Report of the WHO consultation on digital technologies for tuberculosis

Geneva, Switzerland

14-16 November 2022
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**Acronyms & abbreviations**

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACF</td>
<td>active TB case finding</td>
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<tr>
<td>AI</td>
<td>artificial intelligence</td>
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<td>API</td>
<td>application programming interface</td>
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<td>ASCENT</td>
<td>adherence support coalition to End TB</td>
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<td>BMGF</td>
<td>Bill &amp; Melinda Gates Foundation</td>
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<td>CAD-TB</td>
<td>computer-aided detection for TB on chest radiography</td>
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<td>DAK</td>
<td>digital adaptation kit</td>
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<tr>
<td>DHI</td>
<td>WHO Department of Digital Health and Innovation</td>
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<td>DHIS2</td>
<td>district health information software</td>
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<td>DR-TB</td>
<td>drug-resistant TB</td>
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<td>DS-TB</td>
<td>drug-sensitive TB</td>
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<tr>
<td>EMM</td>
<td>electronic medication monitor (also referred to as “digital pillbox” or “smart pillbox”)</td>
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<td>eMR</td>
<td>electronic medical records</td>
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<td>GTB</td>
<td>WHO Global TB Programme</td>
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<td>HISP</td>
<td>a global movement to support DHIS2 implementation</td>
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<td>ICT</td>
<td>information and communication technology</td>
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<td>ITU</td>
<td>International Telecommunication Union</td>
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<td>KNCV</td>
<td>KNCV tuberculosis foundation</td>
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<td>LIMS</td>
<td>laboratory information management system</td>
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<td>LSHTM</td>
<td>London School of Hygiene and Tropical Medicine</td>
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<td>NTP</td>
<td>National TB Programme</td>
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<tr>
<td>SDGs</td>
<td>UN Sustainable Development Goals</td>
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<tr>
<td>SMART</td>
<td>Standards-based, Machine-readable, Adaptive, Requirements-based, and Testable</td>
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<tr>
<td>SMS</td>
<td>short message service (mobile text)</td>
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<td>STP</td>
<td>Stop TB Partnership</td>
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<td>TB</td>
<td>tuberculosis</td>
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<td>TPT</td>
<td>TB preventive treatment</td>
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<tr>
<td>UiO</td>
<td>University of Oslo</td>
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<td>UN</td>
<td>United Nations</td>
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<td>US CDC</td>
<td>United States Centers for Disease Control and Prevention</td>
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<tr>
<td>USAID</td>
<td>United States Agency for International Development</td>
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<tr>
<td>VST (or VOT)</td>
<td>video supported treatment for TB</td>
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<td>WHO</td>
<td>World Health Organization</td>
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Background

The WHO Global Tuberculosis Programme has been working with partners and Member States to engage more comprehensively and promote the use of digital technologies (eHealth and mHealth) in the drive to reach the targets set in the End TB Strategy. In 2015 WHO defined a conceptual framework with 4 functions served by digital technologies for TB: patient care, programme management, surveillance and monitoring, and eLearning. In 2017, for the first time, WHO issued evidence-based recommendations for the use of digital technologies to support treatment adherence for TB patients, alongside other support strategies like material and psychological support and education. These include a variety of technologies including electronic medication monitors (EMMs) that measure the time between openings of a pill box and emit audio alerts or mobile Short Message Service (SMS) to inform patients and caregivers when medication is due. WHO also recommended that video-supported treatment (VST) can replace in-person support.

Following the release of the WHO recommendations in 2017, and upon request of national TB programmes for clearer instructions on how to choose and implement the best suited digital adherence technologies, an implementation handbook was released in 2018. The handbook was informed by experiences and best practices in TB treatment programmes. It has since been translated into French, Russian and Spanish. In recent years, implementation of digital adherence technologies has continued to expand alongside implementation research projects in different countries, such as TB REACH and the ASCENT project. The ASCENT project, funded by UNITAID, has been running in five countries and will end in 2023. Some of its provisional results became available in late 2022. Further, evidence reviews on the effectiveness and cost of digital adherence technologies were updated by the end of 2022, as well as results from a major trial of EMMs in China.

Alongside digital adherence technologies, several other technologies are now in use in the national TB response, such as digital surveillance. A WHO-led collaborative effort, across multiple disease programmes and partners, has been ongoing since 2017 to develop, and support country implementation of digital packages for the collection, analysis, visualization and use of data from routine health facility information systems. The TB-specific packages have been built based on WHO guidance about case-based digital TB surveillance, about routine analysis and use of TB data and about the WHO TB surveillance checklist of standards and benchmarks. The packages are based on WHO data standards and have been developed using DHIS2 software, which many countries have already chosen for use within their health information systems. DHIS2 can be adapted for use with other software. Each package contains a machine-readable configuration (inclusive of an installation guide), an analysis guide with a core set of indicators and dashboards, and an accompanying exercise book. A DHIS2 TB package for case-based data, which enables the digital management of a core set of data items for both individuals with drug-susceptible and drug-resistant TB disease in a single system, has been available since late 2020 for download, as a digital data configuration package in both English and French. WHO has also supported the development of PREVENT TB, a prototype application to illustrate data requirements to generate TB preventive treatment and screening. Other applications of digital health for TB supported by WHO activities in recent years include connected diagnostics and laboratory information systems, telemedicine, and eLearning. In 2021, WHO recommended for the first time the use
of software for the computer-aided detection of TB on digital radiography (CAD-TB) using machine learning.

**Meeting objectives**
The meeting objectives were the following:

1. ongoing work that WHO is engaged in for the coming years on different aspects of digital technologies for TB presented;

2. country programme and partner experiences on the use of different digital technologies to enhance the implementation of TB services discussed;

3. specific to digital adherence technologies for TB, the implications of results from the ASCENT project, other studies in China and South Africa, and evidence reviews on effectiveness and cost from the perspective of national programmes, donors and implementation partners discussed.
Summary of proceedings

Day 1 (14 November 2022)

Opening remarks were made by Tereza Kasaeva, Director of WHO’s Global TB Programme (WHO/GTB), who mentioned that it was heartening to see that most of the partners have managed to attend the consultation in person. While welcoming them, she highlighted how this meeting comes at a crucial stage as the UNITAID-supported ASCENT project draws to a close. Therefore, the global TB community will benefit from the experience acquired in person-centred approaches of digital treatment support that were explored by ASCENT in five very diverse countries. Furthermore, the consultation is an opportunity to hear from other countries about how they are harnessing digital technologies in different aspects of the TB preventive and care pathways as they recover from COVID-19 disruptions. It will be interesting to know how initiatives like DHIS2 are promoting the concept of individual-level data management for TB surveillance, about electronic health records for the management of care, laboratory informatics, telemedicine, artificial intelligence (AI) and more.

This was followed by remarks from Alain Labrique, Director of WHO’s Department of Digital Health and Innovation (WHO/DHI). He echoed Dr Kasaeva’s welcome to participants and mentioned that business as usual will not improve healthcare programmes in the coming years. He appreciated that the TB community has been at the forefront of using digital technologies, including the elaboration of WHO evidence-based guidance. He said COVID-19 has changed how health and care are delivered across the globe. In every region, there has been an increasing trend of providing health care services remotely through digital means and using AI and data across this new landscape. Since 2015, WHO has been working with partners to raise the profile of digital technologies in health care. In 2019, WHO/DHI released guidelines on the use of digital tools for health system strengthening. In 2020, the WHO Member States agreed to implement the global strategy on digital health. Dr Labrique mentioned the most crucial aspect of using digital technologies in building people-centred systems under robust governance and he emphasized the importance of user-centred design and interoperability through common standards. He cautioned that although AI can potentially improve health outcomes simultaneously, it raises some critical concerns across domains of ethics and equity, concerns about the digital divide, data protection and the regulation of the private sector heavily involved in this area. Therefore, there is a need for strong governance to enable AI to be better integrated into current health systems so that they play an impactful role in people’s health. In 2021, WHO published guidance on the ethics and governance of AI, and the one word that he challenged everyone to think through and deconstruct is the word ‘trust’ in this multidisciplinary context. He underlined the need for cross-pollination and collaboration as we move forwards and augured a great success for the meeting.

