case is tracked, monitored and followed up throughout its treatment journey.

Tentative timeline: Month 0-1

Strategic Technical Recommendations

❖ **Application Upgrades including Server Augmentation & Infrastructure Upgrades :** To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Additionally, the advance admin features offered by the version 2.34 of DHIS2 System help the administrators to support the operational needs better for onboarding users, real time change in data variables and user management etc effectively.

Apart from this, version 2.34 of DHIS2 System also supports compliance to GDPR standards and offers more controlled data encryption practises. [17]

✓ **Performance Optimisation & Testing** : To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in database sizing and planning need to be adapted for effective planning . [18]

✓ **Application & System Security Audit**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[19] to cover

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by DHIS2 System/ DHIS2 System for patient data security, hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting.[20]

ACKNOWLEDGMENT

We thank the Line Director National TB Program, **Dr. Michel Kaswa Kayomo** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Gertude Lay*** for providing valuable insights into DRC's vision for creating an advanced case-based TB surveillance and notification system.

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14. Application Training Tool : https://moodle.org/
15. OPEN MRS : https://openmrs.org/
16. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
17. DHIS Security : https://dhis2.org/security/
18. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
19. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
20. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

ETHIOPIA

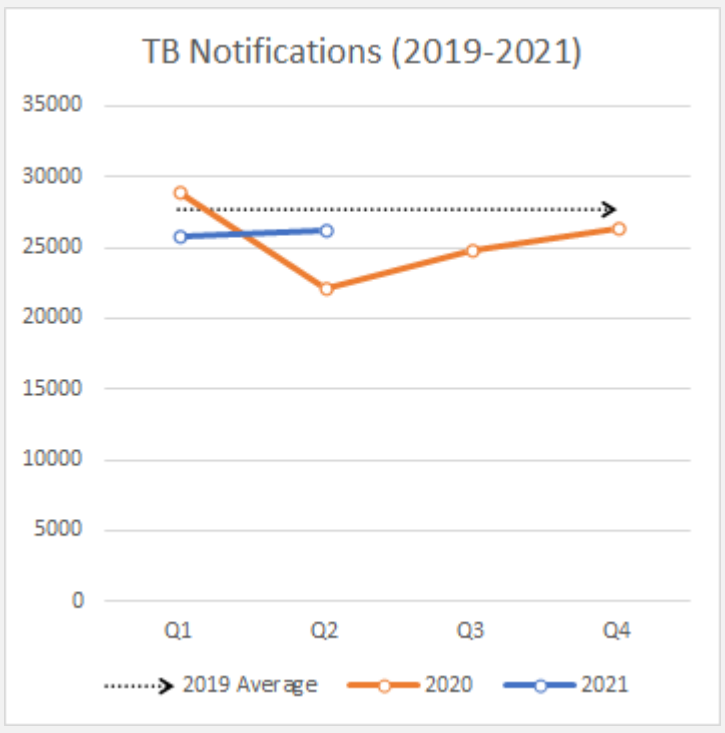
ETHIOPIA

BACKGROUND

According to WHO estimates, 151,000 people newly developed TB in Ethiopia in 2020, of which 108,714 got notified (Global TB report, 2021) [1]. With nearly 9,900 of all people with TB also infected with HIV, Ethiopia is included in the list for the top 30 TB/HIV high burden countries. [2] Children account for nearly 10% of all cases, and many also suffer from TB-HIV coinfection. [1]

Ethiopia has achieved a treatment coverage of 71% of all people living with TB in 2020 and the TB case fatality ratio stands at 15%. Around 31% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment. [1]

Affected by the COVID19 pandemic, country's TB case notification dropped in the second quarter of 2020, however, the health system is making efforts to revive its TB surveillance practices and the notification has improved to reach closer to the 2019 average quarterly notification trend.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Vision and priorities of Ethiopia's National TB Program (NTP) is crucial to the technology innovations in electronic case-based TB system's functioning. Through a consultative process and with input from an external review of the TB-Leprosy program, the Ministry of Health of the Federal Democratic Republic of Ethiopia has updated the National Tuberculosis and Leprosy (TBL) strategic plan in November 2017. The revised plan throws light on the country's focus on – strengthening quality TB diagnostic service availability and utilization, communication and social mobilization to address barriers and increase demand for quality services, adherence support and early case detection in community Care settings, and engagement of CSOs and NGOs in implementing and monitoring of strategic priorities. The plan further highlights and calls for accelerated and coordinated implementation of high impact evidence-based interventions to reduce the burden of TB among PLHIV; and strengthening TB laboratory services, including specimen transportation network. [3]

Ethiopia uses **DHIS2** as the platform for TB notification, and currently, all the data is captured in aggregate form. At the same time, the NTP has a vision to soon transition from aggregate to individual patient data capturing. A pilot for case-based notification for MDR-TB patients has recently been launched (September 2021) across 67 health facilities.

Additionally, to complement the existing national HMIS data systems, the TB Data from DHIS2 can easily be integrated as indicators which enable comprehensive data review and analysis of TB data nationally.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As per 2021 figures, about 38.5% of the population has a cell phone, and only about 11.2% (2018) use smartphones. Internet penetration stands at 20.6% in the country. Enhancing digital inclusion in Ethiopia is essential, given that access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's development aspirations. [4,5]

Apart from implementing the DHIS2 platform, the country is also leveraging other digital innovations for better data collection and data use for positive programmatic outcome as given below:

Smart care/ TENA care EMR is a digital platform that supports longitudinal record-keeping for a variety of health indices, including HIV/AIDS treatment, TB care, VCT, and antenatal care. However, with its limited adaptability and in the absence of any linkage with DHIS2, the system's uptake and use are significantly low. [6]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

In 2018, Ethiopia adopted DHIS2 as the national system for reporting of TB notification data. Manual registers are maintained at the health facilities for capturing all TB specific data and the data is then handed over to the central data entry unit (common to multiple programs) within the facility for the final data entry to DHIS2. For some facilities that do not have the hardware and infrastructure to perform data entry, all the data is compiled and shared with the district/ woreda level, where the data is entered to DHIS2 on behalf of these facilities.

This system has an integrated dashboard that aggregates the data on quarterly basis and automatic reports are generated for analysis. NTP is also working on a Digital health account (DHA), a software support for the existing DHIS2 system (supported by USAID and University of Oslo as Technical Partner), where WHO HQ helps with the further development of dashboard.

The national TB notification system allows management of both DR-TB and DS-TB cases.

SUCCESS STORIES

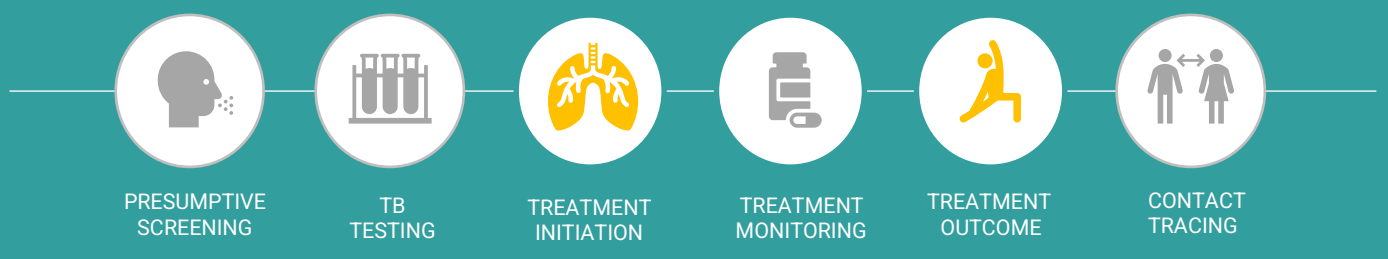
In order to ensure the early identification of all TB cases and strengthening treatment delivery, the country has adopted a One-Stop Shop Approach to TB/HIV integrated service delivery at the clinics. Under this approach, TB and HIV clinics collaborate with each other through cross-referrals, and both TB and HIV patients receive a full package of services in one place. It was further supported by the innovative family-matrix-guided implementation approach through USAID's Challenge TB project, to address access barriers, reduce delays in diagnosis, and improve management of TB among women, children, and other vulnerable groups.

Starting 2020, under the Ascent project, nearly 80 facilities in Addis Ababa and Oramia are participating in the implementation of 3 Digital Adherence Tools (Smart Pillboxes, Video Supported Treatment and Medicine labels/ sleeves), which will support treatment remotely and will provide more flexibility in TB care. The project aims to reach 5000 patients in four years, and in order to arrive on more precise study outcomes, a randomized controlled trial protocol has been introduced for enrolling patients.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Regional level	10	Data not collected at this level			DHIS2 Dashboard
District Level (Woreda)	1104	1104 (Data entered for facilities with inadequate infrastructure)	DHIS2	Aggregated	DHIS2 Dashboard
Facility level	6000	6000	DHIS2	Aggregate	DHIS2 Dashboard
Community level	Data not collected at this level				Data not used at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	Only aggregate data entry in DHIS2
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Treatment initiation
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Aggregate data reporting with the tagged public facilities (some have a formal access to DHIS2)
Frequency of digitization of TB notification	Quarterly
Mode of follow-up with notified cases	Physical visits
Scale of implementation	DHIS2 aggregated system is scaled at National level,
Contact tracing for TB notified cases	None
Multi - channel enablement	Offline and Online use of DHIS2. Use of mobile phones in Case based data entry pilot
Govt. order for mandatory TB notification	None

PRIVATE SECTOR NOTIFICATION

Nearly 100% of the private providers are formally engaged with NTP, and contribute to about 18% of the total identified TB cases. The private sector notification is in the form of aggregate data that is either added in DHIS2 along with the data from some tagged public facility, or otherwise directly entered by the private institution (few formally engaged PPMs have access to DHIS2)

COUNTRY IT CAPACITY

Country Server
DHIS2 platform is shared by other health programs too, and server is maintained at the Health Information Technology Directorate.

Interoperability
Data export and APIs are available for integration with other systems, but it hasn't been explored.

Country IT team
Policy and Planning Directorate of MoH has developed the DHIS2 application and the HIT Directorate maintains the system

ENABLING ENVIRONMENT

38.5%
Mobile penetration (Jan 2021) [4]

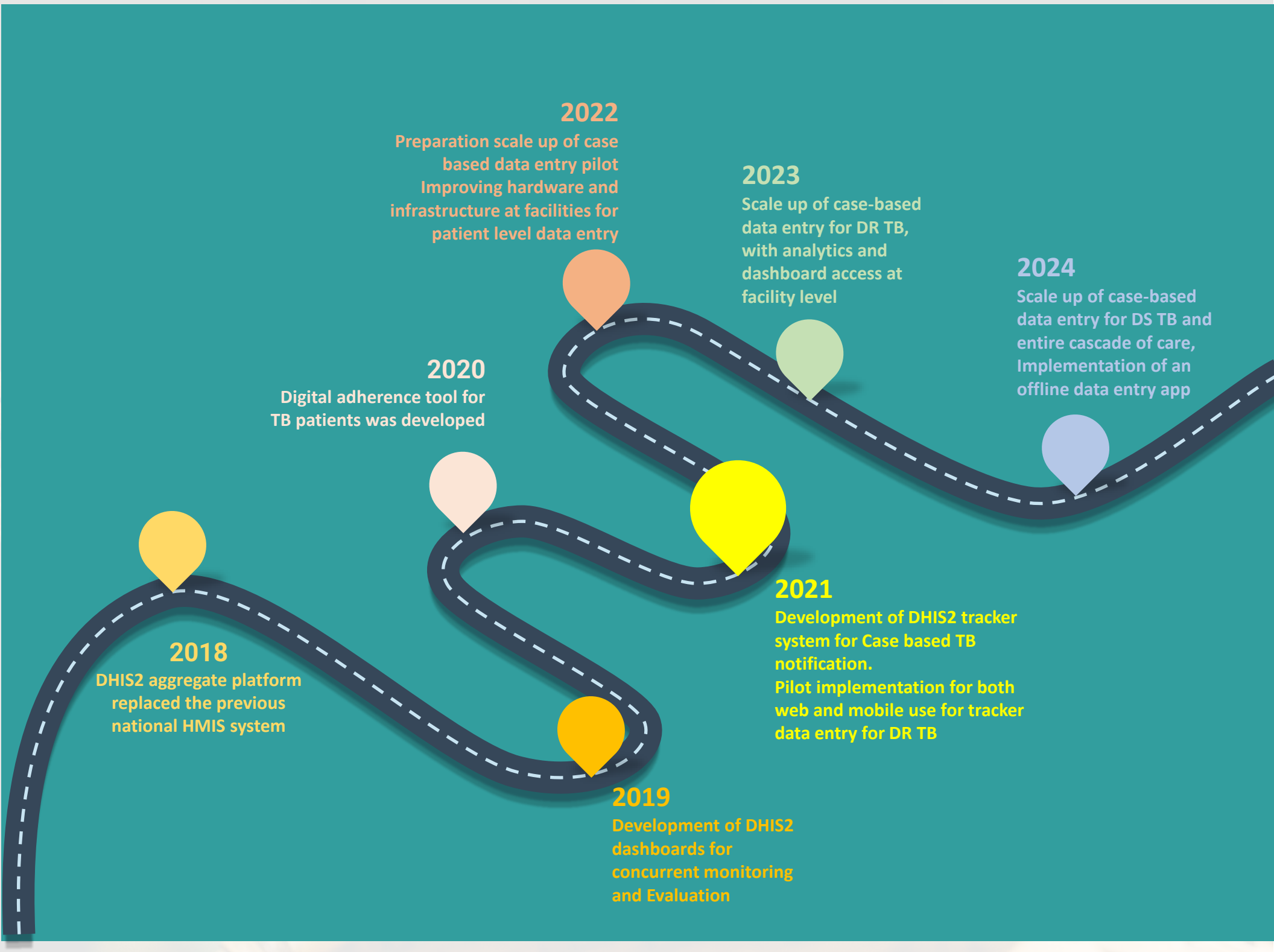
11.2%
Smartphone (2018) [5]

20.6%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- Funding is available from JSI for supporting enhancements of the current analytics tools and dashboard.
- The Global Fund and USAID funds available for developing case-based MDR treatment monitoring and adherence tools
- State (Government) has internal budget for supporting the integration of GeneXpert with the national case-based reporting tool.
- Resources are also available for developing a loss to follow up module, that can generate notifications for such events.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nil	NA	NA	NA	NA
Pharmacovigilance	VigiLyse and Vigibase	Web Application	UMC	UnitAID, USAID, Global Fund	Pilot
Laboratory Information Management	GxAlert	Web Application	Cepheid	USAID	GeneXpert diagnostic sites
Community Led Monitoring (CLM)	eCHIS	Mobile App	MoH	JSI-CIFF	Pilot (120 health posts)
Contact Tracing	Nil	NA	NA	NA	NA

KEY CHALLENGES

- Shortage of personnel and High turnover rate results in an acute crunch of trained manpower at the data entry points.
- With more than 4000 facilities to report data and the internet conditions being very unreliable, real-time case-based data entry remains to be a huge challenge. Internet connectivity is a major bottleneck for the country in transitioning ahead from their current aggregate system.
- DHIS2 being a common tool for all health programs and with it being owned by the Policy and Planning Directorate, thus any changes/ customizations in aggregate forms are to be routed through the M&E team at MoH, which causes significant delays.
- In the current setting, data input from the facilities faces major timeliness issues (because of limited infrastructure) and keeping a check on data quality also is a limitation, which renders the data only partly suitable for any decision making.
- Availability of desktops and laptops for data entry is also inadequate for direct data reporting from facilities, and as a result of this, data is entered from district level and that adds to the delays and data quality concerns with data compilation (data entry away from the site of collection).

NTP VISION

- Transition from aggregate to case-based data collection for the entire cascade of TB care.
- Development and implementation of a mobile app for enabling the data capture on a real time basis.
- Improving infrastructure at facilities with more stable internet connections.
- Improvement in data quality (accuracy, validity and precision) and reducing duplicates.
- Real time dashboards for reviewing data against the targets from Strategic Plan.
- Identifying resources for capacity building of data entry personnel and system implementation.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for fulfilling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Ethiopia has 6000 facilities and to provision tablets for every facility for case-based TB surveillance, **USD 1,200,000** will be needed assuming USD 200 per mobile devices.
  - Tablet (for data use): Ethiopia has 1104 districts and 10 regions to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 222,800** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 2,134,200** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Ethiopia would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Ethiopia already have a strong foundation of DHIS2 aggregate system for TB, around **USD 500,000-750,000** should be budgeted for comprehensive TB surveillance system development and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 120,000-180,000 per annum should be budgeted (or **USD 360,000-540,000** for 3 years assuming USD 2,500 month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. 2-day Training sessions should be planned for each of the 1104 districts over a period of 3 years, which could cost roughly USD 200 per training, amounting to **USD 220,800,** which would be complemented with comprehensive e-training packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 5.0 – 5.5 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Ethiopia

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for development , implementation and scale up / roll out for the TB case based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation and scale of Case Based TB surveillance systems** : The NTP has already established DHIS2 environment which has the core infrastructure in terms of database and deployment environment. It has built the DHIS2 expertise and capacity which acts as a strong foundation for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the DHIS2 tracker app. While the current tracker development has been planned to cover all the DR TB patients, the application should be further expanded to include monitoring of entire continuum of care for both DR and DS TB, including presumptive screening, referral, treatment initiation, treatment adherence & outcome, and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes [7]

  Tentative timeline: Month 0-12

- **Mobile App** : One of the challenges reported by the NTP during the assessment is the lack of availability of real time data for stakeholders. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, which is in line with the country's efforts of improving the overall digital ecosystem.

  As a recommendation, the mobile application offered by DHIS2 which has additional features on data collection, security ,offline data collection, encryption ,version management etc should be extended for use even for aggregate data reporting, specially from facilities with limited IT infrastructure should be reviewed.

  This would also ensure that the data structures are consistent. Also, the app is supported with a configurable set up to support any updates / changes to the program.

  Additionally, the DHIS2 mobile framework uses open-source technologies like Java, Postgres, React and Android, which are easily supported by country IT teams. The standard best practices of mobile development like version management , data encryption etc are also part of the mobile framework which make this a more robust solution. [8]

  Tentative timeline: Month 6-12

- **System Integration**: One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources into the main DHIS2 systems as a central system for effective use.

  The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in use the data effectively for the patient continuum of care as

RECOMMENDATIONS

highlighted by the National program.

Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing that need to be considered. [9]

The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [10]

The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

Tentative timeline: Month 12-18

- **Data Use** :

  The NSP clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data and required line listings available at the lowest level health functionary involved in TB care

  Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports ,individual line lists and job aids with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current DHIS2 and other systems then a more advanced analytical dashboard should be designed linked to the new case-based TB surveillance system that is already being planned.

  To achieve this , and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [11]

  Tentative timeline: Month 6-18

- **Capacity building for application maintenance:** One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires trained personnel on DHIS.

  Strengthening the NTP team with DHIS2 trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 0-6

- **Additional data capturing mechanisms** : To make sure that paper based patient records data is integrated with the DHIS2 tracker systems technical solutions like OCR (optical character recognition) can be considered.

  The DHIS2 platform supports reading from these structures. This would help in data upload of all historical data with less difficulties.

Tentative timeline: Month 6-12

- **E-Learning** :

  To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While DHIS2 offers standard training modules on the application , training tools like Moodle [12] built on standard LMS framework can be reviewed for application rollouts.

RECOMMENDATIONS

Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

- **Patient Interactive Systems:**

  Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients. Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [13]

  Tentative timeline: Month 12-24

- **Data Quality** :

  As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

  UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

  This should be generated automatically through the new case-based TB surveillance system that is already being planned.

  Data access control is one such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

  Tentative timeline: Month 6-18

- **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- **Community Monitoring Systems** : As expressed by the NTP, the national TB notification and surveillance system should explore ready-to-use open source CLM platforms like One Impact

  Tentative timeline: Month 6-12

- **Contact tracing application implementation :**

  To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

  Tentative timeline: Month 6-12

RECOMMENDATIONS

Strategic Technical Recommendations:

Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption & exchange standards.

  Apart from this, 2.34 version also supports compliance to GDPR standards and offers more controlled data encryption practises.[13]

- **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium also may be considered. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning. [14]

- **Application & System Security Audit:**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA [15] to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by DHIS2 [14] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [16]

ACKNOWLEDGMENT

We thank the National TB and Leprosy Program Manager, ***Mr Taye Letta*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Abayneh Admas*** for providing valuable insights into Ethiopia's svision for creating an advanced case-based TB surveillance and notification system.

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8. DHIS2 Mobile App : https://dhis2.org/android/
9. System Integration Tools (Talend , Informatica) : https://www.talend.com/index.php , https://www.informatica.com/
10. DHIS 2 API & DHIS2 Data Transformation Services : https://docs.dhis2.org/en/develop/using-the-api/dhis-core-version-235/web-api.html , https://docs.dhis2.org/en/use/user-guides/dhis-core-version-236/maintaining-the-system/importexport-app.html
11. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
12. Application Training Tool : https://moodle.org/
13. OPEN MRS : https://openmrs.org/
14. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/
15. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
16. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
17. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

GHANA

GHANA

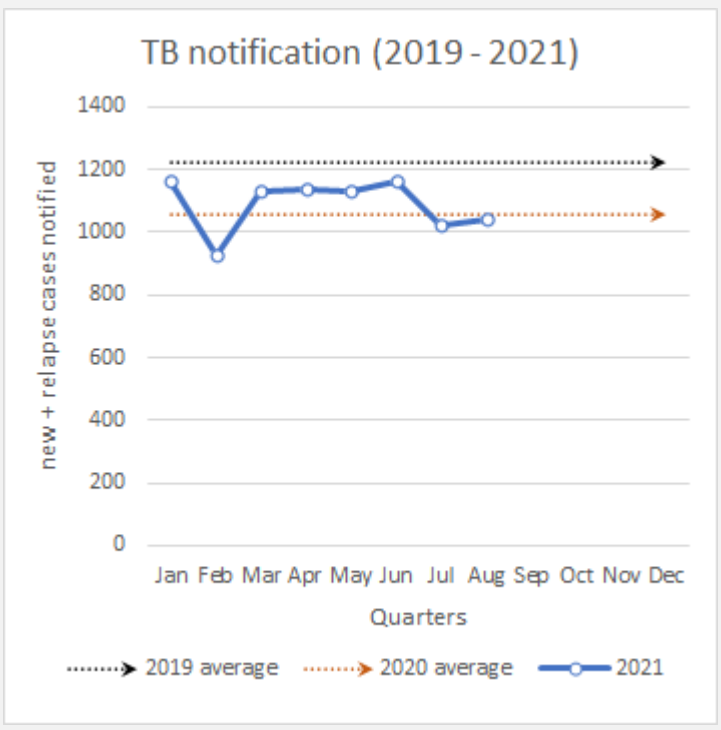
BACKGROUND

According to WHO estimates, of the 44,000 people with TB in 2020 (Global TB report, 2021), 12,922 were notified. With 8,100 of all people with TB also infected with HIV, Ghana is one of the 30 TB/HIV high burden countries. Children in Ghana account for nearly 5% of all cases. [1]

The recent TB prevalence survey reported a prevalence of smear-positive TB of 111 (95% CI: 76–145) per 100,000 among adult population. The prevalence of bacteriologically confirmed TB was 356 (95% CI: 288–425) per 100,000 population.[2]

The TB epidemic in Ghana is generalized, with geographic variation in case notification linked with better access to health facilities. Case notification rates are particularly high among people living with HIV (PLHIV), prisoners, miners, pregnant women, and people with diabetes. [3]

Affected by the COVID19 pandemic, country's TB case notification dropped in 2020-21, however, in 2021, the health system is making efforts to revive its TB surveillance practices rapidly and the case notification is steadily improving to reach near the level of 2019 average figures.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

TB mortality rate in Ghana is considered high with a Case Fatality Rate of 37%.[1] To reduce this burden, detection and treatment gaps must be addressed, funding gaps closed, and new tools should be developed.

The year 2020 began with the focus of the HIV/TB program on development of National Strategic Plan 2021-25 and Global Fund grant applications for NFM 3. Despite the damages it caused, COVID-19, presented an opportunity to build better and resilient health systems.

To support this effort, the NTP has taken a lead in leveraging digital innovations for TB surveillance and monitoring through platforms like **DHIS 2** also known as the DHIMS, which is a web-based system centrally hosted by the Central Health Information Management (CHIM) unit within the Planning Policy Monitoring & Evaluation (PPME) division of Ghana Health Service. This provides a platform for managing health service data nationwide across all service delivery points. This includes data from public, some private, faith-based and quasi-government health facilities. This system is implemented nation-wide.

Apart from this, **TB care e-Tracker** developed by the Policy Planning, Monitoring and Evaluation Division of the Ghana Health Service, in collaboration with the National Tuberculosis (TB) Control Program, is being implemented for individual case management to collect, manage and analyze transactional case-based records for TB screening, TB care & Treatment and adherence from 325 high TB burden district hospitals using the DHIS2 Tracker capture. This system, called TB care e-Tracker, has been deployed in Ghana especially in high TB burden districts. [4]

Additionally, to complement the existing national HMIS data systems, the TB Data from DHIS2 is integrated as indicators which enable comprehensive data review and analysis of TB data nationally.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. With the high political commitment of the government in Ghana to improve the country's digital architecture, Ghana has reached one of the highest mobile penetration in West Africa. With nearly 132.8% of the population having a cell phone, i.e., at least 1 mobile device per person, and the smartphone use is about 98%. Internet penetration also shows decent figures, i.e., approximately 78.3%.[5] It provides a good opportunity to the country to leverage the friendliness of its population with digital tools, which can set a strong ground to implement advanced solutions and ensure adequate uptake.

This country TB digital surveillance assessment report aims at providing strategic recommendations and way forward to country leadership in developing and scaling a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program has been implementing primary two tools for TB surveillance:

DHIS2 based aggregated data collection system, which is being used at all 260 districts in Ghana. Typically, the data from e-tracker is compiled and entered in DHIS2 at the district level. The data is aggregated and reported upwards to regional and national level.

The current system generates monthly reports which are being accessed used at district, provincial and national program managers.

TB care E-tracker tool allows capturing of case-based TB data through the entire cascade of care only for TB confirmed cases starting from Notification, monitoring, treatment outcome. The system works both online and offline. However, scale at which e-tracker is implemented is limited. It is implemented in 325 high burden TB district hospitals only.

One of the biggest challenge highlighted by the NTP is that these two systems (DHIS2 and E-tracker) are not integrated and hence currently both the systems are being used in parallel.

The vision for implementing a case-based TB surveillance on DHIS2 will be an important way forward to have a unified case-based TB surveillance system for both DS TB and DR TB cases.

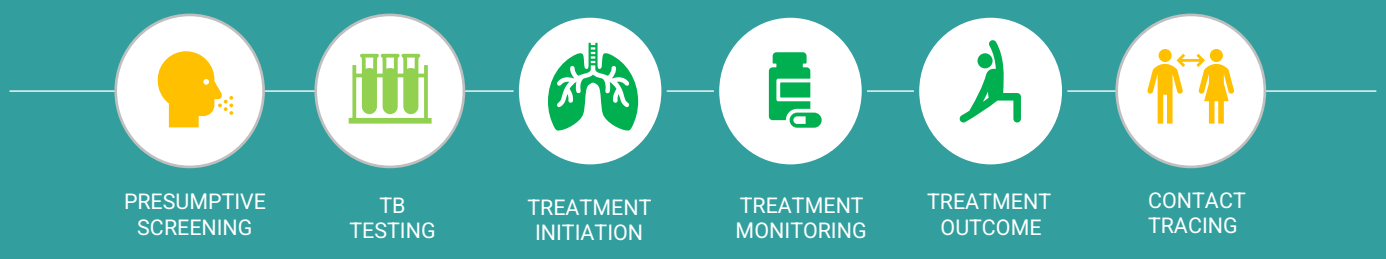
SUCCESS STORIES

Ghana has implemented a unique strategy to get access to TB testing data from private bodies. In order to ensure a complete reporting of all TB positive cases, data from Civil society organizations (along with that from Private sector service providers) is captured from the site of sample testing itself, i.e., government labs. As per the TB service delivery guidelines, Private providers/CSO's collect sputum from community and deposit at the public health facilities for testing (GeneXpert), and results are sent back to these CSOs. The identified positive cases get reported along with the other local cases of that public health facility in the national TB reporting system and hence none of the cases get missed from the final report.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Regional level	16	Data not collected at this level			DHIS2 Dashboard
District/ Municipal/ Metro	260	260	DHIS2	DHIS2: Aggregate	e-Tracker Dashboard DHIS2 dashboard
Sub District level and Facility level	1365	1252	DHIS2	DHIS2: Aggregate	DHIS2 dashboard
		325	e-Tracker	e-Tracker: Case Based	e-Tracker Dashboard
Community level	Data not collected at this level				No Data usage at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	✓
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	✓
Treatment monitoring	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

Source: Survey with Country Team

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	Case based data is available only for 113 high TB burden facilities (e-tracker). Rest of the 1252 facilities enter in DHIS2 in aggregated form
Lowest Unit for TB notification digitisation	Facility Level
Stage of notification	Screening
Level of Access and Use of TB Notification data	Facility level (sites with access to tools), otherwise District level
Private sector notification	Manual notification process
Frequency of digitization of TB notification	Monthly (DHIS2), Daily (eTracker)
Mode of follow-up with notified cases	Manual follow-up- phone calls, household visits
Scale of implementation	DHIS2 aggregated system is scaled at National level E-tracker case based system is scaled only at high burden facilities.
Contact tracing for TB notified cases	Recorded in manual registers. Some related aggregated figures reported in DHIS2
Multi-channel enablement	113 high burden district TB hospitals use E-tracker web application
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

As per NSP 2015-2020, only 2.6% of the notified cases are from the Private Sector and CBOs. 135 CSOs have partnered with the NTP to perform case finding and treatment support activities in all regions of the country.

COUNTRY IT CAPACITY

Country Server
Both system are hosted and managed by the Planning Policy Monitoring & Evaluation (PPME) division of Ghana Health Service

Interoperability
DHIS2 as a platform provides interoperability features like API and data export, but yet to be integrated

Country IT team
In-house IT country team is present in Ghana Health Service, but would like dedicated IT personnel under NTP

ENABLING ENVIRONMENT

132.8%
Mobile penetration (Jan 2021) [5]

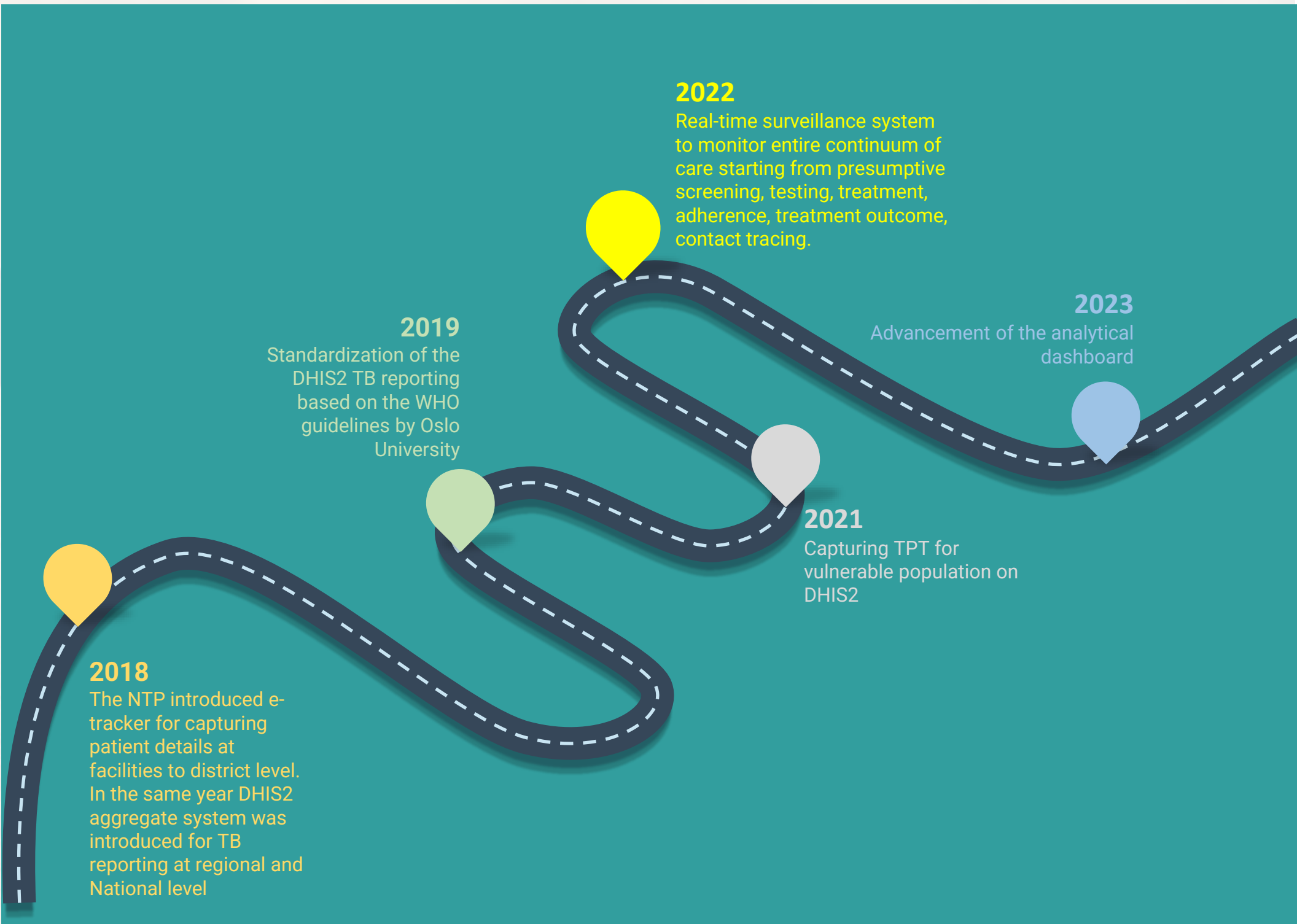
98%
Smartphone (2020) [6]

78.3%
Internet penetration (Jan 2021) [5]

CURRENT RESOURCES AVAILABLE

- A funding under RSSH is available for software extension and development for the enhancing the application.
- Digital TB case notification was included in the concept notes of National Strategic Plan 2020-23, with budget of USD 1 million.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nil	NA			
Logistic Management	Quant TB	Web Application	MSH (Management Sciences for Health)	The Global Fund	National
Laboratory Information Management	GxAlert	Web Application	System one	The Global Fund	Pilot
	ASPECT (upgraded GxAlert)	Web Application	System one	The Global Fund	Pilot
Community Led Monitoring (CLM)	Nil	NA			
Hospital Management System (EHR) for general hospital data	Lightwave Health Information Management System (LHIMS)	Web Application	Lightwave eHealth Solutions		Pilot
Contact tracing module	DHIS2 aggregated	Web Application	PPME, Ghana Health Service	The Global Fund	National

KEY CHALLENGES

- Individual patient level screening data is not captured, and hence a lot of presumptive TB cases get missed (dropouts) from reporting and follow-up.
- Capturing laboratory referral data (linking patient to care after initial diagnosis) is a bottleneck in getting data for the complete cascade of care.
- Limited coverage of eTracker. It is implemented only in 113 high TB burden district hospitals due to infrastructural challenges
- Real time data is not available for all the stakeholders, and this results in delays in planning interventions.
- Lack of a dedicated M&E, system management and software maintenance capacity with NTP.
- Capacity building at all levels is required but resources are inadequate.

NTP VISION

- To build a robust and comprehensive system that has both the systems integrated i.e., e-Tracker and DHIS-2 system
- Monitoring of entire cascade of care starting from presumptive case screening
- Provisioning a real time data availability and bi-directional feedback for taking timely actions at facilities, e.g., Patients alerts
- Improvement of IT infrastructure (both software and hardware) at Health facilities and laboratories.
- Better M&E, system management and software maintenance capacity with NTP

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Ghana has 1050 sub-district facilities and 325 public facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 206,250** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Ghana has 1394 sub districts and 260 districts and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 330,800** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 908,700** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Ghana would need an investment of **USD 24,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Ghana already have a strong foundation for DHIS2 aggregated system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 260 districts, which could cost roughly USD 100 per district, amounting to **USD 26,000** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 2.5 - 3 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Ghana

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"Ghana will ride on opportunities presented to her doorsteps for gain. If Internet penetration is 78.3% and 132.8% of the population are having a cell phone, then with these friendly opportunities presenting as camels in a desert land, the first step is to hop on the camels' back and to invite supporters for advanced digital solutions"

Dr. Yaw Adusi Poku
NTP Manager
Ghana

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for development , implementation and scale of the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation of Case Based TB Surveillance systems** : Ghana has already developed the core infrastructure in terms of the database and deployment of DHIS2 and e-Tracker platforms, which lays a strong foundation for executing the vision of creating a single comprehensive and integrated real-time case-based TB notification and surveillance system.

  It is recommended that this existing capacity is leveraged for developing **e-tracker** for a comprehensive case-based surveillance system, which accommodates monitoring of entire continuum of care for **both DS TB and DR TB** patients starting from presumptive screening, referral, testing, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time. Additionally, inclusion of TB Preventive Treatment (TPT) module and inclusion of data from Lab Referrals and other key modules would make this a comprehensive solution.

  The architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates of TB case-based tracking, currently being used by other countries (and standardized by WHO) can be helpful in fast-tracking the software development processes. [7]

  Tentative timeline: Month 0-12

- **Data Integration :** One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources like e-Tracker into the main DHIS2 systems as a central warehouse for effective use.

  To ensure that there is a seamless integration of data from multiple data systems like e-Tracker and other data sources like excel files maintained at facilities without any data loss , the DHIS2 data upload / transformation API should be explored. The same can even support the movement of case-based records to the central data warehouse or HMIS.

  There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central database.

  This DHIS2 data transformation API feature also offers creation of standard templates which can be easily mapped with external data collection tools. [8]

  Apart from this it also supports batch upload for historical data in large volumes to ensure minimum disruption to the live systems.

  Other source ETL tools over Postgres DB and / or WHO powered XMart [9] which can be installed within the current environment can also be considered.

  Tentative timeline: Month 6-12

- **Data Use :** Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which help in data analysis based on a range of dimensions , data aggregation reports and individual line lists and with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with direct integration of E-tracker and enhancement of the current DHIS2 dashboard, then a more advanced analytical dashboard should be designed and implemented with providing monitoring access at all administrative levels.

RECOMMENDATIONS

To strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics it is also recommended to use the best of the breed tools like Tableau, Power BI which offer these features. The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [10]

Tentative timeline: Month 6-12

- **System Integration:** One of the challenges highlighted by NTP is the leveraging the data collected from the multiple applications / systems into the main e-Tracker systems as a central system for effective use.

  The current e-Tracker platform and infrastructure needs to be extended to support integration with external systems like GeneXpert,TruNat, Digital X-Ray outputs, Pill Boxes and other digital adherence tools which help in use the data effectively for the patient care continuum as highlighted by the NTP.

  Recommended data exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing. [11]

  The DHIS2 platforms architecture is easily compatible with these standard tools and can be considered as an alternate route of system integration. [12]

  Tentative timeline: Month 12-24

- **eLearning :** To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While some platforms offer standard training modules on the application, training tools like Moodle[13] built on standard Learning Management System (LMS) framework can be reviewed for application rollouts.

  Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- **Capacity building for application maintenance**

  Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

  Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- **Mobile application introduction**

  One of the challenges reported by the NTP during the assessment processes is the lack of availability of real time data to stakeholders. One effective way to overcome this is to support the current data collection processes by introducing a mobile application for e-Tracker, which is in line with the country's efforts of improving the overall digital ecosystem.

  The mobile application should be developed such that it supports offline data collection , security, encryption ,version management etc and multiple tools can be evaluated to access the suitability for easily extending to the current systems.

  This would also ensure that the data structures are consistent. Also, the app should be supported with a configurable set up to support any updates / changes to the program.

  Additionally, the mobile framework is recommended to use open-source technologies like Java, Postgres, React and Android, which are easily supported by country IT teams. Also, the standard best practices of mobile development like version management , data encryption etc should be a component to make this a more robust solution. [14]

  Tentative timeline: Month 6-18

RECOMMENDATIONS

❖ **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

Tentative timeline: Month 0-6

❖ **Patient Interactive Systems :** Tracking the lost to follow-up cases is highlighted as one of the main challenges given the migrant population is sizable.

Establishing a direct and secured mechanism for engaging with patient has a potential for drastic improvements by tracking the patients lost to follow-up. Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS [15] can be used for these activities.

Tentative timeline: Month 12-18

Strategic Technical Recommendations

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems.

The technologies that need to be brought in and the areas of inter-connection need special focus.

Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption and data exchange standards.

Apart from this, version 2.34 also supports compliance with GDPR standards and offers more controlled data encryption practises. [16]

✓ **Performance Optimisation & Testing** : To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium also can be considered. Load Testing tools which help in data base sizing and planning need to be adapted for effective planning . [17]

✓ **Application & System Security Audit**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[18] / country specific policies to over

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by DHIS2 [19] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [20]

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr. Yaw Adusi Poku*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Robert Majwala*** for providing valuable insights into Ghana's vision for creating a comprehensive case-based TB surveillance and notification system.

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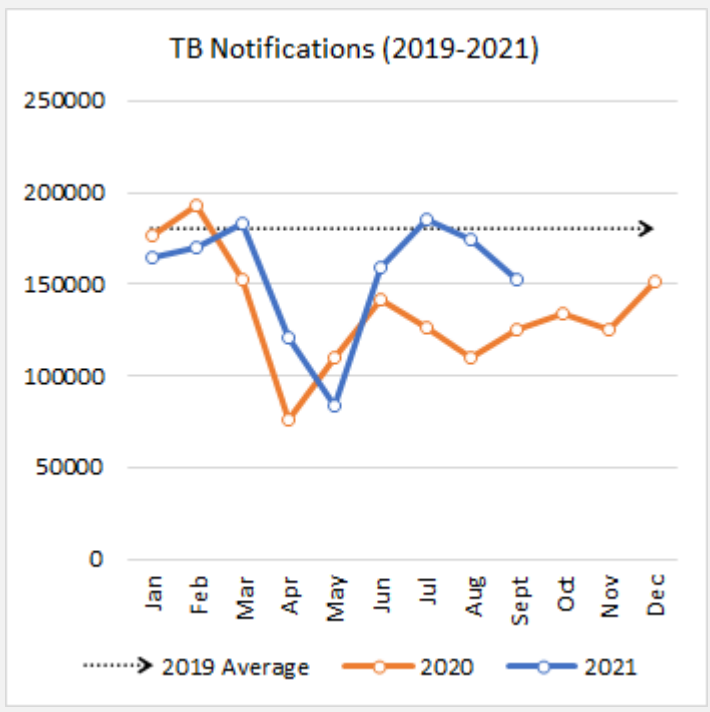
INDIA

INDIA

BACKGROUND

India accounts for about a quarter of the global TB burden with an estimated incidence of 2,590,000 TB cases and 124,000 MDR/RR-TB cases as of 2020. TB kills approximately 480,000 Indians every year, i.e., more than 1,400 every day. India also has more than a million 'missing' cases every year that are either not notified or remain undiagnosed or unaccountably and inadequately diagnosed and treated in the private sector. [1,2]

India was on the up-hill trajectory of notifying TB with a peak of 2.4 million case in 2019. Due to the COVID lock down in India, like in many other countries, notification tumbled by 25% in 2020. However, since India has a very strong TB notification system NIKSHAY, India was able to recognize the decline in TB notification early during the pandemic and mount efforts to mitigate this on priority through TB and COVID bi-directional screening and testing, augmenting laboratory services, and treatment capacity upgrades. [3]



Source: https://www.who.int/teams/global-tuberculosis-programme/data

The national Strategic Plan 20017-2005 (NSP 2017-2025) proposes bold strategies with commensurate resources to rapidly decline TB incidence and mortality in India to SDG target levels by 2025, five years ahead of the global timelines. A major activity for the programme was to set up a state of art TB surveillance system and integrate it into the existing Nikshay platform. [4]

As per the NSP 2017-2025, effective ICT support will be the cornerstone for facilitating engagement, user-friendly patient reporting, people centric treatment adherence monitoring, and for smooth financial transactions. The e-Nikshay platform, supported with efficient call centers and provision of sufficient digital tools to field staff and providers, is key to reaching patients in private sector. Adherence system using ICT platform is also being strengthened with the use of additional tools such as 99 DOTS, Pill box etc. [4]

NIKSHAY platform is one of the most evolved and advanced TB surveillance platform that was developed by National TB Elimination Programme (NTEP) and National Informatics Center (NIC). It has been rolled out across the entire country for TB notification and monitoring of patients through the entire continuum of care at all levels. NIKSHAY platform is much more than just a TB surveillance system. It has various innovations and integrations which sets an example for other countries to learn from.