Dennis Falzon (WHO/GTB) introduced the objectives and the agenda of for the three days (Annex 1).
Session 1. Digital technologies for TB: current WHO engagements and vision for the near future

Dennis Falzon (WHO/GBT), in his presentation, provided an overview of the recent history of the WHO vision and recommendations on digital technologies to end TB, which included the release of the following landmark publications and tools:

- 2012: electronic recording and reporting for tuberculosis care and control
- 2017: mobile application for TB preventive treatment (precursor of the PREVENT TB app)
- 2017: first evidence-based recommendations on digital adherence technologies for TB
- 2018: handbook for the use of digital technologies to support tuberculosis medication adherence
- 2020: implementation research for digital technologies and TB with colleagues from TDR, the Special Programme for Research and Training in Tropical Diseases (IR4DTB)
- 2020: first release of the annual Global TB Report as a mobile app
- 2021: first evidence-based recommendation on computer-aided detection of TB on chest radiography, using AI-empowered software
- 2021: launch of the WHO TB Knowledge Sharing Platform, including the first WHO eLearning modules on TB policy guidance.

In addition, he also mentioned the country support provided by WHO to digitize TB records since many years (including DHIS2 more recently), the various consultations organized with the support of the European Respiratory Society, UNITAID and other partners, and the contributions of the Global task force on digital health for TB in advancing the adoption of digital technologies in TB between 2015-2019. He concluded by mentioning that later in the year the WHO Global TB Programme will create a user guide to help countries navigate to different documents and other resources that will help them plan for digital technologies for TB. The creation of this resource will be informed by the proceedings of this meeting.

Babis Sismanidis (WHO/GBT) spoke about the WHO support for adopting digital technologies to strengthen TB surveillance and routine analysis and use of data. He talked about the mandate of the Global task force on TB impact measurement since its creation in 2006 to strengthen routine TB surveillance, routine analysis, and use of data to improve efforts towards TB elimination. To fulfil this mandate, since 2013 WHO has been undertaking TB epidemiological reviews and surveillance assessments, and more than 130 reviews have been conducted in 85 countries. He also mentioned that a new guidance on TB surveillance is under development and will be released by WHO in early 2023. The new guidance envisions a comprehensive, unified, digital case-based recording and reporting system.

Sameer Pujari (WHO/DHI): presented how digital health is now considered as a vital enabler of health care by WHO. He outlined the salient features of the WHO Global Strategy on Digital Health 2020 – 2025, its vision being to improve health for everyone by accelerating the development and adoption of appropriate digital health solutions to achieve the health-related SDGs. There has been increasing interest in applying AI in health topics such as TB, HIV, universal health care, ageing, and climate change amongst others. Scientific research on AI in health is booming. AI is a fast-growing sector that could become a US$ 15 trillion industry by 2030, with numerous healthcare applications. The WHO-ITU AI4Health Focus Group,
established in 2018 as a joint focus group between WHO, ITU (International Telecommunication Union), and over 100 partners, operates at the interface between machine learning and stakeholders in medicine, public health, government, regulation, statistics, ethics, and more. The group has been instrumental in developing WHO guidance on ethics and governance of AI for health. An eLearning course on ethics and governance of AI in health was launched in June 2022. It lasts 3.5 hours, has eight modules and three practice checklists. By the end of 2022, over 9000 learners from 130 countries had enrolled. Dr Pujari concluded by highlighting the role of governance systems for a scaled, sustainable application of digital technologies and AI for health and a collaborative approach to enable continuity and high sustained return on investment across healthcare.

Representatives from the Ministries of Health of two high TB burden countries next commented on the adoption of digital technologies for TB programmes in the discussion that followed

Pakistan: The entire field of digital health is an opportunity to maximize the impact in healthcare and focus on the actual beneficiaries of healthcare, where the tools can be developed according to needs in a particular setting. Amongst others, technology limits data reporting errors, puts investments to good use, and promotes a timely intervention on triggered alerts. The country is keen to establish an e-health infrastructure but there is a need to sensitize policy makers about the benefits of digitization of healthcare, such as patient information and decision-support systems for providers to optimize TB care.

Zambia: Use of technology in healthcare is an opportunity, however we need solutions relevant at the level of the user. There needs to be a shift in approach where the technologies are designed from the bottom up – from patients and healthcare workers up to the national level and global, such as WHO. Costed implementation plans or guidance on how to develop them for different technologies are lacking.

Session 2. Digital adherence technologies for TB: results of the ASCENT project

Kristian van Kalmthout (KNCV): provided an overview of the UNITAID-funded ASCENT project (Adherence Support Coalition to End TB) and critical lessons learnt. The project started in July 2019 and will finish in December 2023. It has three key outputs: 1) operationalization of digital adherence technology interventions for TB; 2) generation of evidence for optimal use and scale-up of digital adherence technologies; 3) establishing a global market for an optimized product, price, and supply chain of digital adherence technologies. The consortium partners are the KNCV Tuberculosis Foundation, The Aurum Institute, the London School of Hygiene & Tropical Medicine and PATH and partnership with the governments of the implementing countries (Ethiopia, the Philippines, South Africa, the United Republic of Tanzania, and Ukraine). Over 230 different facilities were trained to use digital adherence technologies during the last two years under the project, and over 16,500 patients were enrolled, making ASCENT the largest single evaluation and implementation of these technologies to date. ASCENT plans to develop technical briefs for all three technologies tested, with more detail on what works and what does not. The speaker concluded on some of the key lessons learnt during the project, namely:

1. **99DOTS** medication sleeves proved relatively impractical to scale up. The replacement of sleeves by adhesive labels that could be applied to the blister packs overcame some of the operational problems. Consistent access to a charged cell phone, even a feature phone, and providing network coverage across diverse
provider were challenging. Procuring freephone numbers was difficult in some settings. Daily engagement to call the numbers induced patient fatigue over time.

2. Electronic medication monitors (EMMs) were found to be user-friendly, reusable and suitable to all target users, including those who do not have any communication methods. They can be configured to remind patients. ASCENT facilitated availability of an EMM package through the Stop TB Partnership’s Global Drug Facility using funding from donors like the Global Fund.

3. Video-supported treatment (VOT) was scarcely used in ASCENT projects, and limited to Ukraine and the Philippines. Major challenges were due to the lack of availability of smartphones, data, coverage of network, and privacy related issues. Recording, storing, and sharing of video files as well as their timely review by healthcare staff were burdensome.

4. The single digital calendar platform (Everwell) used by the project was found to be practical to register adherence across different technologies and to trigger action by staff in the event of missed doses.

5. Deployment, customization, data access and integration with existing systems and country support mechanism are key issues to consider when scaling up digital adherence technology in programme settings.

Katherine Fielding (LSHTM, UK) and Degu dare (KNCV): shared information on the progress of the various research studies under the ASCENT project. These research studies aim to implement and evaluate systems using medication sleeves or labels and smart pillboxes, linked to a web-based adherence platform to create a differentiated response to patient adherence among adult TB patients in diverse settings. Of the 13,510 individuals enrolled by June 2022, 63% were male, median age was 40 years, 53% were on smart pillbox and 47% on labels. The project has been using independent, pragmatic two or three-arm cluster-randomized trial designs to generate evidence on the effect of digital technologies on treatment adherence and final treatment outcomes. The primary objective is to evaluate the effect on unfavourable TB treatment outcome (and “recurrence” in Ethiopia) compared with the standard of care. Treatment enrolment has been completed with statistical analysis to start soon. Dissemination of results from the main analysis in four countries is planned in August 2023, while the release of results on TB recurrence from Ethiopia is planned in December 2023. Secondary outcomes (feasibility, fidelity and acceptability) are being measured through sub-studies, namely a quantitative study on patient acceptability and costs; a qualitative study on patient acceptability; and a qualitative study on acceptability & feasibility in healthcare workers and key stakeholders.

Reports by ASCENT research managers on interim results of the sub-studies

Ethiopia: Amare Tadesse provided details of the sub-study on the feasibility and acceptability of digital adherence technologies from the patient perspective. The available results suggest that using digital adherence technologies with differentiated care to support person-centred TB care was feasible and acceptable. However, feasibility challenges are pronounced among participants using medication labels. Structural challenges such as power outages and poor network coverage could be major hindrances and must be addressed. Additional context-specific strategies to support the use of the technologies may further improve intervention delivery.

The Philippines: Jason Alacapa provided details from a sub-study on the patterns of digital and manual adherence technology engagement across five countries. The available results
suggest that consecutive daily treatment interruptions are common in all project countries and digital adherence technologies offer a unique advantage in aggregating adherence data to help improve treatment delivery. Doses were added by healthcare provider after the intended day (“manual dosing”) in all countries: in some this reached 10%. Engaging healthcare providers is critical for the successful implementation of digital adherence technologies.

**South Africa: Tanyaradzwa Dube** shared information from the run-in phase of ASCENT, focusing on South Africa and shared data from a pilot phase of implementing the smart pillbox and SMS self-report using labels. The main challenge with implementing the label was technical difficulty in delivering SMS, leading to excessive reminder messages from the system and patient frustration. As a result, some patients requested to be withdrawn from the study and others were switched to the box during the run-in phase. Enrollment of patients using labels was discontinued in South Africa in November 2021 and all intervention arm participants enrolled from that point on were started on the smart pillbox only. Most patients who had already been assigned to medication labels switched to the pillbox, and a few continued using the labels until they completed treatment.

**United Republic of Tanzania: Andrew Mganga** provided details from a sub-study on factors affecting digital medication adherence among adult TB patients using smart pillboxes in South Africa, Tanzania UR, Ukraine, and the Philippines. The available results suggest that digital medication adherence has been recorded in more than 97% for pillbox users across all implementing countries. Factors associated with digital adherence technology engagement appear to be context specific, as indicated by the varying combinations of risk factors per country. These results are currently under discussion.

**Ukraine: Natasha Deyanona** presented the experience of the use of digital adherence technologies among patients on treatment for drug-susceptible TB enrolled in the ASCENT trial in Ukraine, amidst the current conflict. Adherence was measured using a smart pillbox, and data were recorded on the ASCENT adherence platform. Comparisons were made between adherence data from the first 28 days of treatment for patients enrolled before the start of conflict (July 2021 to January 2022) and after (24 February to 24 March 2022). Although the data are limited there was a clear impact on the completeness of data, with a statistically significant proportion of instances with missing information during the second period (2.4% vs 7.3%). All 4 healthcare workers interviewed from regions of the country that were occupied had migrated out of the regions and attested to the difficulties encountered by patients to use the technologies.

The following issues were raised in the discussion after these presentations:

- The need to establish dosing and adherence patterns that can be considered ‘acceptable’ based on the findings
- The success of digital adherence technologies after they are introduced depends on the baseline implementation model and how the standards of care vary across health facilities
- The influence of COVID-19 pandemic on the standard of care
- The evidence of effectiveness of digital adherence technologies is best measured using a superiority design rather than non-inferiority

Additional comments were made by country representatives on the findings from ASCENT:
**India**: the National TB Elimination Programme has evaluated 99DOTS in India and that evaluation report also can add to the evidence base. A range of adherence support options, including digital tools, is used in India. This “cafeteria approach” allows patients and their healthcare providers to choose the option that suits them most.

**Zambia**: digital adherence technologies provide an opportunity for the programmes to implement differentiated service delivery, particularly as we recover from three years of COVID-19. These technologies are a critical place to enhance and give programmes some level of visibility. The Zambia national TB programme is enthusiastic about implementing some of these proven technologies, however cost may pose a challenge in the programmatic implementation of any innovative technologies.

**Giorgi Kuchukhidze (WHO/EUR)**: delivered the last presentation of Day 1, on the experience of rolling out VST in the WHO European Region. This region has 53 Member States which differ vastly in infrastructure and TB epidemiology. One of the region’s unique features is that 40% of TB patients notified have rifampicin-resistant TB, influenced by high levels of drug-resistance in central and eastern European countries. The region’s standard of TB care has historically focused on the daily administration of medication via in-person encounters in healthcare facilities. Based on the WHO guidelines, the WHO/EUR Regional Technical Advisory Group advised an expansion of VST in 2018-19. Following this, an assessment was made to identify the current use of VST in the Region. Different countries are using different approaches. The assessment identified three apps in Belarus, Republic of Moldova, and Georgia. A practical VST implementation guide was developed to support Member States to adopt VST using suitable approaches. During the COVID-19 pandemic, VST was extensively used in the region, but its uptake remains highly variable, ranging in coverage from 12% of TB patients in the Republic of Moldova to 60% in Kazakhstan. Since evidence on the use of VST from resource-constrained settings is very limited, an operational research protocol to generate evidence on the effectiveness of VST is currently being developed in the region.

**Day 2 (15 November 2022)**

**Session 3. Digital adherence technologies for TB: new findings and evidence reviews**

**Kevin Schwartzman (McGill University, Canada)** presented about three linked systematic reviews on the accuracy, impact, costs, and cost-effectiveness of digital adherence technologies for TB treatment and support. The preliminary results indicate the following: a) **Accuracy**: variable accuracy of digital adherence technologies. Different adherence cut-offs, reference standards, and technology components are used, introducing substantial risk of bias; b) **Health impact outcomes**: varying intervention effects associated with the technologies. Some, particularly VST, appeared to be associated with improved treatment completion for both TB disease and TB infection. Over 90% of patients were engaged and satisfied with VST; adverse events were reported more frequently with VST. Treatment support using feature phones was associated with worse treatment completion. No statistically significant effect on treatment completion was noted with the smart pillbox and 99DOTS. One study reported improved outcomes with mobile texting but other trials failed to show the same effect; c) **Cost and cost-effectiveness**: The scope of costs analysed varied widely; VST was the most extensively studied and was cost-saving for the health care system.
in most cases, but it was mainly evaluated in high-income countries and cost to patients was not considered in most studies.

**Ramnath Subbaraman (Tufts University, USA)** presented the scoping review results for assessing implementation outcomes for TB digital adherence technologies using the RE-AIM framework (Reach, Effectiveness, Adoption, Implementation, Maintenance). He presented the framework to address questions like why implementation matters, what should be measured as implementation outcomes of digital adherence technologies and are the technologies reaching those who are likely to do poorly on treatment. The review indicates that many studies have reported some measures of “reach” (or population coverage) or “implementation” (fidelity of the technology or to the intervention programme). Few studies report on the “adoption” of digital adherence technologies by healthcare providers or long-term “maintenance” by the health system. He highlighted the limited data on adoption of technologies by providers, and an example from India that showed very wide heterogeneity in adoption. He concluded that population coverage, uptake by health systems and implementation of intervention with fidelity are all critical to enhance the public health impact of the technology. The findings point to a need to understand further how well programmes are employing digital adherence technology in the real world, identify points of intervention to improve their functioning and point out areas where research is needed (e.g., “adoption”).

**Salome Charalambous (Aurum Institute, South Africa):** presented the results of the TB MATE study in South Africa on smart pillboxes in South Africa. The study’s primary objective was to evaluate whether implementing smart pillboxes, and differentiated care increased the proportion of persons with DS-TB with >80% adherence compared to the standard of care (without smart pillboxes). TB MATE was a pragmatic cluster randomized control trial, carried out in 18 primary health clinics in 3 South African provinces with varying prevalence of HIV infection but with high detection of TB. The study population (approximately 2600) included adults and children with DS-TB receiving TB treatment at the participating clinics. The preliminary results show that the proportion with <80% adherence in the intervention and control arms was 19% and 48% respectively. These results demonstrate that using smart pillboxes with a differentiated care approach improved treatment adherence in DS-TB patients in settings such as South Africa. The effect of the intervention on final treatment outcomes will be disseminated in early 2023.