Starting with presumptive TB enrolment and referral for testing, progressing through laboratory diagnosis and notification, drug prescription, supporting adherence to treatment till successful outcomes and providing opportunities for post-treatment follow up for long-term, it also has integration with Laboratory Information Management System (LIMS), Prevent-TB India contact-tracing and TPT app, Nikshay Aushadhi (the drug supply chain web and mobile application), PFMS, (the Public Finance Management System that supports direct benefit transfer (DBT) , financial transaction of patient enablers and provider incentives). Various innovative modules and integrated solutions that uses the NISHAY backbone such as Arogya Sathi app (aimed at proactively increasing awareness among the citizens and ensuring availability of free and quality assured drugs), and Nikshay Sampark (the patient support call centre for grievance redressal) and adherence monitoring tools such as 99 DOTS.

Technology penetration plays a crucial role in providing enabling ecosystem to foster digital innovations. As of January 2021, the country has nearly 79% of the population having a mobile phone, and 54% using smartphone. India also has 45% internet penetration which has grown by 8.2% against previous year. This provides a very conducive environment a strong foundation to implement advanced solutions and ensure adequate uptake. [5,6]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

BRIEF OF DIGITAL CASE BASED TB SURVIELLANCE SYSTEM

India uses NIKSHAY platform as the national case-based TB notification and surveillance that is scaled to all TB units and facilities across the country. In 2012, India began its transition towards a digital TB ecosystem with the introduction of the NIKSHAY platform. Over the years this platform has evolved incrementally and has become a real time case-based TB information management tool which is used by both public and private providers in the country.

The central TB Division (CTD) of Ministry of Health and Family Welfare and the NIC have jointly developed Nikshay. To support development and maintenance and to provide technical guidance, there is a core team in CTD supported by WHO India and Bill and Melinda Gates Foundation. Since Nikshay is in continuous evolution, users are regularly alerted on new features through the link https://nikshay.zendesk.com/hc/en-us/articles/360016723931-What-s-New with corresponding online training materials through https://nikshay.zendesk.com/hc/en-us publicly available in Nikshay website www.nikshay.in.

NIKSHAY system is fully accessible to the private sector also. After a self-initiated or facilitated registration in the system, private facilities are provided with access to full cascade of care of patients notified by them.

NTEP publishes real time TB notification report in the website national, state, district, TB Unit level, both for notification from public and private. https://reports.nikshay.in/Reports/TBNotification. NTEP also publishes quarterly reports “Nikshaypatrika” and annual TB report on the website https://tbcindia.gov.in/

Apart from publicly available data and reports, Nikshay system has autogenerated analytics, reports and feedbacks provided to programme managers at all levels.

SUCCESS STORIES

India has been one of the pioneers countries to conceptualize a digital solution to cover the entire TB care cascade for real time case-based surveillance.

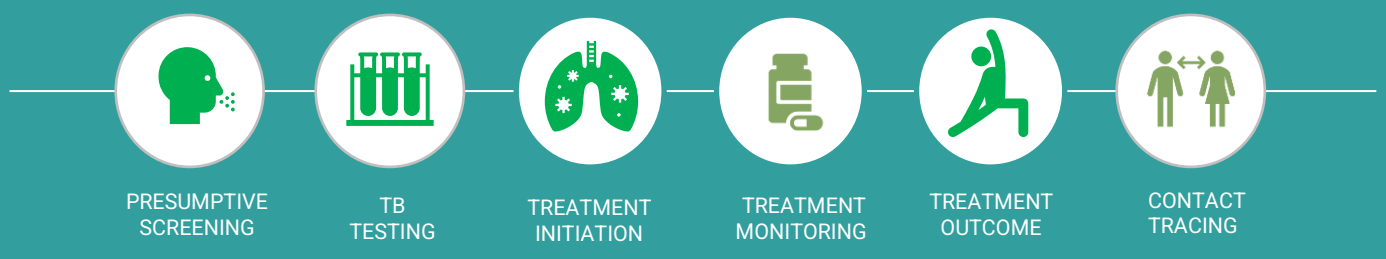
With the launch of Nikshay version 2.0 in 2017, the NTEP has fast expanded the engagement with private sector resulting in a remarkable increase in TB notification. Along with this, active case finding (ACF) strategies supported by Nikshay, 0.7 million cases have been additionally notified by 2019, with a 40% jump compared with 2017, significantly narrowing the gap in treatment coverage. With dashboards available at all levels from peripheral users to the national policymakers, Nikshay has been pivotal in empowering local administrative TB responses by take locally appropriate decisions. During Covid-19 lockdowns, Nikshay has been the warfare tool in daily monitoring of TB notification and treatment adherence at all levels of the programme management units, enabling the country to rapidly catch-up TB care and minimize impact.

The NTEP has also used Nikshay data along with TB drug-sale surveillance, variance in number needed to test in measuring under reporting and decline in incidence to render subnational disease free certification for eligible districts and states. The most remarkable aspect of this tool is its massive scale of implementation, that receives data from all over the country, prominently on a real-time basis making it the largest real time TB surveillance system in the world.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				NIKSHAY Dashboard
State level	36	Data not collected at this level			NIKSHAY Dashboard
District Level	718	Data not collected at this level			NIKSHAY Dashboard
Facility Level	All public and private TB facilities	39136 public facilities (and 244508 private providers)	NIKSHAY Web App	Case-based	NIKSHAY Dashboard
Community level	Outreach workers/STS/ STLS	Across country	NIKSHAY Mobile App	Case-based	NIKSHAY Dashboard

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	Aggregated/ case-based
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	✓
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)**	✓
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

***Targeted population*

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	NIKSHAY
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Diagnosis
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Patient Provider Support Agencies (PPSAs) and Private facilities with access, report Individual cases in NIKSHAY
Frequency of digitization of TB notification	Real time
Mode of follow-up with notified cases	SMS follow ups, Dedicated call centre, Home visits
Scale of implementation	National roll out
Contact tracing for TB notified cases	Currently done through Prevent TB app (Pilot in Kerela and Chhattisgarh); will transition to NIKSHAY
Multi-channel enablement	NIKSHAY has a desktop as well as mobile app for data reporting; a patient centric app has also been introduced
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Private sector clinics and general practitioners have a complete access to NIKSHAY and are mandated to notify all TB cases being identified and/or put on treatment. Patient Provider Support Agencies (PPSAs) are also supporting in getting the private cases notified in NIKSHAY. 30% of the total TB notified is by private sector and the treatment outcome is reported in NIKSHAY by the private sector either directly or through PPSA.

COUNTRY IT CAPACITY

Country Server
Servers are hosted by the National TB Program, and managed by the in-house IT team

Interoperability
NIKSHAY platform allows an integration with other tools through APIs and Data Export mechanisms. Already integrated with LIMS

Country IT team
National TB program has an IT team to handle server and maintenance. App development is outsourced to Everwell.

ENABLING ENVIRONMENT

79%
Mobile penetration (Jan 2021)[5]

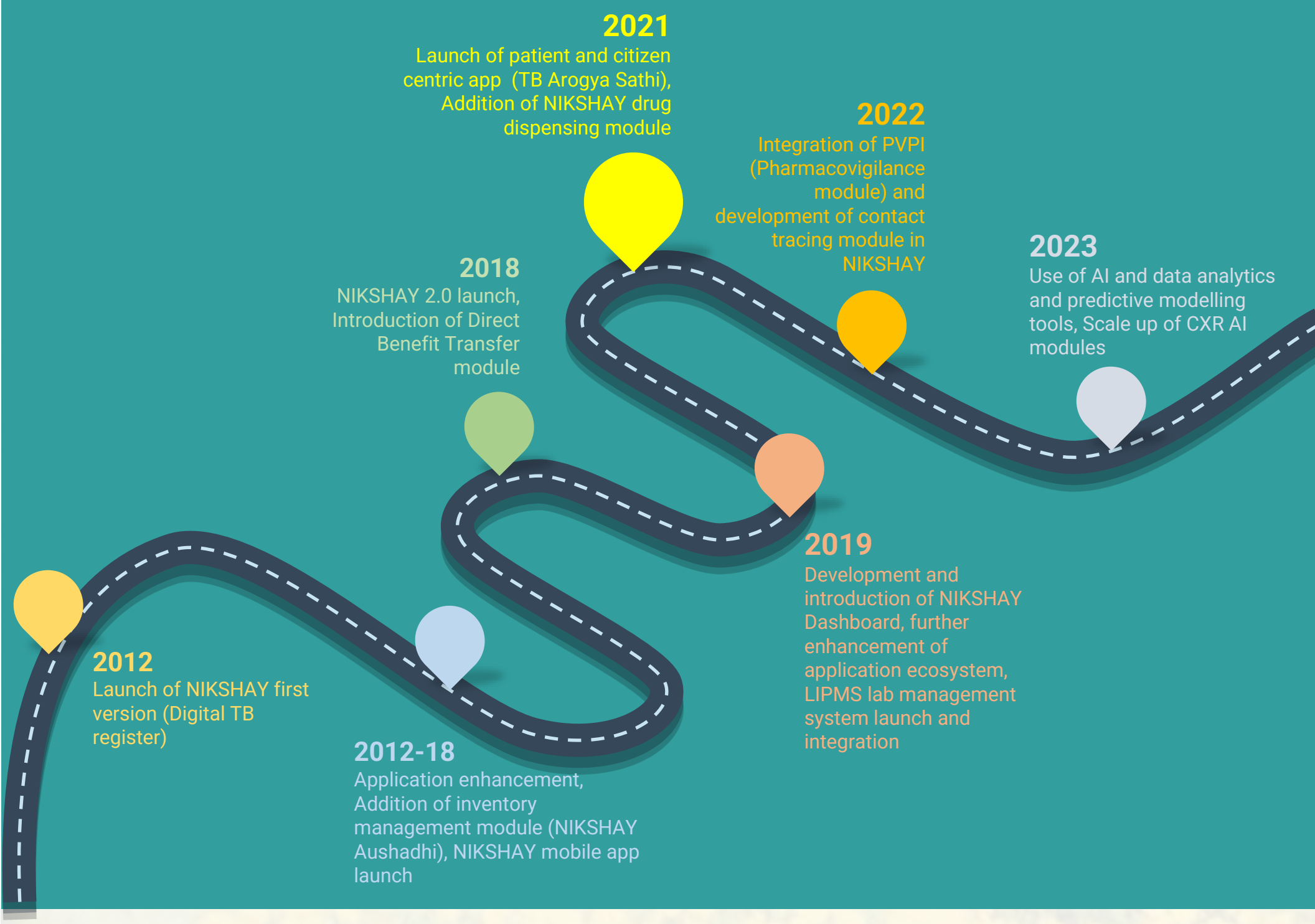
54%
Smartphone (2020)[6]

45%
Internet penetration (Jan 2021)[5]

CURRENT RESOURCES AVAILABLE

- The Global Fund has granted USD 280 million for the period of 2020-2022 to advance tuberculosis prevention and control in India.
- Nikshay platform is supported by domestic resources and by Bill & Melinda Gates Foundation (BMGF)
- A number of supportive digital applications linked to NIKHSAY including Digital Adherence technologies, CLM tools etc. are being supported by agencies like USAID, Stop TB partnership, Global Fund, Wadhwani AI etc.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nikshay Adherence module	Web Application	Everwell	USAID	National
	99DOTS	Mobile application	Everwell	USAID	Pilot
	MERM Box	Smart Med Containers	Everwell	USAID	Pilot
Logistic Management	NIKSHAY Aushadhi	Web Application	CDAC	CDAC	National
Laboratory Information Management	LIMS	Web Application	FIND	The Global Fund	National
	Qure.Ai CXR	Web Application	Qure.Ai	The Global Fund	Pilot
Community Led Monitoring (CLM)	Arogya Sathi (NIKSHAY) TB Mitra	Mobile App Mobile App	Everwell Dure Technologies	USAID	In the process of integration
Contact Tracing	Prevent TB	Web Application	Dure Technologies	WHO	Pilot

KEY CHALLENGES

- Transitioning into paperless reporting of certain features in the programme remains a challenge. Though Nikshay is capable of this transition, issues with integration and operation delay this transition. Paper is still used for referrals, specimen transportation and reporting and treatment adherence monitoring.
- Scaling up of real-time data directly from different devices such as GeneXperts and TrueNAT and DST laboratories to Nikshay.
- LIMS is functional only in reference laboratories .
- Collecting real-time data on diagnostic tests (especially complete address of patients) from the TB laboratories in the private sector though notification from these laboratories has been improving.
- Tracking adverse drug reactions (ADR). However, the module for ADR monitoring is being developed.
- NIKSHAY produces large data base which need to be further analyzed using advanced analytical and data science approaches and predictive modeling.
- Linking other external data sources such as National Integrated Disease surveillance systems (IDSP), Integrated Health Information Platform (IHIP), HMIS, Vital Registration system, SIMS HIV data system etc.

NTP VISION

India has not only envisioned a comprehensive digital TB surveillance system but has also demonstrated that such systems can be implemented at scale at the lowest level of health facilities despite of huge infrastructure and other socio-economic barriers. As per the National Strategic Plan 2017-2025 put forth, India plans to leverage it's existing NIKSHAY platform as a foundation to develop and integrate various other innovation that can be taken up to scale. Some of them are indicated below:

Further enriching the NIKSHAY analytics platform with more granular patient level and aggregated data for decision making and planning.

Further integrating other innovative solutions like Presumptive screening and contact tracing module, AI based CXR integration and community led platforms such as Aarogya Sathi app. and taking it to scale.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for fulfilling country's vision, we have put together an estimated investment requirement and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Server/cloud: Based on the current volumes of new cases, would need an investment of **USD 500,000-600,000** for next 3 years for server and server maintenance. Alternatively, cloud based comprehensive service may be hired with pay-as-you-use arrangement, which can reduce the task of seamless management of hardware and environment.
- **Software Development:** Based on various multi-stakeholder meetings and given the fact already have a strong foundation of a case-based reporting nationally, around **USD 800,000-1200,000** should be budgeted for comprehensive TB surveillance system development and analytical dashboard for data use. Supportive applications and software like ms-sql, asp.net, php, android kit, gis applications etc can be included in the cloud based comprehensive service.
- **Capacity Building and Implementation:** After the software development, a dedicated system admin and a developer should ideally be budgeted. The existing IT resources should be continued. A rough ongoing recurring cost of **USD 200,000- 300,000** should be budgeted for 3 years for technical support.

TOTAL investment of around **USD 2 Million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Data Use:** : Advanced data science, big data analytics and AI based predictive modelling should be leveraged for forecasting demand for testing and treatment and help planning resource utilisation better.

  The data use should also use GIS based hotspot mapping and AI based hotspot predictions to enable epidemiological monitoring

  It should also focus on vulnerability and risk profiling of the patients so that highest risk patients such as patients with high-risk behaviour, nutrition needs, co-morbidity factors or migration factors can be prioritised for closer monitoring and differentiated care.

  Granular outputs of these initiatives must be linked and used for individual patient care with action-oriented reminders, alerts and feeds to patient, family and providers as well as related stakeholders.

  Tentative timeline: Month 0-12

- **Scaling up AI for TB elimination:** CTD is also piloting TRACE-TB (Transformative Research and Artificial Intelligence Capacity for Elimination of TB and Responding to Infectious Diseases) with support from USAID with the ambitious aim of eliminating TB from India by 2025. The work can be leveraged for

  - Using AI to read Line Probe Assay (LPA) to improve efficiency and minimize errors.
  - Identifying patient behavior patterns to identify those at risk of being Lost to Follow Up (LFU), case fatality, drug resistance and other unfavorable outcomes.
  - Cough sound based and voice-based AI tool for screening of tuberculosis which can be used by citizens using Arogya saathi mobile app
  - Automated reading of digital chest x-rays across the country for alerting the providers for TB testing
  - Image processing algorithms for automated reading of skin tests for diagnosis of latent tuberculosis
  - AI based chatbots for citizens, programme staff as well as health care providers for instant solutions and information sharing for faster solutions
  - AI based forecasting of TB drugs requirement for procurement planning, prediction of local drug stock requirement for inventory management and prediction of multi-level stockout and suggestion of action including stock transfer etc
  - AI based prioritization of target population for TB Active Case Finding
  - Algorithmic use of vast information of Nikshay to be used for automated mathematical modelling for burden estimation at local level especially TB unit and district level

  Tentative timeline: Month 6-12

- **Development of more comprehensive e-Learning and Decision Support System (DSS):** AI based decision support system tools can also be used for assisting both medical and non-medical professionals such as outreach workers for sputum collection, lab users or treatment initiators and others to provide a protocolised step by step assisted guide.

  Advances in Artificial Intelligence and Machine Learning algorithms should be explored to provide a more intelligent and intuitive assistance to health staffs for example automated daily tour routes to treatment supervisors for maximum impact based on existing data in their TB units. This

RECOMMENDATIONS

will not only help in improving services but also help in reducing the work burden and help staff focus on actual care.

Tentative timeline: Month 6-9

- **System Integration**: One of the challenges highlighted by NTP is leveraging the data collected from other tools into the main Nikshay system for effective use.

  NIKSHAY has already established integration with external systems, like GeneXpert, TruNat, DBT, 99DOTS, etc. and have plans to integrate AI readings from Chest X-Rays. Additionally, the LIMS integration already in place should be expanded across the country so that all labs are connected to NIKSHAY database facilitating real-time lab data exchanges helping in real-time TB notification at diagnostic stage. Additionally, this integration should enable NTP to establish a molecular epidemiological surveillance system by gathering information on bacillary lineages and strains from the whole-genome sequencing laboratories and the multitude of mutations being captured at various central molecular diagnostic laboratories.

  Nikshay should also be integrated with COVID-19 application of ICMR so that bidirectional screening and testing can be implemented more effectively.
  If other initiatives like NCD-TB screening application is integrated with Nikshay, it can be helpful increasing the case finding efforts as granular individual information on eligible presumptive TB can be sought across the country by NTEP out of community-based screening of population.
  Similarly, it is a long due for Nikshay to be integrated with e-PDS so that the TB patients and families can be linked with additional ration and food supplies.
  We recommend that these integrated systems are scaled up through standard with integration and security protocols such as FHIR/HL7 in addition to in-country Meta-Data and Data Standards (MDDS) and EHR / EMR standards of Health Ministry.

  Though NIKSHAY already follows a strong national data security and privacy guidelines of National Informatics Center and hence other security guidelines should be explored based on need assessment and detailed evaluation. In addition, GDPR standards for more secured and seamless data collection and storage should be also explored.

  Tentative timeline: Month 6-18

- **Expansion and integration of the N-TB Nutrition App:** We recommend to integrate the N-TB nutrition app as one of the integrated modules within NIKSHAY which can enable healthcare workers to assess nutritional status of patients with TB, estimating the weight gain required to reach an acceptable or optimal body mass index, and provides counselling tips on diet and an approximate daily calorie intake required for nutritional recovery.

  Localized and customized diet charts based on the nutritional assessment may be included with pictoral suggestions to patients. The App is currently a stand-alone app but having it integrate with NIKSHAY will help treatment providers to capture nutritional status along with other risk and co-morbidity factors at the treatment initiation stage itself thus helping in recommending patients with appropriate nutritional support and further monitoring.

  Tentative timeline: Month 6-12

- **Scale up of Patient Centric Systems and CLM platforms:** NIKSHAY has taken a huge leap in creating patient centric systems such as Aarogya Sathi and TBMitra App in past. Community led monitoring and community participation is crucial to achieving the TB elimination target of 2025.

  Either an extension of Aarogya Sathi App or integrating it with another TB CLM platform is strongly recommended which will provide a one-stop-shop for TB patients and people at high risk to get services they need.

RECOMMENDATIONS

The Patient centric platform can also integrate with platforms like such as medicine reminders, adverse drug side effect reporting etc.

Tentative timeline: Month 1-12

❖ **Pharmacovigilance integration with NIKSHAY:**

It is also recommended to integrate the National Pharmacovigilance system with the NIKSHAY platform to monitor and report adverse drug side effects specially for both new and generic TB drugs.

The Pharmacovigilance module should not only facilitate in reporting cases at facility and district level but should also be integrated with the patient centric platform recommended previously so that drug side affects can be self reported by the communities themselves.

Tentative timeline: Month 3-8

❖ **Data quality audit**

While Nikshay is well set and implemented across the country, it is important to ensure data quality on an ongoing basis and regular data quality audits should be undertaken preferably using third party assessment mechanisms by agencies like WHO.

Tentative timeline: Month 6-24

ACKNOWLEDGMENT

We thank the Joint Director (TB), ***Dr Nishant Kumar*** and the entire NTP team and partners for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr Vaibhav Shah*** for providing valuable insights into India's journey with Nikshay and vision for creating an integrated health information system.

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INDONESIA

INDONESIA

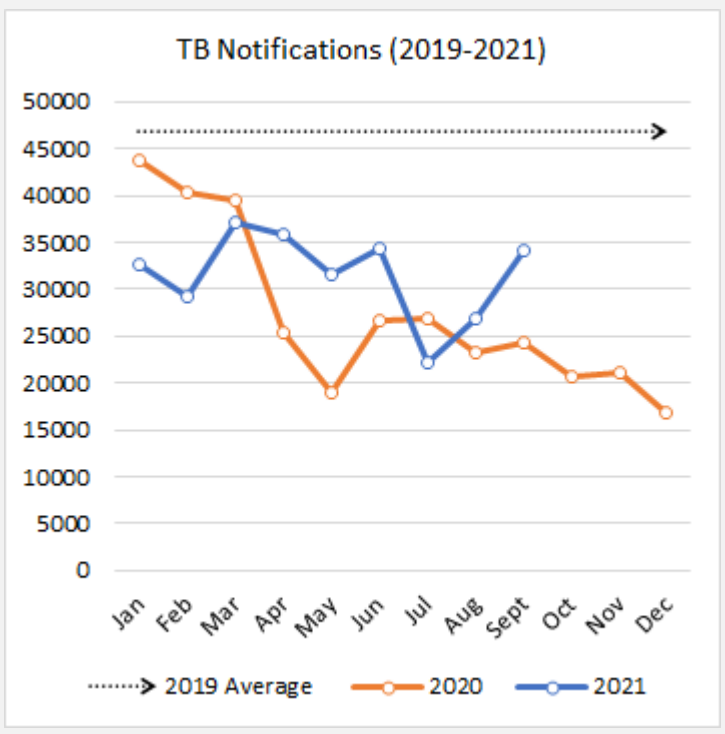
BACKGROUND

According to WHO estimates, Indonesia accounts for the third largest TB burden in the world (WHO Global TB report, 2021). Over 824,000 new TB cases were estimated in 2020, i.e., an incidence rate of 301 for every 100,000 people, of which only 393,323 got reported. Nearly 18,000 people were also estimated to suffer from both TB and HIV. [1]

Overall, Indonesia falls in all the 3 lists of 30 High Burden countries, i.e., high TB, DR-TB and TB/HIV case loads.[2]

In line with WHO's 'End TB Strategy', Indonesia has developed a roadmap for TB elimination for 2020-2030 and seeks to accelerate the TB elimination efforts by 2030, and to end TB by 2050. It speaks of expanding equitable access of innovative case detection and treatment strategies and building on relevant multi-sectoral partnerships with the private sector and civil society to reach the 2030 objectives. [3]

Affected by the COVID19 pandemic, country's TB case notification has majorly dropped in 2020, however, in 2021, the health system has made efforts to revive its TB surveillance practices and the notification is steadily improving to reach closer to previous rates.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In part to address this high burden and to reach their 2030 objectives, Indonesia's MOH has leveraged the ongoing 'digital revolution'. Since 2019, a TB information System (SITB) has been developed and implemented. SITB system integrates the two earlier separate technology systems, i.e., SITT and eTB manager , for DS TB and DR TB respectively.
It is already functional in almost all Puskesmas (PHCs), hospitals and clinics and enables collection, storage and analysis of individual case-based TB data. In 2021, it has also been integrated with GxAlerts in 310 sites. To complement the MoH data and information center, i.e., Pusdatin's DHIS2 ASDK (integrated data warehouse for health programs), SITB has mechanisms of data integration that enables comprehensive data review and analysis of TB data nationally, alongside the data from other health programs.

SITB is supported by a few other digital applications as this analytical framework delineates. With strong technical leadership from the Ministry of Health even in the wake of COVID-19, and financial support from USAID and the Global Fund, Indonesia plans to integrate these various digital systems to enable a sustainable implementation plan in accordance with the Roadmap for TB Elimination, 2020-30.

As a key enabler for the implementation of this technology-driven TB case reporting platform, Indonesia's technology penetration trends stand noteworthy. With nearly 125% of mobile penetration, 67% population using a smartphone and over 73% access to internet in the country, the data reporters are well equipped with an ease in using digital tools, particularly crucial for reporting case-based data.

The implementation of Indonesia's SITB system presents a few good practices, scalable both in the country and beyond.

Apart from SITB, Indonesia has been implementing various pilots which demonstrate pollical will and focus of Indonesia towards digital health:

WiFi TB: A simplified version of the SITB platform with lesser volume of variables to be captured against each TB case. The system is available for use as a mobile app and is used by General Practitioners, Clinics and other private bodies for reporting data to the national system.

SITRUST and EMPATI: It is a set of digital tools that support long term sustainable TB surveillance, prevent, treatment and control by empowering different relevant stakeholders: local governments, health service providers, community organizations, and the private sector. It is supported by USAID and contains – a mobile app (Empati), a knowledge dissemination tool (SOBAT TB) and a lab specimen transport tracking tool (SITRUST).

Based on the multi-stakeholder discussions, interviews, independent research, and guidance from the National TB Program, this assessment report attempts to produce clear recommendations and way forward towards developing a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of the report.

STATUS OF CASE BASED TB NOTIFICATION

As a national platform for all TB case notification, Indonesia TB program primarily uses SITB system to support all TB surveillance, monitoring and response activities:

SITB is the national platform since January 2020 to notify all TB cases. The system supports both online and offline data entry, and has been developed to integrate two legacy systems, i.e., eTB manager (with DR TB data) and SITT (with DS TB data). All the data fed into SITB is owned by the MOH.

Presently, while all newly identified TB patients are enrolled in the SITB platform directly as individuals cases, records for the patients already on treatment are still maintained in the eTB Manager (DR TB cases) or SITT (DS TB cases). The complete transition to SITB is projected for the year 2022.

SITB is used by service delivery stakeholders at different levels: health service facilities, District/ City/ Provincial Health Offices and MOH, as well as civil society organizations to report TB cases.

At hospitals and PHCs where internet is a challenge, the data is entered offline and then downloaded in a ZIP file for sending to the TB program officer, from where it is uploaded online. The system allows data upload at any frequency, however it varies from weekly to fortnightly or monthly, depending on the local arrangements. It is noteworthy that the delay in data entry by the health facility officers (non-routine data updates) and the data syncing delay from offline setups creates a gap in real time access to data, which is one of the key challenges being faced.

SUCCESS STORIES

SITB was successfully conceptualised and rolled out nationally across all Puskesmas/PHCs in just three years, from 2017 to 2020. In 2021, SITB was also integrated with other health information systems such as Gx Alerts.

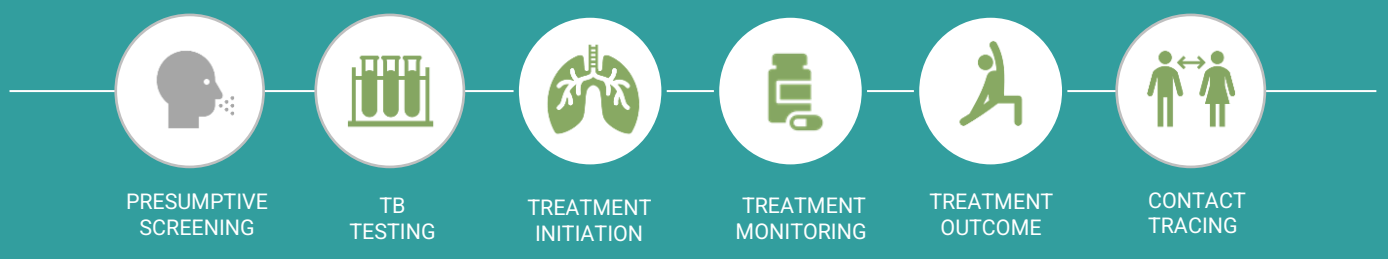
Notification of all TB cases has been declared mandatory by the Ministry of Health in 2016, and a supporting application, WiFi TB mobile app, allows private sector partners to upload data directly into the national database.

Development and implementation of the 'TB Indonesia mobile dashboard' app has been another notable success. This application shares the information related to the TB program (both from SITB and Wifi TB), and is accessible in the public domain.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				SITB Dashboard TB Indonesia mobile dashboard
Provincial level	34	Data not collected at this level			SITB Dashboard TB Indonesia mobile dashboard
District Level (Regencies and Cities)	514	Data not collected at this level			SITB Dashboard TB Indonesia mobile dashboard
Facility Level	13000	13000	SITB (Public and Private hospitals) WIFI TB (General Practitioners, Private clinics)	Case-based (DR TB and DS TB)	SITB Dashboard TB Indonesia mobile dashboard
Community level	Data not collected from this level				No Data usage at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	Aggregated/ case-based
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	SITB, WIFI TB
Lowest Unit for TB notification digitisation	Healthcare facilities (Puskesmas, Private Hospitals, Public Hospitals. General Practitioners, Clinics, etc)
Stage of notification	Testing of presumptive TB case
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Large private hospitals – SITB, Private clinic and GPs – Wifi TB app
Frequency of digitization of TB notification	Online – Real time, Offline – Weekly/Monthly
Mode of follow-up with notified cases	Phone calls, social media, household visits
Scale of implementation	SITB has been established as the national TB case notification system.
Contact tracing for TB notified cases	Available
Multi-channel enablement	SITB online and offline, Wifi TB mobile app
Govt. order for mandatory TB notification	Government order for mandatory TB notification mandates the TB data submission in SITB (as national surveillance system) and WIFI TB (as additional tool for private healthcare notification)

PRIVATE SECTOR NOTIFICATION

While a section of large Private hospitals have access to report data for TB cases in SITB directly, other Private sector clinics and general physicians notify the public health system of individual cases (not aggregated) through the WIFI TB mobile application. In 2020, 61% of private hospitals and 4% of GPs/private clinics across Indonesia have reported TB data to the national database.

COUNTRY IT CAPACITY

Country Server
Servers are hosted by the National TB Program, and managed by the in-house IT team

Interoperability
SITB platform allows an integration with other tools through APIs and Data Export mechanisms.

Country IT team
National TB program employs an in-house IT team to handle server management and application maintenance.

ENABLING ENVIRONMENT

125.6%
Mobile penetration (Jan 2021)[4]

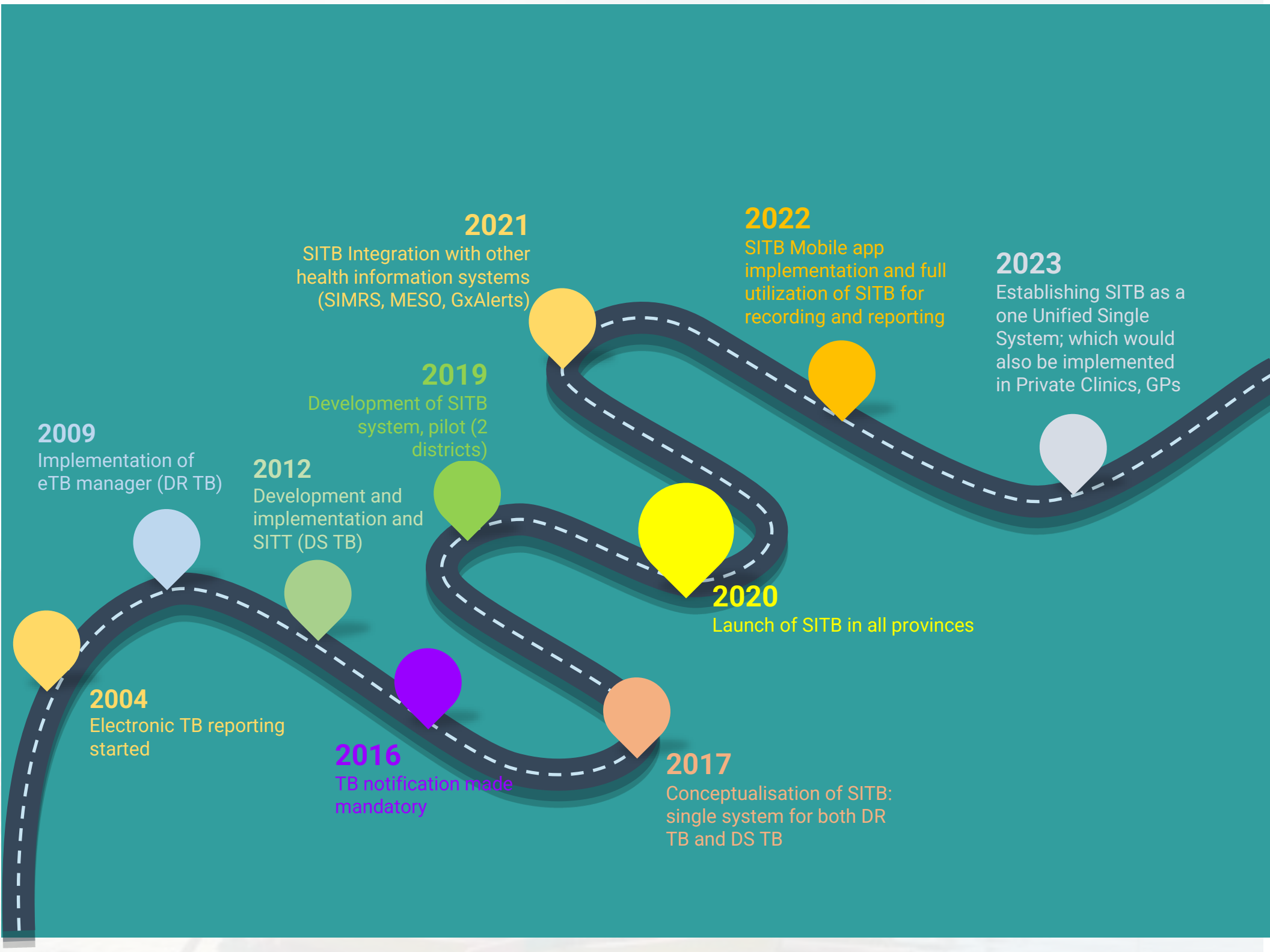
67.15%
Smartphone (2020)[5]

73.7%
Internet penetration (Jan 2021)[4]

CURRENT RESOURCES AVAILABLE

- USD 700,000 mobilised by USAID and The Global Fund was used to develop SITB over three years
- A total of USD 1.8 million was used to implementing the case based TB notification system: on software development, training health staff, dissemination and communication.
- USD 50,000 (as of 2020) is needed as annual recurring cost towards Servers, HR - software development, Ongoing Training, Hardware.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Empati	Web Application	YKI : Yayasan KNCV Indonesia	The Global Fund	National
Logistic Management	Dedicated module in SITB	Web Application	MOH	The Global Fund	National
	SITRUST	Web Application	YKI : Yayasan KNCV Indonesia	The Global Fund	National
Laboratory Information Management	Gx Alert (fully integrated with SITB)	Web Application	System-One	MoH	Implemented at 310 sites
	Dedicated module in SITB	Web Application	MOH	The Global Fund	National
Community Led Monitoring (CLM)	Empati	Mobile App	YKI : Yayasan KNCV Indonesia	The Global Fund	In the process of integration
Contact Tracing	Dedicated module in SITB, SITK	Web Application	MOH	The Global Fund	National

KEY CHALLENGES

- **Availability, capacity and training of data entry professionals:** The crunch on manpower is multifaceted. On one side, the TB officers are having multiple additional responsibilities, and at the same time, the employee turnover rate is quite high.
- **Digital literacy of both professionals and communities:** Mobile apps and other personalised technologies are available and rising in popularity and availability, but not everyone finds them easy to use.
- **Hardware limitations (Electricity, internet connectivity, server capacity, availability of device for data entry):** With Puskesmas often in areas of limited internet connectivity making it difficult to report TB cases in real-time
- **Decentralization of monitoring and evaluation:** Periodic data monitoring and feedback sharing is mostly not practised from the provincial and district level. Data is generally reviewed directly at the national level and hence the feedback sharing (if at all) becomes less effective.
- **Real time data availability:** With a good proportion of data being entered offline and the differences in frequency of data reporting, developing and getting access to a real-time data dashboard for timely actions becomes difficult.

NTP VISION

- Indonesia's National TB Program plans to upgrade relevant infrastructure (server capacity, maintenance) in more than 10,000 Puskesmas. By 2021, SITB is due to be functional across over 2000+ hospitals.
- The NTP will also integrate Empati and other mobile apps into SITB and build a mobile SITB application by 2022.
- The NTP seeks to build digital capacity among all national staff through technological training programs at provincial, district, and health facility levels
- A fully integrated health information system covering all health programs with an Agile framework is envisioned by the MoH.
- Recruiting more staff, conducting their routine training and tracing and addressing data entry backlog.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

Hardware and Infrastructure:

- Mobile Devices (for data collection): Indonesia has 13,000 facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 1,950,000** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): Indonesia has 514 districts and 34 provinces, and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 109,600** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 4,064,400** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
- Server: Based on the current volumes of new cases, Indonesia would need an investment of **USD 20,000-30,000** for next 3 years for server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

Software Development:

- Based on various multi-stakeholder meetings and given the fact Indonesia already have a strong foundation of SITB case-based system for TB, around **USD 400,000-500,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. A 1-day training should be planned for each of the 514 districts, which could cost roughly USD 100 per training amounting to **USD 51,400.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 6.5 - 7 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Indonesia

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"Healthcare system now change into people centered service and the need for digitalization have been vast than before. But, it doesn't happen overnight. The digitalization in health care system is just like summer turn into fall – gradual yet very perceptible. We shall prepare to face the new season of the year. The season of digitalization to bring healthcare equity to everyone"

Dr. Tiffany Tiara Pakasi, MA
NTP Manager
Indonesia

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- **System Integration:** One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources into the main SITB system as a central warehouse for effective use.

  The current SITB platform and infrastructure needs to be extended to support integration with external systems like TruNaat, Digital X-Ray outputs, digital adherence tools, Logistics management information system and Community-led monitoring systems like EMPATI as visioned by the national TB program with the concept of an integrated Health Information Management System (HMIS)

  These data exchanges can be made seamless with API sharing between the platforms and the central repository.

  Recommended data exchange/ ETL tools like Talend, Informatica[6] makes data management task much easier and simultaneously improves data warehousing. These exchange tools also comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes.

  Tentative timeline: Month 0-6

- **Unique Identifiers:** The main difficulty being faced by NTP is the challenge in data exchange without the presence of any unique identifiers in SITB. Data from multiple systems can only be integrated by mapping the various identifiers of a case across these systems.

  It is recommended while capturing the information of the TB cases they should be linked with unique identifiers like national ID to ensure that duplication of the patient is avoided, and case is tracked, monitored and followed up throughout its treatment journey.

  An alternate measure can be the generation of a unique code in SITB by combining multiple attributes from patient demographics and using the same for data exchange.

  Tentative timeline: Month 0-1

- **Data Use**: The NTP's plan clearly emphasizes on the importance and need for improving data use. This can be made possible by making more real time and useful case-based TB data across systems.

  While there is an existing SITB dashboard there is a strong need to strengthen and expand the scope of data visualisation and making effective use of data for predictive modelling , data science and for advanced analytics. It is also recommended to use best of the breed tools like Tableau , Power BI [7] which offer these features. The current SITB platform offers APIs which can be connected for these applications and used as an extended analytical component of the data analysis framework.

  Also , To ensure that there is a seamless data exchange from other platforms like WIFI TB and to support historical data upload from eTB Manager , the data should be extracted, transformed and loaded into the central database.

  While SITB supports API other open source ETL tools over My SQL , Post Gres DB and / or WHO powered Xmart [8] which can be installed within the current environment can also be considered.

  Tentative timeline: Month 6-12

- **Mobile app**: One of the challenges reported by the NTP during the assessment processes is inconsistent data connectivity / network issues which delays reporting of cases. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, that has already been envisioned by the NTP team.

  Other advantages for a mobile application include better performance , effective use of device features like in house system updates ,

RECOMMENDATIONS

usage of location , security measures and tracking user patterns and issue log mechanisms and other analytics measures

Several mobile solutions for real time case-based notification can be explored for local adaption and building the mobile counterpart for SITB. Open source technologies like DHIS2 Mobile App, ODK and KOBO are some notable examples. [9]

Tentative timeline: Month 0-12

- **Continuous training:** Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the new SITB tracker-based application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using SITB for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  Training tools like Moodle [10] built om standard LMS framework can be reviewed for application rollouts.

  Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can

  be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- **Server Augmentation & Infrastructure Upgrades**

  Based on the architecture, the system upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should be such that it supports the integration layer which would be needed for data exchange with national/external systems.

  The technologies that need to be brought in and the areas of inter-connection need special focus. A review of the existing server architecture is advised along with deployment of automated load testing tools like Selenium, Appium [11] which can help in database sizing and monitoring adaptation needs for planning.

  Tentative timeline: Month 6-24

- **Application & System Security Audit**

  To strengthen the current systems framework and ensuring long term sustenance, it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria. This would also include developing a framework which should outline policies in line with recommended security standard policies for a) Patient data management, and b) server and infra guidelines

  Tentative timeline: Month 6-36

- **Capacity building for application maintenance**

  Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

  Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- **Patient Interactive Systems**: Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [12]

  Tentative timeline: Month 6-24

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr Tiffany Tiara Pakasi*** and the entire NTP team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr Jonathan*** for providing valuable insights into Indonesia's vision for creating an integrated health information system.