**Katherine Fielding (LSHTM, UK):** presented results from the cluster-randomized trial of an EMM with event and reminder monitoring used during the treatment of pulmonary TB patients in China. These pillboxes had an audio and visual reminder for patients to take their medication and monthly follow-up visits at monthly clinic visits; the doctor downloaded data from the box, reviewed “box openings”, and changed patient management accordingly. In the control arm patients received the usual standard of care at the TB-designated facility, with medication also kept inside similar pillboxes which had the audio-visual reminders disabled and thus no adherence data records at available for doctors to consult during clinic visits. The study was conducted in 3 provinces in China with 12 clusters per arm: the primary intention to treat analysis included 1298 individuals in the intervention arm and 1388 in the control arm. When compared with controls, participants in the intervention arm had a 64% reduction in months in which >20% doses were missed and a 57% reduction in total missed doses. However, the intervention had no impact on final treatment outcomes, as judged from a
composite index of death, failure, loss to follow-up, switch to multidrug-resistant TB treatment, or recurrence. The authors concluded that monthly review of adherence data may not be adequate to influence treatment effectiveness. Future research could explore more frequent review coupled with swift action in case of interruption. Future trials should continue to measure end of treatment outcomes and recurrence using sensitive end-points to generate robust evidence to influence policy.

Wang Ni (National Centre for TB Control and Prevention, China CDC) reported that China adopted digital adherence technologies for TB care under routine programmatic conditions since 2016. China implemented digital pillboxes on a large scale in 138 counties in the three provinces of Zhejiang (East), Jilin (Middle), and Ningxia (West). Pillboxes contain one month’s supply of fixed-dose combination TB treatment. Under this project, ~64% of the patients accepted to use digital pillboxes and kept using them during treatment (92% at two months of treatment and 84% at six months), with very high levels of treatment success (94%-95%). Currently, digital adherence technologies are being scaled up in the country, and by end 2022, over one third of counties in China are estimated to be using them: about 60% are using pillboxes, 32% mobile apps, and 5% VOT. The lessons learnt from this implementation experience so far are that digital adherence technologies are promising for the medication management of TB patients, with digital pillboxes being the most widely used. VOT is used primarily in the more economically developed regions. Mobile apps tend to be more popular among younger patients. Further promotion of the use of digital adherence technologies will depend on government funding, development of national guidance, and a diversification of technology options to fulfil the person-centred model of health service delivery.

Several key issues were raised and discussed in response to these presentations, namely:

- Selection bias could influence the external validity of the results from the two trials presented, as these studies report on the performance of digital adherence technologies among those who opted for them in the first place. Equity analysis will look at who accepted digital adherence technologies and who did not to help assess for selection bias.
- The importance of providing digital adherence technology to those who need it most.
- The accuracy of records from digital adherence technologies (e.g. box opening) as a proxy measure of medication adherence.
- What level of adherence is required to achieve optimal treatment outcomes? How forgiving or unforgiving are TB treatment regimens to the observed adherence patterns?
- When interpreting the degree of adherence, it is relevant to consider the stage of treatment given that the impact of interruptions may differ if they happen at the beginning of treatment rather than the end.
- Up to now there have not been reliable baseline predictors of adherence that could help prioritize who is offered adherence support, including digital technologies. There is therefore still space for further research in this area, including employment of artificial intelligence approaches. It is important that individuals identified at risk of non-adherence are protected from discrimination.
Session 4. Scaling up digital technologies for TB: country experiences

Suvanand Sahu (Stop TB Partnership): spoke about the Partnership’s initiative since 2020 to map digital technologies in use in national TB programmes, as well as emergent digital health tools of relevance for different use cases in TB prevention and care. He presented the various tools to support TB screening and diagnosis from the landscape mapping work in 13 national TB programmes (e.g., computer-aided detection software, digital radiography, molecular tests, AI-based tools using cough sounds), treatment (e.g., digital adherence technologies), prevention (e.g., PREVENT TB app), community engagement (e.g., OnelImpact community-led monitoring app) and programme management (e.g., AI for hotspot mapping and prediction). Countries surveyed all seek to develop an integrated “backbone” that manages information on TB clinical case management as well as aggregate national reporting. Data privacy and sharing of data are often handled informally, without clear policies on data hosting on the cloud versus in-country server. Countries often create tools *de novo* rather than build upon available platforms. A weak information and communication technology infrastructure – especially connectivity and hardware - often limits the full potential of digital health. He concluded that efforts are required to collectively harness the new opportunities for digital health tools that emerged during the COVID-19 pandemic. There is a need to enhance advocacy with key stakeholders to promote the use of digital tools, and there is also a need for partnerships with big technology companies to strengthen infrastructure, undertake rapid review of new tools, and engage the private sector.

Country experiences in the use of diverse digital technologies for TB

India: Raghuram Rao (Ministry of Health and Family Welfare) mentioned that the New Delhi End TB Summit in 2018 proved to be a landmark event towards the elimination of TB in the country. In this meeting, the Prime Minister of India announced targets for ending TB in India by 2025, five years ahead of the global SDG targets for 2030 and described digital technology as the means to “discover, learn, evolve and implement.” Dr Rao described some key recent developments in the digital ecosystem in India and the journey of the TB digital ecosystem, the hallmark of which is the introduction in 2012 of the web-based *Ni-kshay portal*—an online platform for real-time TB patient tracking, care cascade monitoring and programme management. *Ni-kshay* forms a backbone around which services and care elements have been expanding following a patient life cycle approach including data capture on TB screening, diagnosis, treatment, adverse events monitoring, adherence support and follow up, transfer of financial support to patients, patient education and long-term follow-up. The platform has an architecture that is extensible to other public health problems, such as HIV or COVID-19, and is currently integrated with at least 10 systems across the health and other programmes). The vision is to have it forward compatible with evolving technologies *Ni-kshay* has scored impressive utilization volumes: it now contains data from more than 25 million TB diagnostic test results, 12.1 million TB patients, 1.4 million patients on digital adherence support and on US$250 million paid as enablers to TB patients. He also spoke about the diverse eLearning and AI tools used by the National TB Elimination Programme of India and the digital interface for community support to TB patients under the Prime Minister’s TB-free campaign.

Zambia: Patrick Lungu (Ministry of Health) presented YATHU, a patient-level electronic health records system for drug-resistant TB (DR-TB) care built on the online platform using ASP.net and integrated with DHIS2. YATHU is structured to inform patient management and comprehensively meets the programmatic data needs. The National TB and Leprosy
Programme developed YATHU with support from the University Teaching Hospital and Challenge TB in 2018. YATHU has interfaces for patient registration and patient follow-up and the system is accessible to verified users only. It allows ready availability of DR-TB data to all stakeholders and helps with analysis of interim outcomes by treatment regimen and clinical decision making. It also provides an opportunity to extend remote technical assistance to field implementers. YATHU is integrated with DHIS2, automatically generates reports and provides more comprehensive individual patient data. Some operational challenges have hindered the optimal use of YATHU, such as a slow rate of data entry at facility levels, lack of dedicated data entry staff, non-availability of dedicated computers, and unreliable or no internet access in certain facilities.

**Brazil: Kleydson Andrade (PAHO-WHO Country Office, Brazil)** made a presentation on the Brazilian Information System on TB infection, IL-TB. This is a web-based online system that supports documentation through a mobile application of all range of activities for the programmatic management of TB preventive treatment (TPT), such as identifying individuals with TB infection or at high risk of TB disease, notifying those initiated on TPT, and monitoring and evaluation of those on TPT as per the national requirements. This system was piloted in 2 provinces of the country with support from the UNITAID-supported IMPAACT4TB project between 2018 and 2022, and then it has been scaled up across the country. The system has dashboards to monitor the implementation of the TPT and generates alerts to the health system staff about any actions required at the patient level (e.g., missing tests to rule out TB).

**Kenya: Martin Githiomi (Ministry of Health)** shared details about the case-based diagnostic system TIBU LIMS (laboratory information management system). TIBU System was developed in Kenya and piloted in 2012 in 2 regions (over 50 system users). Following the successful pilot, the NTP carried out a national rollout of TIBU, reaching every TB control zone in Kenya by the end of 2013. DS-TB, DR-TB, leprosy and TPT datasets are entirely digitized and case-based. Over 300 users, including donors and implementing partners, can review aggregate data from facilities. The TIBU LIMS module has been developed more recently. One of its key features is that it can draw data from two molecular diagnostic platforms (GeneXpert® and Truenat®), as well as digital X-ray machines equipped with computer-aided detection software (CAD-TB) and relay test results to the clinician via SMS and email. The major benefit of this system is that national diagnostic data on consumption, utilization, diagnosis, and more are easily retrievable for routine analysis and operational research. TIBU LIMS has been developed in-house and is catering to emerging needs of national programme and providers. The major challenges are the lack of linkage to bacteriological culture data from the TB reference laboratory and funding gaps to maintain the ever-expanding cloud resources. Continuous resource mobilization and eventual set-up in the government health data centre is the way forward to address the challenges in funding.

In the discussion that followed the presentations in this session, several key issues were highlighted, namely:

- The need to understand how countries managed to deploy technologies rapidly to respond to the COVID-19 pandemic and what lessons can be learnt from that experience and applied in TB programmes
- What mechanisms are possible to prevent repeated entries for the same individuals in countries without access to unique personal identifiers at point of care.
• Surveillance systems that collect aggregate data on numbers will not help patient management. In contrast, digital case-based surveillance systems can help both in patient management and in generating surveillance data, and therefore the latter systems should be preferred.

• When designing digital systems for case-based surveillance systems, interoperability needs to be ensured so that the datasets can be transferred easily from one system to another. Establishing norms and standards for data collection and storage across the health system may help address interoperability issues.

In the afternoon of Day 2, meeting participants continued their discussions in four moderated groups dedicated to the following subjects:

• Group A - Integrated systems for TB surveillance and care
• Group B - Connected diagnostics for TB
• Group C - Digital adherence support for TB
• Group D - Harnessing evolving technologies to end TB

Day 3 (16 November 2022)

The morning of the last day of the meeting started with reports from the group work held on Day 2. The following were the summary conclusions presented by the rapporteurs of each of the four groups

Group A - Integrated systems for TB surveillance and care

The group drew experience from relevant examples presented during the meeting and from elsewhere. The group acknowledged the increasing intent of countries to have paper-based systems replaced by electronic medical records both for TB surveillance and care. The group advised that before integrating the two systems, the definitions and objectives of surveillance and patient care be specified and that the national context in data governance, overall public health surveillance, health system architecture, and healthcare-seeking behaviour be considered. An integrated system must subscribe to the principles of people-centred and rights-based care. It must be acceptable and serve the purposes of multiple audiences: people accessing care, frontline healthcare facility staff, and decision-makers (subnational, national, global). The major challenge is that setting up such a system and maintaining it will be very resource intensive.

Group B - Connected diagnostics for TB

The group listed some of the major bottlenecks for connected diagnostics, namely country-level restrictions on data sharing, such as requirements for data hosting on in-country servers; access to data; recurring licensing fee for software (especially in donor-funded programmes); limited human resource capacity within the country to maintain and troubleshoot the issues with software platforms; and lack of standards for connectivity. For CAD-TB, the major challenge with connected diagnostics is that most radiography facilities in low- and middle-income countries use analogue X-rays. These bottlenecks can be addressed by the development of an implementation plan template with guidance on a) technology selection which should have evaluation criteria like the inclusion of user inputs, interoperability, and licensing costs linked to hardware and ICT infrastructure maturity clauses, so that countries can select the appropriate tool for their context; b) how to scale up the solution (LIMS, connected diagnostic platform) across the country; c) calculating costs; d) the need to leverage
opportunities brought about by universal health coverage investments and policy efforts to address some of the bottlenecks; e) Quality assurance mechanisms like SLIPTA/SLMTA\(^1\) can be leveraged to drive standardization around connectivity; f) expansion of AI capability beyond the currently recommended CAD-TB use-case, such as to interpret analogue x-ray images and to other health areas beyond TB; g) convening forums where innovators can be familiarized with country requirements.

Solutions to enhance the adoption of LIMS in public and private sectors were reported to be the creation of financial and non-financial incentives for the private sector, easy-to-use digital reporting tools adapted to the context, and remote training for the private sector facilities. The challenges for enhancing adoption include concerns around data sharing and patient privacy. Aggregating data reporting requirements can address this.

Regarding the minimum standards and attributes for connected diagnostics, the group suggested the following: a) ability to feed into facility-level workflows that enable the collection of longitudinal data; b) offline capability with data storage; c) minimum information requirements to be accessible on the diagnostic device without additional costs to health programmes; d) inclusion of data relevant for stock management; and e) linking data into patient tracking software to reduce loss to follow-up.

**Group C - Digital adherence support for TB**

The group concluded that for digital adherence technologies for TB to be scaled up by public and private healthcare providers, the technology needs to be patient-centric, there should be adequate room for local adaptation, strengthening access to infrastructure (network and connectivity), incentives for use, a framework for technical standards and quality assurance to justify costs. The key funding considerations in establishing and scaling up digital adherence technologies for TB in countries are to address funding constraints and adopt a targeted approach, so that patients have the level of support they need. The technology needs to be positioned in a patient-centred treatment support environment along with systems for providing medication, nutritional support, smartphones, psychosocial support, patient education, reporting adverse events, and bidirectional communication.

**Group D - Harnessing evolving technologies to end TB**

The group highlighted several evolving technologies that could address current shortfalls in TB case-finding and early diagnosis, such as predictive modelling, hotspot mapping to improve contact evaluation, AI-based cough and chest sound screening, targeted messages using social media, interconnected health information systems, linking of databases on high-risk populations, chatbots and the internet of things (IoT). Harnessing technologies for patient support systems include interlinking of social support systems and other health services, clinical decision support systems to capture diverse issues such as resistance patterns and dosing, exploring the roles of block-chain in health care, education platforms for patients, community and health professionals, adverse events management, and person-owned medical records. There are several opportunities for governments to support digital innovation: they can establish innovation exchange platforms drawn from the experience in other health programmes or sectors; provide funding through domestic or external sources.

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1 stepwise laboratory quality improvement process towards accreditation / strengthening laboratory management toward accreditation
(including crowdsourcing) for evidence-supported innovations; collaborate with UN and other international agencies and develop appropriate regulatory pathways.

Session 5. Deep dive on digital technologies to strengthen TB surveillance and promote analysis & use of data

Vittoria Crispino, Yury Rogachev (HISP Centre, University of Oslo): introduced the DHIS2 digital environment for TB surveillance. DHIS2 is a web-based, free, open-source software platform that supports aggregate and case-based ("tracker") data collection, data management, and analysis. It is highly configurable to allow tailoring to local needs and every national DHIS2 system is different once configured. The platform architecture and Web API will enable the development of custom applications on top of DHIS2 to address country-specific needs and the development of integrations with other existing systems. This is key for data warehousing. The user organizations fully own and govern their DHIS2 system - server, database, and data. It has a large stakeholder community that includes national bodies, nongovernmental agencies, donors, and international organizations. Since 2017, the HISP Centre at the University of Oslo (UiO) has been collaborating with WHO to create standardized metadata packages for TB surveillance. A demonstration was given of the WHO DHIS2 TB package, explaining its various features.

In the discussion that followed the presentation, key issues highlighted included the following:

- We have heard countries going in different directions when digitizing data for TB surveillance. Is DHIS2 one of the optional products for them to consider? What is the current target market for it?

  In response:
  - DHIS2 is essentially an off-the-shelf solution for implementing a TB digital surveillance system according to WHO requirements. This can be helpful for countries that are transitioning from paper-based to the digital system or want to replace or strengthen their existing digital systems for TB.
  - For countries using or planning to use platforms other than DHIS2, WHO recommendations on data standards may be followed to manage TB data.

- Where are the DHIS2 data stored?

  In response:
  - Data can be stored on cloud or in-country server. If different programmes in a country are using different instances of DHIS2 independently there is technical guidance on how to move, track data, and aggregate DHIS2 data.

- What kind of vulnerability assessments have already been factored into the current version of the package and the overall security of the system?

  In response:
  - DHIS2 follows all the data security requirements that are needed.

- Interest was expressed about the possibility in DHIS2 to use barcodes or QR codes that can be printed and scanned to improve accuracy or reduce manual data entry and transcription errors. Likewise, questions about the type of data (including X-ray images) that can be attached to the patient record in DHIS2.