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8. WHO Xmart : https://portal-uat.who.int/xmart4/docs/general/Overview.html

9. Open Source Mobile Applications (DHIS2 Mobile App : https://dhis2.org/android/ KOBO : https://www.kobotoolbox.org/ ODK https://opendatakit.org/)

10. Application Training Tool : https://moodle.org/

11. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/

12. OPEN MRS : https://openmrs.org/

KENYA

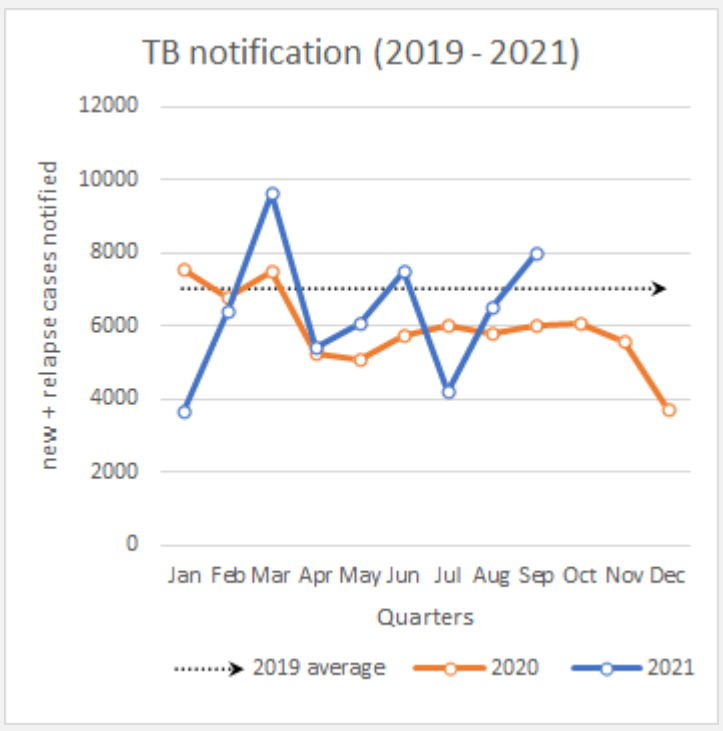
KENYA

BACKGROUND

According to WHO estimates, 139,000 people have newly developed TB in Kenya in 2020, of which 72,943 got notified (Global TB report, 2021) [1] With nearly 35,000 of all people with TB also infected with HIV, Kenya is included in the list for the top 30 TB/HIV high burden countries. [2] Children account for nearly 8% of all cases, and many also suffer from TB-HIV coinfection. [1]

Kenya has achieved a treatment coverage of 51% of all people living with TB in 2020 and the TB case fatality ratio stands at 6% (out of total cases put on treatment). 46% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment. [1]

The COVID19 pandemic has impacted the TB notification rates in Kenya and in 2020, it fell much below the 2019 average monthly notification, however, in 2021, the health system is making efforts to revive its TB surveillance practices rapidly and the case notification has steadily improved to reach back near the 2019 levels.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In order to achieve the key milestones of reducing TB deaths by 75% and TB incidence rate by 50% by 2025, Kenya's National Strategic Plan (NSP) for TB, leprosy, and lung health 2019-2023 lays emphasis on the need to ensure the provision of quality care and prevention services for all patients suffering from TB, more specifically, by investing in patient-centered care, developing bold policies and building supportive systems, and investing in research and innovation. NTP envisions the closing of gaps along the care continuum to find, treat, and cure all people with TB; differentiate its response by county to address the local TB priorities; optimize the integration of TB services in the universal health coverage (UHC) model; prevent latent TB infection; and implement a patient-centered approach that promotes quality of care, each of which creates an opportunity to exploit technological advances to make the processes more robust and seamless at the same time. [3]

Kenya has a TB reporting platform known as **TIBU**, which captures case-based data. The case-based data is entered in TIBU by the TB coordinators (in the frequency of monthly or quarterly) on behalf of the facilities. Further, the case-based data is aggregated and summarized for further uploading in **KHIS2** (DHIS2-based system) on a quarterly basis, which is used by NTP for program review. Additionally, to complement the existing national HMIS data systems, the TB Data from KHIS2 can easily be analysed with indicators of other programs, which enable comprehensive data review and analysis of TB data nationally.

To strengthen the community-based screening practices of the NTP and improve the frequency of data reporting, a supporting tool called TIBU lite is also being piloted at some facilities.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. With the high political commitment of the government in Kenya to improve the country's digital architecture, Kenya has reached one of the highest mobile penetration in Eastern Africa; with nearly 108.9% of the population having a mobile phone, i.e., at least 1 mobile device per person, and the smartphone use of about 99.7%. However, the internet penetration is still improving at a steady pace, i.e., approximately 40%. It is thus a good opportunity for the country to leverage the friendliness of its population with digital tools, which can set a strong ground to implement advanced solutions and ensure adequate uptake.[4]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

In 2012, Kenya developed and launched the **TIBU** system with technical support from KNCV, which was later modified in 2014 to match the WHO TB surveillance guidelines. The system was initially developed to address the documentation challenges in the private sector but has further been expanded to cover the public facilities and faith-based organizations. Over the last 5 years, the system has also been enhanced to cover active case finding & TPT modules and is further being customized to cover the entire cascade of care and producing program monitoring dashboards.

The case-based data in TIBU is entered by the TB coordinators. With about 4700 TB sites and 300 TB coordinators, each TB coordinator is assigned 14-15 TB sites for data entry (both DS and DR TB) and supervision. TB coordinators visit once or twice in the month to these sites to upload the data into the TIBU system.

This case-based data from TIBU is aggregated on a quarterly basis and uploaded to the national KHIS2 platform, which helps with the data dissemination for program review from National to district level. Along with it, a Patient Management System (web-based version of TIBU) is another tool to support routine data use.

SUCCESS STORIES

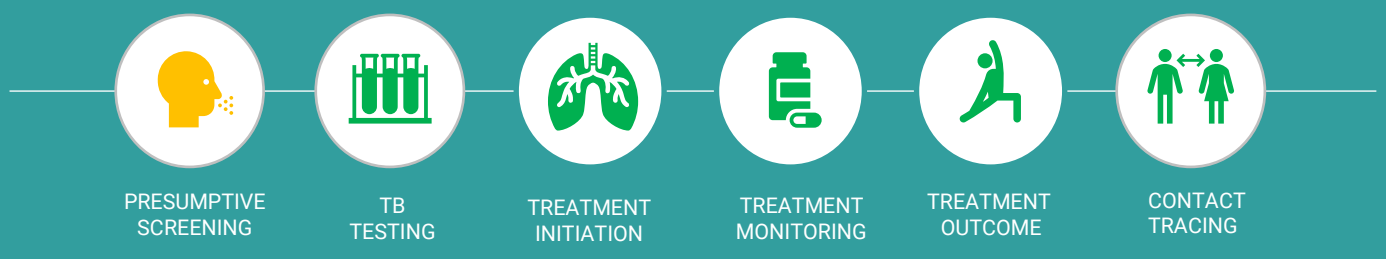
As per the old TB notification reports the NTP, there was an 11-day delay on an average in notifying a TB case, while with the introduction of TIBU and its evolution over the last few years, this has now improved to nearly 5 days currently, which is further being planned for case reporting within 24 hours of treatment initiation.

Seeing the gaps in hardware and internet infrastructure at the facilities, Kenya has chosen an alternate arrangement to ensure the capturing of case-based data for TB, and the same is successfully running across the country. The TB coordinators have been given android tablets which they use for patient data entry on behalf of the health facilities under their jurisdiction (as part of their monthly visits) and hence the records are digitized for al TB health centers regularly.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				Patient Management System (TIBU) KHIS2 Dashboard
County level	47	Data not collected at this level			Patient Management System (TIBU) KHIS2 Dashboard
Sub county Level	300	300 (on behalf of facilities)	TIBU KHIS2	Case Based Aggregate	Patient Management System (TIBU) KHIS2 Dashboard
Facility level	4700 - TB treatment units (public, private)	4700	Manual	Case Based	Patient Management System (TIBU)
Community level	Data not collected at this level				No data usage at this level

CASCADE OF CARE MONITORING



Digital (Aggregated) Digital (Case Based) Manual

KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	TIBU TB surveillance system
Lowest Unit for TB notification digitisation	Sub county level (on behalf of facilities)
Stage of notification	Treatment initiation
Level of Access and Use of TB Notification data	Facility level (Patient Management System)
Private sector notification	Case based TB notification in TIBU (contributes 20.4% of all TB notification)
Frequency of digitization of TB notification	Quarterly (data uploading and backlog clearing)
Mode of follow-up with notified cases	Phone calls, Physical visits
Scale of implementation	National level (data of all TB facilities)
Contact tracing for TB notified cases	Contact Management register in TIBU (for contacts <5 years)
Multi-channel enablement	Android mobile app for TIBU data entry
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Nearly 50-60% of the private providers have an access to the TIBU surveillance system and use it for direct notification of TB cases. NTP is also planning to integrate with the Electronic Health Records systems of bigger private hospitals in the near future, for getting access to the remaining TB cases on treatment. Private sector contributes to nearly 20.4% of the total TB case notification.

COUNTRY IT CAPACITY

Country Server
TIBU platform is hosted by the NTP at the Kenya Country cloud server (certified/commercial Data Center)

Interoperability
Data export from TIBU in JSON/XML and APIs are available and integrated with KHIS2

Country IT team
TIBU is completely owned by the NTP team (have access to source code), and its management is done by outsourcing to a tech partner (Iridium)

ENABLING ENVIRONMENT

108.9%
Mobile penetration (Jan 2021) [4]

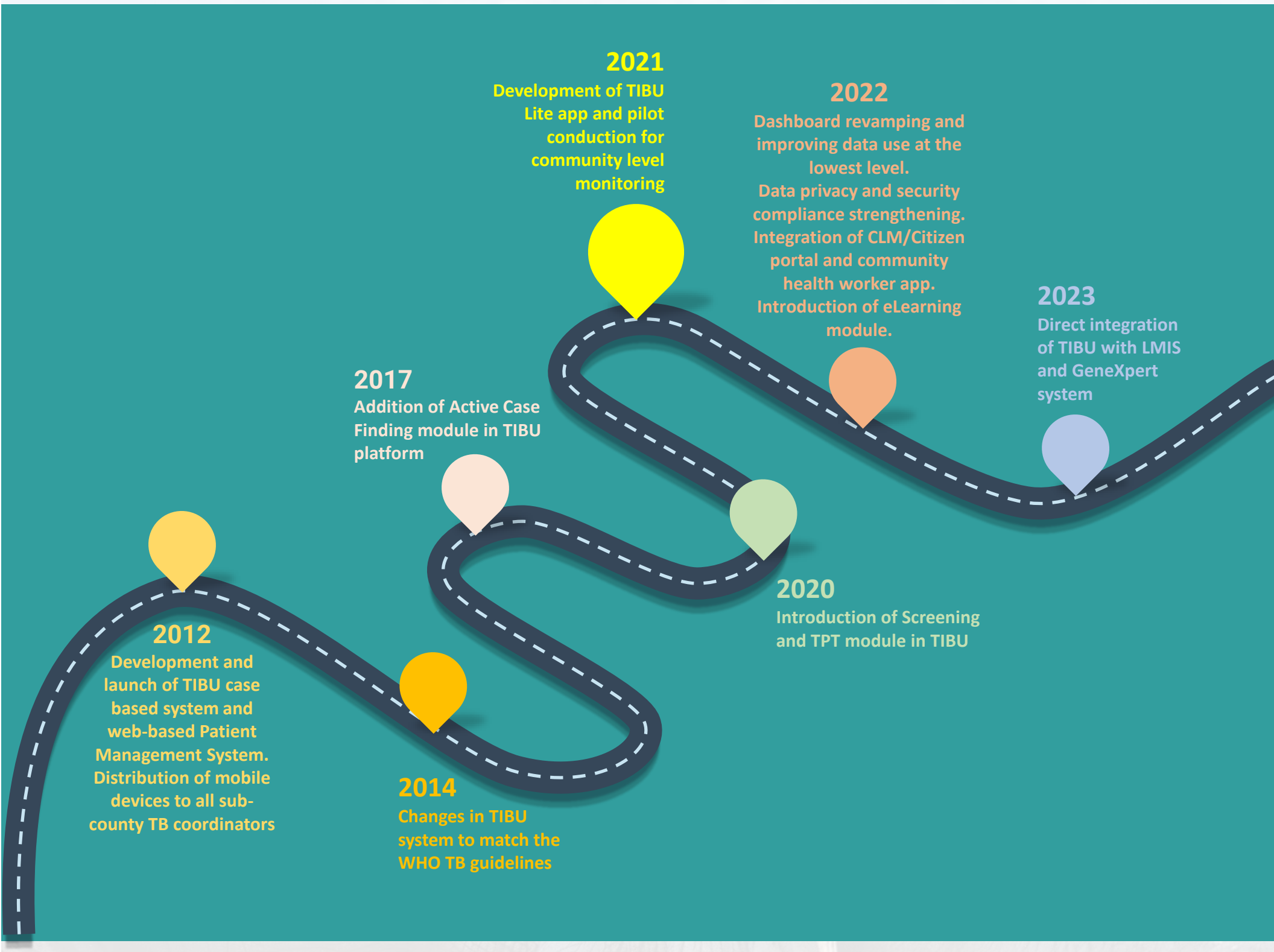
99.7%
Smartphone (2018) [4]

40%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- Funding of USD 1 million is available from USAID and The Global Fund for supporting the enhancements of the current software to online/offline mobile versions.
- Additional funding of USD 20,000 is present for development of a private sector module.
- Funds of USD 0.3 million from The Global Fund is available for bearing the hardware costs like procurement of mobile phones or laptops, and additionally USD 70,000 is present for rolling out of the system at the lowest level of data reporting.
- USAID grant of USD 20,000 is available for bearing the hosting and deployment costs for the system.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence and Contact Tracing	Nil	NA	NA	NA	NA
Logistics Management Tool - eLMIS	TBMeds, KEMSA LMIS	Web Application	NTP, CHAI	CHAI	National
Laboratory Information Management	GxAlert	Web Application	CHAI	Centre for Health Solution, USAID	180 GeneXpert diagnostic sites
	LabWare	Web Application	South African vendor	AMREF, The Global Fund	National
Community Led Monitoring (CLM)	TIBU Lite Community Module	Mobile App	NTP, AMREF	USAID	To be implemented soon
Pharmacovigilance	Tibu Pharmacovigilence module	Web Application	Iridium	USAID	National

KEY CHALLENGES

- Shortage of personnel (TB coordinators) and High data entry burden poses an acute crunch of trained manpower at the data entry points.
- With the internet conditions being very unreliable, real-time case-based data entry from the facility level with the software remains to be a huge challenge.
- Availability of and lack of maintenance of hardware (desktops/laptops/tablets) for data entry is also inadequate for direct data reporting from facilities, and as a result of this, data is entered from sub county level and that adds to the delays and increases burden on the TB coordinators.
- Gaps in the availability of smartphones with the health workers limits the usage of TIBU app on the ground.
- In the absence of any patient/community centric applications, the access to information at the grassroots remains limited, and crucial information for program monitoring and planning, like TB adherence, gets missed in the data.
- Getting data from the entire private sector requires more system expansion, but funding it is a bottleneck.

NTP VISION

- Expanding the features of TIBU to cover additional module for Screening and Contact Tracing module.
- Extending TIBU usage at the facility level for a real time case notification.
- Development and implementation of a mobile app for enabling the data capture on a real time basis.
- Improvement in data quality (accuracy, validity and precision).
- Encouraging private sector for reporting in TIBU.
- Making the point of diagnosis as the notification trigger and integration with other systems (GeneXpert, LIS, etc).
- Enhancement of dashboards to strengthen data analysis and usage of data by stakeholders.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for fulfilling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Kenya has 4700 TB facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 705,000** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Kenya has 300 sub-counties and 47 counties. To promote active data use, each sub-county (i.e., the associated TB coordinated) should be given a tablet which would cost roughly around **USD 69,400** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 1,514,100** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Kenya would need an investment of **USD 30,000-40,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Kenya already have a strong foundation of TIBU case-based notification and DHIS2 aggregate reporting nationally, around **USD 1,500,000-2,000,000** should be budgeted for comprehensive TB surveillance system development and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each 197 districts over a period of 3 years which could cost roughly USD 100 per training amounting to **USD 19,700.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 4.5 – 5.0 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Kenya.

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

Digital TB surveillance system, that is scalable and integrates all services; data, laboratory and commodity management will remain a key pillar in TB control as we work towards ending TB by 2035. The rollout of the TIBU system is a major milestone that promotes the use of data for decision making at all levels. In the near future, this technology will offer real opportunities to improve TB outcomes and enhance efficiency. It will reduce the usage paper-based registers in health facilities, workload, costs and ultimately conserve our environment.

Dr. Waqo Ajersa
Head - National Tuberculosis Leprosy and Lung Disease Programme (NTLP)
Ministry of Health, Kenya

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation and scale up of Case Based TB surveillance systems :** The NTP has already established a conducive environment and core infrastructure in terms of database and deployment. It has built the local expertise and capacity which acts as a strong foundation for executing the vision of establishing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the TIBU platform implementation. While currently, data is getting entered monthly or quarterly by the TB coordinators (sub-county level staff) on behalf of the facilities, the application should further include the monitoring of entire continuum of care including presumptive screening, referral, treatment initiation and adherence, treatment outcome & contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes [5]

  Tentative timeline: Month 0-12

- **Mobile app :** One of the challenges reported by the NTP during the data collection processes is the lack of availability of real time data for stakeholders and inadequate availability of laptops/ desktops. One effective way to overcome this is to support the current data collection processes by introducing a mobile application at all health facilities, which is in line with the country's efforts of improving the overall digital ecosystem.

  As a recommendation, access to TIBU mobile app version should be expanded to facility level, so that features of security, offline data collection, encryption, version management etc can be leveraged while entering case-based data reporting, even from facilities with limited internet infrastructure.

  This would also ensure that the data structures are consistent. Also, the app should be supported with a configurable set-up module to support any updates/ changes to the program.

  Additionally, the mobile framework is recommended to use open-source technologies like Java, Postgres, React and Android, which are easily supported by country IT teams and are advised to follow the standard best practices of mobile development like version management, data encryption etc which make it a more robust solution. [6]

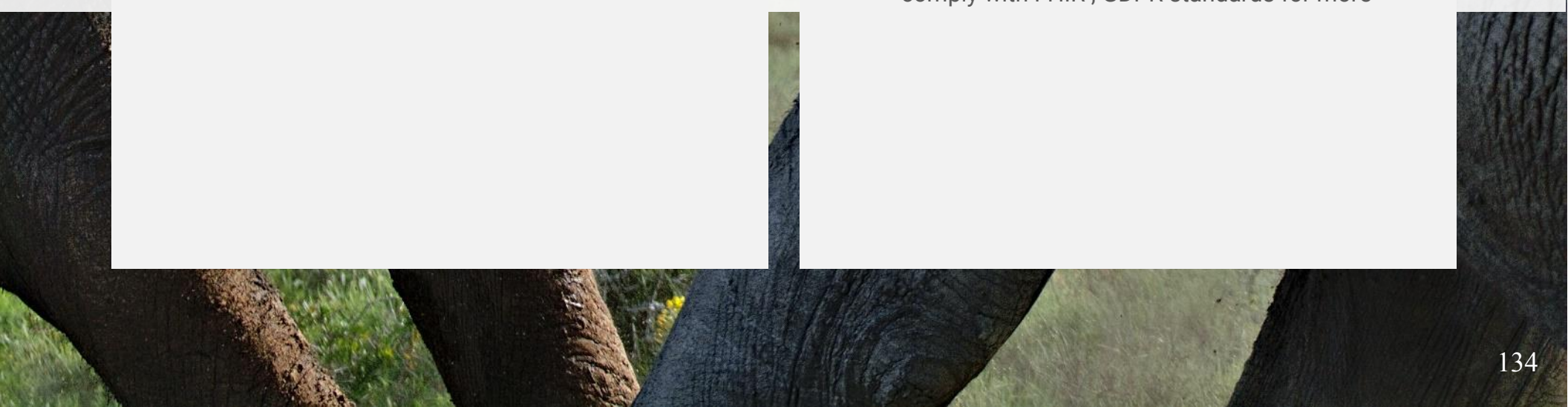
  Tentative timeline: Month 6-12

- **System Integration**: One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources into the main TIBU/KHIS2 platform as a central system for effective use.

  The current KHIS2 and TIBU platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in using the data effectively for the patient continuum of care as highlighted by the National program.

  Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing should be evaluated. [7]

  The data exchange process should follow and comply with FHIR , GDPR standards for more



RECOMMENDATIONS

secured and seamless data exchange supporting standard data taxonomy and meta data management processes.

The KHIS2 platform's architecture is easily compatible with these standard tools and processes making this an effective solution. [8]

Tentative timeline: Month 12-18

- **Data Use :** Country's NTP clearly emphasizes on the importance and need to improve data use. This can be made possible by making case-based TB data and required line listing available at the lowest level health functionary involved in TB care.

  Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table, event reports which support dimensions, data aggregation reports, individual line lists and job aids with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current KHIS2 and TIBU system then a more advanced analytical dashboard should be designed linked to the new case-based TB surveillance system that is already being planned.

  To achieve this , apart from the standard DHIS2 dashboard features and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. The current KHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [9]

  Tentative timeline: Month 6-18

- **Capacity building for application maintenance:** One of the main challenges identified with the NTP is ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up, the system support team requires trained staff on DHIS2 & TIBU.

  Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 0-6

- **Additional data capturing mechanisms :** To make sure the case-based data entry from facilities using a mobile app is convenient, technical solutions like OCR (optical character recognition) should be incorporated in TIBU.

  With the platform supporting this feature, it would also help in data upload of any historical data with less difficulties and will make the daily data entry more seamless.

  Other features like a data transformation API can offer the option of creating standard templates, which can be easily mapped with the data collection tools like TIBU, which can support batch upload large volumes of data.

  Tentative timeline: Month 6-12

- **e-Learning**: To address the challenges with periodic training of facility level staff to orient them on using TIBU system for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While some systems offer standard training modules on the application, training tools like Moodle [10] built on standard LMS framework can be reviewed for application rollouts.

  Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

RECOMMENDATIONS

❖ **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

Tentative timeline: Month 0-6

❖ **Data Quality :** As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

This should be generated automatically through the case-based TB surveillance system that is already implemented.

Data access control is one such DQA measure that will regulate user's access to only relevant metadata, and hence support data privacy. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

Tentative timeline: Month 6-18

❖ **Community Monitoring Systems :** As expressed by the NTP, the national TB notification and surveillance system should have necessary mechanism to integrate with ready-to-use open source CLM platforms like One Impact.

Tentative timeline: Month 6-12

❖ **Patient Tracking System:** Tracking lost to follow-up cases and enabling real time notifications for patients is highlighted as one of the main challenges.

Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients. Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [11]

Tentative timeline: Month 12-24

Strategic Technical Recommendations:

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption & exchange standards.

  Apart from this, 2.34 version also supports compliance to GDPR standards and offers more controlled data encryption practises.[12]

- **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning. [13]

RECOMMENDATIONS

- **Application & System Security Audit:**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA [14] to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by DHIS2 [14] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [15]

ACKNOWLEDGMENT

We thank the National TB Leprosy and Lung disease Program Manager, ***Dr. Waqo Ajersa*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Aiban Robono*** for providing valuable insights into Kenya's vision for creating an advanced case-based TB surveillance and notification system.

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13. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
14. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
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MOZAMBIQUE

MOZAMBIQUE

BACKGROUND

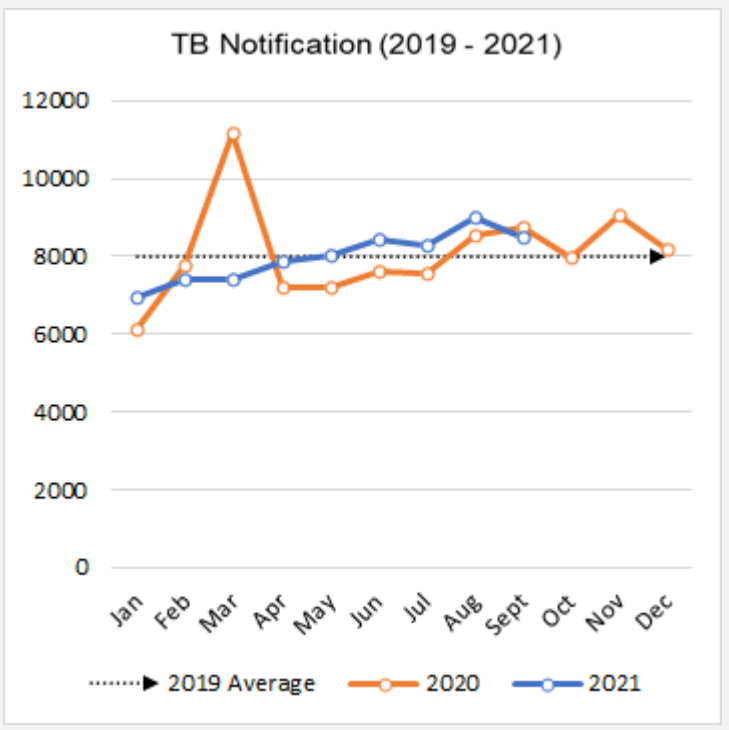
According to the WHO Global TB report 2021, around 115000 new TB cases emerged in Mozambique, at an incidence rate of 368 for every 100,000 people, and 32,000 people are estimated to suffer from both TB and HIV. [1]

With 1,223 individuals in the country developing MDR/RR TB annually, and another 66 confirmed for XDR-TB, Mozambique is also a DR-TB high burden country. [1]

Overall, Mozambique falls in all the 3 lists of 30 High Burden countries, i.e., high TB, DR-TB and TB/HIV case loads. [2]

In line with WHO's End TB strategy, Mozambique has achieved a treatment coverage of 84% of all people living with TB in 2020 and the TB case fatality rate stands at 11%. [1]

Affected by the COVID19 pandemic, country's TB case notification dropped in the second quarter of 2020, however, in the next months, the health system has made efforts to revive its TB surveillance practices and the notification has steadily improved to reach above the monthly notification average figures from 2019.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Vision and priorities of Mozambique's National TB Program (NTP) is crucial to the technology innovations in electronic case-based TB system's functioning. The NTP has developed an outline and concept note for the new National Strategic Plan (NSP) for TB 2020-2029.

The structure largely mirrors the WHO's End TB strategy, with an emphasis on patient-centered prevention and care, bold policies and strong systems, and enhanced innovation and research.[3]

Since 2016, Mozambique uses **DHIS2** as the platform for TB notification (**SIS-MA**), and currently, all the data is captured in aggregate form from all facilities across the country. At the same time, the importance of implementing a case-based system was realized and the NTP introduced a case-based TB notification pilot in 100 facilities of 3 provinces in 2021. The aggregated data reporting continues from all facilities (including pilot sites).

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As per 2021 figures, 50.4% of the population has a cell phone, and nearly 34.2% use smartphones. Internet penetration stands at 21.2% in the country. Enhancing digital inclusion in Mozambique is essential, given that access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's development aspirations. [4]

Apart from implementing the DHIS2 platform, the country is also leveraging other digital innovations as pilots to improve data collection and use, as given below:

Infomovel (Commcare) is one such patient tracking tool developed to support community health workers (CHWs) administer services; focused on HIV/AIDS, tuberculosis, and prevention of mother-to-child transmission (PMTCT). The system has been expanded to national scale in 2019 and supports linkages between community workers and health facility focal points by including case management support. [5]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

In 2016, Mozambique adopted SIS-MA (DHIS2) as the national system for reporting of TB notification data. Manual registers are maintained at the health facilities for capturing all TB specific data and the data is then digitized by entering in SIS-MA on a monthly basis.

In 2020, the country has also implemented a pilot for case-based reporting in 3 provinces, however the aggregate reporting continues in parallel.

This system has an integrated dashboard that aggregates data, and automatic reports are generated for analysis. Based on role and access of a user in SIS-MA, the data is filtered to only show relevant figures.

The national TB notification system allows management of both DR-TB and DS-TB cases.

SUCCESS STORIES

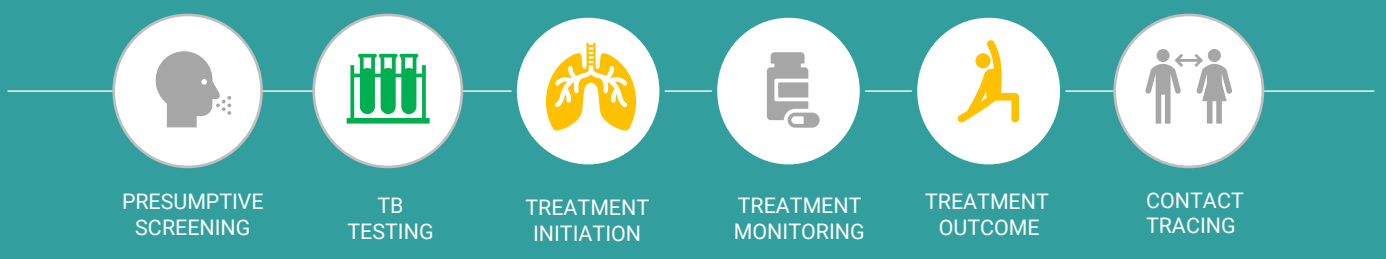
In 2011, Mozambique piloted the GeneXpert machines and its diagnostic connectivity solution, GxAlerts was introduced in 2014. Expansion of the GeneXpert network has been coupled with the expansion of GxAlerts to full national scale, capturing 90% of all GeneXpert test results. This has significantly improved the timely dissemination of diagnostic results to the clinicians and timely initiation of treatment for Drug Resistant TB cases, which has increased to over 85% by the end of 2020.

In the last 6 years of its implementation, SIS-MA (DHIS2 aggregate) has successfully got established as the national TB surveillance system and is now receiving data from all facilities across the country. With help from WHO HQ and University of Oslo, the country has adopted the standard DHIS2 tracker and dashboard templates, and the related training and pilot implementation with android-based data entry is in process.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Provincial level	11	Data not collected at this level			DHIS2 Dashboard
District Level	161	161 (for facilities with hardware/ connectivity issues	DHIS2	Aggregate	DHIS2 Dashboard
Facility level	675	DHIS2 675 – Aggregate, 100 – Tracker	DHIS2	Aggregate, Case based (pilot sites)	DHIS2 Dashboard
Community level	Data not collected at this level				Data not used at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	✓
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	Only aggregate data entry in DHIS2 (Case based data entry pilot running in 3 provinces)
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Treatment initiation
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Aggregate data reporting with the public facilities (data submitted manually)
Frequency of digitization of TB notification	Monthly
Mode of follow-up with notified cases	Phone calls, Physical visits
Scale of implementation	DHIS2 aggregated system is scaled at National level, (DHIS2 tracker pilot – 3 provinces)
Contact tracing for TB notified cases	Component of the screen tool (DHIS2 based), but yet to be implemented)
Multi- channel enablement	Web based data entry
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Nearly 100% of the private clinics are formally engaged with NTP, and contribute to about 18% of the total identified TB cases. The private sector notification is in the form of aggregate data that is either added in DHIS2 along with the data from some tagged public facility, or otherwise directly entered by the private institution (few formally engaged PPMs have access to DHIS2)

COUNTRY IT CAPACITY

Country Server
DHIS2 platform is shared by other health programs too, and server is maintained centrally by the Department of Information and Systems, Ministry of Health

Interoperability
Data export and APIs are available for integration with other systems. Linking GeneXpert is being explored.

Country IT team
While small changes are managed internally, Saudigitus (HISP Mozambique) team supports MoH for major system enhancements

ENABLING ENVIRONMENT

50.4%
Mobile penetration (Jan 2021) [4]

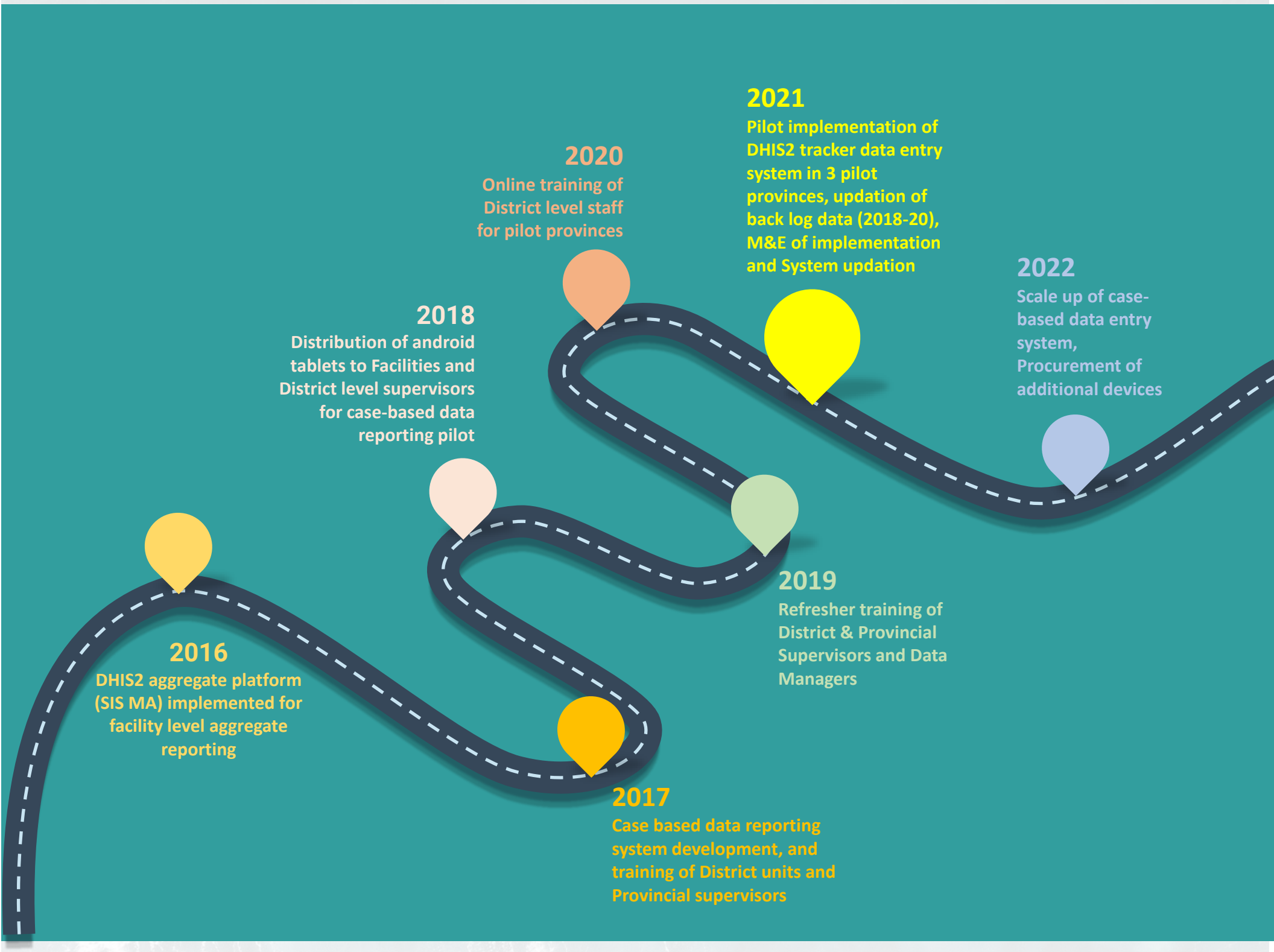
34.2%
Smartphone (Jan 2021) [4]

21.2%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- Software development and upgradation of DHIS2 is the responsibility of the Department of Information and Systems (DIS) team of the MoH, and all related support is arranged from the MoH directly.
- USD 0.17 million is available from a Global Fund grant, for covering the training costs for national level implementation of the case-based TB notification system.
- Annually, USD 70,000 is allocated by MoH for handling the day-to-day internet costs for keeping the system functioning.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Module in SIS TB case based reporting tool	Web application	Saudigitus	The Global Fund	Pilot
Logistics Management system	Ferramenta Central	Web Application	CMAM (Central da Medicamentos e Artogos Medicos)	Information not available	Being planned for covering TB services soon
Laboratory Information Management	GxAlert (Aspect)	Web Application	SystemOne	The Global Fund	National
	DisaLink	Web Application	Laboratory System Technologies (Pty) Ltd.	PEPFAR	Implemented at Reference Labs
Community Led Monitoring (CLM)	OneImpact	Mobile App	Dure Technologies	The Global Fund	Pilot project (extension of ADPP initiative)
Contact Tracing	DHIS2 Community Screening tool	Web application	University of Oslo	The Global Fund	Yet to be implemented

KEY CHALLENGES

- Shortage of trained manpower and high turnover rate at the data entry points makes it different to plan a transition to case based reporting.
- Unreliable internet connectivity is a major bottleneck for the country in transitioning ahead from their current aggregate system.
- With DHIS2 being owned by the DIS unit at MoH, any changes/ customizations in forms are to be routed through the MoH, which causes significant delays.
- Even at the facility level, a heavy reliance exists on the aggregate data. Even at the sites with DHIS2 tracker pilot, the produced case-based data is not used frequently, which makes the transition more difficult.
- NTP has a limited in-house capacity to handle DHIS2 customization, and thus, currently the maintenance is outsourced, which increases the budget constrains being faced for case-based system implementation.
- Procurement of hardware and training conduction is a well identified impediment for moving towards a case-based data entry from across the country, which makes the plans heavily dependent on external funding.
- Integration with other software platforms like GeneXpert can make the processes sustainable, but the country is subject to budget constrains to work towards it.

NTP VISION

- Expansion of case-based system nationwide and complete transition from aggregate to case-based data collection.
- Real time data availability for effective decision making and program monitoring.
- Improvement in data quality and incorporation of the entire cascade of TB care & contact screening.
- Development and implementation of community led monitoring tools.
- Building internal capacity for system management and finding ways to sustain training of users.
- Extending the use of DHIS2 to other implementing partners

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Mozambique has 675 facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 101,250** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Mozambique has 161 districts and 11 provinces and to promote active data use, each district and province should be given a tablet which would cost roughly around **USD 34,400** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 254,100** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and province user)
  - Server: Based on the current volumes of new cases, Mozambique would need an investment of **USD 24,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Indonesia already have a strong foundation of DHIS2 aggregated system for TB, around **USD 500,000-1,000,000** should be budgeted for an comprehensive TB surveillance system and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Trainings should be planned for each 161 districts which could cost roughly USD 100 per training amounting to **USD 16,100.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 1.5 – 2.0 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Mozambique.

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"The implementation of a surveillance system is very useful for the Program as it allows active monitoring of the disease and behavior over time. With the introduction of patient-centered monitoring, it is expected to have greater visibility of patient management actions, which can allow control of all adversities, their frequency to make sure that there is rapid intervention. This will also allow the linkage between interventions on each patient, their contacts, as well as monitoring the implementation of all required and recommended actions."

Dr Ivan Manhiça
Former NTP Manager
Mozambique

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation and scale up of Case Based Notification systems** : The NTP has already established DHIS2 environment which has the core infrastructure in terms of database and deployment. It has even secured a decent technical support through the DHIS2 expertise from their partners, which acts as a strong foundation for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the DHIS2 tracker app implementation. While the current tracker development (being piloted) has been planned to cover details of case-based notification system for both DS TB and DR TB patients , the application should also include monitoring of entire continuum of care including presumptive screening, referral, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes [6]

  Tentative timeline: Month 0-12

- **Mobile app :** One of the challenges reported by the NTP during the assessment is the lack of availability of real time data for stakeholders and inadequate availability of laptops/ desktops. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, which is in line with the country's efforts of improving the overall digital ecosystem.

  As a recommendation, the latest DHIS2 mobile app version which has additional features on data collection, security ,offline data collection, encryption ,version management etc should be extended for use even for aggregate data reporting, specially from facilities with limited IT infrastructure should be reviewed.

  This would also ensure that the data structures are consistent. Also, the app is supported with a configurable set up to support any updates/ changes to the program.

  Additionally, the DHIS2 mobile framework uses open-source technologies like Java, Postgres, React and Android, there are easily supported by country IT teams also the standard best practices of mobile development like version management , data encryption etc which make this as more robust solution. [7]

  Tentative timeline: Month 6-12

- **System Integration**: One of the challenges highlighted by NTP is the leveraging of data collected from the multiple sources into the main DHIS2 systems as a central system for effective use.

  The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools

RECOMMENDATIONS

which help in using the data effectively for the patient care continuum as highlighted by the National program.

Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing should be evaluated. [8]

The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes

The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [9]

Tentative timeline: Month 12-18

- **Data Use :**The NSP 2020-2029 clearly emphasizes on the importance and need to improve data use. This can be made possible by making case-based TB data and patient line listing available at the lowest level health functionary involved in TB care

  Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports and individual line lists and with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current DHIS2 and other systems then a more advanced analytical dashboard should be designed linked to the new case-based TB surveillance system that is already being planned.

  To achieve this, and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics, it is also recommended to use best of the breed tools like Tableau , Power BI, which offer these features. The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [10]

  The existing data analysis tools being used the MoH, like Zenysis, should also be explored for extending to the tuberculosis datasets.

  Tentative timeline: Month 6-18

- **Capacity building for application maintenance:** One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires trained personnel on DHIS.

  Strengthening the NTP team with DHIS2 trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 0-6

- **Additional data capturing mechanisms** : To make sure that paper based patient records (legacy data) is integrated with the DHIS2 tracker systems, technical solutions like OCR (optical character recognition) can be reviewed.

  The DHIS2 platform supports reading from these structures. This would help in data upload of all historical data with less difficulties.

RECOMMENDATIONS

This DHIS2 data transformation API feature also offers creation of standard templates which can be easily mapped with external data collection tools. Apart from this it also supports batch upload of historical data in large volumes to ensure minimum disruption to the live systems.

Tentative timeline: Month 6-12

- **e-Learning**: To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While DHIS2 offers standard training modules on the application , training tools like Moodle [11] built on standard LMS framework can be reviewed for application rollouts.

  Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

  Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

  Tentative timeline: Month 0-3

- **Data Quality :** As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

  UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

  This should be generated automatically through the new case-based TB surveillance system that is already being planned.

  Data access control is one such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

  Tentative timeline: Month 6-18

- **Community Monitoring Systems** : As expressed by the NTP, the national TB notification and surveillance system should have necessary mechanism to integrate with ready-to-use open source CLM platforms like One Impact.

  Tentative timeline: Month 6-12

- **Patient Tracking System:** Tracking lost to follow-up cases and enabling real time notifications for patients is highlighted as one of the main challenges.

  Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking the lost to follow-up patients. Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [12]

  Tentative timeline: Month 12-24

- **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

RECOMMENDATIONS

Strategic Technical Recommendations:

Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption & exchange standards.

  Apart from this, version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises.[13]

- **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable a reliable platform which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium also can be considered. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning. [14]

- **Application & System Security Audit:**

To strengthen the current systems framework and ensure long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA [15] to cover

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by DHIS2 [14] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [16]

ACKNOWLEDGMENT

We thank the National TB and Leprosy Program Manager, ***Dr Ivan Manhiça*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Tomas Dolce*** for providing valuable insights into Mozambique's vision for creating an advanced case-based TB surveillance and notification system.

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13. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/
14. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
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NIGERIA

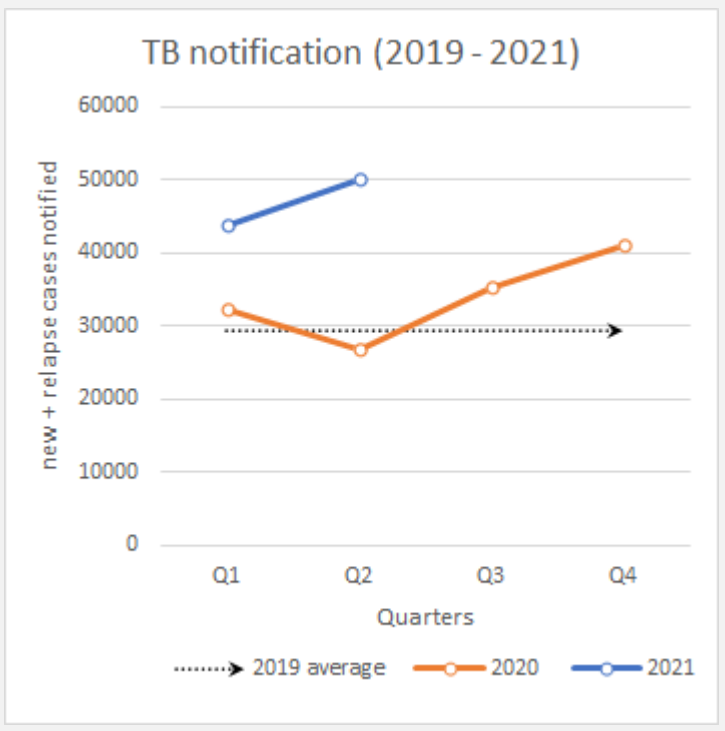
NIGERIA

BACKGROUND

Nigeria is among the 30 high burden countries for TB.[1, 2] In 2020, the estimated incidence of TB in Nigeria was 452,000 TB cases; out of which, 138,591 were diagnosed and notified.[1] This gap in TB case identification is a major area of focus for the national TB program.

With over 34,000 of all people with TB also infected with HIV and 2061 MDR/RR TB confirmed cases, Nigeria is included in the list for the top 30 TB/HIV as well as DR-TB high burden countries too.