Natschja Ratanaprayul (WHO/DHI): provided an overview of SMART guidelines that are a part of the digital health initiative of WHO. SMART Guidelines (Standards-based, Machine-
readable, Adaptive, Requirements-based, and Testable) are a comprehensive set of reusable digital health components (e.g., interoperability standards, code libraries, algorithms, technical and operational specifications) that transform the guideline adaptation and implementation process to preserve fidelity and accelerate uptake. SMART Guidelines provide a five-step pathway (Layers 1 to 5) to advance the adoption of best clinical and data practices, even if a country is not yet fully digital. The five layers comprise documentation, procedures, and digital health components to steer guideline localization and implementation through digital systems and promote advanced analytics. They inform guideline developers on how to translate recommendations into specifications and standards that can be integrated into digital systems, and countries on localizing, making interoperable, institutionalizing, and updating digital systems consistent with evidence-based recommendations. SMART Guidelines content is by design software-neutral, formulated for adaptation into whichever software platforms a country has elected to use.

Constantin Corman (WHO/DHI): presented an overview of the Layer 2 (L2) of the digital adaptation kit (DAK) for TB that is under development. There are eight components of the L2 TB DAK. These are: specifying the health interventions (component 1), creating generic personas (component 2), user scenarios (component 3), business processes and workflows (component 4), identifying the core data elements (component 5), decision-support logic (component 6), indicators and performance metrics (component 7), and high-level functional and non-functional requirements (component 8). In his presentation, he outlined how the TB guidelines will be translated into the 8 components of the TB DAK.

In the discussion that followed the presentations, key issues highlighted included the following:

- Who is the intended user of this DAK at the country level?
  In response:
  o The primary audience for DAK include health programme managers, software developers and implementers of digital systems. DAK is expected to be the bridging language between the health programme experts with a vision to bring digital technologies and the technical partner responsible for bringing that vision to life.

- How flexible is the DAK for country-level adaptations?
  In response:
  o DAK is very customizable to the country’s needs.

- Other discussion ensued on the practicalities of how quickly or easily the DAK can be modified to changing clinical guidelines; how information about these products will best be disseminated to countries; how does DAK handle variations in country policies and health system workflows; and views on how to promote the value of DAK to countries so that they use this approach rather than build their own systems from scratch.

Jean-François Saint-Pierre (WHO/DNA): WHO has a mandate (WHO Constitution art. 61-65) to collect data on health and health policy trends and disseminate that information to all stakeholders on time. WHO’s transformation agenda highlighted an urgent need to reduce data fragmentation and increase efficiencies in WHO’s end-to-end data processes. Emphasis was placed on the consolidation of health data and assets for external and internal users and modern technologies, including analytics and visualization methods. Responding to Member States and Programme, Budget, Administration Committee recommendations (EB146/3), the World Health Data Hub has been established to resolve issues related to data fragmentation.
by consolidating WHO’s data repositories, portals and datasets, reducing the data collection burden on countries, supporting country capacity in data and health information systems and also to track WHO’s Global Programme of Work 13 Triple Billion targets and health-related SDGs by providing timely, reliable, and actionable data. The architecture of the data hub and the progress were presented. The latest products from the World Health Data Hub are available at this weblink.

Cicilia Gita Parwati (WHO/ GTB) presented how TB can benefit from collaborating with the World Health Data Hub. She mentioned that in recent years there has been a considerable increase in tools to generate and analyze data. This tends to increase the availability of data and evidence to inform decision-making and programme planning. However, the greater availability of data has not always increased its systematic use and analysis of data for national strategic and operational planning for TB. In 2021, WHO released a compendium of tools that the countries are using or can use to generate, analyse and use data and evidence to support TB decision-making process. In this context, WHO plans to have a single platform where all the relevant TB data can be uploaded by the member countries and stored, and to create sets of dashboards for standardized analysis and visualization within the platform. Standard indicators will be generated to inform programme planning and implementation. To meet this objective, the Global TB Programme will use the World Health Data Hub to create a TB digital platform. This work started in the last quarter of 2021 and by mid-2023 it is planned to create standard data entry forms and visualizations for countries to upload, store and visualize their data to inform programmatic planning.

In the discussion that followed the presentations, key issues highlighted included the following:

• What are the forms of data entry? Would it be primarily manual? Or collected automatically from different sources?
  In response:
  o Multiple data entry is not required, linkages with existing data systems can be established through available data integration tools.
  • Can data from operational or implementation research also be entered on the data hub? If so, how?
  In response:
  o Standardization of indicators from each data source is an important process towards developing a standardized analytical dashboard. Therefore, inclusion of operational or implementation research data would only be possible if research carried out in multiple settings employs standardized indicators that are useful for TB decision making and that can be extracted from the results of the study.
  • Can the country impose any restrictions on the use of data?
  In response:
  o Yes, the country would decide whether to share the access to the TB digital platform for non-published data to entities that are considered appropriate).
  • Other discussion related to the quality assurance of the data and checking their validity before countries upload the data
Marek Lalli (WHO/GTB): outlined the training materials being developed by WHO/GTB through the WHO Academy on the analysis and use of TB surveillance data and the application for TB-specific surveillance developed to promote and strengthen standardized TB data collection, analysis and use for programmatic action. This module uses DHIS2 standardized dashboards to facilitate visualization, analysis, and interpretation of routine TB surveillance data and indicators, with exercises to guide through routine analysis and questions to stimulate interpretation. The course modules encompass an introduction to TB data and surveillance systems; TB notification; TB treatment outcomes; TB/HIV; and drug-resistant TB, followed by a final assessment.

Zubair Asghar Raja (University of Oslo, Pakistan) and Adnan Bashir (HISP Pakistan) presented the surveillance systems catalysing digitization of TB prevention and care in Pakistan and provided details on the progress of adopting DHIS2 in Pakistan. The architecture and data flows of the system were shared. The DHIS2 TB Package being supported by WHO has been customized and piloted. One district from each province has been selected for the pilot phase. Once the feedback is received and enhancements have been incorporated in the package a countrywide rollout of case-based “tracker” module will be initiated. Several integrations are in the pipeline in the public and private sectors, including collaboration with a local provider to enable an AI-based framework for active TB case finding. A Master Facility List is being developed as a backbone for the interoperability of various data systems. Challenges include the non-availability of a unified data format, lack of geographical information and issues with governance and long-term management of the Master Facility List, its hosting, operation, and maintenance.

Session 6. Conclusion and way forwards:

The final session of the meeting started with a discussion among a panel of key stakeholders. The question to the panellists was the following: What should be a basic digital tool package that ALL countries should aim for while continuing to innovate, and how will partners support them in the context of new global commitments? The following key points were made in response to this question

The Global Fund (Nnamdi Nwaneri): Ensuring foundational aspects such as the governance framework for adopting digital technologies are in place. Countries will need to understand and prioritize which available digital tools are most important to the country’s context. Most importantly, countries must work towards having functional and real-time case-based surveillance systems at the basic package level. Under their data strategy initiative, the Global Fund works closely with many partners to ensure that digital tools are available for the countries to adapt.

USAID (Sevim Ahmedov): Echoed the comments made by the Global Fund representative. Given that there are several digital tools already available, and in the pipeline, there is a need to ensure that digital technologies do not do any harm. Therefore, countries need due diligence regarding what tools are appropriate for solving the existing problems and support to adopt them. A basic package for different countries could mean different things to different countries. Digital tools supporting case-based surveillance systems, diagnosis and laboratory-based information systems appear to be priorities.
**FIND (Rigveda Kadam):** Agreed with all that has been said by the previous speakers and felt that a one-size-fits-all approach to defining the basic package may not be appropriate. From the perspective of laboratory informatics, tools that allow the entry of eligible persons into TB care and a rapid adoption of connected digital tools such as CAD-TB and cartridge-based nucleic acid amplification tests can be one of the priorities. But the focus should be on technology selection, addressing gaps in digital data governance and establishing a framework for rapid evaluation and adoption of existing and emerging digital tools and technologies.