Among the notified cases, 36% were women, 57% were men, and 7% were children.[1] Though the case detection for TB is low in Nigeria, this is one of the few countries which have shown an increase in overall TB notification in 2020, against 2019.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Nigeria has taken some significant steps towards meeting the End TB Targets and is aiming at reducing the TB prevalence rate by 50 percent and TB mortality by 75 percent by **2025**.[5] In 2020, NTP conducted an end-term assessment to evaluate the current NSP to inform and prioritize the innovations and activities for **National Strategic Plan for TB** (NSP 2021-2025). The revised NSP (2021-2025) highlights the importance of strengthening the information management systems for the provision of TB care.[6]

With technical support and resources from USAID and Global Fund, the Management Science for Health (MSH) in Nigeria has invested in eTB manager Case Based TB notification system to capture real-time TB data, which is extracted and imported to the national DHIS2 portal.[6]

Currently, e-TB Manager is deployed nation-wide, and data is entered by all 774 local government supervisors, more than 300 high-burden TB facilities, 16 DR-TB treatment centers, and 37 TB program managers.[7] To feed data to the national HMIS (DHIS2), eTB manager has mechanisms for data integration which enable comprehensive data review and analysis of TB data nationally.

Under the revised NSP (2021-2025) and with continued government commitment, eTB manager platform is undergoing an assessment to improve and standardize its data indicators, integration with laboratory network and engaging all care providers.[6] Enhancement are underway to the e-tb mobile version to allow for an offline version that will ensure continuous data entry without internet connectivity, thereby allowing health units to notify and follow-up with presumptive clients and cases even when internet connectivity is lacking.

In Nigeria, TB prevalence survey found that approximately 29% of cases were being treated in the private sector. Therefore, engagement of private providers is critical. In July 2020, the National Tuberculosis and Leprosy Control Program (NTBLCP) along with, the Institute of Human Virology Nigeria (IHVN) launched a mobile application the Mobile Application for Tuberculosis Screening (MATS) for screening and notifying tuberculosis (TB) cases by private health care providers in order to ensure treatment of more cases in the country. Use of MATS has shown significant progress in increase in the TB screening efficiency and linkage between the facility and community-based units. [4]

Information and communication technology (ICT) promote social, economic and political accountability and improves the delivery of basic health services, Internet user penetration in Nigeria is at 51 percent. As of July 2021, there were more than 108 million internet users in Nigeria. It has roughly 170 million mobile phone users based on subscriptions. However, only 10 to 20 percent of the population uses smartphones while the rest rely on more traditional mobile phones, thus limiting their options to voice calls and text messages.[8] Enhancing digital inclusion in Nigeria is essential, given that access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's development aspirations.

This country digital assessment report is prepared based on the discussions held with the NTP Nigeria and its partners. The report aims at providing strategic recommendations and way forward to country leadership in developing and scaling a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

Nigeria uses two platforms to support their routine TB notification and surveillance:

eTB Manager: It has been deployed nation-wide, with data coming from more than 300 high burden TB facilities and data entry by all 774 local government supervisors. It was initially introduced in 2011 for DR-TB case reporting and was expanded to DS-TB reporting in 2016.

The remaining low burden centres with no access to the platform are reporting case based data via paper forms to district facilities where data entry is done by the Local Government TB supervisor in the eTB manager system.

The current version of eTB manager is used for both DR-TB and DS-TB notification, monitoring and treatment outcome.

DHIS2: The national HMIS of Nigeria has data sets that capture TB data from across the country. Data is extracted from eTB manager and imported on this platform.

The current system generates quarterly reports which are being used by district, state and national program managers.

The NTP is committed to build a comprehensive TB surveillance mechanisms and systems for the country. Under NSP (2021-2025) NTP has plans for system integrations to support the building of this holistic system.

System integrations with laboratory management systems, standardizing the templates and improving all aspects of TB prevention and services are priority for the NTP.

SUCCESS STORIES

MATS app is a case-based notification system for all private providers (For profit Private providers, Faith based Organisations, and any other private player notifying for TB).

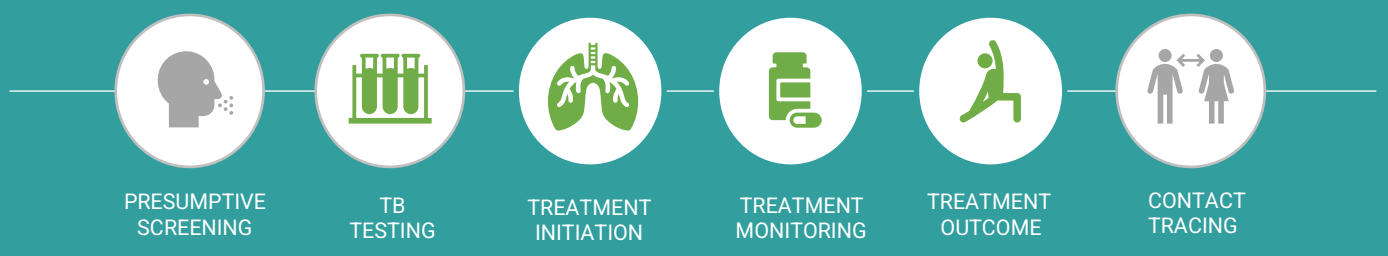
The private sector in Nigeria contributed 14% to the total national TB case notification in 2019, and with the improved PPM engagement strategy, the contribution has increased to 26% in 2020. Continuous effort is fostered and has led to increased number of engaged PPM facilities to use the MATS app. The application is already rolled out in 21 out of 37 states and there is a plan to integrate data from MATS app with eTB manager and GxAlerts systems.

Upgrade and deployment of the application are implemented by IHVN under the Public-Private Mix (PPM) grant funded by the Global Fund to Fight AIDS, Tuberculosis and Malaria.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				Excel Pivot eTB manager Dashboard
State level	36+ Federal Capital Territory (Abuja)	Data not collected from this level			Excel Pivot eTB manager Dashboard
District level	774	774	eTB Manager (Data received from Low burden Facilities) DHIS2	Case Based Aggregate	Excel Pivot eTB manager Dashboard DHIS2 dashboard
Facility Level	17699	~ 9000 (Low Burden)	Paper based /eTB manager Web app	Case Based	Excel Pivot eTB manager Dashboard
		370 (High Burden)	eTB manager Web/mobile version		
Community level	Data not collected from this level				

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE-BASED TB SURVEILLANCE

Electronic system for case based TB Notification	eTB manager is the national TB case notification system.
Lowest Unit for TB notification digitisation	High Burden Facilities, District level (Low Burden Facilities)
Stage of notification	Registration for presumptive
Level of Access and Use of TB Notification data	Facility level
Private sector notification	MATS App is used for private sector- this is being integrated with e-TB Manager and GXAlert
Frequency of digitization of TB notification	High burden facilities - Real Time Low burden facilities - Ranges from real time to Quarterly
Mode of follow-up with notified cases	Flagging module helps in identifying gaps that promotes the facility users to call or physical visit for follow up
Scale of implementation	National Roll-out
Contact tracing for TB notified cases	Paper based
Multi-channel enablement	eTB mobile app and web application
Govt. order for mandatory TB notification	Mandatory case notification Govt. notice was passed in 2017

PRIVATE SECTOR NOTIFICATION

The private sector contribution for notification all types of TB cases is 26%. Country has acknowledged the importance and contribution of private sector in improving TB. In 2020, MATS application was launched to ensure real time TB notification by private providers players.

COUNTRY IT CAPACITY

Country Server
In country hosting outsourced to 3rd Party agency

Interoperability
Necessary APIs available, Data export available but to be integrated

Country IT team
NTP employs an in-house IT team that provides technical support

ENABLING ENVIRONMENT

90%
Mobile penetration (Jan 2021)[8]

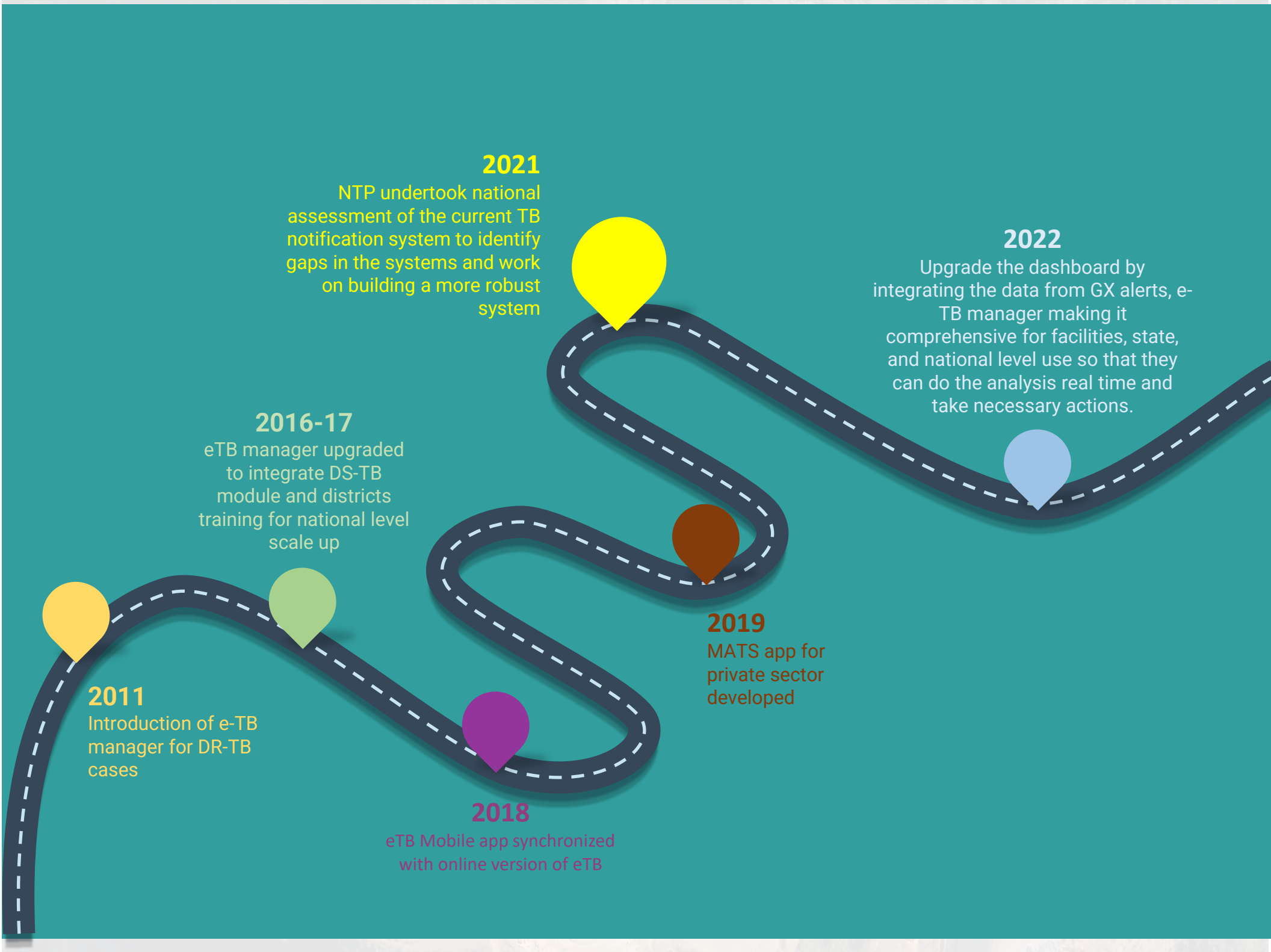
32%
Smartphone (2019)[9]

50%
Internet penetration (Jan 2021) [8]

CURRENT RESOURCES AVAILABLE

- USD 0.6 Million is current available resource with the country to continue its national level scale up of e-TB manager to the lowest reporting Unit.
- USD 0.4 million fund is available for purchase of Hardware (Mobile phones, Desktops). This is supported by Global Fund.
- Country has proposed an e-learning module to be developed for its resources under C19RM

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	99DOTS	SMS based adherence system	Everwell	KNCV- Stop TB Partnership	Pilot
	Video DOTS				
Logistic Management	LMIS- National health management information system	Web Application	Chemonics	USAID	National
Laboratory Information Management	GxAlert	Web Application	SystemOne/ASPECT	The Global Fund	National
	CAD4TB	Web Application	DELFT	KNCV- USAID	Pilot
	21DCXR with CAD4TB	Web Application	DELFT	The Global Fund	Pilot
Community Mapping (for contact tracing)	EWORS	Web Application	EWORS	KNCV- USAID	Pilot
Contact Tracing	Comm care contact tracing module	Web Application	Dimagi	KNCV	Yet to be implemented

KEY CHALLENGES

- **Limited IT Capacity :** The in-house IT Team's capacity is limited. The NTP does not own the source code for the platform. Therefore, NTP relies on 3rd party developer for system upgrades. This is time consuming and causes delays in system enhancements and in fixing bugs.
- **Hardware limitations (Power Supply internet connectivity, server capacity, availability of device for data entry):** Infrastructure issues in rural and remote areas delays data entry into the system, resulting in backlogs.
- **Backlog clearing** is one of the main challenges of the system due to high volume data (as high as 200 records per day) and long notification forms (multiple data variables entry). The system does not allow partial data saving and entry to mitigate the backlogs.
- **Technical and user experience** challenges combined with lack of digital skills with the staff at the facility level further hampers data entry into the system.
- **Real time data availability:** With a good proportion of data being entered offline and the differences in frequency of data reporting, developing and getting access to a real-time data dashboard for timely actions becomes difficult.
- **Inadeuate data analysis:** despite publicly available e-TB manger dashboard in the programme website, data analysis is inadequate and limited.

NTP VISION

- To build a robust and comprehensive system that has streamlined the data variables to be captured for a case to ease out the workload, decreasing the backlog, and promoting real-time data entry.
- Templatizing the entry of case-based data in stages.
- Adding modules on contact tracing and case management in the system
- Integration of the GXalert within the workflow of the eTB manager system.
- Upgrade the DHIS2 dashboard by integrating the data from GX alerts, eTB manager and MATS app making it comprehensive for Facilities, Districts, State, and National level use so that they can do the analysis in real time and take necessary actions.
- Fill in for the training gaps by building digital capacity among its staff and supplying adequate hardware and software.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

Hardware and Infrastructure:

- Mobile Devices (for data collection): Nigeria has 17,699 facilities and the system is expanding to additional 5000 facilities in 2022. To provision mobile device for every facility for case-based TB surveillance, **USD 3,404,850** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): Nigeria has 774 districts and 37 states (Abuja as federal state) and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 162,200** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 7,053,000** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user).
- Server: Based on the current volumes of new cases, Nigeria would need an investment of **USD 30,000-40,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

Software Development:

- Based on various multi-stakeholder meetings and given the fact Nigeria already have a strong foundation for e-TB Manager system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 774 districts, which could cost roughly USD 100 per district, amounting to **USD 77,400,** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 10.5 – 11.5 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Nigeria.

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

""Data is light, and the Nigeria TB Programme is poised towards having a robust electronic data management and reporting system for an effective and efficient evaluation of our interventions as well as for resource mobilization"

Dr. CHUKWUMA ANYAIKE
NTP Manager
Nigeria

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

❖ **Strategic Costing Plan** : As a first step it is important for the country to create a comprehensive budget plan for development , implementation and scale up / roll out for the TB case-based surveillance system.

Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

Tentative timeline: Month 0-1

❖ **Expansion of TB surveillance system** : The NSP (2021-2025) clearly highlights the importance of strengthening the TB Notification information system for improving all the TB service provisions [6]

Nigeria has already developed and deployed the Case based TB notification eTB manager which is used as the real time digital surveillance system in its 370 high burden TB sites. The rest of the low burden sites are also covered with near real time implementation. At the same time, DHIS2 is already functional across the country. The presence of these systems lay a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

It is recommended that the current eTB manager/DHIS2 infrastructure needs to be scaled up to cover the whole country. The system needs to support integration with external systems like Gen Xperts, Tru-Nat, Digital X-Ray outputs, current National Health management systems and MATS app as visioned by the national TB program with the concept of an integrated Health Information Management System (HMIS).

These data exchanges can be made seamless with API sharing between the platforms and the central repository.

Recommended data exchange/ ETL tools like Talend, Informatica[10] makes data management task much easier and simultaneously improves data warehousing. These exchange tools also comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes.

Tentative timeline: Month 0-6

❖ **Data use**: The NTPs plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

In the existing dashboard there is a strong need to strengthen and expand the data visualization scope and making effective use of data for predictive modelling , data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI[11] which offer these features. The current eTB manger platform offers APIs which can connect to these applications and be used as an extended analytical component of the
data analysis framework.

Also , To ensure that there is a seamless data exchange from other platforms like MATS app, the data should be extracted, transformed and loaded into the central database.

While eTB supports API other open source ETL tools over My SQL , Post Gres DB and / or WHO powered Xmart[12] which can be installed within the current environment can also be considered. These tools also help in upload of historical data to clear backlogs through templates.

Tentative timeline: Month 6-12

❖ **Mobile app** : One of the challenges reported by the NTP during the data collection processes is inconsistent data connectivity / network issues which delays reporting of cases.

RECOMMENDATIONS

In coordination with the National TB and Leprosy Control Programme and other implementing partners, MSH, under the USAID funded Challenge TB (CTB) project, has developed an offline-mode mobile application—an android based local data storage application version of e-TB Manager.

Other advantages for a mobile application include better performance, effective use of device features like in house system updates, usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

Several mobile solutions for real time case-based notifications can be explored for local adaption and building the mobile counterpart for eTB. Open-source technologies like DHIS2 Mobile App, ODK and KOBO are some notable examples.[13]

Tentative timeline: Month 0-6

- **Device Procurement:** One of the limitations highlighted by NTP is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

Tentative timeline: Month 0-6

- **eLearning:** Digital training packages to train health professionals on eTB use and workflows

Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the new eTB tracker-based application but also on the latest manual of procedure and continued medical education on TB care.

To address the challenges with periodic training of facility level staff to orient them on using eTB for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training. The C19 RM eLearning system will cover TB management, and the electronic platform training module can be affixed to it

Training tools like Moodle[14] built on standard LMS framework can be reviewed for application rollouts. Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level.

This will help in developing and enhancing M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 1-4

- **Server Augmentation & Infrastructure Upgrades**

Based on the architecture, the system upgrade would be done with the database, a middleware system, the operating system or the hardware. Additionally, the architecture should be such that it supports the integration layer which would be needed for data exchange with national/external systems.

The technologies that need to be brought in and the areas of inter-connection need special focus. A review of the existing server architecture is advised along with deployment of automated load testing tools like Selenium, Appium [15]

RECOMMENDATIONS

which can help in database sizing and monitoring adaptation needs for planning.

Tentative timeline: Month 6-24

- **Capacity building for application maintenance:** Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

  Strengthening the NTP team with trained system administrators which will help in improving and expediting the planned implementations.

  Tentative timeline: Month 6-24

- **Community Led Monitoring**: Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

  Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [16]

  Tentative timeline: Month 6-24

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr. Chukwuma Anyaike*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Obioma Chijioke-Akaniro*** and ***Mr. Mohammed Amjad*** for providing valuable insights into Nigeria's vision for creating a comprehensive case-based TB surveillance and notification system.

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9. Geopoll Mobile penetration in Nigeria 2021: https://www.geopoll.com/blog/mobile-penetration-nigeria/

10. System Integration tools (Talend, Informatica) : https://www.talend.com/solutions/data-protection-gdpr-compliance/ https://www.informatica.com/content/dam/informatica-com/en/collateral/solution-brief/informatica-gdpr-solution_solution-brief_3412en.pdf

11. Data Visualisation Tools (Power BI , Tableau) : https://powerbi.microsoft.com/en/, https://www.tableau.com/

12. WHO Xmart : https://portal-uat.who.int/xmart4/docs/general/Overview.html

13. Open-Source Mobile Applications KOBO: https://www.kobotoolbox.org/ ODK https://opendatakit.org/)

14. Application Training Tool : https://moodle.org/

15. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/

16. OPEN MRS : https://openmrs.org

PAKISTAN

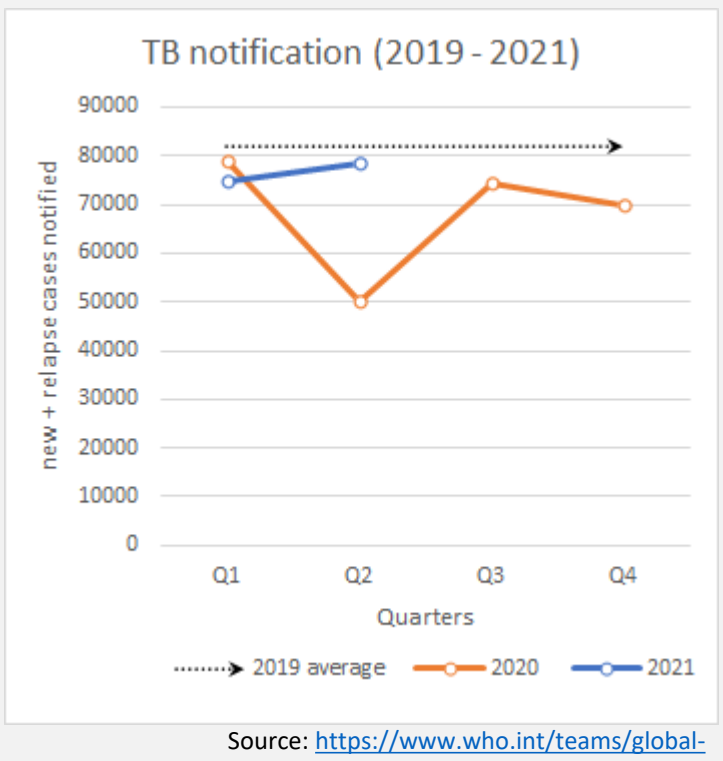
PAKISTAN

BACKGROUND

Pakistan is ranked as the 5th highest TB burden country and annually contributes to nearly 5.8% of new cases of TB worldwide (WHO Global TB report, 2021). Out of the 573,000 new cases estimated for 2020, a total of 276736 (48%) were notified.[1] Bridging this case-detection gap is a key priority for the National TB Program. The 2019 evaluation conducted by World Health Organization (WHO) and Joint Program Review Mission (JPRM) recommended that, “Pakistan should take urgent action not only to find all persons affected by TB but also find them as early as possible to interrupt the chain of TB transmission”.

With 2,689 laboratory confirmed cases of MDR-TB and another 839 patients identified with XDR-TB in 2020, Pakistan is also included in the list of 30 High Burden countries for Drug Resistant TB.[1, 2]

Affected by the COVID19 pandemic, country’s TB case notification dropped in 2020, however, in 2021, the health system is making efforts to revive its TB surveillance practices and the notification is steadily improving to reach 2019 levels.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In 2018, the National TB program, with support from WHO HQ and University of Oslo, introduced the **DHIS2 aggregate** data collection platform, which is being managed centrally by the Common Management Unit (CMU); for HIV, TB and Malaria under the Ministry of Health. Currently, the key challenges faced by NTP with this aggregated data system are delays in data upload (lack of real time data access) and the chance of duplicity of cases.

With the strong leadership and vision of the National TB Program, a clear roadmap has been defined in National Strategic Plan (NSP 2020-23) to leverage the current DHIS2 platform and develop a comprehensive case-based TB surveillance system on DHIS2 tracker. The NTP also envisages to expand DHIS2 system to all private providers for improving the private sector notification. Additionally , to complement the existing national HMIS data systems , the TB Data from DHIS2 can easily be integrated as indicators which enable comprehensive data review and analysis of TB data nationally.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. With about 77% of the population using a mobile phone and just around 51% smartphone penetrance, where internet access is only with about 27% population, the country requires a greater focus on the development of infrastructure to enable a smooth implementation of IT solutions.

Apart from implementing DHIS2 platform the NTP in Pakistan has a vision to leverage many other digital innovations for better data collection and data use as given below:

MATCH AI: The MATCH AI platform has been developed by The Royal Tropical Institute (KIT) and EPCON for TB case finding. This solution uses spatial, programmatic, and contextual data to better predict where missed people with TB are most likely to be found at the district and sub-district level. The objective of MATCH AI conceptual framework is to help close the TB case detection gap by focusing on high impact district and sub-district locations, a strategy promoted by the Zero TB Initiative.

CHS-HMIS: An internal patient health information management and field monitoring system known as CHS-HMIS. The system has four primary components: 1) a center-based module that allows for test booking, patient registration and TB recording and reporting; 2) a field-monitoring system that captures data from ACF camps, GP clinic locations, monitoring visits and PPM notifications; 3) a web-based dashboard and 4) a lab management system that allows for online reporting and viewing of test results for patients, including both for TB and other paid diagnostic services.

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program has been implementing primary two tools for TB surveillance:

DHIS2 based aggregated data collection system which is being used at all 150+ districts in Pakistan. Typically the manual TB registration forms are sent to the district office where the district data entry operator then feeds the data for TB cases initiated on treatment into the DHIS2 system.
The current system also generates quarterly reports which are being accessed used at district, provincial and national program managers.

Excel based Electronic Nominal Recording Reporting System (ENRS) tool which allows capturing of individual DR TB cases through the entire cascade of care only for TB confirmed cases starting from Notification, monitoring, treatment outcome.

One of the biggest challenge highlighted by the NTP is that these two systems (DHIS2 and ENRS) are not integrated and hence currently both the systems are being used in parallel.

However, the vision for implementing a case based TB surveillance on DHIS2 tracker will be an important way forward to have a unified case based TB surveillance system for both DS TB and DR TB cases.

SUCCESS STORIES

The NTP has put in place Mandatory Case Notification (MCN) guidelines that mandates a health provider to notify TB cases to the central helpline through an SMS. A helpline representative will collect the patient data and will upload in the DHIS2. This case-based notification is currently on pilot trial in four provinces of Sindh, Khyber Pakhtunkhwa, & Punjab. This pilot trial is expected to generate evidence for nationwide scale up of case-based TB surveillance system.

With support from Global Fund, the NTP is also in the process of designing and development of a comprehensive case-based tracker system on DHIS2 and, a pilot has been planned to be launched in Islamabad. The learnings from this pilot will pave the way to national scale-up of case-based TB surveillance system in the country.

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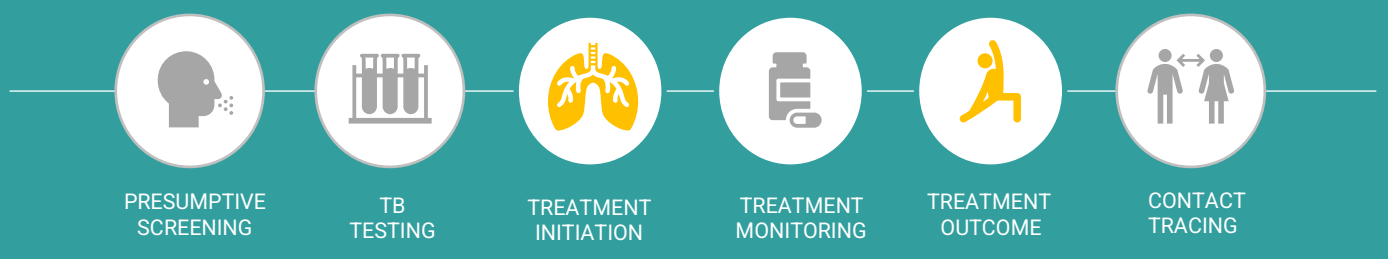
ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Provincial level	4	Data not collected at this level			DHIS2 Dashboard
District level	160	160	DHIS2 Web Application	Aggregated	DHIS2 Dashboard
Facility Level	1600	1600	ENRS Excel Tool	Case Based (DR TB); Aggregated (DS TB)	No digital tool for data use
Community level	Pilot sites		DHIS2 Tracker-Mobile App	Case Based	No digital tool for data use

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	
Treatment start and end date	
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	
Treatment monitoring/adherence	
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	
Key-population wise aggregate numbers and proportions notified	
Estimate/Target wise notification/treatment coverage (proportions)	
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	Currently only aggregated DHIS2 system available
Lowest Unit for TB notification digitisation	District level DHIS2 aggregated data (Facility level reports data in Excel sheets)
Stage of notification	Treatment initiation stage
Level of Access and Use of TB Notification data	District level
Private sector notification	Manual notification process (Mandatory Case Notification with a helpline being piloted)
Frequency of digitization of TB notification	Quarterly
Mode of follow-up with notified cases	Manual follow-up- phone calls, household visits
Scale of implementation	DHIS2 aggregated system is scaled at National level
Contact tracing for TB notified cases	Not implemented yet
Multi-channel enablement	DHIS2 web application
Govt. order for mandatory TB notification	Mandatory case notification Govt. notice was passed and was linked with DHIS2 in 2020

PRIVATE SECTOR NOTIFICATION

Mandatory Case Notification (MCN) is a case-based notification guideline that mandates all health providers (private & public) to get in touch with a dedicated call center (and helpline) and submit TB patient data

COUNTRY IT CAPACITY

Country Server
Servers are managed by CMU (central unit), Ministry of Health, Pakistan

Interoperability
DHIS2 as a platform provides interoperability, but yet to be integrated

Country IT team
Limited capacity - DHIS2 experts with CMU team. Technical support sought from partner agencies

ENABLING ENVIRONMENT

77.7%
Mobile penetration (Jan 2021) [3]

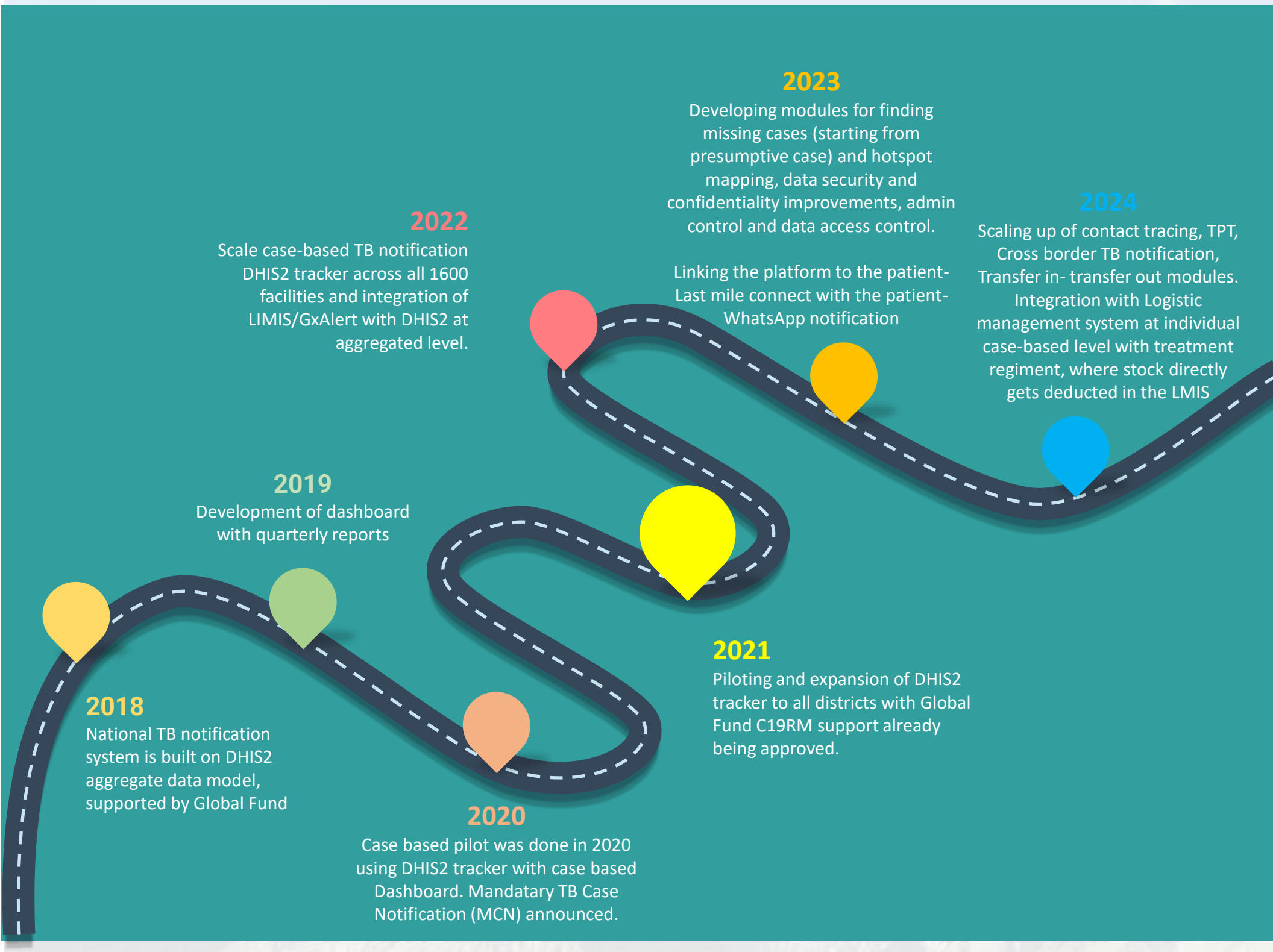
51%
Smartphone (2020) [4]

27.5%
Internet penetration (Jan 2021) [5]

CURRENT RESOURCES AVAILABLE

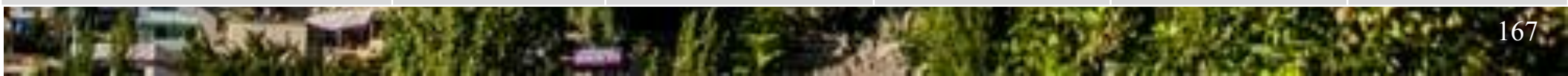
- USD 1.5 Million was invested from 2018-2020 for the development of the current DHIS2 aggregate system
- USD 833,000 (2.5 Million for 2020-2023) is needed as annual recurring cost towards Servers, Human resource- DHIS2 developers, Ongoing Training, Hardware. (NSP 2020-23)
- C19RM has been approved for piloting and scaling of digital case-based TB notification system.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nil	NA	NA	NA	NA
Logistic Management	TB DMIS	Web Application	Ministry of Health	USAID	National
Laboratory Information Management	G xAlert	Web Application	Cepheid	Information not available	Pilot
	Digital X-Ray	Web Application	DELFT CAD4TB	The Global Fund	Pilot
Community Led Monitoring (CLM)	OneImpact	Mobile App, Social Media	Dure Technologies	Stop TB Partnership	Pilot
Contact Tracing	Nil	NA	NA	NA	NA



KEY CHALLENGES

- Lack of single, integrated platform for reporting and analyzing PPM and ACF interventions in real time, that can be used by all partners in Pakistan
- CHS-HMIS is not integrated with DHIS2 or the MATCH AI platform, and the system operates as a standalone service. TB records and forms while entered digitally are printed subsequently and entered manually for routine reporting to the TB program. Linkages of this dataset within the MATCH AI-DHIS2 system can potentially yield valuable information for improving programmatic performance in the country
- Inadequate server capacity (shared server hosting with other programs) and lack of in-house technical support team for configuring the DHIS2 system and its maintenance, which creates delays and restricts ongoing enhancements
- Lack of adequate finances and Human resource, and Poor IT infrastructure at facilities for digital notification
- Challenges with limited digital literacy, and insufficient ongoing capacity building and training of health staff
- Lack of availability of hardware devices for HCW for field activities

NTP VISION

- Develop a mobile based real-time case-based TB notification at the lowest unit (pilot already planned)
- Monitoring of entire cascade of care starting from presumptive case screening
- Seeking resources for enabling a case-based TB notification system
- Enabling Private sector notification directly into the future case-based notification system
- Integration of the logistic management system (TB DMIS) with the DHIS2 based system
- Integration of cross-border TB efforts (being implemented by UNHCR) into the centralised TB notification system.
- Mechanisms to reduce duplications- centralization of system and UI
- Integration of CLM- Mercy Corp and Stop TB REACH solutions

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

Hardware and Infrastructure:

- Mobile Devices (for data collection): Pakistan has 1600 TB units and to provision mobile device for every facility for case-based TB surveillance, **USD 240,000** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): *Pakistan* has 160 Districts and 4 Provinces units, 30 DR-TB units and 63 provinces to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 32,800** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 176,400** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
- Server: Based on the current volumes of new cases, Pakistan would need an investment of **USD 30,000-40,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

Software Development:

- Based on various multi-stakeholder meetings and given the fact Pakistan already have a foundation for DHIS2 aggregate system for TB, around **USD 50,0000-1,000,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. Four training sessions should be planned for each 160 districts over a period of 3 years which could cost roughly USD 100 per training amounting to **USD 16,000.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 1.5 - 2 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Pakistan .

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"The National TB Control Program Pakistan, under the visionary leadership of the Common Management Unit to fight against AIDS, TB & Malaria, Ministry of National Health Services, Regulations & Coordination, has achieved a revolutionary milestone towards digitization by rolling out of case based DHIS2 in the year 2021 for effective TB surveillance in the country with the support of national and international partners."

Dr. Abdul Wali Khan
NTP Manager
Pakistan

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step it is important for the country to create a comprehensive costed action plan for development, implementation and scale up / roll out for the TB case-based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- **Implementation of TB Case Based Notification systems :** The NTP has already established DHIS2 environment which has the core infrastructure in terms of database and deployment environment. It has built the DHIS2 expertise and capacity which acts as a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for developing **DHIS2 tracker** for creating case-based notification system which accommodate monitoring of entire continuum of care for both **DS TB and DR TB** patients starting from presumptive screening, referral, testing, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity. Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes. [6]

  Tentative timeline: Month 0-6

- **System Integration :** One of the challenges highlighted by NTP is the leveraging of data collected from multiple sources into the main DHIS2 systems as a central system for effective use.

  The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GeneXpert,TruNat, Digital X-Ray outputs, Pill boxes and other digital adherence tools which help in use the data effectively for the continuum of care as highlighted by the NTP.

  Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing should be evaluated. [7]

  The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes

  The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [8]

  Tentative timeline: Month 6-12

- **Capacity building for application maintenance :** One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires personnel trained on DHIS2.

RECOMMENDATIONS

Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

Tentative timeline: Month 0-6

- **Data Use** : The NSP 2017-20 clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data and patient line listing available at the lowest level health functionary involved in TB care.

  Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports and individual line lists and with timeline views are extremely useful.

  As expressed by the NTP, the recommendation is to first upgrade the current aggregated DHIS2 based Dashboard and leverage the fullest potential.

  Also , to ensure that there is a seamless data exchange from ENRS, LMIS without any information loss and to effectively use data from Match AI , TB – DMIS the DHIS2 data transformation API should be explored.

  There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central database.

  This DHIS2 data transformation API feature also offers creation of standard templates which can be easily mapped with external data collection tools. [9]

  Other source ETL tools over Postgres DB and / or WHO powered XMart which can be installed within the current environment can also be considered. [10]

  Once a robust data analytics and data use has been established with the current DHIS2 and other systems then a more advanced analytical dashboard should be designed linked to the new case-based TB surveillance system that is already being planned.

  To achieve this , and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling , data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [11]

  Tentative timeline: Month 6-18

- **Mobile Use:** As the NTP already have a vision to implement mobile based TB surveillance, it is recommended that the model is first piloted and validated in the top 10% most high burden facilities in Pakistan. This will help validate the solution in a short period with effective cost.

  In addition, the Mobile App for data collection should also have treatment supervisor specific Dashboard and case management module to handle individual cases better in terms of follow-up, alerts and other care interventions.

  As a recommendation the latest DHIS mobile app version which has additional features on data collection , security ,offline data collection , encryption etc supported with a configurable set up should be evaluated to fast track the development of the changes from the learnings of the pilot and for the national scale up.

  The DHIS2 mobile application has features for auto – alerts and aggregated data set analysis which should be enabled for improved data use. DHIS2 Mobile app also supports features for restricted data access for different user groups , , version management which make this as more robust solution. [12]

  Tentative timeline: Month 6-12

- **Data Quality :** NTP clearly emphasizes on the importance and need to introduce improved data collection practices and validations to avoid data duplicity and redundancy for better data quality.

RECOMMENDATIONS

Some standard recommendations include

- ✓ UIC Code : The NTP already uses a 14-digit patient code. This should be generated automatically through the new case-based TB surveillance system that is already being planned. Having a centralized Unique Patient ID system or leverage existing national ID and an improved search functionality can help drastically reduce the duplication of records.

- ✓ DHIS2 data de-duplication feature should also be explored which would enable restriction of multiple case data entries based on patient profile and other variables configuration.

Additionally , as part of standard practices, the application(s) / solutions should follow the data quality mechanisms or the Data Quality Assurance (DQA) framework. [13] Some recommendations include

- ✓ Data Validations for data inputs at every level
- ✓ Retrieval of existing user driven values / attributes to avoid data discrepancy
- ✓ Smart follow up questions to validate previously entered data.

These standard practices are configurable using the DHIS2 ruleset feature which is applicable to both web / mobile app interfaces. This will ensure that the data collected from multiple sources is in a standard structure and format.

Data access control is another DQA measure that will regulate user's access to meta-data. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access. [14]

This can be implemented using the DHIS user access and data management feature for restricted data access and control. Apart from this DHIS2 admin also has privileged access to configure the user data roles.

Tentative timeline: Month 3-6

- ❖ **Community Monitoring Systems :** As expressed by the NTP, the national TB notification and surveillance system should have necessary mechanism to integrate with ready-to-use open source CLM platforms like One Impact.

  Tentative timeline: Month 6-12

- ❖ **Modules for Migrants :** Pakistan receives a huge number of migrant workers from neighbouring borders such as Afghanistan and similarly a large number of migrant population crosses borders from Pakistan to other neighbouring countries. In order to strengthen the cross-border TB initiatives, it is recommended to accommodate additional cross border modules like transfer-in and transfer-out that would help track treatment across borders and also help reduce large number of lost to follow-up cases attributed to cross border migration.

  The cross border monitoring platform (built on DHIS 2.34) developed by UNDP under the Global Fund multi-country grant can be integrated with the DHIS2 tracker in future.

  Tentative timeline: Month 0-6

- ❖ **Patient Interactive Systems** : Tracking lost to follow-up cases is highlighted as one of the main challenges given the high migrant population.

  Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients. Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [15]

  Tentative timeline: Month 12-18

- ❖ **e-Learning :** Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the new DHIS2 tracker-based application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  While DHIS2 offers standard training modules on the application , training tools like Moodle[16]

RECOMMENDATIONS

built on standard LMS framework can be reviewed for application rollouts.

Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers , administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

Strategic Technical Recommendations

- Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- ✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption , data exchange standards.

- Additionally, the advance admin features offered by this version help the administrators to support the operational needs better for onboarding the users , real time change in data variables and user management etc effectively.

  Apart from this version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises. [17]

  Performance Optimisation & Testing : To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium also may be considered. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning . [18]

- ✓ **Application & System Security Audit**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[19] / other country specific guidelines to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by DHIS2 [20] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of app hosting. [21]

ACKNOWLEDGMENT

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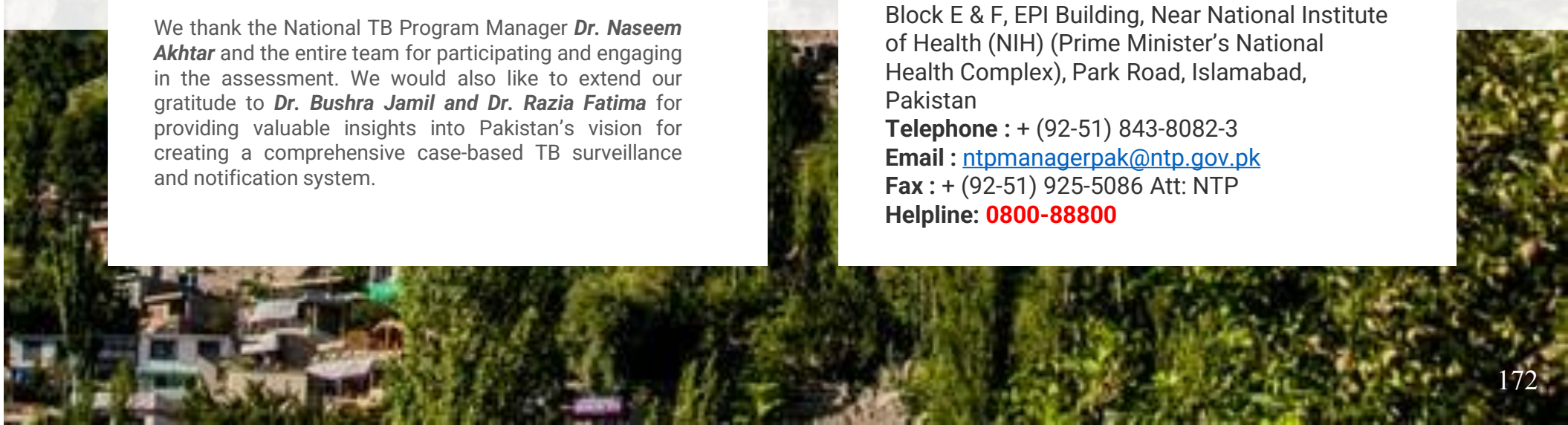

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PHILIPPINES

PHILIPPINES

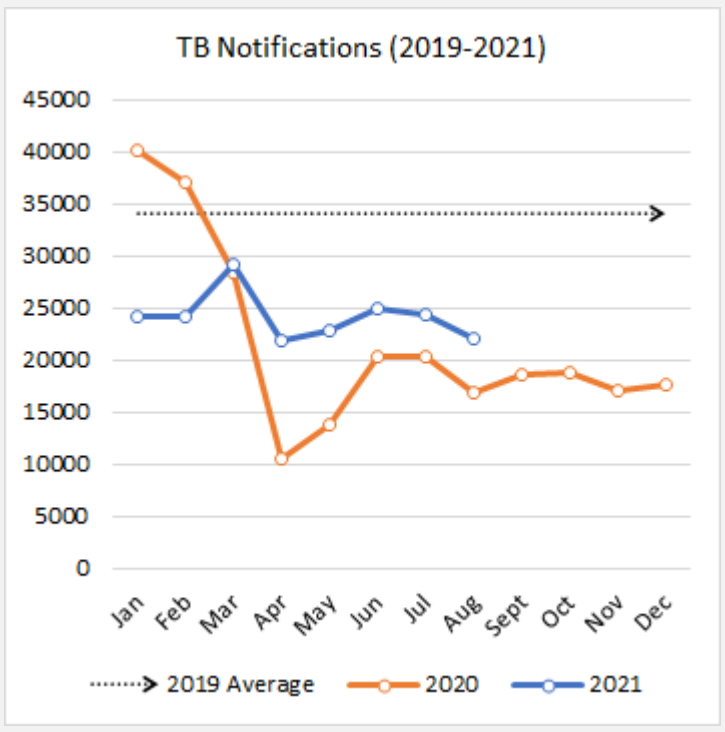
BACKGROUND

Philippines accounts for the fourth largest TB burden in the world (WHO Global TB report, 2021). Over 591,000 new cases emerged (i.e., an incidence rate of 539 for every 100,000 people) in 2020, out of which 256,000 cases were notified achieving a treatment coverage of 43%. More than 12,000 people are estimated to suffer from both TB and HIV.[1]

Overall, Philippines falls in all the 3 lists of High Burden countries, i.e., high TB, DR-TB and TB/HIV case loads.[2]

The TB case fatality ratio stands at 6%. In 2020, about 5.6% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment. [1]

Affected by the COVID19 pandemic, country's TB case notification has majorly dropped in 2020, however, in 2021, the health system has made efforts to revive its TB surveillance practices and the notification is steadily improving to reach closer to previous rates.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Philippines's updated Strategic TB Elimination Plan (PhilSTEP I) 2020-23 aims to achieve a 50% reduction in TB mortality and 12% reduction in TB incidence by 2023. It lays focus on screening interventions like focusing on maximizing Chest X-ray usage for screening and hence identifying asymptomatic patients (specially at facilities); and strengthening community-based screening through volunteers and health workers. Similarly, to improve TB testing, it intends to broaden the access to GeneXpert testing to conduct DST for all TB cases and leveraging the mandatory notification guideline and involvement of private sector to improve case notification, patient diagnosis and treatment adherence. [3]

Philippines uses **Integrated Tuberculosis Information System (ITIS)** as the primary tool for TB notification and has started capturing individual records for each patient registered for treatment. All patients diagnosed with TB are encoded in the notification module of ITIS by both private and public health facilities. ITIS has been supported by The Global Fund since its inception in 2016. The system has been developed and managed by KMITS, an integral part of Deptt of Health (DOH). ITIS also allows direct data entry from private TB service providers, which requires them to first get registered as an ITIS user through KMITS.

Additionally, to complement the existing national HMIS data systems, the TB Data from ITIS is extracted and integrated as indicators. ITIS serves as a backbone for all-other digital innovations in TB like CareTB, RaceTB etc. ITIS database hosted and managed by DOH also serves as central data repository for all other TB data systems in the country.

Some of the innovations that leverages ITIS as a foundation are listed below. A more comprehensive list is given later in this report:

ITIS Lite is a lighter version of the platform (both web and mobile based), which is routinely used by Private physicians to report patient data.

CareTB is a complementary tool (fully integrated with ITIS) that aids in patient screening & contact tracing and provides a patient interface for reporting and accessing data.

RaceTB: a fully integrated analytical TB dashboard for different stakeholders to access and review indicators at multiple levels.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As of January 2021, the country has nearly 138.2% of the population having a mobile phone, i.e., at least 1 mobile device per person, and the smartphone use is about 98.5%. Even the internet penetration shows decent figures, i.e., approximately 67%. It thus is a good opportunity for the country to leverage the friendliness of its population with digital tools, which can set a strong ground to implement advanced solutions and ensure adequate uptake.[4]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

Philippines introduced the case-based notification system ITIS (web app) across the country in 2016, which was relaunched with a mobile app in 2021. Modules for encoders are well developed and the NTP is further focused on enhancing the reporting mechanisms for better program management. The ITIS system also has a Universal search module in place to avoid duplication i.e., before a case is added into the system it does a universal search.

ITIS is also used by private facilities and private physicians. Upon registering, a private facility gets an ITIS account to encode patients, however private physicians are using 'ITIS Lite' (a simplified version of ITIS) for reporting patient data to the government database.

The national program values real time monitoring and has established mechanisms to always provide a seamless access of data to their stakeholders. The program managers who are on travel or at sites, can get access to real time information through an external application, the RaceTB dashboard (available in web version and mobile version), which is connected to ITIS.

One of the key strengthens of ITIS platform is the ability to integrate with other innovations like CareTB which allows monitoring of patients through continuum of care including presumptive screening, referral, testing, treatment, outcome as well as help strengthen community-led interventions by empowering patients to access a range of services like information, community forum and reporting etc.

SUCCESS STORIES

National TB Program (NTP) of the Department of Health (DOH) has always been in the forefront of leveraging digital innovations for improving programmatic outcomes. One of the greatest achievements of ITIS platform is its ability to integrate with other digital innovations be it End TB App Suite or ITIS lite. Datawarehouse developed by DOH and WHO allows bringing all data system under one umbrella.

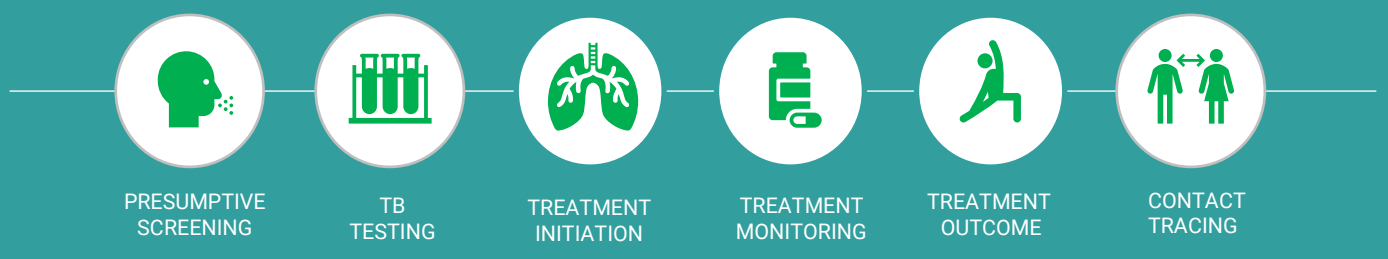
The End TB App suite[5] which consists of CareTB mobile app fully integrated with ITIS that allows monitoring of patients through continuum of care at field level as well as patient central module for self screening, behavior change communication and Community Led Monitoring (CLM). RaceTB dashboard that facilitates decision making, Lead TB that allows facility supervision and GuideTB eLearning tool.

It is also worthy of mention how CareTB platform was leveraged to create COVID Kaya which is the national COVID monitoring system in Philippines demonstrating the extendibility of these tools for other programs.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				ITIS/RaceTB (web and mobile app)
Regions	17	Data not collected at this level			ITIS/RaceTB (web and mobile app)
Cities and Municipalities	1634 (144+1490)	1634 (Encoding of manual data collected from private providers)	ITIS	Case Based	ITIS/RaceTB (web and mobile app)
Facility Level	3600	3600	ITIS, CareTB	Case Based	ITIS/RaceTB (web and mobile app)
Community level	NA	Pilot	CareTB	Case Based	No data use at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	ITIS / ITIS Lite, Care TB
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	TB Diagnosis (confirmed cases)
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Private health facilities that have an access, use ITIS Lite to report data, while others submit individual manual records for entry by TB coordinators
Frequency of digitization of TB notification	Real time (can be upto Quarterly)
Mode of follow-up with notified cases	Physical visits and Phone calls by Community Health Workers; Emails and SMS – ITIS notifications; CareTB patient module
Scale of implementation	National level
Contact tracing for TB notified cases	Yes (ITIS and Care TB)
Multi - channel enablement	Web and Mobile application for ITIS, Care TB Mobile app
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Nearly 20% of the total TB case notifications are contributed by the Private sector. The private facilities that have access to ITIS (provided by KMITS) use ITIS / ITIS Lite app to report individual cases, while other private practitioners submit manual individual records to the City/Municipal level for data entry by TB coordinators.

COUNTRY IT CAPACITY

Country Server
The ITIS application is hosted centrally at KMITS data center of the DoH

Interoperability
Data export and APIs are available in ITIS and being used for integration with the End TB app suite and other tools

Country IT team
The KMITS team (dedicated to NTP) has developed and is managing ITIS platform in-house

ENABLING ENVIRONMENT

138.2%
Mobile penetration (Jan 2021) [4]

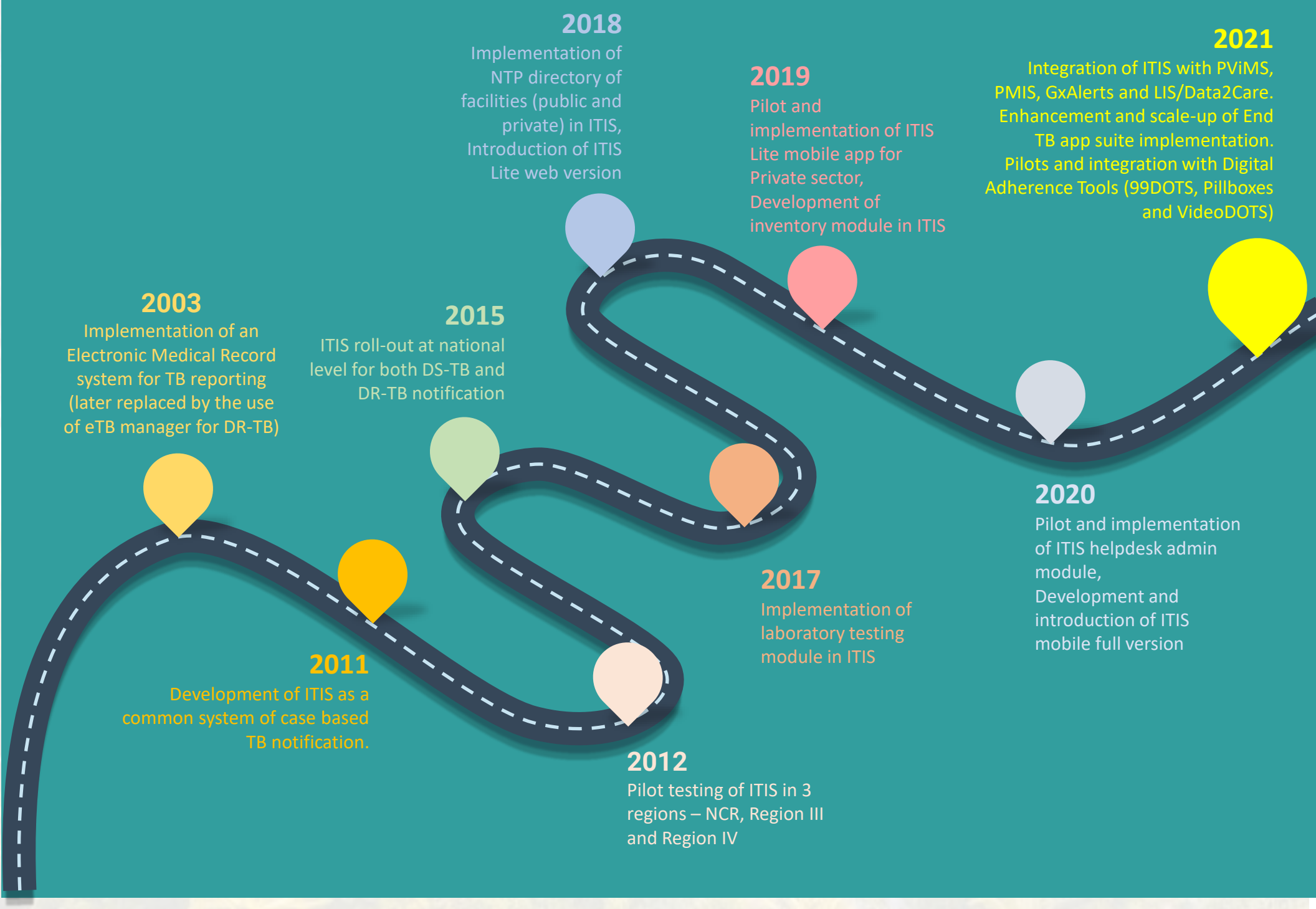
98.5%
Smartphone (2018) [4]

67%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- USAID's 2020 TB budget allocates USD 14.5 Million to support TB initiatives of the country in line with NSP 2020-23.
- In June 2021, USAID has announced another USD 57 million for supporting urgent tuberculosis recovery efforts of seven countries, which includes Philippines.
- The Global Fund has been supporting the development of ITIS, hardware and HR; and in the year 2021, USD 37 million has been provided to support Philippines in fighting COVID-19, adapting HIV, TB and malaria programs, and strengthening systems for health under C19RM.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	99 DOTS VideoDOTS Smart Pillbox evriMED CareTB	Mobile application Video conferencing Smart Med Containers Web application Mobile and web app	Everwell SureAdhere Everwell WisePill Dure Technologies	UnitAid and KNCV UnitAid, J&J, KNCV UnitAid and KNCV USAID WHO, URC	Pilot implementations
Logistics Management Tool	QuantTB PMIS	Web Application Web application	MSH DOH	USAID USAID	Pilot National scale
Laboratory Information Management	GeneXpert (ASPECT) GxAlerts+ITIS Data2Care C360 C360+ITIS	Web Application Web Application Web Application Web Application Web Application	SystemOne SystemOne Savics Cephield Cephield, DureTech	SystemOne SystemOne USAID The Global Fund WHO, FHI360	Pilot implementations
Community Led Monitoring (CLM)	CareTB (OneImpact adapted in End TB app suite)	Mobile Application	Dure Technologies	Stop TB Partnership, WHO	Pilot
Contact Tracing	CareTB and ITIS ConnecTB	Mobile and web app Mobile and web app	Dure, KMITS Yano Tech	WHO, The Global Fund USAID	Pilot implementations
eLearning	GuideTB DOH academy	Web application Web application	Dure Technologies DOH	WHO USAID, The Global Fund	National scale implementations
Supervision and monitoring	LeadTB	Mobile application	Dure Technologies	WHO	National
Pharmacovigilence	PVIMS	Web application	MSH	USAID	Pilot

KEY CHALLENGES

- The staff designated at the data entry points are shared resources with other programs and are inadequately trained, which causes concerns on data quality and delays in reporting.
- With the internet conditions being very unreliable at several facilities, real-time case-based data entry remains a challenge.
- The lack of devices at sub-national level limits the timely data entry as well as the data usage for decision making.
- With the inconsistency of reporting frequency at different reporting units, complete real time data is not received and in turn, the analytical report outputs are generated on a quarterly frequency, that leaves less scope for data driven actions.
- Another challenge faced is duplication of records. There has been an attempt to integrate PhilHealth as a universal identifier for reducing duplication.

NTP VISION

- Transitioning to complete real-time case-based data reporting from all facilities.
- Extending presumptive screening and household contact tracing at outreach level.
- Leveraging predictive modeling and other data science tools for better decision making and planning
- Enabling real-time integration with Laboratory information tools like GxAlerts.
- Functionality of instant notifications and automated translation of data to actionable with Artificial intelligence.
- Scale up of EndTB suite and innovations with AI and Alert systems, Decision Support systems, integration with Telecare services.
- Strengthen and scale Community Led Monitoring systems like CareTB patient app (built on OneImpact platform).

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for fulfilling country's vision, we have put together an estimated investment requirement and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Philippines has 3600 facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 540,000** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Philippines has 1634 cities and municipalities and 17 regions. To promote active data use, each city, municipality and region should be given a tablet which would cost roughly around **USD 330,200** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 1,890,360** should be considered for 3 years (assuming USD 100 mobile data cost for a year per facility, district & regional user)
  - Server: Based on the current volumes of new cases, Philippines would need an investment of **USD 40,000-50,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Philippines already have a strong foundation of a case-based reporting nationally, around **USD 700,000-800,000** should be budgeted for comprehensive TB surveillance system development and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. A 1-day training should be planned for each of the 1634 cities and municipalities, which could cost roughly USD 100 per training amounting to **USD 163,400.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 4 – 4.5 million for 3 years** will be needed for further strengthening and maintaining a comprehensive case-based digital TB surveillance system for Philippines

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"The National TB Control Program has gone a long way in its information system. Before the Integrated TB Information System (ITIS) was available, we were only able to complete our annual reports after two years. Data generated were used to plan our activities and to forecast the needed commodities. You can just imagine the several assumptions that we have to make to ensure that the numbers will almost be correct. Now that ITIS is available, we have our data after a month of the end of every quarter. We look forward to having accurate and real time data to ensure that services needed by the patients and challenges encountered by the program are addressed promptly. This will make our goal of providing patient-centered care a reality as we move towards Universal Health Care."

Anna Marie Celina G. Garfin, MD
ex - NTP Manager
Philippines

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** In order to further strengthen and develop to a fully functional digital TB surveillance system, a comprehensive costed action plan for necessary enhancement may be prioretized.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the sub national infrastructure for direct data entry and data use from the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to real time notification and information use.

  Tentative timeline: Month 0-3

- **Mobile App** : One of the challenges reported by the NTP is the infrastructure inadequacy and lack of availability of real time data for stakeholders from reporting sites with less connectivity. One effective way to overcome this is to support the current data collection processes by scaling CareTB platform and ITIS lite platform for enabling field based real-time data collection through the entire continuum of care starting from presumptive screening, referral, testing, treatment, treatment adherence, outcome.

  The mobile app should have additional features like offline mode, GIS capabilities, encryption, version management etc. and should be extended for use even for aggregate data reporting of stocks or other datasets, specially from facilities with limited IT infrastructure.

  This would also ensure that the data structures are consistent. Also, the app should be supported with a configurable set up to support any updates/changes to the program. Additionally, the app should use standard mobile framework with Java, Postgres, React and Android, which can be easily supported by country IT teams and compatible with the ITIS system.

  Following the standard best practices of mobile application development can make this a more robust solution.

  Tentative timeline: Month 6-12

- **Data Use:** The NTPs plan clearly emphasizes on the importance and need for improve data use. For a country like Philippines, where already a solid IT foundation exists, the aim should be on data use, which is not only crucial at the National or State or district level in aggregated forms, but actual impact of data use is best materialised when used by the local health staffs like including outreach workers. Additionally necessary job aids/line lists etc can be auto generated that could make the job easier for TB staff and supervisors.

  The recommendation to improve data use is by enhancing the existing dashboard and analytical platforms like RaceTB and CareTB dashboard that not only offers aggregated indicators across the cascade of care but also provide granular patient level data across continuum of care for programmatic decisions. The local dashboard for the facility level health staff and outreach workers should have risk profiling and daily scheduler for following up and managing individual TB cases better including real-time monitoring of treatment adherence.

  Advanced data science and AI based predictive modelling should be leveraged for forecasting demand for testing and treatment and help planning resource utilisation better, or to predict the risk of death and being loss to follow up to provide differentiated care to those patients.

  The data use should also use GIS based hotspot mapping and AI based hotspot predictions to pre-empt any disease outbreaks.

  It is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [6]

  Tentative timeline: Month 3-12

RECOMMENDATIONS

- **System Integration**: One of the challenges highlighted by NTP is leveraging the data collected from other tools into the main ITIS system for effective use.

  The current ITIS platform and infrastructure needs to be extended to support integration with external systems like Telecare platforms, GenXpert, TruNat, Digital X-Ray outputs, Smart Pill boxes and other adherence tools (99DOTS, ConnectTB, etc) which help in using the data effectively for the patient continuum of care as highlighted by the National program. It is also recommended that National ID systems like PhilHealth system should be integrated with the ITIS system for eliminating duplication of records.

  Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing should be evaluated. [7]

  The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

  Tentative timeline: Month 12-18

- **Development of more comprehensive eLearning tools:** A national IT system has its own capacity and training requirements, which creates a need for development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the ITIS application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using ITIS (web or mobile app) for direct data reporting, the DOH must engage in development of a comprehensive eLearning module for app training. Training tools like Moodle [8] built on standard LMS framework can be reviewed for application rollouts.

  AI based decision support system for TB care provider should also be built into the eLearning module making it the one stop shop for all health workers.

  Tentative timeline: Month 0-3

- **Scale up of Patient Interactive Systems and CLM platforms:** Establishing a direct and secured mechanism for engaging with patients and the engaging community in monitoring TB interventions has potential for drastic improvements in tracking lost to follow-up patients, reducing stigma and improving care & service delivery.

  Auto generation of notification and messaging using the CareTB patient module and by communication channels like Social Media channel, IVRS and SMS outbound messages should be further scaled to cover all patients receiving services.

  CareTB CLM platform (built on OneImpact) should be further enhanced and scaled to maximise reach and engagement with patient communities at the last mile and to strengthen the efforts of the civil society organizations and communities TB peer support network groups with the end objective of supporting patient not only with their programmatic needs but also social and human right needs as part of the broader CLM guidelines in the country.

  Tentative timeline: Month 6-24

- **Data Quality** :

  As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

  UIC Code: Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records. Integration with PhilHealth ID can also help reduce duplication. This should be generated automatically through the case-based TB surveillance system.

  Data access control is another such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

  Tentative timeline: Month 6-18

RECOMMENDATIONS

Strategic Technical Recommendations:

Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

- **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

  Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

  Recommended data system architecture would include updating the current ITIS and CareTB systems to the most updated technology stack, which would offer better features on data management , encryption & exchange standards.

  Apart from this, systems should also support compliance to GDPR standards and offers more controlled data encryption practises.

- **Performance Optimisation & Testing :** To support the national scale up and implementation strategies, it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning. [9]

- **Application & System Security Audit:**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA [10] to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by ITIS and Care TB [14] for patient data security, hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [11]

ACKNOWLEDGMENT

We thank the National TB and Leprosy Program Manager, ***Dr. Anna Marie Celina G. Garfin*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Ms. Donna Geviola*** for providing valuable insights into Philippine's vision for creating an advanced case-based TB surveillance and notification system.

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3. TB Data References : https://www.usaid.gov/sites/default/files/documents/Philippines_TBRM21_TB_DIAH_Version_Final.pdf
4. Digital Landscape : https://datareportal.com/reports/digital-2021-philippines
5. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
6. End TB App suite: https://ntp.doh.gov.ph/resources/downloads/endtb-appsuite/
7. System Integration Tools (Talend , Informatica) : https://www.talend.com/index.php , https://www.informatica.com/
8. Application Training Tool : https://moodle.org/
9. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
10. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
11. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

SOUTH AFRICA

SOUTH AFRICA

BACKGROUND

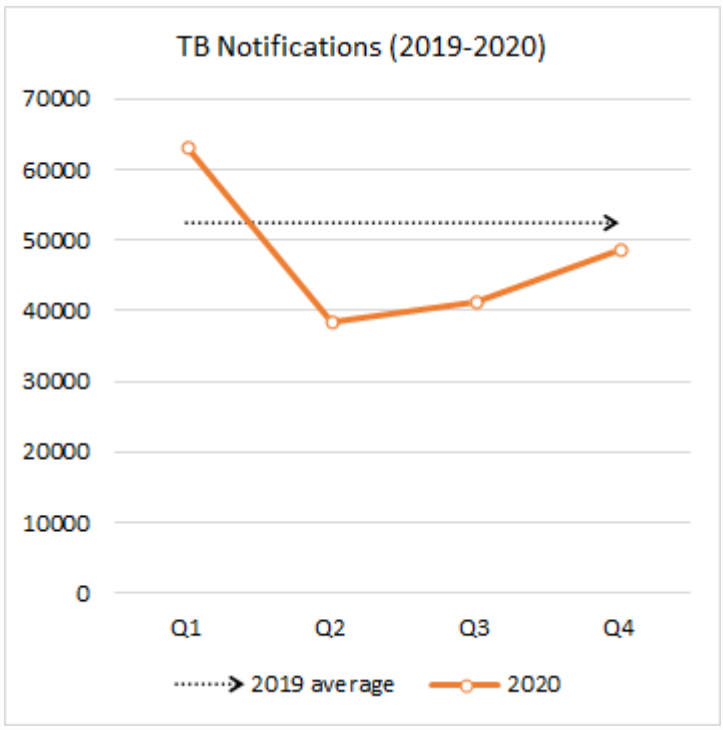
According to WHO estimates, South Africa accounts for the eighth largest TB burden in the world (WHO Global TB report, 2021). In 2020, approximately 328,000 new cases emerged at an incidence rate of 554 for every 100,000 people, and 234,000 people are estimated to suffer from both TB and HIV.[1]

With 6,784 individuals in the country developing drug resistant TB annually, and another 733 confirmed for XDR-TB, South Africa is a DR-TB high burden country. [1]

Overall, South Africa falls in all the 3 lists of 30 High Burden countries, i.e., high TB, DR-TB and TB/HIV case loads.[2]

South Africa has achieved a treatment coverage of 58% of all people living with TB in 2020 and the TB case fatality ratio stands at 19%. 51% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment. [1]

Affected by the COVID19 pandemic, country's TB case notification dropped in the second quarter of 2020, however, the health system is reviving its TB surveillance practices and the notification is steadily improving to reach 2019 levels.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Through the National Strategic Plan (NSP) for HIV, TB, and sexually transmitted infections (STIs) 2017-2022, the Government of South Africa has committed to achieving the targets of United Nations General Assembly (UNGA) High-Level Meeting. The NSP has set direction for- Acceleration of preventive efforts to reduce TB incidence; Reduction of morbidity and mortality through the provision of high-quality treatment care and support; Expanding target interventions to vulnerable communities; Increasing access while reducing stigma, justice and discrimination; Promoting sustainability through leadership and partnerships; Mobilization of domestic resources; and Strengthening strategic information systems.[3]

South Africa primarily uses **TIER.Net** as the tool for DS-TB notification, and the Electronic Drug-Resistant Tuberculosis Register (**EDRWeb**) surveillance system for DR-TB reporting. Currently, out of the 4,300 TB health facilities, 3,000 have a direct access to enter case-based DS-TB data in the TIER.Net and 400 DR-TB facilities have access to EDRWeb. The remaining 1,300 facilities with infrastructural challenges submit manual reports to the sub-district or district level for data entry. The data is further imported in aggregate form to the **Integrated WebDHIS** (DHIS2) portal of MoH. Case based data for both DR- and DS-TB is submitted in DHIS2, however aggregate data integration does not include a lot of key variables from individual line lists (Migration, Patient transfers, etc), which currently restricts effective program monitoring.

The National Department of Health further envisions an integrated HIV-TB Electronic Health Record model, which would be integrated with the TB and HIV surveillance systems. Additionally, to complement the existing national HMIS, the TB data imported to DHIS2 is available as indicators for analysis with other data points, however, with the existing inconsistencies between systems, the related use for program management remains restricted.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As per 2021 figures, about 168.5% of the population has a cell phone, and more than 91.2% use smartphones (2019). Internet penetration further stands at decent figures (i.e., 64%) in the country. It is thus a good opportunity to strengthen stakeholder coordination and leverage the friendliness of South Africa's population with digital tools, which can set a strong ground to implement advanced digital solutions and ensure adequate uptake. [4,5]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem for TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based TB surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.

STATUS OF CASE BASED TB NOTIFICATION

Currently the National TB program has been implementing primarily two tools for TB surveillance:

EDRWeb is the National TB program's web-based tool for collection of case-based DR-TB records from the DR-TB facilities, and it is also integrated with an EDRWeb Dashboard for data visualization.

TIER.Net is the Health Information Systems Unit's desktop tool for collection of case-based data for DS TB (and HIV) patients, which was developed as an extension of its predecessor, i.e., ETR.Net. Currently, the system is implemented across 3000 facilities and captures data of all TB patients put on treatment at the DS TB sites. With the complete ownership with HMIS unit and system deficiencies, there are challenges associated with use of TIER.Net.

The case-based data entered by the facilities (or districts, on behalf of some facilities without connectivity) is extracted in encrypted dispatch files, which are later used for importing to DHIS2 portal (called, Integrated WebDHIS) after conversion. The data received in DHIS2 is in Aggregate format and the reconciliation of dispatch files and data upload is yet not completely automated. Additionally, due to the lack of checks / validations, data can be duplicated too. This imported data is aggregated in the system and is disseminated upto the National level for program review and monitoring.

NTP further plans to use EDRWeb as the tool of choice for all TB reporting and will soon take up the incorporation of DS-TB notification and introduction of mobile apps for seamless data entry.

SUCCESS STORIES

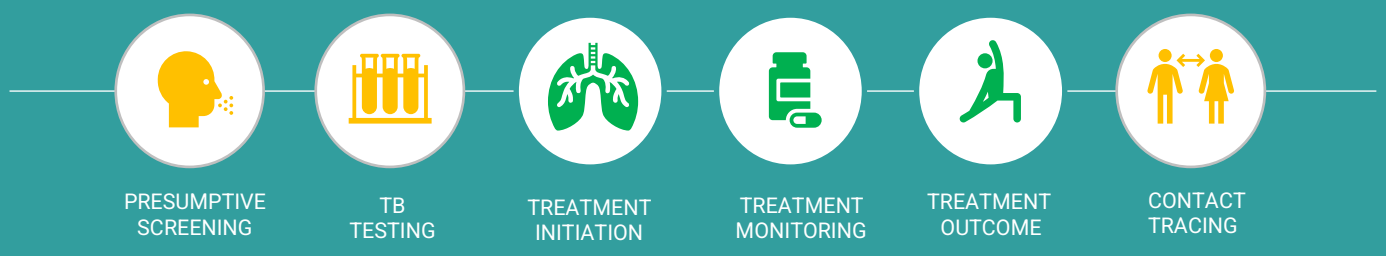
The development of EDRWeb is a notable example of a successful development of TB notification solution under NTP's leadership. The platform is implemented and functional across all DR-TB sites and is working efficiently to cater to the related data needs for program management. Soon, the system is planned to be expanded for covering DS-TB reporting as well, which will establish it as the national tool for real time case-based TB notification, surveillance and data management.

As an innovation from the sub-country level, the Western Cape province of South Africa has developed a comprehensive and user-friendly public access dashboard (updated on a monthly basis) that aids in an effective data dissemination and also allows basic options and features to dive deeper into the presented data.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard EDRWeb dashboard
District and Metropolitan Municipalities	52	Data not collected from this level			DHIS2 Dashboard EDRWeb dashboard
Local Municipalities (sub-district)	280	280	DHIS2	Aggregate data (import of extracted data files)	DHIS2 Dashboard EDRWeb dashboard
Facility level	4300 (1300 facilities send manual records to sub-district level for data entry)	3000 – DS TB reporting in TIER.Net, 400 – DR TB reporting in EDRWeb	TIER.Net (DS TB facilities) EDRWeb (DR TB facilities) Manual registers (all facilities)	Case Based	EDRWeb dashboard
Community level	Data not collected at this level				No digital tool for data use

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	
Comorbidity wise aggregate numbers and proportions notified	
Key-population wise aggregate numbers and proportions notified	
Estimate/Target wise notification/treatment coverage (proportions)	
Provider-type disaggregated treatment outcomes (proportions)	
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	TIER.Net – DS TB EDRWeb – DR TB
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Treatment initiation
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Manual notification process – Data submitted to sub district level for data entry
Frequency of digitization of TB notification	Daily - TIER.Net and EDRWeb Monthly - import to DHIS2
Mode of follow-up with notified cases	Manual follow-up- phone call, physical visit
Scale of implementation	National roll out
Contact tracing for TB notified cases	Done on manual registers and aggregate data (<5 years child contacts) reported in DHIS2
Multi-channel enablement	Offline data entry in TIER.Net with the desktop application
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Private health providers submit their data to the sub-district level for data entry. Data is received as aggregate figures.

COUNTRY IT CAPACITY

Country Server
TIER.Net system is hosted by the HMIS division of MoH, and EDRWeb is hosted by an outsourced private data centre.

Interoperability
Data export functionality present for integration with other systems, which is being used for importing data to DHIS2.

Country IT team
TIER.Net - developed by University of Cape Town and managed by HMIS/MoH
EDRWeb - developed by WAM Technologies and managed by NTP

ENABLING ENVIRONMENT

168.5%
Mobile penetration (Jan 2021) [4]

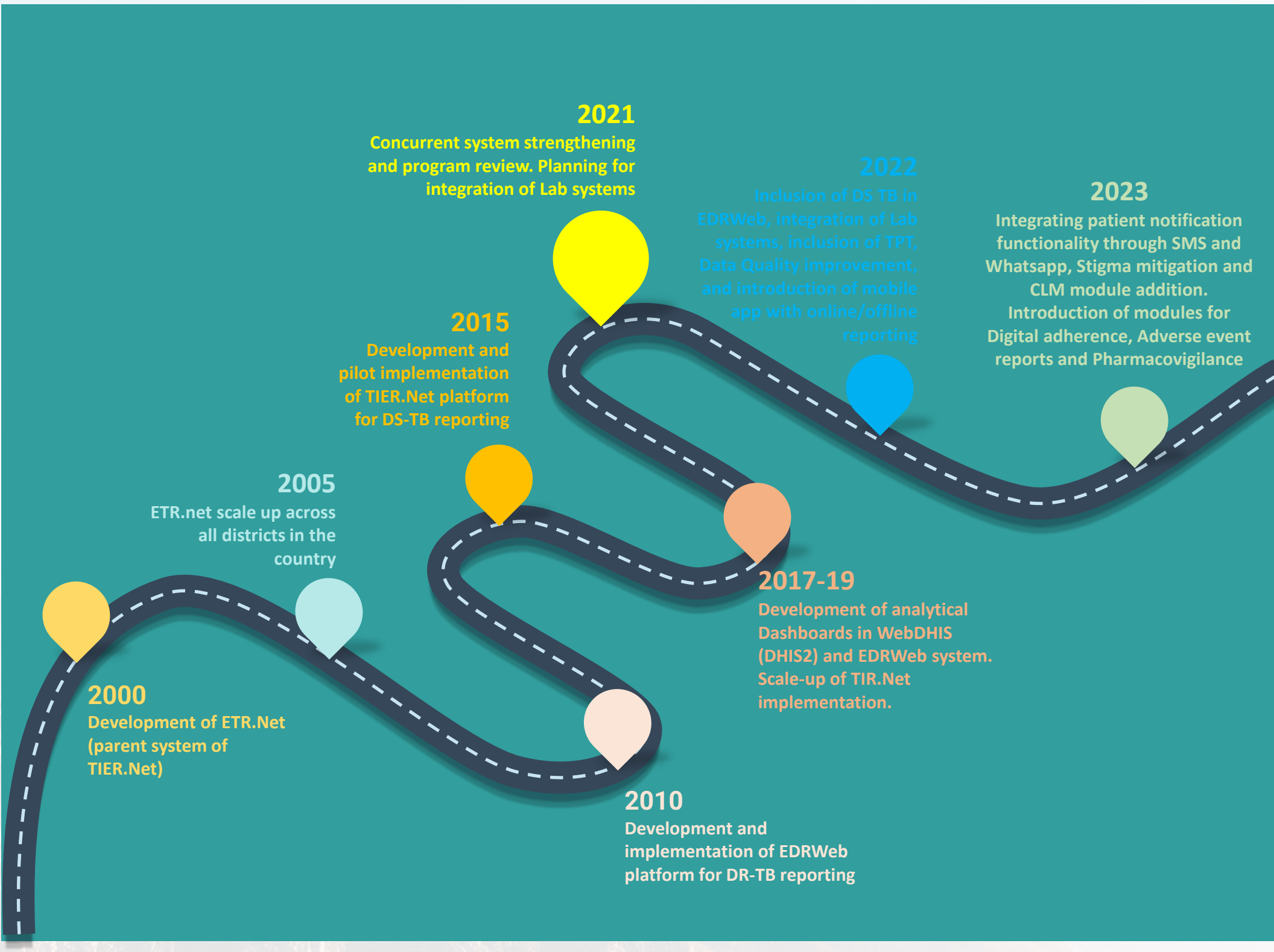
91.2%
Smartphone (2019) [5]

64%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- USAID funding of USD 1 million is available with NTP for covering recurring costs, such as hosting and deployment, project management, technical support and internet costs.
- The Global Fund has funded the development of TIER.Net and conduction of user trainings.
- CDC has supported the development and initial training on EDRWeb, and now the funding support is being provided by USAID till 2024.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Wisepill, PCAM	Pill boxes	Wise Pill	Stop TB Partnership	Pilot
Logistic Management	Stock Visibility System	Web Application	Mezzanine	Ministry of Health	National
Laboratory Information Management	GxAlerts	Web Application	Cepheid	National Health Laboratory Services	National
	Digital X-Ray	Web Application	Qure.AI	The Global Fund	Pilot
Community Led Monitoring (CLM)	SMS to patients (Ritshitze)	SMS	Ritshitde	PEPFAR	Pilot
Contact Tracing	Nil	NA	NA	NA	NA

KEY CHALLENGES

- Shortage of personnel and lack of training, results in an acute crunch of trained manpower at the data entry points.
- Availability of desktops and laptops for data entry at 1300 facilities is inadequate for direct data reporting, and as a result of this, data is entered from sub-district level, which causes delays and data quality concerns.
- Inconsistency with electricity and internet connectivity, along with an inadequate hardware maintenance causes challenges in real time data reporting.
- TIER.Net system (DS TB) is an offline desktop application and as a result, however the data is entered on a daily basis (varies across facilities), its compilation and data access for stakeholders is challenging.
- It being a shared system with other programs, NTP does not have an ownership on TIER.Net, which causes major dependency on the HMIS team for smallest of changes and configurations.
- Without 100% transition to real-time case-based reporting and automatic integration with tools like DHIS2 and GeneXpert (and other NHLS tools), major gaps will remain around access to real time data, its analysis and use for action by the stakeholders.

NTP VISION

- System enhancement to capture data for screening and Lab services in real time, to improve drop-outs and reducing the loss to follow up.
- Inclusion of migrant care in the region for improving patient coverage and continuity for treatment.
- Development of an advanced program monitoring dashboard, to enhancing data quality, enabling tracking of cross border patient movement, improving visualization of patient trends and identifying bottlenecks at facilities.
- Improving EDRWeb's interoperability with other systems.
- Technical assistance and support for betterment in IT infrastructure at facilities, Human resource training, and concurrent capacity building.
- Introduction of a mobile app for strengthening data entry from all TB facilities.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): South Africa has 4300 TB facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 645,000** will be needed assuming USD 150 per mobile devices. If needed, additional budget can be booked for community settings.
  - Tablet (for data use): South Africa has 280 sub-districts, 52 districts and 9 provinces, and to promote active data use, each sub-district, district and province should be given a tablet which would cost roughly around **USD 68,200** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 1,290,000** should be considered (assuming USD 100 mobile data cost for the entire year per facility)
  - Server: Based on the current volumes of new cases, South Africa would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact South Africa already have a strong foundation for case-based reporting of TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system, system integrations and dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 280 sub-districts, which could cost roughly USD 100 per sub-district, amounting to **USD 84,000,** which will be further supported with e-Learning packages.

TOTAL investment of around **USD 2.5 – 3.0 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for South Africa

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step it is important for the country to create a comprehensive costed action plan for development, implementation and scale up of the TB case-based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan with timelines. The plan will help the country to assess and monitor the progress and to mitigate risks

  Tentative timeline: Month 0-1

- **Establishing EDRWeb as the core Case Based TB surveillance system :** The NTP has already established a strong case-based reporting environment through the TIER.Net and EDRWeb platforms, which forms the core infrastructure in terms of database and deployment environment. It has built the expertise and capacity for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  While the current EDRWeb case-based system development is covering only a section of the TB care continuum, the application should be further expanded to include a comprehensive monitoring for both DR and DS TB through a single system, including presumptive screening, referral, cross border migration and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Tentative timeline: Month 0-12

- **Technical and Functional review of TIER.Net**: A key challenge highlighted by NTP is the restricted environment offered by TIER.Net and its ineffective use due to system deficiencies.

  A thorough technical and functional review of the TIER.Net platform is crucial to understand these inconsistencies and gather learnings to refine the existing as well as future solutions.

  Tentative timeline: Month 0-12

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the data collection processes at the facility and community level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification from the site of service delivery.

  Tentative timeline: Month 0-6

- **System Integration:** One of the challenges highlighted by NTP is the leveraging of data collected from the multiple sources (like GeneXpert) into the main EDRWeb and TIER.Net systems for effective use.

  The current EDRWeb / TIER.Net system infrastructure needs to be extended to support bi-directional integration and interoperability with external systems like National EHR, NHLS, GeneXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in using the data effectively for the patient continuum of care as highlighted by the National program.

  Recommended exchange / ETL tools like Talend and Informatica can make the data management task much easier and simultaneously improve data warehousing. [6]

  With data export functionalities, the platform architecture of EDRWeb is compatible with these standard tools and processes making this an effective solution. [7]

  The data exchange process should follow and comply with FHIR, GDPR standards for more secured and seamless data exchange.

  Tentative timeline: Month 0-6

RECOMMENDATIONS

❖ **Mobile app : I**mplementation of data collection via mobile app to ensure ease of use and real time reporting to the national database.

One of the challenges reported by the NTP is inconsistent data connectivity, network issues and system restrictions that delay reporting of cases, and an inconsistent availability of hardware for data entry. One effective way to overcome this is to support the current data collection processes by introducing a mobile application for the government facilities.

Other advantages for a mobile application include better performance, effective use of device features like in house system updates , usage of GPS, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

Several mobile solutions for real-time case-based notification can be explored for local adaption and building the mobile counterpart for eTB manager. Open-source technologies like ODK and KOBO are some notable examples. [8]

Tentative timeline: Month 0-12

❖ **E-Learning** :

To address the challenges with periodic training of facility level staff to orient them on using TIER.Net and EDRWeb for real time data reporting, the MoH must engage in development of an eLearning module for application training.

While some software offer standard training modules on the application, training tools like Moodle [9] built on standard Learning Management System (LMS) framework should be reviewed for application rollouts.

Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care, modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

❖ **Capacity building for application maintenance**

Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

Strengthening the NTP team with trained system administrators will help in reducing costs (in seeking technical support) and improving and expediting the implementations.

Tentative timeline: Month 6-24

❖ **Contact tracing application implementation**

To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

Tentative timeline: Month 6-12

❖ **Patient Interactive Systems for ensuring retention on TB treatment :** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

Expanding the already running pilots of Community Monitoring tools in the country, to leverage features like auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages, should be considered. Existing solutions like the SMS notifications to patients for lab results can be further scaled, and Open-source applications like Open MRS can also be used for these activities. [10]

Tentative timeline: Month 6-24

❖ **Community Monitoring Systems :** As expressed by the NTP, the national TB notification and surveillance system should have necessary mechanism to integrate with ready-to-use open

RECOMMENDATIONS

source CLM platforms like One Impact, where they can connect with their peers, community and authorities to report issues like stigma and their reservations towards adhering with prescribed drugs.