**BMGF (Daniel Chin):** Digital systems are no longer optional but essential for programme planning and implementation. Programmes need real-time data on various issues (e.g., gaps in the TB care cascade); therefore, countries need to be supported in adopting digital tools and systems that provide real-time data. Analytical tools such as dashboards that help in data visualization and building human resource capacity, especially those in low- and middle-income countries, to understand and use data for programme planning and implementation are the next most important. Such systems are already feasible in the short run (e.g. TB funding proposals developed by countries in 2023 for Global Fund support). In the longer run countries should aspire to develop digital tools that can map out its priority programmatic gaps.

**University of Oslo (Vittoria Crispino):** Countries have made a lot of progress in adopting DHIS2 in a very short time, and several countries have also understood the importance of digital tools during the COVID-19 pandemic. Prioritizing from the range of available technologies should be based on what is beneficial instead of what is just interesting. Assessing where the countries are with respect to the use of digital tools and what is needed, and developing a stepwise plan for them is the way forward. The focus should be on long-term sustainability and the usefulness of the tools and building the capacity to use the data.

**Stop TB Partnership (Suvanand Sahu):** Globally, the move is towards digitalization, so it is essential to be ahead or at least within the curve. In this context, every country should take a proactive approach to achieve a digital transformation of the TB response. Getting the private sector involved in TB is the next issue to be addressed, given that both the health and non-health private sectors bring a lot of innovation. Lots of learnings will happen from south-south collaboration, and all partners must encourage this. International partners also have a responsibility to help countries address some of the cross-cutting issues such as governance, interoperability, and funding. Learning from the COVID-19 experience, there is a need for making simple real-time data on specific core indicators displayed transparently in the public domain, which can be accessed daily by everyone, including the policy makers.

**UNITAID (Draurio Barreira):** Priority should be on evidence generation on what works and based on that evidence, updating guidance on various digital tools with a more robust recommendation and supporting countries in adopting proven tools. The priority should also be on rapidly adopting tools and technologies that help in case detection so that the impact of COVID-19 on the TB burden can be rapidly reversed. Tools that help treatment, adherence, and prevention are the other priorities. Identifying gaps in technologies and tools and support for closing those gaps will be the priority for UNITAID.
In the discussion following the panel presentations, comments highlighted the importance of collaboration, partnerships, creating a data dashboard for better data visualization and data utilization, enhancing country leadership in digital transformation, and understanding the perspectives of end-users.

**Avinash Kanchar (WHO/GTB)**: delivered the final presentation of the meeting, relating to plans for the forthcoming WHO guidance for the use of digital technologies in tuberculosis prevention and care in 2023. This guidance will link to practical advice on how to implement technologies such as the ones discussed during the consultation that has been provided by WHO in the past, and update and add to it. Different options on how to deliver the guidance are under discussion.

In the **discussion** that followed it was suggested to include information on investments required to achieve the digital transformation in the upcoming WHO guidance. It was suggested that the guidance should cover not only well-known use-cases on surveillance and digital adherence technology but should encompass a broader vision of digital transformation needed to end TB.

**Tereza Kasaeva (Director WHO/GTB)** thanked all participants at the conclusion of the meeting. WHO will closely examine all the new findings, suggestions and experiences shared during this meeting to update its guidance on new game-changing tools and technologies to improve the TB response.
## Annexes

### Annex 1 – Programme

**WHO consultation on digital technologies for tuberculosis**  
14-16 November 2022  
*Centre International de Conférences Genève (CICG)*, Rue de Varembé 9-11, Geneva, Switzerland

<table>
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<th>Day 1 - Chair: Dennis Falzon  Rapporteurs: Inez de Kruijf-Carter, Avinash Kanchar</th>
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<td><strong>Time</strong></td>
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| 13:00 – 13:10 | Opening remarks | Tereza Kasaeva, Director WHO Global TB Programme (WHO/GTB)  
Alain Labrique, Director WHO Department of Digital Health and Innovation (WHO/DHI) |
| 13:10 – 13:15 | Meeting objectives, agenda overview and house rules | Dennis Falzon (WHO/GTB) |
| **Session 1. Digital technologies for TB: current WHO engagements and vision for the near future** |
| 13:15 – 13:30 | WHO vision and recommendations on digital technologies to end TB: a recent history | Dennis Falzon (WHO/GTB) |
| 13:30 – 13:45 | WHO support to strengthen TB surveillance and routine analysis and use of data | Babis Sismanidis (WHO/GTB) |
| 13:45 – 14:00 | The WHO Global Digital Health Strategy and digital governance | Sameer Pujari (WHO/DHI) |
| 14:00 – 14:10 | Discussion | Chair |
| **Session 2. Digital adherence technologies for TB: results of the ASCENT project** |
| 14:10 – 14:30 | Overall ASCENT implementation & transition progress | Kristian van Kalmthout (KNCV) |
| 14:30 – 14:45 | **ASCENT research progress**  
Studies overview, country updates and plan to disseminate results | Degu Dare (KNCV)  
Katherine Fielding (LSHTM) |
| 14:45 – 15:35 | **Interim results from ASCENT sub-studies by ASCENT Research Managers**  
Feasibility and acceptability of digital adherence technologies from the patient perspective | Amare Tadesse (Ethiopia)  
Jason Alacapa (the Philippines)  
Tanyaradzwa Dube (South Africa)  
Andrew Mganga (Tanzania UR)  
Natasha Deyanona (Ukraine) |
<p>| 15:35 – 15:45 | Open discussion |  |
| <strong>Break</strong> |
| 16:00 – 16:30 | National programme perspectives on the significance of the ASCENT project findings for their countries | Representatives of Ministries of Health |
| 16:30 – 16:45 | Programmatic implementation of digitally supported TB treatment and prevention in Europe | Giorgi Kuchukhidze (WHO/EUR) |
| 16:45 – 17:15 | Open discussion &amp; close of Day 1 | Chair |</p>
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<th>Session 3. Digital adherence technologies for TB: new findings and evidence reviews</th>
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<td>9:00-9:05</td>
<td>Recap from Day 1</td>
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<td>9:05-9:20</td>
<td>Systematic review on effectiveness and costs associated with digital adherence technologies to improve adherence to TB treatment</td>
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<td>9:20-9:35</td>
<td>Approach and framework for the evidence review on digital adherence technology implementation</td>
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<td>9:35-9:50</td>
<td>TB MATE study in South Africa on smart pill boxes</td>
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<td>9:50-10:05</td>
<td>Results from clinical trial on medication boxes in China</td>
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<td>Mapping the technology landscape of national TB programmes</td>
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<td>Briefing on Group work (in plenary)</td>
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<td>14:00 – 15:30</td>
<td>Group work on key enablers and challenges for adoption and scaleup of digital tools (ONLY IN-PERSON Participants assigned to each group. Groups will have a moderator and appoint a rapporteur. They will answer questions to be given before the session)</td>
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<td>17:15 – 18:15</td>
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### Day 3 Chair: Anand  Date Rapporteur: Marek Lalli

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| 8:30 – 9:15 | Presentations in plenary  
  Group A, B, C, D (5 min presentation, 5 min discussion) |

#### Session 5. Deep dive on digital technologies to strengthen TB surveillance and promote analysis & use of data

**Strengthening TB surveillance**

<table>
<thead>
<tr>
<th>Time</th>
<th>Topic</th>
<th>Speakers</th>
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| 9:15 – 10:15 | DHIS2 digital environment for TB surveillance  
  Demonstration of WHO DHIS2 TB packages                                           | Vittoria Crispino (HISP Centre, University of Oslo)  
  Yury Rogachev (HISP Centre, University of Oslo) |
| 10:15 – 11:00 | An overview of SMART guidelines  
  Digital adaptation kit for TB (level 2)                                            | Nataschja Nash-Mendez (WHO/DHI)  
  Constantin Corman (WHO DHI) |

**Break**

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<th>Time</th>
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| 11:15 – 12:00 | Promoting analysis and use of data  
  World Health Data Hub  
  Digital platform to support strategic planning | Jean-Francois Saint-Pierre (WHO DNA)  
  Gita Parwati (WHO GTB) |
| 12:00 – 12:30 | a. eLearning module for analysis and use of TB surveillance data  
  b. app for surveillance | Marek Lalli (WHO GTB) |
| 12:30 – 13:00 | Surveillance systems catalysing digitization of TB prevention and care in Pakistan | Zubair Asghar Raja (University of Oslo, Pakistan)  
  Adnan Bashir (HISP Pakistan) |