Tentative timeline: Month 6-12

❖ **Data Use :** The NTP's plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data and required linelistings available across systems in a more real time fashion.

Building on the current EDRWeb and DHIS2 visualization modules that offer a dashboard for reviewing program and data indicators, additional features of pivot table , event reports which support dimensions, data aggregation reports, individual line lists and job aids are extremely useful.

Apart from the standard DHIS2 and EDRWeb dashboard features (and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics) it is recommended to use best of the breed tools like Tableau, Power BI (well compatible with the open-source technologies, like DHIS2) which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [11]

Tentative timeline: Month 6-12

❖ **Data Quality :** As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

This should be generated automatically through the case-based TB surveillance system that is already implemented.

Data access control is one such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

Tentative timeline: Month 6-18

Strategic Technical Recommendations

❖ Application upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas:

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management, encryption, data exchange standards.

Additionally, the advance admin features offered by this version help the administrators to support the operational needs better for onboarding users, real time change in data variables and user management etc effectively.

Apart from version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises. [12]

✓ **Performance Optimisation, Audits & Testing** : To support the national scale up and implementation strategies it is very essential to have system(s) and application testing and periodic auditing done to enable full proof platform and which also helps in architecture updates and augmentation.

Automated System and Application Testing tools like Selenium and Appium can be used. Load

RECOMMENDATIONS

Testing tools which helping in database sizing and planning need to be adapted for effective planning . [13]

✓ **Application & System Security Audit**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the

security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[14] to cover:

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by DHIS2 [15] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [16]

ACKNOWLEDGMENT

We thank the National Program Manager, **Dr Lindiwe Mvusi** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Sicelo Dlamini*** for providing valuable insights into South Africa's vision for creating an advanced case-based TB surveillance and notification system.

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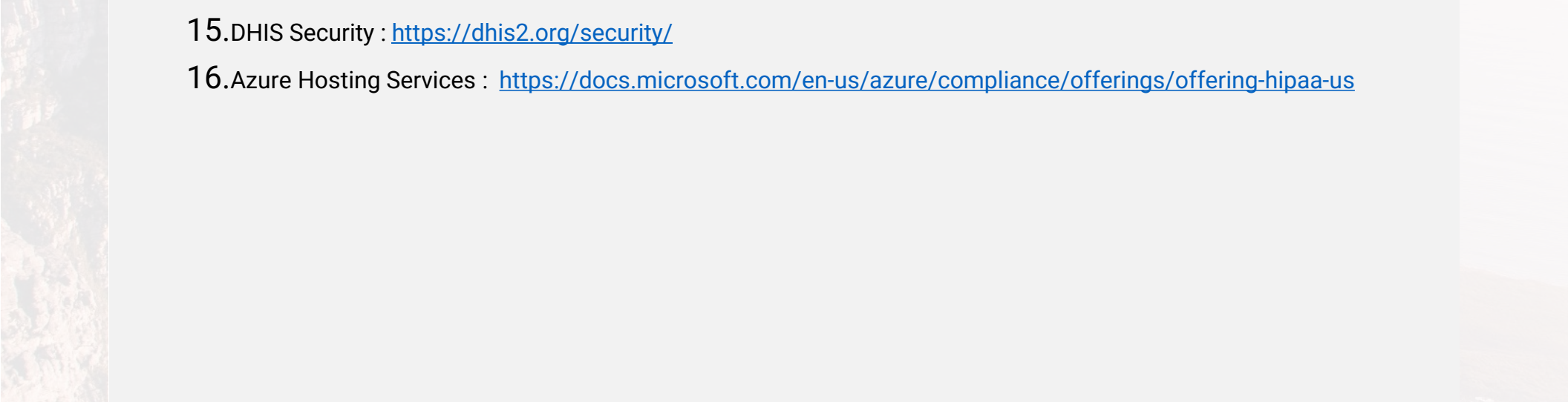
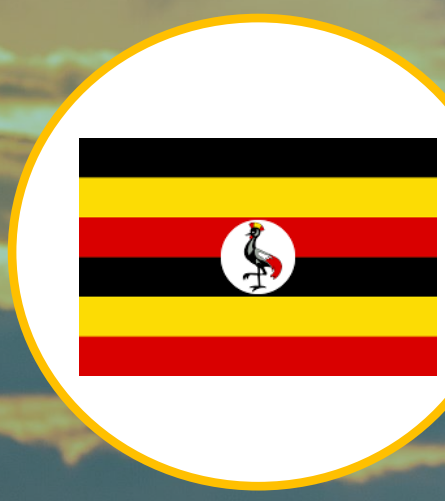
11. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
12. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/
13. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
14. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
15. DHIS Security : https://dhis2.org/security/
16. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us





UGANDA

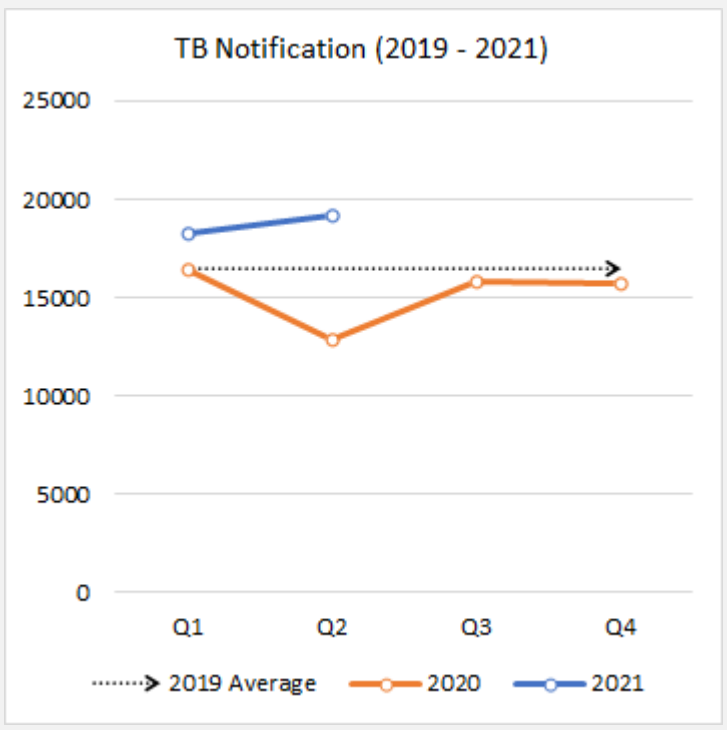
UGANDA

BACKGROUND

According to WHO estimates, 90,000 people newly developed TB in Uganda in 2020 of which 62,526 got notified (Global TB report, 2021) [1]. With nearly 30,000 of all people with TB also infected with HIV, Uganda is included in the list for the top 30 TB/HIV high burden countries. [2] Children account for nearly 12% of all cases, and many also suffer from TB-HIV coinfection

These numbers have been on a steady decline for the last decade [1] . In line with WHO's End TB strategy, Uganda has achieved a treatment coverage of 68% of all people living with TB in 2020 and the TB case fatality rate stands at 19%. 34% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment.

Affected by the COVID19 pandemic, country's TB case notification dropped in 2020, however, in 2021, the health system is making efforts to revive its TB surveillance practices and the notification has improved to reach above the 2019 average quarterly notification trend.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In order to achieve the key milestones, the National Tuberculosis and Leprosy Control Program (NTLP) , through its National Strategic Plan (NSP) 2021-25, aims to reduce TB incidence by 20%, with focus on areas, such as, strengthening community systems for high-risk populations and scaling-up TB preventive therapy (TPT); enhancing the public-private collaboration; adoption of new technologies; supporting digital information management; and multi-sectoral collaboration and resource mobilization for TB.[3]

Recent modifications in the TB reporting protocol have been highly instrumental in giving direction towards capturing more comprehensive data and paving way for the incremental implementation of case-based reporting from facilities. For instance, the system originally notified patients upon start of treatment (using a National Identification Number or NIN), however from 2020 the patient is notifiable at the time of diagnosis. The NTP now identifies the location of diagnosis of a patient and shares information in an aggregated format.

The **DHIS2 aggregate** data model based national TB surveillance system is supported by the Global Fund and CDC (as well as PEPFAR and WHO for HIV/AIDS programs), and for technical support around DHIS2 customization, HISP Uganda and the WHO HQ continue to offer technical guidance. This system is built as a component of the National HMIS platform.

In parallel to their COVID-19 response, Uganda's MOH has collaborated closely with the national TB program to enable the **DHIS2 tracker** (**eCBSS** – Electronic Case Based Surveillance System – TB and Leprosy) across 100 facilities. While the data is owned by the ministry of health (MOH) and is hosted in MOH servers, the NTP has enabled the case-based data collection at 100 health facilities and aggregated data management continues for the remaining sites for both DR-TB and DS-TB cases. Additionally, to complement the existing national HMIS data systems, the TB Data from DHIS2 can easily be integrated as indicators which enable comprehensive data review and analysis of TB data nationally.

It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. In Uganda, while 60% of the popular has a cell phone, the smartphone use is only about 16% and internet penetration is close to 24%. It thus becomes crucial for the country to develop this infrastructure, both for improving the digital literacy and at the same time creating a strong ground to implement advanced solutions and ensuring their adequate uptake.

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report attempts to produce clear recommendations and way forward towards developing a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF ELECTRONIC CASE BASED TB NOTIFICATION

In 2020, Uganda adopted DHIS2 as the national system for a weekly reporting of TB notification data. This has helped the national program to monitor TB diagnosis cascade at facility level, and the platform has further developed over the last 2 years to introduce a Case based tracker system, which is being piloted at 100 facilities currently. All the 15 RRHs (Regional Referral Hospitals) are also included in this pilot, and the data is directly collected in eCBSS platform.

This system has an integrated dashboard that aggregates the data on weekly basis and automatic reports are generated for analysis.

The national TB notification system allows management of both DR-TB and DS-TB cases.

The data is first maintained in manual registers offline, and then transformed to digital form by reporting aggregate data in DHIS2 (case-based data from pilot sites) either from the facility directly or entered from the district level where infrastructure is inadequate at facilities.

SUCCESS STORIES

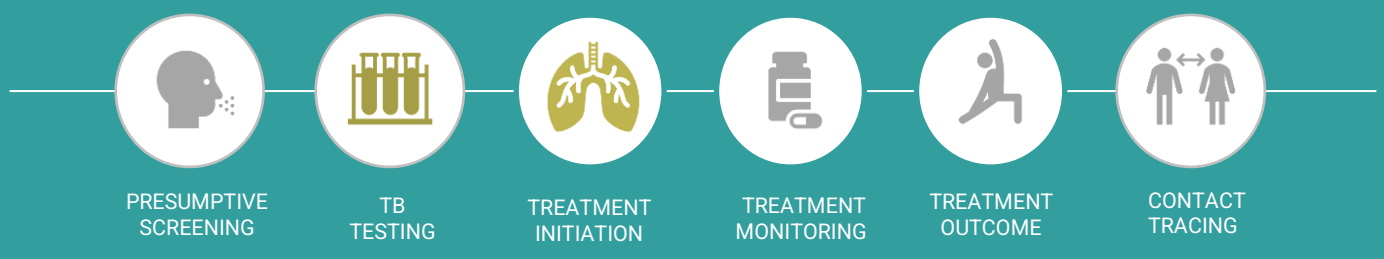
Since 2020 Uganda's NTP and MOH have collaborated closely (during the COVID pandemic) to notify patients at the time of diagnosis itself (i.e., not after treatment initiation) by linking a National Identification Number, and thus capturing data of the entire cascade of care. NTP now identifies the location of diagnosis of a patient and shares information in an aggregated format.

The use of the offline provision of DHIS2 android capture app in the implementation of the Electronic Case-based surveillance system (eCBSS) pilot is noteworthy in tackling the challenge of internet connectivity at the remote facilities and outreach. The same is further being explored for supporting the health workers in contact tracing activities on ground.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Regional Level	15 (RRHs)	15	DHIS2 Tracker – eCBSS pilot	Case-based	DHIS2 Dashboard
Districts and Cities	148	148	DHIS2	Aggregated	DHIS2 Dashboard
Facility Level	1700	100 – eCBSS 1600 – Paper based/DHIS2	DHIS2 Tracker – eCBSS pilot sites, DHIS2 Aggregate at other facilities	Case-based, Aggregated	DHIS2 Dashboard
Community level	Pilot sites	15	DHIS2 Android Capture app	Case based (contact tracing)	No Data usage at this level

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	✓
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	DHIS2 tracker (eCBSS) – 100 facilities; remaining 1600 report aggregate data
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Diagnosis stage
Level of Access and Use of TB Notification data	Facility level (and above)
Private sector notification	Manual notification process (a few providers have direct DHIS2 access for data entry)
Frequency of digitization of TB notification	Aggregate – Weekly to quarterly eCBSS – Real-time
Mode of follow-up with notified cases	Physical visits
Scale of implementation	National rollout
Contact tracing for TB notified cases	DHIS2 tracker pilot
Multi-channel enablement	Use of DHIS2 Android capture mobile app for eCBSS data entry
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR ENGAGEMENT

Private sector partners enrolled under the national TB program align with electronic notification of aggregated TB data. Private providers outside the NTP support efforts through a manual notification process.

COUNTRY IT CAPACITY

Country Server
The DHIS2 platform is hosted managed by the Ministry of Health

Interoperability
DHIS2 as a platform provides APIs for interoperability, but yet to be integrated with other tools

Country IT team
NTP has an in-house IT team, but the system support is taken from HISP Uganda and MoH.

ENABLING ENVIRONMENT

60%
Mobile penetration [4]
(Jan 2020)

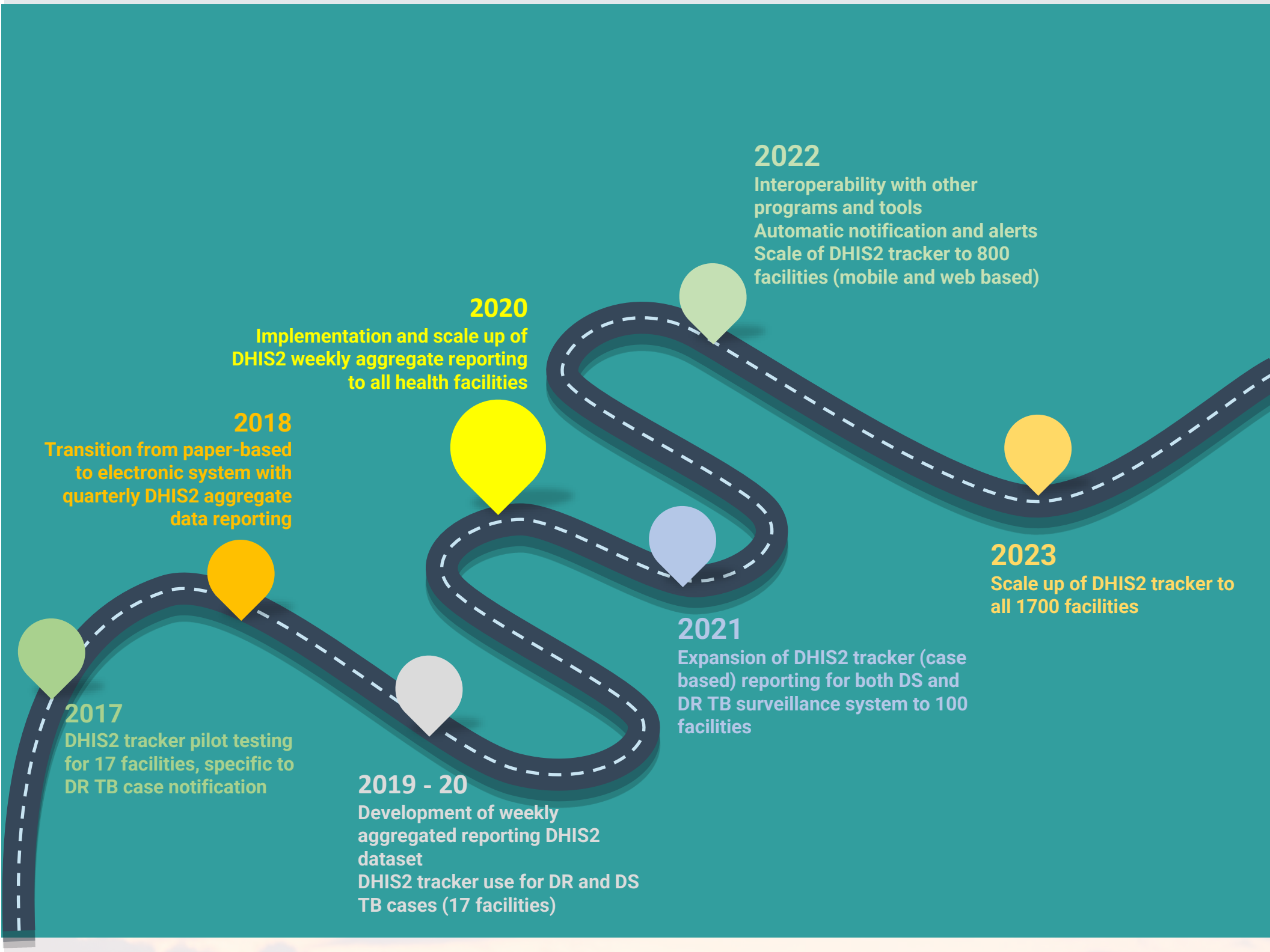
16%
Smartphone [5]
(2019)

24%
Internet penetration [4]
(Jan 2020)

CURRENT RESOURCES AVAILABLE

- Uganda's NTP reports some availability of infrastructure at the time of development of the electronic case based surveillance system.
- So far about USD 200,000 has been used to develop the system, conduct national site visits, develop and disseminate resource material, train health workers at 100 facilities and conduct supervision.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Video DOTS	Web application	ZMQ	Information not available	Pilot
	99 DOTS	Mobile application	Everwell	TB Reach Wave 8, 9	Pilot
Logistic Management	DHIS2 dataset	Web Application	HISP Uganda	The Global Fund	National
Laboratory Information Management	DHIS2 dataset	Web Application	HISP Uganda	The Global Fund	National
	GeneXpert	Web Application	Cephield	Information not available	National
Community Led Monitoring (CLM)	Toll Free Call center	Telephonic	Ministry of Health	Ministry of Health	National
Contact Tracing	DHIS2 tracker	Mobile application	HISP Uganda	The Global Fund	Pilot

KEY CHALLENGES

- **Digital infrastructure:** Uganda's current IT infrastructure at sub-national level and at the facilities is inadequate for further scale up beyond the current 100 facilities, and the related funding also faces a shortage.
- **Training manpower:** Expanding the case based electronic TB surveillance system would increase data entry burden and requires training of health professionals at all planned 1700 facilities. With the current HR availability at facilities, trainer manpower for data entry is an immediate need.
- **Internet availability:** Its unreliability affects data entry and analysis even in the initial 96 facilities. Scaling up to more disconnected and marginalised community areas will require political will and investment.
- **Interoperability:** Program is currently unable to generate data from GeneXpert system due to the high costs of integration, hence the utilization of GxAlerts is not at par.
- **Legacy data migration and backlog:** Scale up of eCBSS to all facilities would result in significant data entry backlogs and NTP's current capacity is insufficient to handle this additional load.

NTP VISION

- As part of the National Strategic Plan for 2020/21-2024/25, the NTP envisions point-of-care data collection, enabling real time actionable information management.[3]
- Uganda's NTP also plans to expand the electronic case based surveillance system (eCBSS) on a national level to all 1700 health facilities across the country. This will require infrastructure investment, training programs and political commitment.
- Establishing a real time access to data for the stakeholders.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

Hardware and Infrastructure:

- Mobile Devices (for data collection): Uganda has 1700 facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 255,000** will be needed assuming USD 150 per mobile devices.
- Tablet (for data use): Uganda has 135 districts and 15 regions and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 30,000** assuming USD 200 per Tablet devices.
- Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 555,000** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
- Server: Based on the current volumes of new cases, Uganda would need an investment of **USD 15,000-20,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

Software Development:

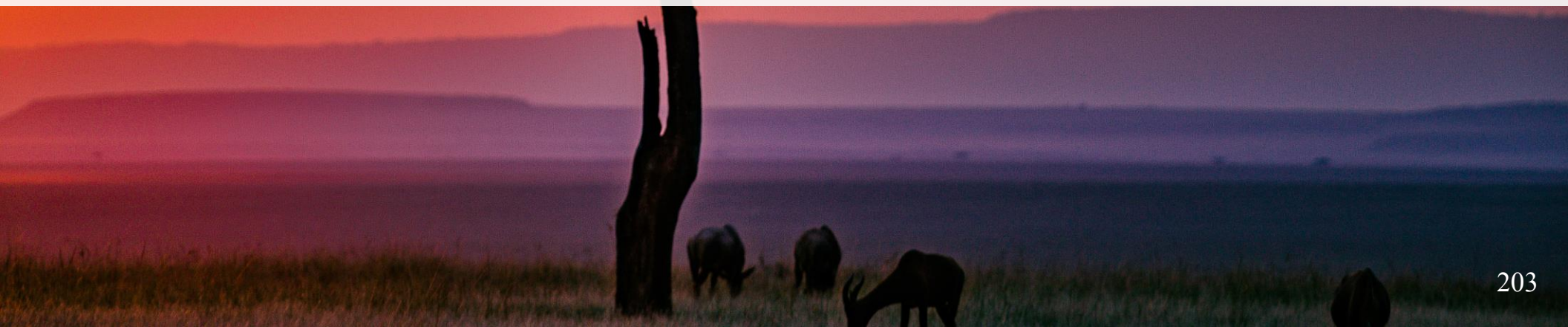
- Based on various multi-stakeholder meetings and given the fact Uganda already have a strong foundation for DHIS2 aggregated system for TB, around **USD 500,000-750,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

Capacity Building and Implementation:

- After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 120,000-180,000 per annum should be budgeted (or **USD 360,000-540,000** for 3 years assuming USD 2,500 month per resources). Additionally, reskilling of the current IT team should be budgeted.
- Training: This would involve training material development and onsite and remote training of the trainers. Ttraining sessions should be planned for each 135 districts over a period of 3 years which could cost roughly USD 100 per training amounting to **USD 13,500,** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 2-2.5 millions for next 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system in Uganda.

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.



RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation and scale of TB Case Based Notification systems :** With the help of HISP Uganda the NTP has already established DHIS2 environment which has the core infrastructure in terms of database and deployment environment. It has built the DHIS2 expertise and capacity which acts as a strong foundation for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the DHIS2 tracker app. While the current tracker has been planned to cover the details for creating case-based notification system for both DS TB and DR TB patients , the application should also include monitoring of entire continuum of care including presumptive screening, referral, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes[6]

  Tentative timeline: Month 0-12

- **Mobile app**

  One of the challenges reported by the NTP during the data collection processes is the lack of availability of real time data for stakeholders. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, which is in line with the country's efforts of improving the overall digital ecosystem.

  As a recommendation, the latest DHIS2 mobile app version (already being piloted by Uganda for eCBSS and contact tracing from outreach) which has additional features on data collection, security, offline data collection, encryption ,version management etc should be extended for use even for aggregate data reporting, specially from facilities with limited IT infrastructure should be reviewed.

  This would also ensure that the data structures are consistent. Also, the app is supported with a configurable set up to support any updates / changes to the program.

  Additionally, the DHIS2 mobile framework uses open-source technologies like Java, Postgres, React and Android, there are easily supported by country IT teams also the standard best practices of mobile development like version management, data encryption etc which make this as more robust solution. [7]

  Tentative timeline: Month 6-12

- **Device Procurement:** One of the limitation highlighted by NTP is the need to improve the data collection processes at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-6

- **System Integration**: One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources into the main DHIS2 systems as a central system for effective use.

RECOMMENDATIONS

The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GeneXpert, TruNat, Digital X-Ray outputs, Pill bill boxes and other adherence tools, current LMIS and CLM systems which help in use the data effectively for the patient continuum of care as highlighted by the National program.

Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing should be evaluated. [8]

The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes

The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [8]

Tentative timeline: Month 12-18

- **Data Use**: Advanced dashboard analytics to strengthen the current Monitoring and Evaluation framework

  The NSP 2021-2025 clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data and patient line listing available at the lowest level health functionary involved in TB care

  Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table , event reports which support dimensions , data aggregation reports and individual line lists and with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current DHIS2 and other systems then a more advanced analytical dashboard should be designed linked to the new case-based TB. To achieve this , and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. The current DHIS2 platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework. [9]

  Tentative timeline: Month 6-18

- **Capacity building for application maintenance**: One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires trained personnel on DHIS2.

  Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

  Tentative timeline: Month 0-6

- **Contact tracing application implementation :**

  To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

  Tentative timeline: Month 6-12

- **Additional Systems** : To make sure that paper based patient records data is integrated with the DHIS2 tracker systems technical solutions like OCR [10] can be reviewed.

  The DHIS2 platform supports reading from these structures. This would help in data upload of all historical data with less difficulties.

  Tentative timeline: Month 6-12

RECOMMENDATIONS

❖ **e-Learning** : Digital training packages to train health professionals on DHIS2 data entry, information use, M&E and workflows:

To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

While DHIS2 offers standard training modules on the application , training tools like Moodle[7] built on standard Learning Management System (LMS) framework can be reviewed for application rollouts.

Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

❖ **Patient Interactive Systems :** Tracking lost to follow-up cases and enabling real time notifications for patients is highlighted as one of the main challenges. Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [11]

Tentative timeline: Month 12-24

Strategic Technical Recommendations:

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption , data exchange standards.

Apart from this, version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practices. [12]

✓ **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium may be considered. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning. [13]

✓ **Application & System Security Audit:**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

RECOMMENDATIONS

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[14] other country guidelines cover

- Patient Data Management
- Server & Infra guidelines

Apart from application measures offered by DHIS2 [14] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [15]

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr. Stavia Turyahabwe*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to **Dr. Robert Majwala** for providing valuable insights into Uganda's vision for creating a comprehensive case-based TB surveillance and notification system.

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7. System Integration Tools (Talend , Informatica) : https://www.talend.com/index.php , https://www.informatica.com/

8. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043

9. Application Training Tool : https://moodle.org/

10. DHIS2 Mobile App : https://dhis2.org/android/

11. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/

12. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/

13. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/

14. DHIS Security : https://dhis2.org/security/

15. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

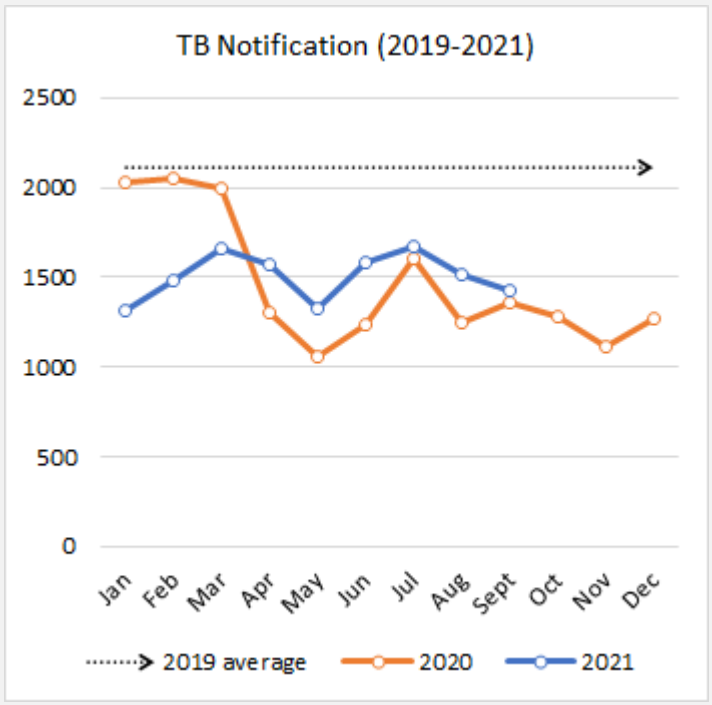
UKRAINE

UKRAINE

BACKGROUND

According to the latest WHO estimates, Ukraine has the 4th highest TB incidence rate, 3rd highest TB mortality rate (excluding HIV) and the highest mortality due to HIV-associated TB, among the 53 countries of the WHO European Region, As per WHO 2021 Global TB report, the TB incidence in Ukraine is 73 cases per 100,000. The estimated proportion of rifampicin-resistant TB (RR-TB) among new and previously treated TB cases was 27% and 43%, respectively, in 2019.[1]

Affected by the COVID19 pandemic, country's TB case notification has majorly dropped in 2020, however, in 2021, the health system has made efforts to revive its TB surveillance practices and the notification is steadily improving to reach closer to previous rates.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Ukraine adopted the *National Strategy on HIV/AIDS, Tuberculosis and Viral Hepatitis* Response for the period until 2030, aimed at establishing an effective system for TB diagnosis, treatment and prevention, accessible to all people of the country.[2]

Ukraine has adopted the framework of the Concept of Informatization of Health Care of Ukraine for 2013-2018. In accordance with that concept, the Unified Health Information System of Ukraine must be created. Thus, the Management Information System for the Socially Significant Diseases (MIS SSD) is designed to create a unified repository of data on epidemiological surveillance of tuberculosis, HIV, and hepatitis C, medical surveillance, as well as information support for monitoring and evaluation, procurement planning, accounting, and control. movement of medicines and medical products. Currently, the MIS SSD is in the process of realization in the fields.

Ukraine is committed to achieve the targets set out in the WHO Global End TB Strategy.[3] Improving the provision of TB treatment and increasing the treatment success rate is a priority for the NTP. The NTP is committed to ensure access to new TB drugs and novel shorter treatment regimens for successful treatment of individuals with MDR-TB.[2,3] The Government of Ukraine is working towards improving the system of organization and provision of TB care; ensure effective detection of new cases and prevention of progression of existing cases to drug-resistant TB (DR-TB); and improve the quality and effectiveness of TB treatment.[2]

Ukraine has an extensive system of specialized TB services with 5110 hospital beds for TB nationally. Over 90% of TB patients (with both DS-TB and DR-TB) start their treatment in hospitals.[4]

The main challenges of the TB response in Ukraine include insufficient detection of TB late enrollment in treatment, which results in high mortality due to TB, especially among people with DR-TB and TB/HIV coinfection. TB.[5]

In 2010, Ukraine introduced a National electronic register for TB patients – "**eTB Manager**" – that included data on all TB patients registered in the country. The electronic register was funded by USAID and The Global Fund's support, under its Strengthening Pharmaceutical Systems program, implemented by MSH. eTB Manager has enabled better follow-up of patients who transfer between treatment facilities or move from the penitentiary system to public facilities.[6,7]

Ukraine has set digital transformation as a policy priority, marked by recent successes in implementation of the ProZorro and eHealth systems, 4G mobile coverage, and the introduction of eServices in the public and private sectors.[8] As per 2019 figures, internet penetration stands at 67.6% in the country, and about 67% of the population uses smartphones.[9] Use of Digital or electronic health applications to manage tuberculosis can contribute to large-scale implementation of new diagnostics and novel medicines, particularly in resource-constrained settings.

This country digital assessment report aims at providing strategic recommendations and way forward to developing and scaling a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

The Primary tool implemented by the National TB program for TB surveillance is :

- ✓ **eTB Manager** (as of June 2021): It has been deployed at more than 540 TB servicing Units. It was initially introduced in 2010 under USAID and The Global Fund support initiative.

In 2022, Ukraine plans to initiate the piloting of **MIS SSD**, and after the initiation stage, the countrywide scale-up of MIS SSD is planned to replace eTB manager.

Currently, there are two systems of data collection that are working in parallel, the first one is electronic data reporting, and the second is paper-based reporting. Both systems are being used for data cross-check and eliminating possible mistakes in the reporting. Data accuracy and completeness in being checked on a routine basis at the regional and national levels.

The current version of eTB manager is used for both DR-TB and DS-TB notification, monitoring and treatment outcome, & has 3 sections- Laboratory, Pharmaceutical management and Patient cases. Users of the system can have administrative or data reporting roles.

The current system also generates quarterly and other reports in real time, which are being accessed and used by district, oblast, and national program managers.

Ukraine is in the process of transition to MIS and the TB component will be added as a dedicated module in it. Data from eTB Manager is also being transferred to the new system, and upon full operationalization, MIS SSD will be linked with the national health insurance system (NHSU), through the E-Health Platform.

SUCCESS STORIES

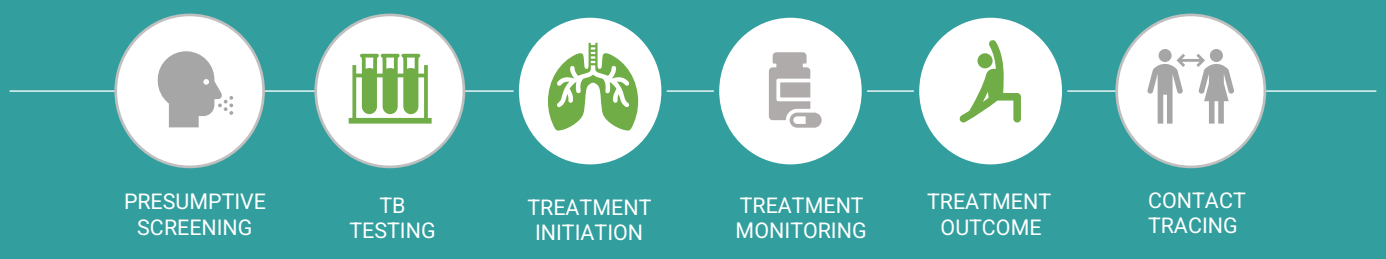
A key success of the digital health system implementation in Ukraine is the creation of a single-source repository data on TB, HIV, Hep C, under MIS SSD. This system complies with the national legislations on security and date protection, and also aims to eliminate paper reporting and reduce the workload for the staff in the fields.

OneImpact community-led monitoring (CLM) empowers people affected by TB to access health and support services, claim their human rights, and identify and reduce stigma. The NTP in its NSP (2021) mentions its importance and the change brought by the platform in mobilizing the communities. NTP is considering to integrate the application with the e-TB manager system

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				eTB manager Dashboard
Oblast level	24 (2 special cities)	Data not collected from this level			eTB manager Dashboard
Raion level	140	140	eTB manager	Case Based	eTB manager Dashboard
Facility Level	530+ (TB servicing Unit)	530 (2000 Users)	eTB manager Paper Based	Case Based	eTB manager Dashboard Excel
Community level	Data not collected from this level				

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	✓
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	
Type of health facility (Public, Private etc.)	
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASE TB SURVEILLANCE

Electronic system for case based TB Notification	eTB manager
Lowest Unit for TB notification digitisation	TB servicing units
Stage of notification	Treatment Initiation
Level of Access and Use of TB Notification data	District/ Region level
Private sector notification	Manual notification. Accounts to nearly 1% of the total reporting
Frequency of digitization of TB notification	Real time
Mode of follow-up with notified cases	Phone calls, Household visits
Scale of implementation	National Roll-out
Contact tracing for TB notified cases	None
Channel enablement	eTB web application
Govt. order for mandatory TB notification	None

PRIVATE SECTOR NOTIFICATION

Majority of the TB case notifications are provided by state TB physicians from the state hospitals. The proportion of state notifications amounts to 99%, and the remaining 1% of TB notifications are provided by the private sector.

COUNTRY IT CAPACITY

Country Server
National TB program uses a cloud based server to support the data storage and use.

Interoperability
Necessary APIs available, Data export available

Country IT team
In-house country IT team

ENABLING ENVIRONMENT

139.4%
Mobile penetration (Jan 2021)[9]

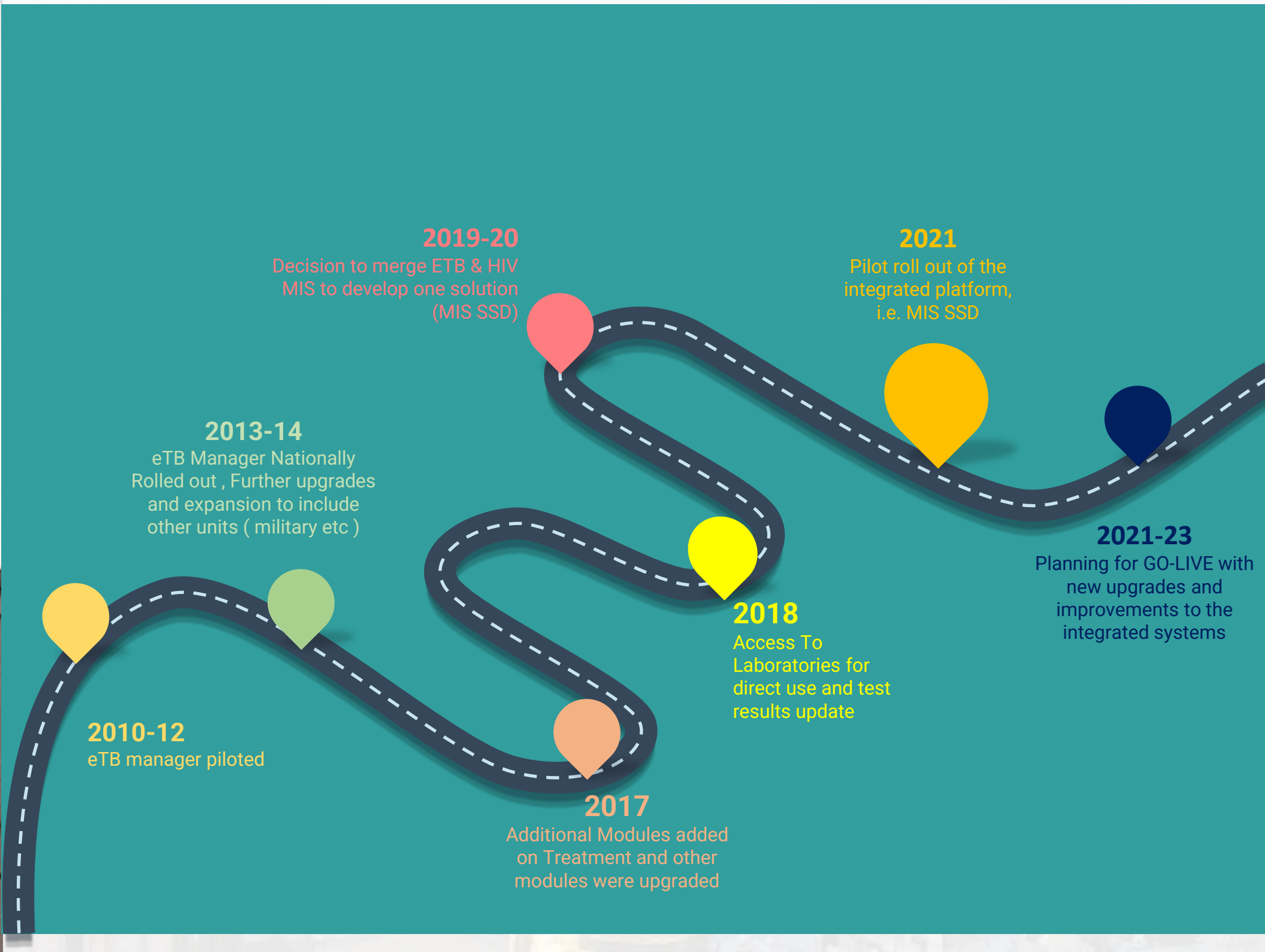
67%
Smartphone (2019) [9]

67.6%
Internet penetration (Jan 2021) [9]

CURRENT RESOURCES AVAILABLE

- Ukraine has received USD 35.8 million grant funds from the Global Fund to fight AIDS, Tuberculosis and Malaria.
- Ukraine was awarded five-year USAID-funded the STCEU project designed to decrease the TB burden in Ukraine.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	VDOT EvriMED pillbox	Mobile app Tabletop dispenser	Sure Adhere Wisepill	Stop TB partnership	Pilot
Logistic Management	HIV MIS	eTB manager	MSH	USAID	Under development
	Quan TB	Web Application	SIAPS	USAID	Limited use
Laboratory Information System	LMIS	eTB manager	MSH	USAID	Under Development
Community led Monitoring	OneImpact	Mobile app	Dure Technologies	Stop TB	Pilot (under consideration to be integrated)
Contact Tracing	Nil				

KEY CHALLENGES

- **Unified system:** Fragmentation of systems for different diseases has resulted in a proliferation of multiple parallel systems, which is now being unified in the MIS SSD system, which further needs interlinkage with other digital health systems.
- **Data duplication:** due to usage of multiple parallel system (eTB manager and paper based) data is often duplicated which results in hampering the data quality
- **Insufficient internet** coverage results in delayed data entry and reporting.
- **Lack of Technical support and capacity: A**t peripheral sites, regular training, data security and protection of data is limited, that results in loss of data.
- **Funding and Financial requirements:** NTP is exploring fundings for improving the MIS SSD system, internet connectivity and transitioning to updated WHO case definitions (2020-21).

NTP VISION

- NTP plans to pilot MISS SSD TB Module in 2022 and scale it up to the national level. This would allow moving from the old E TB Manager to a new system and having single data source repositories.
- Improving decision making based on timely data analysis, operation research, and training and capacity building.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Ukraine has 540 TB services units and to provision mobile device for every facility for case-based TB surveillance, **USD 81,000** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Ukraine has 140 districts and 24 Oblasts, and Kyiv and Odessa as special cities. To promote active data use, each district and region should be given a tablet which would cost roughly around **USD 33,200** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 211,800** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Ukraine would need an investment of **USD 30,000-40,000** for next 3 years for server hosting support and maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Ukraine already have a strong foundation for e-TB Manager system for TB, around **USD 250,000-400,000** should be budgeted to support the customization support for the comprehensive TB surveillance system in MIS SSD and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 288,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 140 districts, which could cost roughly USD 100 per district, amounting to **USD 14,000,** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 1– 1.5 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Ukraine .

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

"The paradigm shift towards digitalization of healthcare in Ukraine allows the national tuberculosis program to become more proactive and respond quickly to new challenges. By strengthening digital systems, the country increases the capacity of national programme, modernizes staff education, and strengthens surveillance. All of these are integral components in achieving the national goal of ending tuberculosis."

Dr. Yana Terleieva
NTP Manager, Public Health Center
Ministry of Health, Ukraine

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

❖ **Strategic Costed Plan**: As a first step it is important for the country to create a comprehensive budget plan for scale up and development of new module for the TB case-based surveillance system.

Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

Tentative timeline: Month 0-1

❖ **Device Procurement:** One of the limitations highlighted by NTP is the need to improve the data collection processes for direct data entry from the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

Tentative timeline: Month 0-3

❖ **Enhancement of Case Based Notification systems:** The NSP highlights the importance of strengthening the TB Notification information system for improving all the TB service provisions [2]

Ukraine has already developed and deployed a Case Based TB notification e-TB manager in its about 540 TB service units. The presence of the system lays a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

It is recommended to scale-up the new MIS SSD system and its extension to support integration with external systems like Gene Xperts, Digital X-Ray outputs, current National Health management systems and MATS app as visioned by the national TB program with the concept of an integrated Health Information Management System (HMIS). As per the NTP team, it is planned to start the pilot on TB module of MIS SSD in 2022 in two regions of Ukraine. After the initial stage, the countrywide scale-up of TB component of SSD MIS is expected.

These data exchanges can be made seamless with API sharing between the platforms and the central repository.

Recommended data exchange/ ETL tools like Talend, Informatica[10] makes data management task much easier and simultaneously improves data warehousing. These exchange tools also comply with FHIR , GDPR standards for more secured and seamless data exchange supporting standard data taxonomy and meta data management processes.

Tentative timeline: Month 0-6

❖ **Data Use:** The NSP emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

Building on the current e-TB manager that offers a dashboard and linelist for reviewing of Program and data indicators, additional features of pivot table, event reports which support dimensions, data aggregation reports and individual line lists are extremely useful.