**Lunch Break**

#### Session 6. Conclusion and way forwards

| Time   | Panel discussion:  
  What should be a basic digital tool package that ALL countries should aim for while continuing to innovate and how will partners support them in the context of new global commitments |
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<tr>
<td>14:00-15:30</td>
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  **Moderator**: Anand DATE  
  • UNITAID  
  • USAID  
  • The Global Fund  
  • BMGF  
  • Stop TB Partnership  
  • FIND  
  • University of Oslo |

**Break**

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<tr>
<td>16:00 – 16:30</td>
<td>WHO guidance for the use of digital technologies in tuberculosis prevention and care – an outline and method of work unto 2023</td>
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</tbody>
</table>
| 16:30-16:45 | Main messages  
  Closing remarks and next steps | Tereza Kasaeva, Director WHO Global TB Programme |
Annex 2 – Participants

1. Jason Alacapa
   ASCENT Project
   Philippines

2. Salome Charalambous Johns
   The Aurum Institute – ASCENT Project
   South Africa

3. Degu Dare
   ASCENT Project
   Netherlands

4. Inez de Kruijf-Carter
   ASCENT Project
   Netherlands

5. Natasha Deyanova
   ASCENT Project
   Ukraine

6. Hoang Nam Do
   Ministry of Health
   Viet Nam

7. Tanya Nicolette Dube
   ASCENT Project
   South Africa

8. Emmanuel Nkiligi
   Ministry of Health
   United Republic of Tanzania

9. Katherine Fielding
   LSHTM – ASCENT Project
   United Kingdom of Great Britain and Northern Ireland

10. Taye Letta Janfa
    Ministry of Health
    Ethiopia

11. Patrick Lunlu
    Ministry of Health
    Zambia

12. Githiomi Martin
    Ministry of Health
    Kenya

13. Andrew Mganga
    ASCENT Project
    United Republic of Tanzania

14. Mustafa Jamal Kazi
    Ministry of Health
    Pakistan

15. Raghuram Rao
    Ministry of Health
    India

16. Amare Tadesse
    ASCENT Project
    Ethiopia

17. Kristian van Kalmthouth
    ASCENT Project
    Netherlands

18. Job van Rest
    ASCENT Project
    Netherlands

19. Ni Wang (virtual)
    Ministry of Health
    China

20. Zhongdan Chen (virtual)
    WHO Country Office

21. Lastone Chitembo
    Zambia

22. Clarissa Blanca Halum
    Philippines

23. Kleydson Alves
    Brazil

24. Johnson John Lyimo
    United Republic of Tanzania

25. Parmar Malik
    India
<table>
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<th>No.</th>
<th>Name</th>
<th>Organization/Position</th>
<th>Country</th>
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<tr>
<td>26</td>
<td>Eunice Omesa</td>
<td>WHO Country Office (cont.)</td>
<td>Kenya</td>
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<td>27</td>
<td>Quang Hieu Vu</td>
<td>WHO Country Office (cont.)</td>
<td>Viet Nam</td>
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<td>28</td>
<td>Jean Louis Abena Foe</td>
<td>WHO Regional Office</td>
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<td>Victor Alegana</td>
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<td>30</td>
<td>Pedro Avedillo (virtual)</td>
<td>WHO Regional Office</td>
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<td>31</td>
<td>Vineet Bhatia</td>
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<td>32</td>
<td>Giorgi Kuchukhidze</td>
<td>WHO Regional Office</td>
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<td>33</td>
<td>Araksya Hohannesyan (virtual)</td>
<td>WHO Regional Office</td>
<td>Denmark</td>
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<td>Martin van den Boom</td>
<td>Regional Office for the Eastern Mediterranean</td>
<td>Egypt</td>
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<td>35</td>
<td>Sevim Ahmedov</td>
<td>USAID</td>
<td>United States of America</td>
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<td>36</td>
<td>Zubair Asghar Raja</td>
<td>DHIS-2</td>
<td>Pakistan</td>
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<td>37</td>
<td>Draurio Barreira Cravo Neto (virtual)</td>
<td>Unitaid</td>
<td>Switzerland</td>
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<td>38</td>
<td>Adnan Bashir</td>
<td>HISP Centre</td>
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<td>39</td>
<td>Adithya Cattamanchi</td>
<td>UCSF</td>
<td>United States of America</td>
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<td>40</td>
<td>Daniel Chin</td>
<td>Bill &amp; Melinda Gates Foundation</td>
<td>United States of America</td>
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<td>41</td>
<td>Vittoria Crispino</td>
<td>DHIS2</td>
<td>Spain</td>
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<td>Anand Date</td>
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<td>Puneet Dewan</td>
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<td>Agnes Dzokoto (virtual)</td>
<td>The Global Fund</td>
<td>Switzerland</td>
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<td>Egwuma Efo</td>
<td>KNCV</td>
<td>Netherlands</td>
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<td>46</td>
<td>Babajide Fawole (virtual)</td>
<td>Unitaid</td>
<td>Switzerland</td>
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<td>Cherise Scott</td>
<td>Unitaid</td>
<td>Switzerland</td>
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<td>48</td>
<td>Jessica Haberer (virtual)</td>
<td>Massachusetts General Hospital</td>
<td>United States of America</td>
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<td>49</td>
<td>Rigveda Kadam</td>
<td>FIND</td>
<td>Switzerland</td>
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<tr>
<td>50</td>
<td>Brian Kaiser (virtual)</td>
<td>Stop TB Partnership</td>
<td>Switzerland</td>
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</tbody>
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Partners (cont.)

51. Amera Khan  
Stop TB Partnership  
Switzerland

52. Muhammad Amir Khan  
CSTF  
Pakistan

53. David Larner  
Adappt LTD  
United Kingdom of Great Britain and Northern Ireland

54. Nnamdi Nwaneri  
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Switzerland

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Switzerland

56. Zhi Zhen Qin  
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Switzerland

57. Yury Rogachev  
DHIS-2  
Norway

58. Suvanand Sahu  
Stop TB Partnership  
Switzerland

59. Srinath Satyanarayana (virtual)  
Public Health Consultant  
India

60. Kevin Schwartzman  
McGill University  
Canada

61. Ramnath Subbaraman  
Tufts University School of Medicine  
United States of America

62. Zelalem Temesgen  
Mayo Clinic  
United States of America

63. Bruce Thomas  
The Arcady Group  
United States of America

64. Mariam Touré  
Unitaid  
Switzerland

65. Vipin Yadav  
Dure Technologies  
Switzerland

66. Kristian van Kalmthouth  
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Netherlands

67. Tereza Kasaeva  
Global TB Programme  
Switzerland

68. Alain Labrière (virtual)  
Digital Health and Innovation  
Switzerland

69. Stephen Mac Feely  
Data and Analytics  
Switzerland

70. Matteo Zignol  
Global TB Programme  
Switzerland

71. Jean-François Saint-Pierre  
Data Exchange  
Switzerland

72. Shada Alsalamah  
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Switzerland

73. Hong Anh Chu (virtual)  
Analytics and Delivery for Impact  
Switzerland

74. Constantin Corman  
Public Digital Health Technology  
Switzerland
WHO headquarters (cont.)

75. Dennis Falzon  
Global TB Programme  
Switzerland

76. Avinash Kanchan  
Global TB Programme  
Switzerland

77. Marek Lalli  
Global TB Programme  
Switzerland

78. Corinne Merle  
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Switzerland

79. Fuad Mirzayev  
Global TB Programme  
Switzerland

80. Peter Nguhiu  
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Switzerland

81. Linh Nguyen  
Global TB Programme  
Switzerland

82. Natschja Ratanaprayul Nash-Mendez  
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83. Liana Oganezova  
Global TB Programme  
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84. Cicilia Parwati  
Global TB Programme  
Switzerland

85. Debora Pedrazzoli  
Global TB Programme  
Switzerland

86. Sameer Pujari (virtual)  
Digital Health and Innovation  
Switzerland

87. Charalampos (Babis) Sismanidis  
Global TB Programme  
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88. Vanessa Veronese  
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Switzerland
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Web site: www.who.int/tb