To strengthen and expand the data visualisation scope and making effective use of data for predictive modelling, data science and for advanced analytics, it is recommended to use best of the breed tools like Tableau , Power BI which offer these features. APIs can be generated and connected with these applications, and these can be used as an extended analytical component of the data analysis framework. [11]

Tentative timeline: Month 6-12

❖ **Mobile app:** Implementation of data collection via mobile app to ensure ease of use and real time reporting:

One of the challenges reported by the NTP during the data collection processes is inconsistent data connectivity/network issues which delay reporting of cases, and inconsistent availability of hardware for data entry. One effective way to overcome this is to support the current data collection processes by introducing a mobile application for government facilities as well.

RECOMMENDATIONS

Other advantages for a mobile application include better performance , effective use of device features like in house system updates , usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

Several mobile solutions for real time case-based notifications can be explored for local adaption. Open-source technologies like DHIS2, Mobile App, ODK and KOBO are some notable examples. [12]

Tentative timeline: Month 0-12

❖ **Capacity building for application maintenance**

Planning for capacity building includes workforce assessment, ranging from ICT professionals to health care workers. Since the application requires regular updates and adaptations, the system support team requires trained personnel on the technology stack in use.

Strengthening the NTP team with trained administrators will help in reducing costs (in seeking technical support) and improving and expediting the planned implementations.

Tentative timeline: Month 6-24

❖ **eLearning:** Packages to train health professionals on SSD MIS TB module's use and workflows

Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the SSD MIS TB module but also on the latest manual of procedure and continued medical education on TB care.

To address the challenges with periodic training of facility level staff to orient them on using the MIS SSD TB module for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training. Training tools like Moodle [13] built on standard LMS framework can be reviewed for application rollouts.

Additionally, for training and updates on the latest manual of procedure and continued medical education on TB care, modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, especially for the case-based tracker roll out within the existing applications.

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staff involved in TB care.

Tentative timeline: Month 0-12

❖ **Patient Interactive Systems:** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

Auto generation of notification and messaging by the system through communication channels like Social Media channel, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [14]

Tentative timeline: Month 0-12

❖ **Contact tracing Module:** Contacts of TB patients are at the greater risk of obtaining either TB infection or TB disease, depending on factors such as type of contact infectiousness of source case and environmental characteristics. In addition, host-related factors (age and immunology) additionally intervene with the likelihood of the patient getting to be infected or ill.

For this, the recommendation is to build additional modules for Contact Tracing, Presumptive Screening and TPT by leveraging the MIS SSD system and expanding its workflow.

Tentative timeline: Month 0-12

❖ **Unique Identifiers:** Duplication of data due to multiple systems are used for data entering. This results in missing out some of crucial and patients are often not followed-up or tracked.

It is recommended while capturing the information of the TB cases they should be linked with unique identifiers like national Id, to ensure that duplication of the patient is avoided and case is tracked, monitored and followed up throughout its treatment journey.

Tentative timeline: Month 0-1

RECOMMENDATIONS

- **Bi-directional notification from other National health information systems:** Integration of the existing platform with other national health information systems like on COVID, HIV will help in increasing the TB coverage. This will help in linking TB cases for co-infection analysis, improve case finding from other sources (GeneXpert), provide access to more detailed information etc.

  Tentative timeline: Month 3-6

- **Integration of CLM tools:** Putting people at the heart of the TB response is critical to ending TB. Every year millions of people affected by TB are missed by health systems because of barriers to health services, human rights violations, TB stigma and barriers to support services.

  Community-led monitoring (CLM) can supplement national TB data by collecting information on these challenges that would otherwise be excluded, producing shadow reports that hold governments accountable, and building evidence to inform civil society and community advocacy for improved care and services.

  It is recommended to integrate CLM tools like OneImpact and other platforms for HIV, COVID and other diseases with e-TB manager.

  Tentative timeline: Month 12-18

RECOMMENDATIONS

Strategic Technical Recommendations

❖ Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

Additionally, advance admin features can help the administrators to support the operational needs better for onboarding users, real time change in data variables and user management etc effectively.

✓ **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is essential to have system(s) and application testing done to enable full proof platform and which also helps in architecture updates and augmentation.

Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in database sizing and planning need to be adapted for effective planning [15]

✓ **Application & System Security Audit**

To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[16] to cover

- Patient Data Management
- Server & Infra guidelines

Apart from application measures for patient data security, hosting solutions offered from Azure, also cover these as part of their deployment options which can be considered as part of systems hosting.[17]

ACKNOWLEDGMENT

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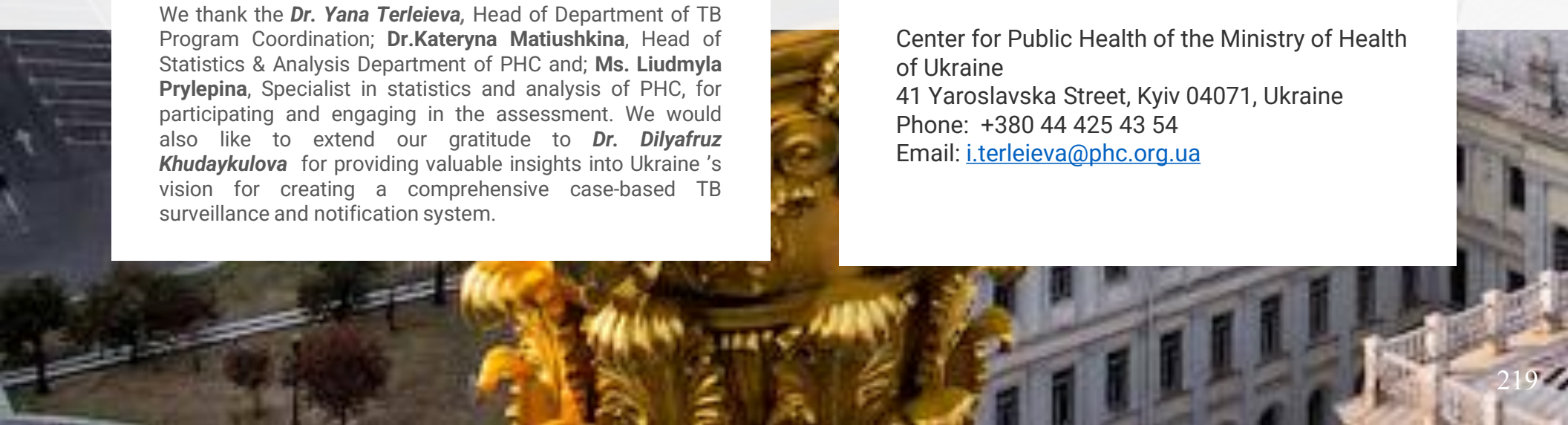

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12. Open Source Mobile Applications (DHIS2 Mobile App : https://dhis2.org/android KOBO: https://www.kobotoolbox.org/ ODK https://opendatakit.org/)

13. Application Training Tool : https://moodle.org/

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UNITED REPUBLIC OF TANZANIA

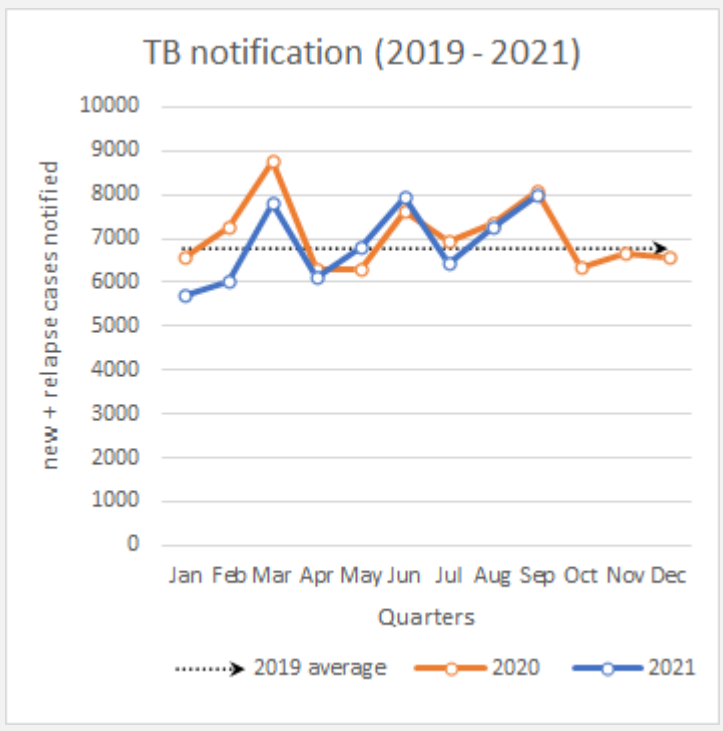
UNITED REPUBLIC OF TANZANIA

BACKGROUND

According to WHO estimates, 133,000 people newly developed TB in Tanzania in 2020, of which 85,597 cases got notified (Global TB report, 2021) [1]. With nearly 28,000 of all people with TB also infected with HIV, Tanzania is included in the list for the top 30 TB/HIV high burden countries. [2] Children account for nearly 16% of all cases, and many also suffer from TB-HIV coinfection. [1]

Tanzania has achieved a treatment coverage of 64% of all people living with TB in 2020 and the TB case fatality ratio stands at 22%. 62% of the children (aged <5 years) that are household contacts of bacteriologically-confirmed TB cases have also been put on preventive treatment. [1]

In 2020, the COVID19 pandemic has impacted the TB case notification in Tanzania, however, with NTP's efforts, it has steadily improved through 2021 to reach above the 2019 average figures of monthly notification.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Tanzania's National Strategic Plan (NSP) VI (2020-2025) describes the country's strategy to achieve the Sustainable Development Goals (SDGs) by 2030 and WHO's End TB Strategy targets by 2035. To capitalize on success and achievements from the previous NSP, the new NSP VI continues to prioritize areas such as - Expanding access to quality TB diagnostic services including the adoption of new, innovative technologies; Eliminating TB case finding gaps particularly among vulnerable populations; Increasing treatment coverage by effectively addressing barriers to access and utilization of services; Increasing the detection and treatment coverage of DR-TB and MDR-TB; and, Continuing to strengthen collaborative TB/HIV activities, management of comorbidities, and TB infection prevention for high-risk populations. [3]

Tanzania uses **DHIS2 Tracker** as the tool for TB notification, called the electronic TB and Leprosy (ETL) platform and currently, all the data is captured in case-based record form. The current DHIS2 system has been developed (and maintained) with support from The Global Fund from 2017-18 and the platform operationalization and M&E is funded by USAID. Data for both DR and DS TB is entered, and 3 tracker programs are used for TB reporting – TB register, MDR TB register, and Culture & DST register.

Additionally, to complement the existing national HMIS data systems, the TB Data from DHIS2 is available with other program indicators in the DHIS2 National Data Warehouse, enabling comprehensive data review and analysis of TB data nationally.

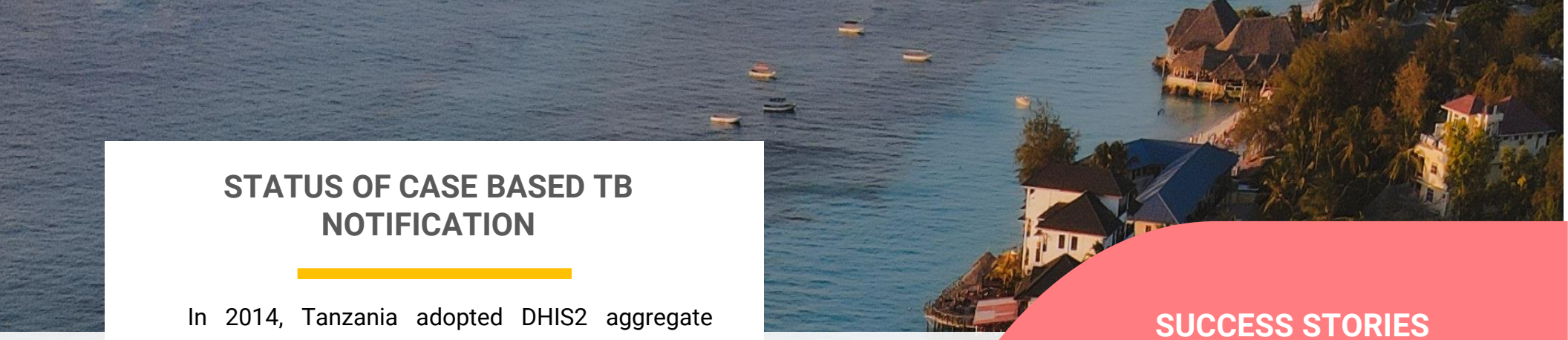
It is empirical that technology penetration plays a vital role in enabling the evolution of information systems from paper to digital solutions. As per 2021 figures, about 82.7% of the population has a cell phone, and nearly 59.6% use smartphones. Internet penetration stands at 25% in the country. Enhancing digital inclusion in Tanzania is essential, given that access to reliable and affordable connectivity is a foundational step in maximizing the impact of deploying digital technologies on the government's development aspirations. [4]

Apart from implementing the DHIS2 platform, the country is also leveraging other digital innovations for better data collection and data use for positive programmatic outcome as given below:

Tambua TB is a self screening USSD application (using a quick code or Toll-free number), that aids in general TB education for the clients, self-screening and patient follow-up. It has been integrated into DHIS2 ETL in 2019. [5]

99DOTS is a SMS communication system for treatment and follow-up of both Susceptible and MDR-TB patients in the mining areas. [5]

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report is an attempt to describe the current capacity and identified gaps/ challenges in the digital ecosystem of TB surveillance. The report shares strategic recommendations for developing a comprehensive case-based surveillance system in the country while leveraging the existing infrastructure, in-house capacity, and assets.



STATUS OF CASE BASED TB NOTIFICATION

In 2014, Tanzania adopted DHIS2 aggregate platform as the national system for reporting of TB notification data, which was later transitioned in 2018 to the use of DHIS2 tracker system, called DHIS2 ETL (electronic TB and Leprosy platform). This system was developed with support from USAID and The Global Fund, and the technical support for changes and customizations is offered by the USDM (University of Dar es Salaam) and HISP Tanzania (country affiliate of the University of Oslo). Manual registers are maintained at the health facilities for capturing all TB specific data and the data for patients diagnosed positive is then entered from the facility in the DHIS2 tracker on a monthly to quarterly frequency. For some facilities that do not have the hardware and infrastructure to perform data entry, all the data is compiled and shared with the district, where case-based data is entered to DHIS2 tracker for these facilities.

This system also has an integrated dashboard that was incorporated in 2019 and is accessible from all user of the system, filtering data as per the user's authority and level of access.

SUCCESS STORIES

Tanzania is one of the pioneer countries to adapt and implement WHO's standard DHIS2 TB surveillance tracker template, in their national DHIS2 ETL system in 2014, and it is now successfully receiving case-based data from all districts across the country.

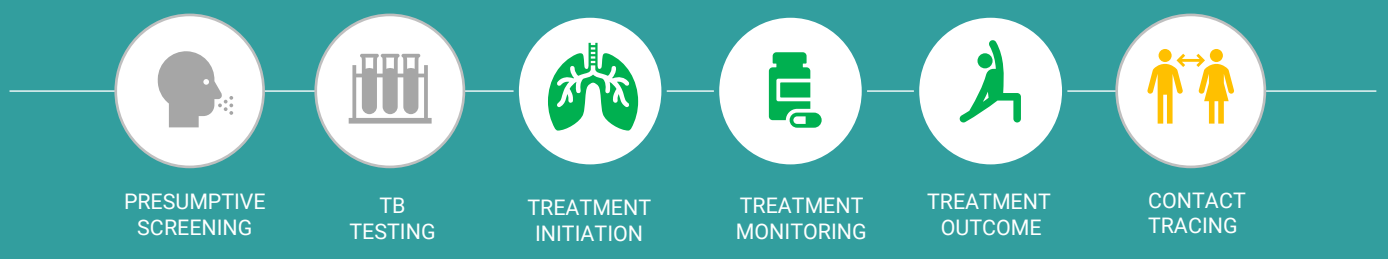
NTP's collaboration with the University of Dar-es-Salaam is a unique example of using local resources to ensure sustainability of the implemented solutions, and same has allowed the system to grow each year, and this partnership has been recognized at various platforms as a best practice use case.

Tanzania is also implementing a pilot project of digital technology use for supporting patients with treatment from a distance to allow more flexibility in TB care delivery (Unitaid-funded ASCENT project). The pilot aims to test the implementation of 3 digital technologies: Smart Pill boxes, Video supported treatment and Medication labels/sleeves. This approach helps the health workers to have a direct access to patient's treatment data in real time and ensures a more robust adherence to the regimen advised.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected at this level				DHIS2 Dashboard
Regional level	31	Data not collected at this level			DHIS2 Dashboard
District Level	184	184	DHIS2 Tracker	Case Based	DHIS2 Dashboard
Facility level	3500	500 - Direct data entry to DHIS2 3000 – Paper records sent to district	DHIS2 Tracker, Manual registers	Case Based	DHIS2 Dashboard
Community level	Data not collected at this level				No data usage at this level

CASCADE OF CARE MONITORING



Digital (Aggregated) Digital (Case Based) Manual

KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	✓
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASED TB SURVEILLANCE

Electronic system for case based TB Notification	DHIS2 ETL (Tracker)
Lowest Unit for TB notification digitisation	Facility level
Stage of notification	Diagnosis (confirmed cases)
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Private health facilities also have access and reports cases in DHIS2 ETL platform
Frequency of digitization of TB notification	Monthly to Quarterly
Mode of follow-up with notified cases	Physical visits and Phone calls by Community Health Workers
Scale of implementation	National level
Contact tracing for TB notified cases	Yes (Aggregate data)
Multi - channel enablement	Only web based reporting
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Private sector reports case based records of all TB patients on treatment, directly in the DHIS2 ETL application. Out of the total TB notification in the country, nearly 19% is contributed by the private service providers.

COUNTRY IT CAPACITY

Country Server
The application is hosted centrally by the HMIS division of Ministry of Health (MoHCDGC)

Interoperability
Data export and APIs are available for integration of the DHIS2 ETL platform with other systems.

Country IT team
NTP has a shared ownership of DHIS2 ETL platform with MoH, and takes technical support from University of Dar-es-Salaam.

ENABLING ENVIRONMENT

82.7%
Mobile penetration (Jan 2021) [4]

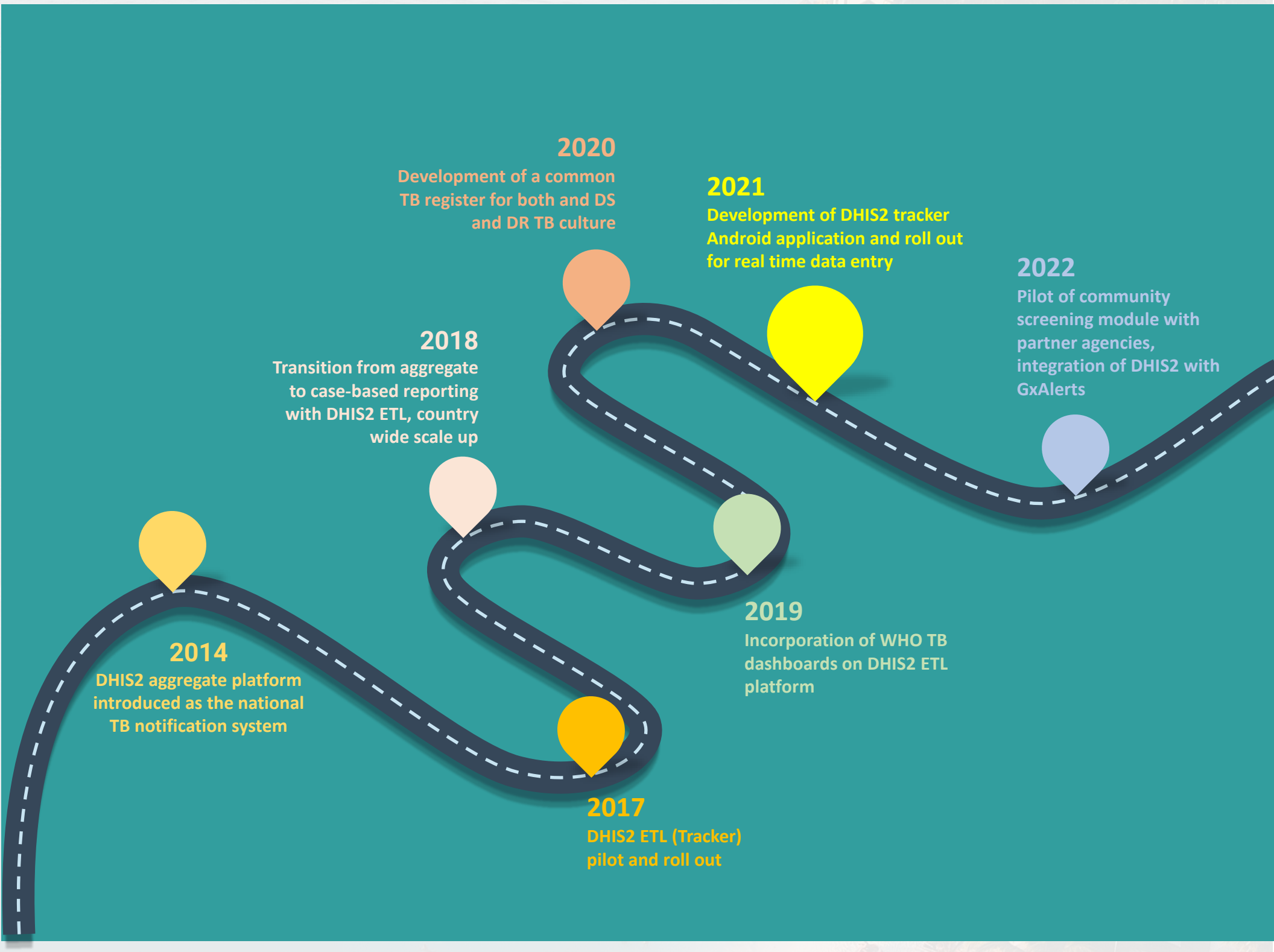
59.6%
Smartphone (2018) [4]

25%
Internet penetration (Jan 2021) [4]

CURRENT RESOURCES AVAILABLE

- The Global Fund has an active TB grant of USD 42 million for Tanzania till December 2023, with the principal recipient being Ministry of finance and Planning, where nearly USD 8.2 million has been disbursed.
- Funding of USD 350,000 is available for extending the current application to mobile version; incorporating the entire cascade of care; strengthening private sector notification; contact tracing and community led monitoring.
- Another 6 million is present with the country for system implementation and M&E support.
- Funds of nearly USD 200,000 are also available to bear the ongoing recurring costs like hosting, maintenance support and project management.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Everwell Hub (99 DOTS), Tambua TB	SMS and Web application	Everwell	KNVC, USAID	Tambua TB – National Everwell - Pilot
Logistics Management Tool	eLMIS	Web Application	Global Health Supply Project	USAID	National
Laboratory Information Management	GxAlert	Web Application	Cepheid	USAID	259 GeneXpert diagnostic sites
Community Led Monitoring (CLM)	OneImpact	Mobile App	Stop TB Partnership	USAID	Pilot
Contact Tracing	Nil	NA	NA	NA	NA

KEY CHALLENGES

- The staff designated at the data entry points is inadequately trained in using DHIS2 tracker and this raises concerns for the reliability of data that is entered.
- With the electricity and internet conditions being very unreliable, real-time case-based data entry remains to be a challenge.
- In the current setting, data outputs at the facility level have a limited usage and measures to keep a check on data quality are also not well realized, which primarily prevails due to an insufficient data analysis and data use skill at this level
- Availability of desktops and laptops for data entry is also inadequate for direct data reporting from facilities, and as a result of this, some facilities rely on data entry from districts, and it adds to delays and quality issues.
- With the connectivity issues, the facilities sometimes have a complete dependency is on generation of data exports for usage in decision making, which gets challenging.
- The system is presently not integrated with the auxiliary systems like Hospital EMRs, GeneXpert and Community monitoring tools, which raises the data entry workload on the staff.

NTP VISION

- Transitioning to real-time case-based data entry from all facilities.
- Incorporating the entire cascade of TB care, and modules for contact tracing and community led monitoring.
- Development and implementation of an android app with offline capability to support data entry.
- Improvement in data quality (accuracy, validity and precision) and reducing duplicates.
- Advanced dashboards for access to more granular data at all administrative levels, integration of GIS features in the application and capacity building for improving data use.
- Integration with Community Led Monitoring (CLM) initiatives and National EMR system of HMIS.
- Direct integration of DHIS2 with Lab information systems, including GeneXpert machines.

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for fulfilling country's vision, we have put together an estimated investment requirement and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Tanzania has 3500 TB facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 525,000** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Tanzania has 184 districts and 31 regions. To promote active data use, each district should be given a tablet which would cost roughly around **USD 43,000** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 1,114,500** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Tanzania would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Tanzania already have a strong foundation of DHIS2 case-based reporting nationally, around **USD 700,000-800,000** should be budgeted for comprehensive TB surveillance system development and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. A 1-day training should be planned for each of the 184 districts, which could cost roughly USD 100 per training amounting to **USD 18,400.** Also, a dedicated trainer should be budgeted in case there is none. E-training options with necessary modules also need to be considered.

TOTAL investment of around **USD 2.5 – 3 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Tanzania

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations suggested based on the findings of this assessment of country's digital ecosystem and infrastructure:

- **Strategic Costing Plan :**As a first step it is important for the country to create a comprehensive costed action plan for development, implementation and scale up of the TB case based surveillance system.

  Based on NTPs vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan with timelines. The plan will help the country to assess and monitor the progress and to mitigate risks

  Tentative timeline: Month 0-1

- **Implementation and scale of Case Based Notification systems** : The NTP has already established a strong DHIS2 tracker environment which has the core infrastructure in terms of database and deployment environment. Also, it has built the DHIS2 expertise and capacity which acts as a strong foundation for executing the vision of implementing a comprehensive and integrated real-time case-based TB surveillance and notification system.

  It is recommended that this existing capacity is leveraged for expanding the DHIS2 tracker app. While the current tracker development has been planned to cover treatment initiation data capturing from all facilities on a monthly to quarterly frequency, the system should be expanded to capture the entire continuum of care for both DR and DS TB, including presumptive screening, referral, treatment initiation, treatment adherence & outcome, and contact tracing in real-time.

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Some of the existing templates already built on DHIS2 tracker systems currently being used by other countries such as WHO's prevent TB tool or other DHIS2 tracker-based systems can be explored for fast-tracking the software development processes [6]

  Tentative timeline: Month 0-12

- **Mobile App** : One of the challenges reported by the NTP is the infrastructure inadequacy and lack of availability of real time data for stakeholders. One effective way to overcome this is to support the current data collection processes by introducing a mobile application, which is in line with the country's efforts of improving the overall digital ecosystem.

  As a recommendation, the latest DHIS2 mobile app version which has additional features on data collection, security ,offline data collection, encryption ,version management etc should be extended for use even for aggregate data reporting, specially from facilities with limited IT infrastructure should be reviewed.

  This would also ensure that the data structures are consistent. Also, the app is supported with a configurable set up to support any updates / changes to the program.

  Additionally, the DHIS2 mobile framework uses open-source technologies like Java, Postgres, React and Android, which can be easily supported by country IT teams. It also follows the standard best practices of mobile development like version management , data encryption etc which make this a more robust solution. [7]

  Tentative timeline: Month 6-12

- **System Integration**: One of the challenges highlighted by NTP is leveraging the data collected from multiple sources into the main DHIS2 systems as a central system for effective use.

  The current DHIS2 platform and infrastructure needs to be extended to support integration with external systems like GenXpert, TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in using the data effectively for the patient continuum of care as highlighted by the National program.

  Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and

RECOMMENDATIONS

simultaneously improve data warehousing should be evaluated. [8]

The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [9]

The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

Tentative timeline: Month 12-18

❖ **Data Use** :

The NSP clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data and patient line listing available at the lowest level health functionary involved in TB care.

Building on the current DHIS2 visualization module which offers a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table, event reports which support dimensions, data aggregation reports and individual line lists and with timeline views are extremely useful.

Once a robust data analytics and data use model has been established with the current DHIS2 and other systems, then a more advanced analytical dashboard should be designed linked to the new case-based TB surveillance system that is already being planned.

To achieve this , apart from the standard DHIS2 dashboard features and to strengthen and expand the data visualisation scope, making effective use of data for predictive modelling & data science, and for advanced analytics, it is also recommended to use best of the breed tools like Tableau , Power BI which offer these features. The current DHIS2 platform offers

APIs which can be connected for these applications and be used as an extended analytical component of the data analysis framework. [10]

Tentative timeline: Month 6-18

❖ **Capacity building for application maintenance:** One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up, the system support team requires trained personnel on DHIS2.

Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

Tentative timeline: Month 0-6

❖ **Additional data capturing mechanisms** : With the new tracker-based system being introduced, making sure that paper-based patient data is integrated with the DHIS2 tracker systems is crucial. Technical solutions like OCR (optical character recognition) should be considered.

The DHIS2 platform supports reading from these structures. This would help in data upload of all historical data with less difficulties.

Tentative timeline: Month 6-12

❖ **E-Learning** :

To address the challenges with periodic training of facility level staff to orient them on using DHIS2 for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

While DHIS2 offers standard training modules on the application , training tools like Moodle [11] built on standard Learning Management System (LMS) framework can be reviewed for application rollouts.

Additionally, for training and updates on the latest manual of procedure and continued medical education, TB care modules can be developed for Health providers & administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, specially for using the case-based tracker system and other existing applications.

RECOMMENDATIONS

Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 0-3

❖ **Patient Interactive Systems:**

Establishing a direct and secured mechanism for engaging with patient has a potential for drastic improvements by tracking the patients lost to follow-up. Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [12]
Tentative timeline: Month 12-24

❖ **Data Quality** :

As part of the standard practice, the application(s) / solutions should follow a set of standard data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data credibility and use.

UIC Code : Having a centralized Unique Patient ID system or leveraging existing national ID supported with an improved search functionality can help drastically reduce the duplication of case-based records.

This should be generated automatically through the case-based TB surveillance system.

Data access control is another such DQA measure that will regulate user's access to only relevant metadata. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

Tentative timeline: Month 6-18

❖ **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to real-time case-based notification.

Tentative timeline: Month 0-6

❖ **Community Monitoring Systems** : As expressed by the NTP, the national TB notification and surveillance system should explore ready-to-use open source CLM and Self reporting platforms like One Impact

Tentative timeline: Month 6-12

❖ **Contact tracing application implementation :**

To strengthen the TB surveillance efforts of the country and for reaching out to all TB positive individuals, an active focus on contact tracing becomes crucial. The standard guidelines for household screening can be incorporated as a module in the national TB notification tool and be implemented to fast track the country's efforts to eliminate TB and target the initiation of preventive treatment for all TB contacts.

Tentative timeline: Month 6-12

Strategic Technical Recommendations:

Application Upgrades including Server Augmentation & Infrastructure Upgrades : To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would cover the technical and operational objectives.

The strategy recommended would cover the following core areas

✓ **Technical Upgrades**: Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national / external systems. The technologies that need to be brought in and the areas of inter-connection need special focus.

RECOMMENDATIONS

Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management, encryption and exchange standards.

Apart from this, version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practises.[13]

- ✓ **Performance Optimisation & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable a reliable platform and which also helps in architecture updates and augmentation.

  While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium also can be considered. Load Testing tools which help in data base sizing and planning need to be adapted for effective planning. [14]

- ✓ **Application & System Security Audit:**

  To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

  These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA [15] to cover

  - Patient Data Management
  - Server & Infra guidelines

  Apart from application measures offered by DHIS2 [14] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [16]

ACKNOWLEDGMENT

We thank the National TB and Leprosy Program Manager, ***Dr. Liberate Mleoh*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Dr. Emmanuel Matechi*** *and* ***Mr. Immanuel Nkiligi*** for providing valuable insights into Tanzania's vision for creating an advanced case-based TB surveillance and notification system.

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6. DHIS2 Meta Data Tools : https://dhis2.org/metadata-package-downloads/#tb
7. DHIS2 Mobile App : https://dhis2.org/android/
8. System Integration Tools (Talend , Informatica) : https://www.talend.com/index.php , https://www.informatica.com/
9. DHIS 2 API & DHIS2 Data Transformation Services : https://docs.dhis2.org/en/develop/using-the-api/dhis-core-version-235/web-api.html , https://docs.dhis2.org/en/use/user-guides/dhis-core-version-236/maintaining-the-system/importexport-app.html
10. DHIS2 Power BI : https://community.dhis2.org/t/dhis2-to-powerbi-connector-is-ready-check-out-the-video-test-it-use-it-and-give-us-feedback/37043
11. Application Training Tool : https://moodle.org/
12. OPEN MRS : https://openmrs.org/
13. Features of DHIS 2.34 : https://dhis2.org/overview/version-234/
14. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/
15. HIPAA Compliance Framework : https://www.hhs.gov/hipaa/for-professionals/security/laws-regulations/index.html , https://www.hipaajournal.com/considered-phi-hipaa/
16. Azure Hosting Services : https://docs.microsoft.com/en-us/azure/compliance/offerings/offering-hipaa-us

VIET NAM

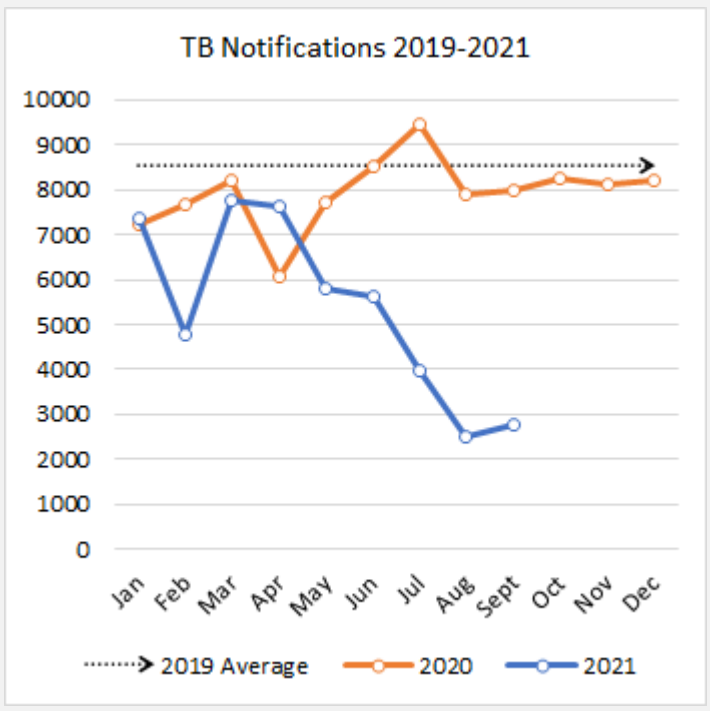
VIET NAM

BACKGROUND

Tuberculosis (TB) remains a significant cause of morbidity and mortality in Viet Nam, and it is included in the list of top 30 high TB burden countries in the world, and has a TB incidence of nearly 176 per 100, 000 individuals annually [1]. In 2020, Vietnam was one of the 10 countries accounted for about 70% of the global gap between the estimated global incidence of MDR/RR-TB each year and the number of people enrolled in treatment. [2]

As per the 2020 estimates, out of the 172,000 people with TB in Viet Nam, 101,705 got notified. With nearly 3,714 of people getting confirmed for MDR/RR-TB and another 340 confirmed cases of XDR-TB, Viet Nam is also included in the list for the top 30 DR-TB high burden countries. [1,2]

During the COVID19 pandemic, country's TB case notification has remained broadly unimpacted in 2020, however, with the first wave hitting in later part of 2021, the TB case notification has been heavily impacted and the health system is now making efforts to revive its strong TB surveillance practices and reach back to the previous rates.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

Vietnam has approximately 90 million inhabitants in 63 provinces, 700 districts and 11145 communes.[4] Regarding the TB and MDR-TB epidemiology in Vietnam, the country is among high burden countries with MDR TB.[5]

In Vietnam, TB surveillance is done through a web-based system that was implemented since 2009 and used by TB staff nationwide from district to national level since 2015.[1]

The Vietnam TB Information Management Electronic System (VITIMES) is a system designed to collect patient-based data on patients screened and notified and their treatment outcomes[2] VITIMES was introduced in two phases: Phase I at the provincial level with aggregated data being entered from quarterly paper reports from the districts and Phase II at the district level where individual patient information is entered. Phase I was implemented by all 63 provinces in 2010; Phase II coverage was implemented nationwide by 2015.[2]

In 2011, the Vietnam NTP introduced e-TB Manager for MDR-TB surveillance.[7] The largest TB hospital in Ho Chi Minh City was engaged in its roll-out. This was developed by MSH with support from USAID and WHO. The system was stabilized in 2014. The NTP has also developed a pharmacovigilance component with e-TB Manager to monitor adverse events in patients with bedaquiline-containing treatment regimens. The Clinton Health Access Initiative supported the NTP to link an SMS alert system with e-TB Manager for PLHIV suspected of having DR-TB

Vietnam's National Strategic Plan (NSP) 2021-2025 aims to decrease TB transmission by finding and treating all TB cases.

The ministry of Health (MOH) Vietnam and the NTP is prioritizing patient-centered care, bold policies, expanding partnerships, and strengthening health systems, as well as investing in key innovations and research, through the new NSP 2021-2025 which is aligned with the National Action Plan to End TB by 2030. [3]

This assessment report aims at providing strategic recommendations and way forward to country leadership in developing and scaling a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

There are two primary tools implemented by the National TB program for TB surveillance :

- ✓ **VITIMES:** a web-based system designed to collect patient-based data on patients screened for TB, notified TB cases and the treatment outcomes of TB patients.

It was implemented in two phases, in phase I VITIMES was implemented at the provincial level with aggregated data being entered from quarterly district paper reports. In Phase II, VITIMES was implemented at the district level where individual patient information was collected. By 2015, the system was implemented in all 63 provinces and over 90% of the 701 districts.

- ✓ **e-TB Manager:** to capture MDR-TB patient data e-TB manager was introduced in 2011. with multiple iterations and contextualization, it was stabilized in 2015 in alignment with government policies.

e-TB manager is available at all current PMDT treatment centers and treatment satellites, a total of 41 by the end of 2014.

The NTP is working towards integrating VITIMES and e-TB manager into a single comprehensive system.

The current systems generates quarterly reports which are being accessed used at district, State and national program managers.

SUCCESS STORIES

In 2015, a m-health module was introduced and piloted for “Monitoring and treatment support” of TB patients.

Through this module, NTP has been able to send out medication reminders to TB patients through SMS for taking drug on time, follow-up exam on-time, and provide knowledge about TB etc.

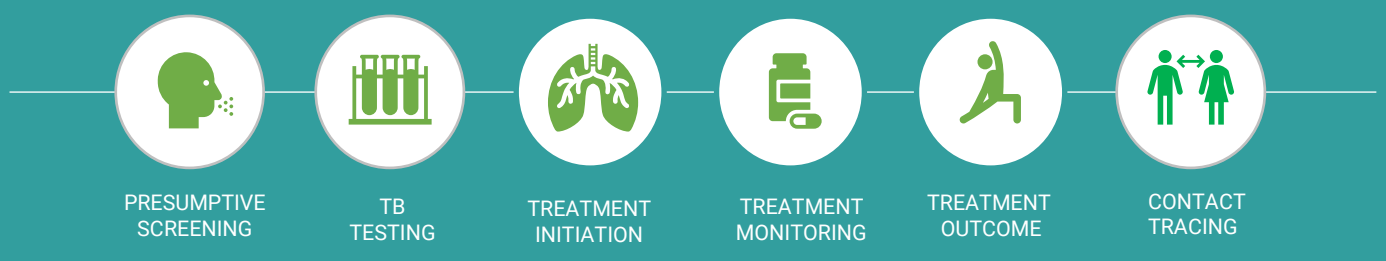
Further this module support monitoring of cases at commune level. TB specialist at commune level will input monitoring report while/ after visiting TB patient's household.

The module is under discussions for scale-up. It is tied up with VITIMES. NTP is currently supporting 3G fee for commune staff and is exploring funds for scale-up.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				Real-time VITIMES and e-TB Dashboard
Provincial level	63	63	VITIMES/e-TB Manager	Case Based	Real-time VITIMES and e-TB Dashboard
District level	713	713	VITIMES/e-TB Manager	Case Based	Real-time VITIMES and e-TB Dashboard
Facility Level	30 DR-TB Centres	30 DR-TB Centres	VITIMES/e-TB Manager	Case Based	Real-time VITIMES and e-TB Dashboard
Community level	Data not collected from this level				

CASCADE OF CARE MONITORING



Digital (Aggregated) Digital (Case Based) Manual

KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	✓
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	✓
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	✓
Date of test result	✓
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	✓
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring/adherence	✓
Treatment outcomes	

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	✓
Treatment initiation (proportion)	✓
Treatment monitoring/adherence	✓
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASE TB SURVEILLANCE

Electronic system for case based TB Notification	VITIMES (Vietnam TB Information Management Electronic System) and e-TB Manager are the two digital tools for TB case notification system.
Lowest Unit for TB notification digitisation	District Level (TB public Units)
Stage of notification	Registration for presumptive screening
Level of Access and Use of TB Notification data	Facility level
Private sector notification	Using VITIMES in available clinics. Few private players are submitting paper based to district level where it is entered in VITIMES
Frequency of digitization of TB notification	Real Time
Mode of follow-up with notified cases	Phone calls, Household visits, notification trigger using Mobile app
Scale of implementation	National Roll-out
Contact tracing for TB notified cases	ACIS application has contact tracing module integrated in 2018
Multi –channel enablement	VITIMES and e-TB web application
Govt. order for mandatory TB notification	Yes

PRIVATE SECTOR NOTIFICATION

Currently, Private sector notification accounts for approximately 10% of all TB notification. The private sector providers are using VITIMES for TB notification. Private sector sends data jointly with the public health reporting units (Districts). It is currently aggregate, or case based, depending upon the local infrastructure and manpower available.

COUNTRY IT CAPACITY

Country Server
Vietnam has an in-house country server dedicated to the TB program

Interoperability
Necessary APIs available, Data export available

Country IT team
In-house country IT team supported by outsourced IT team

ENABLING ENVIRONMENT

157.9%
Mobile penetration (Jan 2021)[8]

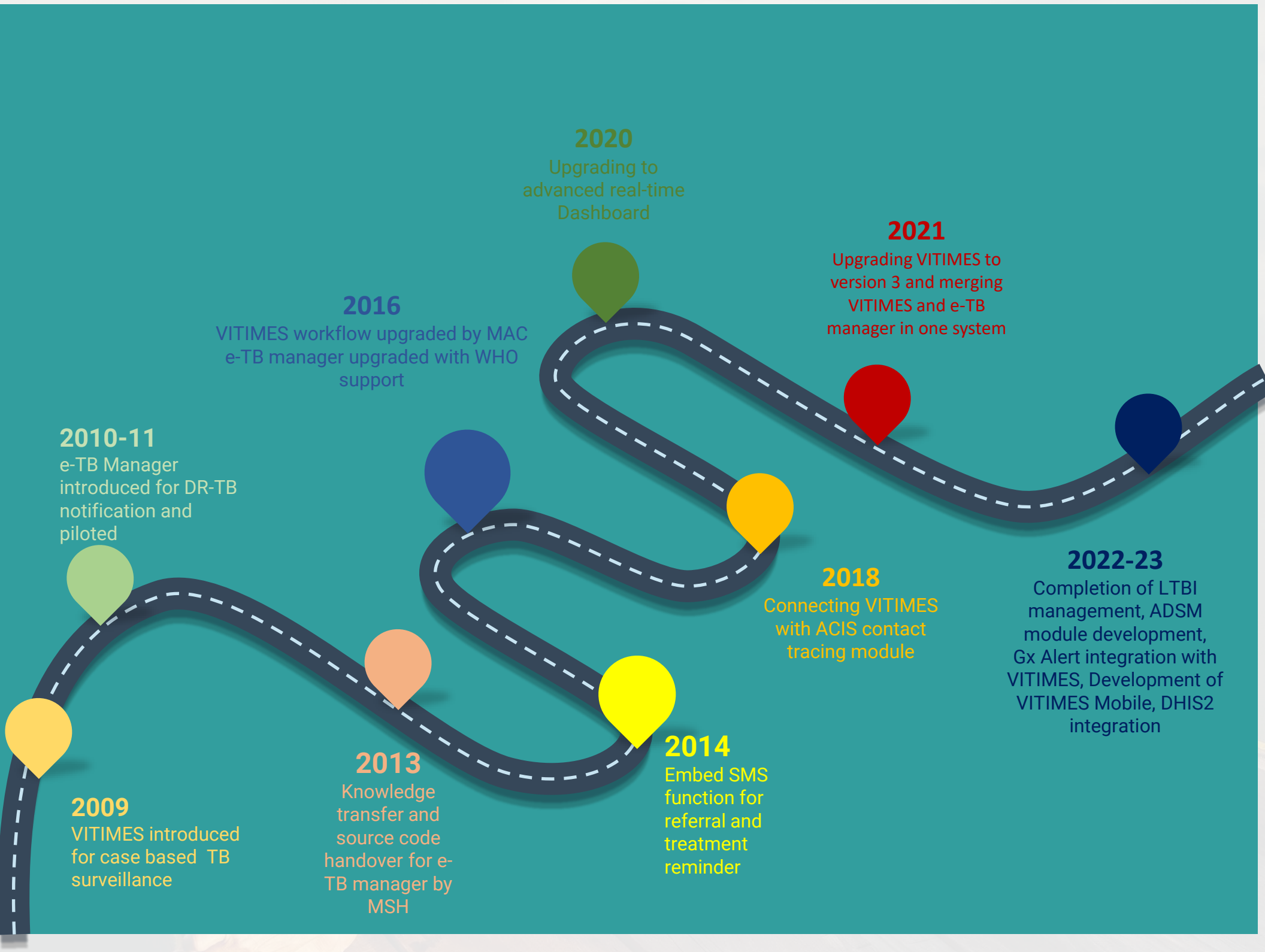
63.1%
Smartphone (2019)[9]

70.3%
Internet penetration (Jan 2021)[8]

CURRENT RESOURCES AVAILABLE

- In 2016, USD 15,000 was allocated for the platform upgrade but the actual development was roughly accounted for USD 50,000.
- Annual recurring cost for maintenance and upgrading, Server renting, Maintenance, Upgrading fee, SMS fee (mHealth function), and Support internet fee for district levels is approximately USD 140000.
- Annual recurring cost for developing the IT system is USD 2000-5000.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Within VITIMES & e-TB manager	Web application	MSH	WHO, USAID	National Roll -out
Logistic Management	Within VITIMES & e-TB manager	Web application	MSH	WHO, USAID	National Roll -out
Laboratory Information System	Within VITIMES & e-TB manager	Web application	MSH	USAID	National Roll -out
GX Alert Integration	GX Alert notification	Web application	System one	CDC	Pilot
Digital CXR Integration	PACS (connected to the hospital information system)	Web application			Pilot
	Qure.Ai	Mobile app		FHI and USAID	Pilot
	DrAids	Mobile app	Vin Group	Vin Group	Pilot
Community led Monitoring	ZeroTB Vietnam	Social Media Channels (facebook) and website			
Contact Tracing	ACIS	Web Application	TechUp	CHAI	Pilot

KEY CHALLENGES

- **Multiple channels for data entry :** Vietnam has two parallel electronic systems, and it also uses paper-based data recording and reporting. Several facilities are more comfortable with paper-based reporting, and hence electronic reporting is still relatively unpopular. Thus, resulting in delayed data entry and access to real-time information.

- **Multiple Data information systems and lack of dedicated staff for data entry: Data capturing, and** reporting is currently relied on health service delivery staff and case-based data entry is done in multiple information systems which causes burn-out in its health delivery staff, thus impacting quality of care.

- **Data is not real time:** Data available is not real-time **and** the reporting frequency varies from daily at some sites to quarterly at others.

- **Missing Data:** Due to multiple systems for data entry and lack of dedicated data entry staff often results in missing data as not all data is entered into the system.

- **Lack of Mobile application:** All data entry is web based. No mobile device integration.

- **Dashboard configuration:** Dashboards have not been configured as of now (in process, with Global Fund support) and are also not considered to be of much value as the reporting is not real time.

NTP VISION

- System upgradation and integration into one comprehensive system for both DS-TB and DR-TB. Integrating e-TB Manager and VITIMES into a single system for all TB notification data reporting.

- Developing systems capability to get integrated with other national systems to ensure data sharing and timely decision making.

- Establishing a central data warehouse to make enable effective data use

RESOURCE NEED

Based on multi-stakeholder discussions, country feedbacks and recommendations for full-filling country's vision, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**

  - Mobile Devices (for data collection): Vietnam has 713 DS-TB and 30 DR-TB services units and to provision mobile device for every facility for case-based TB surveillance, **USD 111,450** will be needed assuming USD 150 per mobile devices.

  - Tablet (for data use): Vietnam has 713 DS-TB districts units, 30 DR-TB units and 63 provinces to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 161,200** assuming USD 200 per Tablet devices.

  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 241,800** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)

  - Server: Based on the current volumes of new cases, Vietnam would need an investment of **USD 30,000-40,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**

  - Based on various multi-stakeholder meetings and given the fact Vietnam already have a strong foundation for e-TB Manager system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.

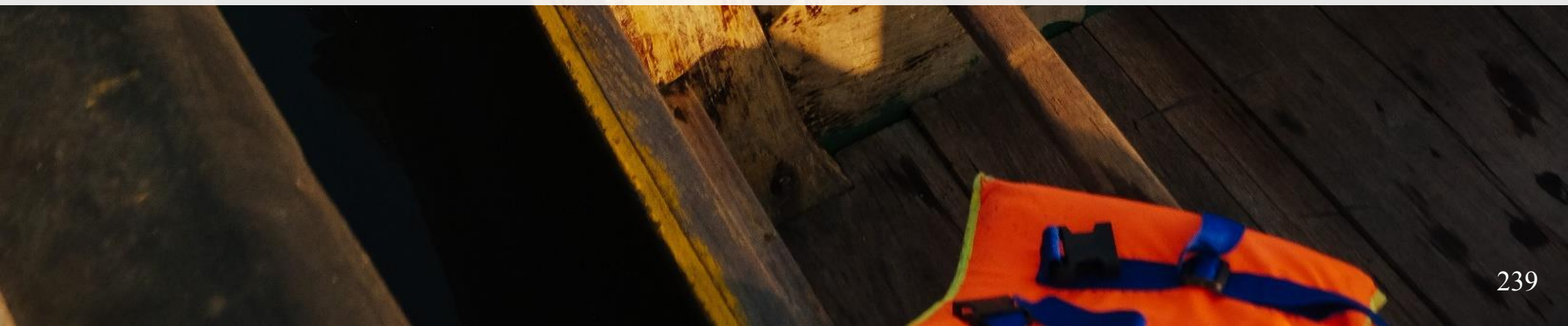
- **Capacity Building and Implementation:**

  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.

  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each 713 districts over a period of 3 years which could cost roughly USD 100 per training amounting to **USD 71,300,** which will be further supported with e-Learning packages**.** Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 1.5 - 2 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Vietnam .

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.



RECOMMENDATIONS

Following are some of the key recommendations based on the findings on Vietnam's digital ecosystem and infrastructure:

- **Strategic Costing Plan :** As a first step, it is important for the country to create a comprehensive costed action plan for development , implementation and scale of the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements , the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **System Integration:** The NSP (2021-2025) clearly highlights the importance of strengthening the TB Notification information system for improving all the TB service provisions [3]

  Vietnam has already developed and deployed a case-based TB notification VITIMES and e-TB manager for DS-TB and DR-TB respectively. Both the systems have been rolled out in 713 District DS-TB Units and 30 high burden DR-TB sites. The presence of the system lays a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

  Currently VITIMES and e-TB manager are in process of upgradation and needs to be integrated into one system. Additionally , the architecture and infrastructure needs to be extended to support integration with external systems like GeneXpert ,TruNat, Digital X-Ray outputs, Pill Boxes and other digital adherence tools which help in use the data effectively for the patient continuum of care and as a vision of an integrated Health Information Management System (HMIS).

  These data exchanges can be made seamless with API feature offered by both the platforms.

  Additionally , other recommended data exchange/ ETL tools like Talend, Informatica[10] makes systems data management task much easier and simultaneously improves data warehousing. These exchange tools also comply with FHIR, GDPR standards for more secured and seamless data exchange.

  Tentative timeline: Month 0-6

- **Data Use:** The NTPs plan clearly emphasizes on the importance and need for improve data use. This can be made possible by making case-based TB data across systems more real time and useful.

  In the existing dashboard there is a strong need to strengthen and expand the data visualization scope and making effective use of data for predictive modelling, data science and for advanced analytics it is also recommended to use best of the breed tools like Tableau , Power BI [11] which offer these features. The current e-TB manger platform offers APIs which can connected for these applications and be used as an extended analytical component of the data analysis framework.

  This would help to collate compare and review data across eTB Manager & DHIS2 systems.

  Tentative timeline: Month 6-12

- **Data Integration** : One of the challenges highlighted by NTP is the leveraging the data collected from the multiple sources into the main systems as a central warehouse for effective use.

  To ensure that there is a seamless integration of data from multiple data systems like VITIMES, e-Tracker and other data sources like excel files maintained at facilities without any data loss , the data upload / export API should be explored.

  There may also be some other distributed data collection systems and processes which are existing, and it might be difficult to replace them, in such a scenario data can be extracted, transformed and loaded into the central database.

  While transformation and data export options

RECOMMENDATIONS

offered by the current systems can be used for this other source ETL tools over Postgres DB and / or WHO powered XMart [12] which can be installed within the current environment can also be considered.

Tentative timeline: Month 6-12

- **Mobile app:** One of the challenges reported by the NTP during the assessment processes is multiple data inconsistent data connectivity / network issues which delays reporting of cases.

  The advantages for a mobile application include better performance , effective use of device features like in house system updates, usage of location , security measures and tracking user patterns and issue log mechanisms and other analytics measures.

  Several mobile solutions for real time case-based notifications can be explored for local adaption and building the mobile counterpart for VITIMES and e-TB. Open-source technologies like DHIS2, Mobile App, ODK and KOBO are some notable examples.[13]

  Tentative timeline: Month 0-6

- **e-learning:** Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive e-Learning module allowing all health staffs involved in data collection process for training not only on the new VITIMES and e-TB tracker-based application but also on the latest manual of procedure and continued medical education on TB care.

  To address the challenges with periodic training of facility level staff to orient them on using VITIMES and e-TB for direct data reporting, the MOH must engage in development of a comprehensive e-Learning module for app training.

  Training tools like Moodle [14] built on standard Learning Management System (LMS)

framework can be reviewed for application rollouts.

Additionally for training and updates on the latest manual of procedure and continued medical education on TB care modules can be developed for TB Health providers, administrators at facility and district level to develop and enhance M&E competencies for ensuring a consistent program oversight, especially for the case-based tracker roll out within the existing applications Guide TB platform developed by WHO Philippines is a good example of eLearning module for health staffs involved in TB care.

Tentative timeline: Month 1-4

- **Server Augmentation & Infrastructure Upgrades**

  Based on the architecture, the system upgrade would be done with the database, a middleware system, the operating system or the hardware.

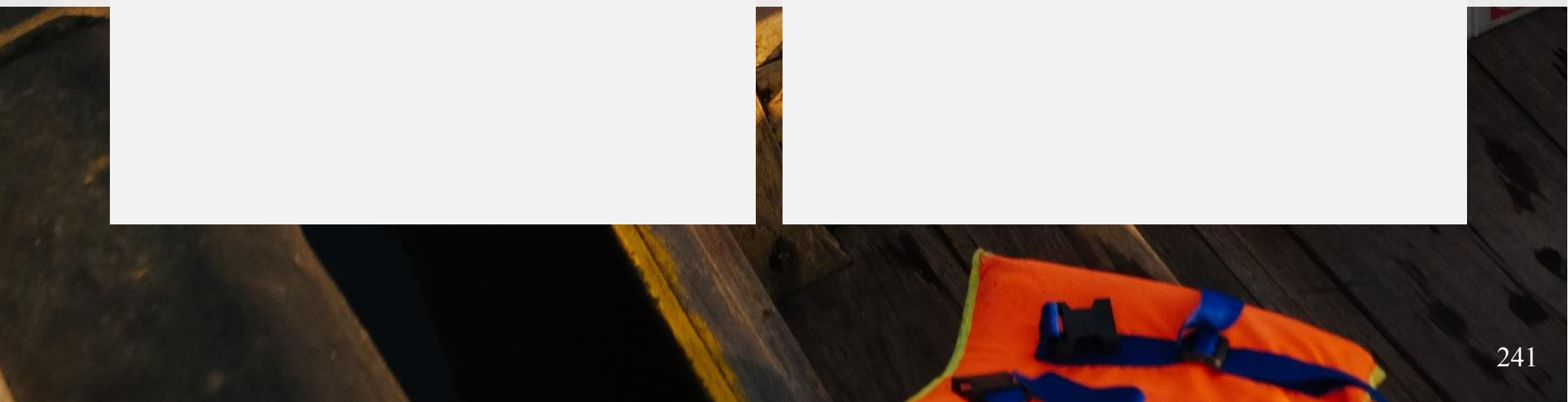
  Additionally, the architecture should be such that it supports the integration layer which would be needed for data exchange with national/external systems.

  The technologies that need to be brought in and the areas of inter-connection need special focus. A review of the existing server architecture is advised along with deployment of automated load testing tools like Selenium and Appium [16] which can help in database sizing and monitoring adaptation needs for planning.

  Tentative timeline: Month 6-24

- **Capacity building for application maintenance**

  Planning for capacity building includes workforce assessment, ranging from ICT professionals to health workers providing care services. Since the application requires regular



RECOMMENDATIONS

updates and adaptations, the system support team requires trained personnel on the technology stack in use.

Strengthening the NTP team with trained system administrators will help in improving and expediting the planned implementations.

Tentative timeline: Month 6-24

- **Patient engagement strategies:** Establishing a direct and secured mechanism for engaging with patient has potential for drastic improvements in tracking lost to follow-up patients.

  Auto generation of notification and messaging by the system through communication channels like Social Media, IVRS and SMS outbound messages should be explored. Open-source applications like Open MRS can be used for these activities. [15]

  Tentative timeline: Month 6-24

- **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

  Tentative timeline: Month 0-1

- **Expanding Modules VITIMES:** The recommendation is to integrate and include the data currently collected from applications like ACIS application via APIs and also expand the additional modules on Contact Tracing and Presumptive Screening, LTBI in VITMES to actively find the cases and determining the possibility of contacts being infected with TB would reinforce contact investigations by enhancing prioritization so high-risk contacts can be focused on first.

  The additional modules can be built on by leveraging on the existing platform of VITIMES and expanding it with new upgraded version of the application.

  Tentative timeline: Month 12-24

- **Unique Identifiers:** There may be duplication of data since multiple systems are used for data entry. This also results in missing out some crucial information to track and follow up the patients

  Having a centralized Unique Patient ID system or leveraging the existing national ID and an improved search functionality can help drastically reduce the duplication of case-based records.

  It would also ensure that patients are tracked, monitored and followed up throughout the treatment journey.

  Tentative timeline: Month 0-6

- **Community Monitoring Systems** : As expressed by the NTP, the national TB notification and surveillance system should have also consider data integration with their current social media channels and also explore use of ready-to-use open source CLM platforms like One Impact.

  Tentative timeline: Month 12-24

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Prof.*** **Nguyen Viet Nhung** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Ms. Luong Anh Binh*** for providing valuable insights into Vietnam's vision for creating a comprehensive case-based TB surveillance and notification system.

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12. WHO Xmart : https://portal-uat.who.int/xmart4/docs/general/Overview.html

13. Open Source Mobile Applications (DHIS2 Mobile App : https://dhis2.org/android KOBO: https://www.kobotoolbox.org/ ODK https://opendatakit.org/)

14. Application Training Tool : https://moodle.org/

15. OPEN MRS : https://openmrs.org

16. Performance Tools (Selenium , Appium) : https://appium.io/ , https://www.selenium.dev/

ZAMBIA

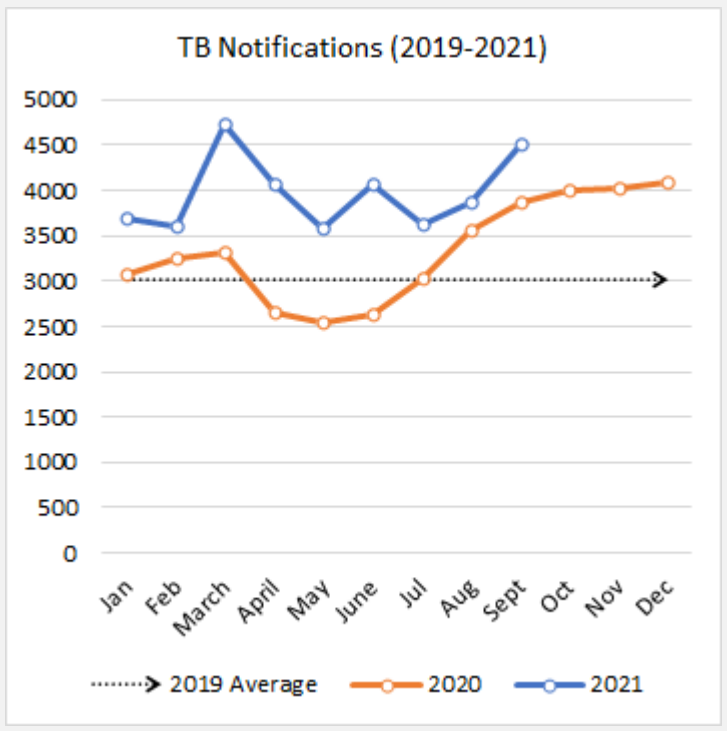
ZAMBIA

BACKGROUND

With an estimated TB incidence of 59,000 (319 TB cases per 100,000 in 2020), Zambia is ranked 21st among the 30 high TB burden countries. (WHO Global TB report, 2021) [1]

In 2020, Zambia reported 40,000 new and relapse cases, with a treatment coverage of 68%. Most of the missing cases are expected to be found in large peri-urban informal settlements of large cities.[2] Based on data from the TB prevalence survey, about 50% of the symptomatic TB cases are missed at the health facility. TB cases are missed at the health facility due to low index of suspicion of TB, failure to complete the TB diagnostic cascade, use of less sensitive diagnostic tools, out of pocket expenditure for patients, low awareness for TB in communities and weak public private coordination. [3]

During the COVID19 pandemic, the TB case notification in Cameroon was impacted and the numbers reduced to lower than 2019 average monthly notification, however, the country soon revived its surveillance practices, and the overall notification trend has improved consistently in the following months.



Source: https://www.who.int/teams/global-tuberculosis-programme/data

In 2020, 100% percent of the new TB cases were tested for rifampicin resistance. [4]

The National Strategic Plan (NSP) for TB prevention, care and control 2022-2026 envisioned a TB-free Zambia by 2030. More specifically, by providing equitable access to cost-effective, high-quality TB services, and reducing the number of TB deaths. The NSP prioritizes finding the 'missing cases' to bridge the case detection gap; enhancing diagnostic services; expanding programmatic management of DR-TB; enhancing TB/HIV collaboration; scaling-up of TB preventive therapy (TPT); and strengthening multisectoral and community partnerships. [4]

Currently, Zambia is relying on routine surveillance data from health facilities collected through the NTP in manual paper-based formats, to measure progress towards TB control targets. This data is further aggregated at the district level and entered nationally in the DHIS2 platform. This data has limitations such as under-reporting, and it does not provide information on the number of undetected cases in the community and on those individuals seeking care outside of the public sector. This combined with HIV pandemic and poverty in the country also contributes to the high TB burden in the country. [5]

Zambia has pledged to achieve UN high level key TB targets and has taken some significant steps towards it. The National TB program is committed and willing to transition from an aggregate based TB notification system to a case-based TB notification system. Under its revise NSP (2021-2026), the NTP is aiming to build a comprehensive, integrated and interoperable digital platform.

The NTP is leveraging on SmartCare digital platform that were primarily developed for HIV programs (in 2007) and now is integrating them with TB services. Systems like DISA is being used at the labs for recording TB test results. Over the time NTP has upgraded its country servers and is investing in new age digital technologies to streamline national rollout of advanced web-based version for TB notification.

With changing times and recent surges of COVID-19 pandemic, disease surveillance and response systems has become central and critical to inform operational and strategic decision-making for multi-level health systems. Ongoing health systems strengthening, and patient-centered engagement strategies are needed at every step of the care cascade; however, scale-up of active case finding strategies is particularly critical to ensure individuals with TB in the population reach initial stages of care. Additionally, a renewed focus on PLHIV and individuals with drug-resistant TB is urgently needed to improve TB-related outcomes in Zambia.

Based on the multi-stakeholder discussions, interviews and independent research, and guidance from the National TB Program, this assessment report attempts to produce clear recommendations and way forward towards developing a comprehensive case-based TB surveillance system while leveraging the existing infrastructure, in-house capacity and assets. Detailed recommendations are provided in the later section of this country report.

STATUS OF CASE BASED TB NOTIFICATION

National TB program has been implementing DHIS2 as the tool for TB surveillance:

- ✓ **DHIS2 based aggregated data collection system** which is being used at all 116 districts in Zambia. Typically, the manual TB registers are sent to the district office where the district data entry operator then feeds the data into the DHIS2 system.

The data is entered on a weekly basis in the current system and a monthly report is generated which are being accessed used at district, provincial and national program managers.

In line with country's vision outlined in the NSP 2017-21 to establish an electronic case-based data recording system, the HMIS is undergoing a transition to integrate the complete cascade of care by using a DHIS2 tracker data model.

Currently, aggregated TB datasets only capture cases initiated on treatment. The tracker model will expand this to register all patients, including presumptive TB cases.

SUCCESS STORIES

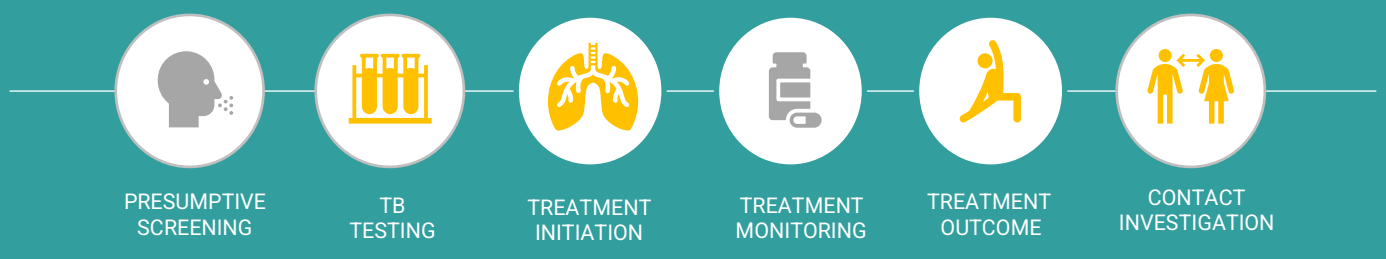
In 2010, Zambia introduced SmartCare electronic health record system, which was implemented for monitoring HIV cases, and the same is now being expanded for TB services by adding TB modules to the system. The primary intent of this system is to associate each patient record with a unique identifier and and ensuring case-based data collection at the facility level on a timely basis. Patients are issued smart-cards at their initial consultation which contains all their clinical information and treatment details and can be accessed from any SmartCare facility. Smart care system help in avoiding de-duplication of the cases and improves the ability of tracking and monitoring of cases in their TB treatment journey.

NTP has already piloted Smart Care TB module online version in 10 facilities and offline desktop version in 50 facilities.

ELECTRONIC TB NOTIFICATION DATA COLLECTION AND USE

	TARGET	CURRENT SCALE	COLLECTION TOOLS	DATA TYPE	DATA USAGE
National level	Data not collected from this level				DHIS2 Dashboard
Provincial level	10	Data not collected from this level			DHIS2 Dashboard
District level	116	116	Excel sheet, DHIS2 (in place but not used effectively)	Aggregated	DHIS2 Dashboard
Facility Level	3113	597	Excel sheet	Aggregate	Data is not used at this level
		50	SmartCare-TB offline module	Case Based	
		10	Smart Care-TB online module	Case Based	
Community level	Data not collected from this level				

CASCADE OF CARE MONITORING



KEY DATA VARIABLES

	YES/NO
Demographic details (Age, DOB, Gender)	✓
Address and contact details (Country, Province, District, House address)	
Geolocation (GPS coordinates of the household)	
Contact details (Phone number/Mobile number, WhatsApp, Email etc.)	
Health Facility address	✓
Type of health facility (Public, Private etc.)	✓
Site of TB (Pulmonary, Extra-pulmonary)	✓
Type of diagnostic test (Microscopy, GeneXpert, TruNaat, CXR, etc.)	
Date of test result	
Drug susceptibility (DSTB, DRTB)	✓
Treatment Regimen	✓
Treatment start and end date	
Co-morbidity (HIV, Diabetes, COVID-19 etc.)	✓
Treatment monitoring	
Treatment outcomes	✓

KEY INDICATORS

	YES/NO
Presumptive screening (proportion)	
Treatment initiation (proportion)	✓
Treatment monitoring	
Treatment outcome (proportion)	✓
Spatial distribution of TB notification	
Age-group & sex wise aggregate numbers and proportions notified	✓
Basis of diagnosis wise aggregate numbers and proportions notified	✓
Type/site/drug resistance wise aggregate numbers and proportions notified	✓
Provider source-wise aggregate numbers and proportions notified	✓
Comorbidity wise aggregate numbers and proportions notified	✓
Key-population wise aggregate numbers and proportions notified	✓
Estimate/Target wise notification/treatment coverage (proportions)	✓
Provider-type disaggregated treatment outcomes (proportions)	✓
Comorbidity disaggregated treatment outcomes (proportions)	✓
Key population disaggregated treatment outcomes (proportions)	✓

✓ Digital (aggregated) ✓ Digital (case based)

STATUS OF ELECTRONIC CASE BASE TB SURVEILLANCE

Electronic system for case based TB Notification	At 597 TB facilities, aggregated DHIS2 system available Smart care TB module is under pilot in 10 facilities for case based data
Lowest Unit for TB notification digitisation	District level DHIS2 aggregated data Smart care piloted for case based TB notification from facilities
Stage of notification	Bacteriologically positive TB confirmation at Labs
Level of Access and Use of TB Notification data	District level
Private sector notification	Providers under SLA - Direct access to DHIS2 , Others - Manual notification using excel sheets
Frequency of digitization of TB notification	Monthly
Mode of follow-up with notified cases	Manual follow-up-household visits
Scale of implementation	DHIS2 aggregated system is scaled at National level
Contact tracing for TB notified cases	Aggregate number of contacts captured in DHIS2
Multi-channel enablement	DHIS2 web application, Desktop app of SmartCare
Govt. order for mandatory TB notification	Mandatory case notification Govt. notice was passed for both private and public providers in 2000

PRIVATE SECTOR NOTIFICATION

Overall, there is a limited involvement of private pharmacies and providers in TB service delivery.

From the centers that have the capacity to deliver TB services, some have access to DHIS2 aggregate platform (through a formal agreement) and enter data directly, while others submit data to the district level in excel sheets (like the one used from public facilities).

COUNTRY IT CAPACITY

Country Server
Servers are managed by the Ministry of Health

Interoperability
DHIS2 as platform provides interoperability but yet to be integrated

Country IT team
DHIS2 system has been developed and managed in-house by IT team of MoH

ENABLING ENVIRONMENT

89.7%
Mobile penetration (Jan 2021) [6]

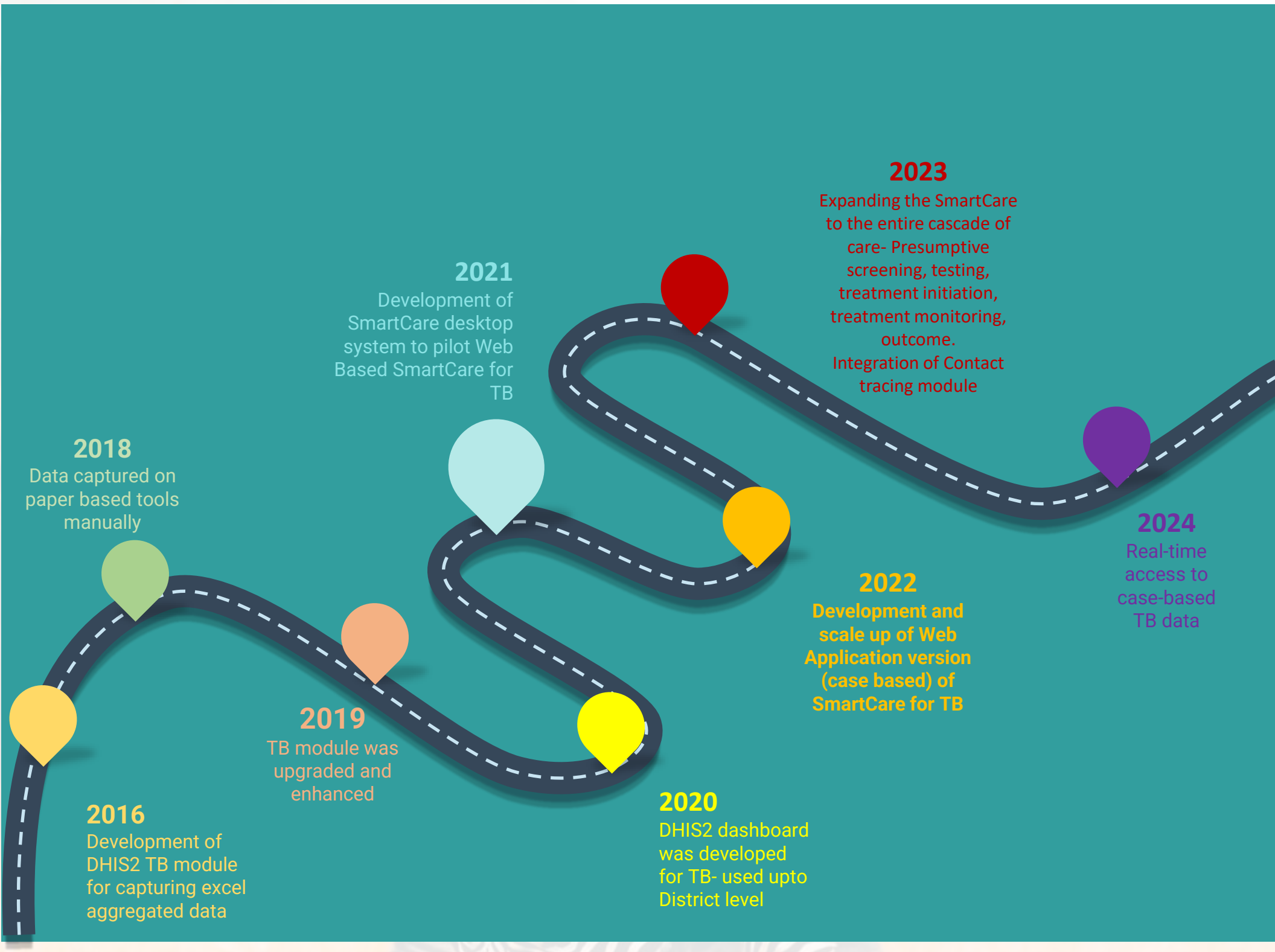
13.2%
Smartphone (2018) [7]

29.4%
Internet penetration (Jan 2021) [6]

CURRENT RESOURCES AVAILABLE

- FY2020 budget of USAID for Zambia allocated USD 5.5 Million for supporting the TB program in Zambia.
- For the year 2020-22, Global Fund has granted USD 16,568,354 for the country.
- The MoH has further developed a comprehensive Health Care Financing Strategy for 2017-27 to give direction to their various initiatives.

MILESTONES ACHIEVED AND ROAD MAP



OTHER COMPLEMENTING DIGITAL TOOLS

PURPOSE	TOOLS	CHANNEL	DEVELOPED BY	SUPPORTED BY	SCALE
Digital Adherence	Nil				
Logistic Management	eLMIS	Web Application	MOH	USAID, CDC	National Roll out
Laboratory Information Management	DISA (connected to GeneXpert)	Web Application	MOH	USAID, CDC PEPFAR, Global Fund	Pilot
	DataToCare	Web Application	USAID	USAID	Application is not functional
Community Led Monitoring (CLM)	Nil				
Contact Tracing	Nil				

KEY CHALLENGES

- **Real Time access to data:** With only aggregated TB notification data being entered at district level (weekly basis), there is a delay in getting access to program data to take actions.
- **Data Quality, Duplication and Under reporting: D**ue to paper-based reporting at the facility level, there is always a risk of duplication, under reporting and data loss.
- **Infrastructure and training:** For Zambia to enable a fully functional case-based TB notification system, provisioning of digital infrastructure, training and capacity building remains to be a bottleneck.
- **Integration of DISA with TB notication system:** To fully utilize the potential of using technologies like GeneXpert, DISA system integration with the case-based TB notification system (SmartCare) is critical.

NTP VISION

- The National Tuberculosis program is committed to UN High Level TB Targets. To achieve this, Zambia has built up its National servers and IT capacity to host applications. Now it is working towards developing a robust and comprehensive real time case-based TB notification system.
- In order to get all data reported in a single case-based data repository, scale up of SmartCare implementation to all TB facilities is crucial.
- Developing a mobile based real-time case-based TB notification at the lowest unit. Leveraging on existing technologies and Innovations. Zambia is investing in Smart Care digital platform that was built for HIV cases and now is expanding it to TB care and services.
- Monitoring of entire cascade of TB care starting from presumptive case screening in order to ensure end to end TB case treatment and management.
- Extending case-based reporting to the private sector is also included in the plans of NTP.

RESOURCE NEED

Based on assessment findings and country feedbacks, we have put together an estimated investment requirements and areas needing support for provisioning of a comprehensive case based digital TB surveillance system.

- **Hardware and Infrastructure:**
  - Mobile Devices (for data collection): Zambia has 3116 facilities and to provision mobile device for every facility for case-based TB surveillance, **USD 467,400** will be needed assuming USD 150 per mobile devices.
  - Tablet (for data use): Zambia has 116 districts and 10 Provinces and to promote active data use, each district and region should be given a tablet which would cost roughly around **USD 25,200** assuming USD 200 per Tablet devices.
  - Internet: In case WiFi is not available in each facility, then mobile internet cost of around **USD 311,600** should be considered (assuming USD 100 mobile data cost for the entire year per facility, district and regional user)
  - Server: Based on the current volumes of new cases, Zambia would need an investment of **USD 20,000-30,000** for next 3 years for server and server maintenance.

Note: Existing devices available through other health programs can be leveraged. In that case, the above-mentioned costing can be accordingly considered.

- **Software Development:**
  - Based on various multi-stakeholder meetings and given the fact Zambia already have a strong foundation for DHIS2 aggregated system for TB, around **USD 250,000-400,000** should be budgeted for a comprehensive TB surveillance system and analytical dashboard for data use.
- **Capacity Building and Implementation:**
  - After the software development, a dedicated pool of technical resources will be needed to support platform administration, data management and support. A team of 4-6 skilled resources attributing to a cost of around USD 48,000-72,000 per annum should be budgeted (or **USD 144,000-216,000** for 3 years assuming USD 1,000 per month per resources). Additionally, reskilling of the current IT team should be budgeted.
  - Training: This would involve training material development and onsite and remote training of the trainers. Training sessions should be planned for each of the 116 districts, which could cost roughly USD 100 per district, amounting to **USD 11,600** which will be further supported with e-Learning packages. Also, a dedicated trainer should be budgeted in case there is none.

TOTAL investment of around **USD 1.5 – 2.5 million for 3 years** will be needed on developing a comprehensive case-based digital TB surveillance system for Zambia

Disclaimer: The above budget is a function of number of facilities, districts and regions and expected volume of data. This only provides a ballpark figure of what is needed in terms of budget.

RECOMMENDATIONS

Following are some of the key recommendations for the NTP and Country teams:

- **Strategic Costing Plan:** As a first step, it is important for the country to create a comprehensive costed action plan for enhancement and scale up for the TB case-based surveillance system.

  Based on NTP's vision and the recommendations for improvements, the plan should clearly define targets with actionable interventions and funding requirements supported with a detailed work plan along with timelines. The plan will help the country to assess and monitor the progress to ensure that any risks can be duly mitigated.

  Tentative timeline: Month 0-1

- **Implementation and scale up of case-based notification system on priority:** In line with country's vision outlined in the NSP 2017-21, Zambia has already piloted SmartCare electronic case-based TB notification system online version in 10 facilities, and prior to that, the country has already rolled out SmartCare services for HIV cases successfully. Leveraging on the existing infrastructure in terms of database and deployment for Smart Care can lay a strong foundation for executing the vision of creating a comprehensive and integrated real-time case-based TB surveillance and notification system.

  For this, the SmartCare system is desired to be implemented across all TB facilities and customized in line with the national TB treatment guidelines. This case-based notification system must accommodate components of monitoring of entire continuum of care for both DS TB and DR TB patients, starting from presumptive screening, referral, testing, treatment initiation, treatment adherence, treatment outcome and contact tracing in real-time

  The solution architecture should support adding all the above components in phases supported with versioning to ensure seamless upgrades and continuity.

  Tentative timeline: Month 0-12

- **System Integration:** As visioned by the national TB program with the concept of an integrated Health Information Management System (HMIS), leveraging the current platform and foundation, basic integration and data exchange mechanisms should be worked out to avoid duplication of efforts and complement the existing data systems.

  The current SmartCare platform infrastructure needs to be extended to support integration with national DHIS2, DISA system (GeneXpert), TruNat, Digital X-Ray outputs, Pill boxes and other adherence tools which help in using the data effectively for the patient continuum of care as highlighted by the National program.

  Recommended exchange / ETL tools like Talend , Informatica which include these features make the data management task much easier and simultaneously improve data warehousing. [8]

  The DHIS2 platforms architecture is easily compatible with these standard tools and processes making this an effective solution. [9] The data exchange process should follow and comply with FHIR , GDPR standards for more secured and seamless data exchange.

  Tentative timeline: Month 6-18

- **Mobile app:** NTP also envisages the need to simplify the data collection processes to enable robust data analytics and data use. Some of the activities include:

  Inconsistent internet connectivity/network issues majorly hinder the data reporting. One effective way to overcome this is to support the current data collection processes by introducing a mobile application which will make the data entry process easier and will have features to store data offline which can then later be synched with the central systems.

  The advantages for a mobile application include better performance, effective use of device features like in house system updates, usage of location, security measures and tracking user patterns and issue log mechanisms and other analytics measures.

  The mobile application should be easily extendable to the current framework to support and ensure that the data structures are consistent and there is minimum effort to support any updates / changes to the program.

RECOMMENDATIONS

Additionally, the mobile frameworks using open source and standard technologies like Java, Postgre, React and Android, that are easily (java , react) supported by country IT teams will also have the standard best practices of mobile development like version management, data encryption, etc and will make this a more robust solution.[10]

Apart from the standard mobile / web interface there would be other sources of data collection, which include spreadsheets , csv , other apps that would need to be standardized and integrated with the existing DHIS2 aggregate and smart care system.

To ensure that there is a seamless integration from multiple channels without any data loss, the DHIS2 data transformation API also offers creation of standard templates which can be easily mapped with external data collection tools, apart from this, it supports batch upload for large volumes to ensure minimum disruption to the live systems. [11]

Tentative timeline: Month 0-6

- **Data Quality:** NTP clearly emphasizes on the importance and need to improve data use and improving the data collection practices. As part of standard practices, the application(s)/solutions should follow the data quality mechanisms or the Data Quality Assurance (DQA) framework which would help in improved data use.

  Data access control is another DQA measure that will regulate user's access to meta-data. It will involve the principle of least privilege (POLP), i.e., user's access will be determined based on their role in the project. POLP will define and limit what data they have access to and who has that access.

  The training component of the application will also come with an e-learning package that should have a module on DQA and will support routine annual and periodic independent assessments of reported data.

- **Advanced dashboard analytics:** To strengthen the current Monitoring and Evaluation framework, it is recommended to build on the current visualization modules. To offer a comprehensive dashboard for reviewing of program and data indicators, additional features of pivot table, event reports, etc, which support dimensions, data aggregation reports and individual line lists and with timeline views are extremely useful.

  Once a robust data analytics and data use model has been established with the current systems, then a more advanced analytical dashboard should be designed linked to the SmartCare case-based TB surveillance system that is already being piloted.

  To achieve this , apart from the standard dashboard features (and to strengthen and expand the data visualisation scope and making effective use of data for predictive modelling), data science and advanced analytics tools are recommended, like Tableau , Power BI, etc, which offer these features.

  Based on the discussions, the current platform offers APIs which can be connected for these applications and be used as an extended analytical component of the data analysis framework.

Tentative timeline: Month 6-12

- **eLearning module for health staff:** To address the challenges with periodic training of facility level staff to orient them on using DHIS2/Smart care system for direct data reporting, the MOH must engage in development of a comprehensive eLearning module for app training.

  Any national scale roll-out will have its own capacity and training challenges which requires development of a comprehensive eLearning module allowing all health staffs involved in data collection process for training not only on the Smart care application or DHIS2 system but also on the latest manual of procedure and continued medical education on TB care.

RECOMMENDATIONS

While DHIS2 offers standard training modules on the application , training tools like Moodle[12] built on standard LMS framework can be reviewed for application rollouts.

❖ **Device Procurement :** One of the limitation highlighted by NTP is the need to improve the hardware availability at the facility level. To streamline this, procurement, distribution and maintenance of the required data entry equipment like laptops, mobile/tablet devices should be done on an urgent basis. Improving the current infrastructure at the facilities is crucial for a complete transition to digital notification.

Tentative timeline: Month 0-6

❖ **Capacity building for application upgrade and server maintenance**

One of the main challenges highlighted by the NTP is the ongoing maintenance and enhancements of the platform. Since the application requires regular updates and to ensure effective adaptation and scale up the system support team requires trained personnel on DHIS.

Strengthening the NTP team with DHIS2 trained system administrators will help in improving and expediting the planned implementations.

Tentative timeline: Month 6-24

Strategic Technical Recommendations

❖ **Application Upgrades including Server Augmentation & Infrastructure Upgrades:** To make sure that systems implementation and scale up of application is supported well, the key need is to have a long-term strategic plan which would over the technical and operational objectives.

The strategy recommended would cover the following core areas:

✓ **Technical Upgrades:** Based on the architecture, the upgrade would be done with the database, a middleware system, the operating system or the hardware.

Additionally, the architecture should support the integration layer which would be needed for data exchange with other national/ external systems. The technologies that need to be brought in and the areas of inter-connection need special focus. Recommended data system architecture would include updating the version of the current DHIS2 to 2.34 which offers better features on data management , encryption , data exchange standards.

Additionally, the advance admin features offered by this version help the administrators to support the operational needs better for onboarding users , real time change in data variables and user management effectively.

Apart from version 2.34 also supports compliance to GDPR standards and offers more controlled data encryption practices. [13]

✓ **Performance Optimization & Testing :** To support the national scale up and implementation strategies it is very essential to have system(s) and application testing done to enable a reliable platform and which also helps in architecture updates and augmentation.

While core teams from the user community who are involved in the testing learn and automatically get trained, Automated System and Application Testing tools like Selenium and Appium can be used. Load Testing tools which helping in data base sizing and planning need to be adapted for effective planning .[14]

Application & System Security Audit: To strengthen the current systems framework and ensuring long term sustenance it is important to have regular evaluation of the security of the information and systems by measuring how well it conforms to an established set of criteria.

RECOMMENDATIONS

These would also include developing a framework which should outline policies in line with recommended standard policies like HIPAA[15] to cover Patient Data Management and Server & Infra guidelines.

Apart from application measures offered by DHIS2 [16] for patient data security , hosting solutions offered from Azure also cover these as part of their deployment options which can be considered as part of systems hosting. [17]

ACKNOWLEDGMENT

We thank the National TB Program Manager ***Dr. Patrick Lugnu*** and the entire team for participating and engaging in the assessment. We would also like to extend our gratitude to ***Rhehab Chimzizi*** and **Mushota Kabaso** for providing valuable insights into Zambia's vision for creating a comprehensive case-based TB surveillance and notification system.

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