Costs of Digital Adherence Technologies for Tuberculosis Treatment Support, 2018–2021

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Digital adherence technologies are increasingly used to support tuberculosis (TB) treatment adherence. Using microcosting, we estimated healthcare system costs (in 2022 US dollars) of 2 digital adherence technologies, 99DOTS medication sleeves and video-observed therapy (VOT), implemented in demonstration projects during 2018–2021. We also obtained cost estimates for standard directly observed therapy (DOT). Estimated per-person costs of 99DOTS for drug-sensitive TB were $98 in Bangladesh (n = 719), $119 in the Philippines (n = 396), and $174 in Tanzania (n = 976). Estimated per-person costs of VOT were $1,154 in Haiti (87 drug-sensitive), $304 in Moldova (173 drug-sensitive), $452 in Moldova (135 drug-resistant), and $661 in the Philippines (110 drug-resistant). 99DOTS costs may be similar to or less expensive than standard DOT. VOT is more expensive, although in some settings, labor cost offsets or economies of scale may yield savings. 99DOTS and VOT may yield savings to local programs if donors cover infrastructure costs.

As part of the mission to cure and ultimately eliminate tuberculosis (TB), maintaining treatment adherence poses a substantial barrier (*1*). Persons with TB must complete multidrug regimens typically lasting ≥6 months. Even small lapses in adherence can be associated with poorer treatment outcomes, including relapse with the potential for further transmission (*2*). TB prevention and care programs have often sought to improve adherence, and hence treatment outcomes, by using directly observed therapy (DOT) (*3*,*4*). However, healthcare system barriers (mostly resource limitations), coupled with stigma, loss of autonomy, and the heavy burden of DOT clinic visits, can result in subpar outcomes and adherence that may not exceed that of self-administered treatment (*5*–*8*). Those limitations have led the World Health Organization (WHO) to recommend community or home-based DOT over healthcare facility–based DOT or unsupervised treatment (*4*).

WHO defines a DOT provider as any person who observes the person with TB taking their medications in real time (*4*). By leveraging current advances in mobile technologies, person-centered treatment observation can be achieved by digital adherence technologies (DATs) such as medication sleeves, smart pill boxes, and video-supported therapy. Moreover, real-time digital adherence information offers the possibility of tailoring treatment support to individual needs. However, before TB programs adopt those technologies as a central strategy for treatment support, evidence for their effectiveness must be robust. Demonstration projects highlighting feasibility and acceptability of DATs for TB treatment support provide substantial evidence; to date, evidence is more limited for clinical outcomes with use of DATs than for other forms of treatment observation or self-administered treatment (*9*–*11*). In principle, DATs can enable expansion of TB treatment supervision and support while reducing the burden on persons with TB and their providers.

Information about the cost to TB programs of those technologies and their real-world cost-effectiveness comes largely from pilot and modeling studies (*11*,*12*). To estimate the cost of 2 DATs currently recommended for use by WHO (*4*), we used data from

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implementation studies in Bangladesh, Haiti, Moldova, the Philippines, and Tanzania. Each demonstration project participating in this study received local institutional ethics review board approval.

Methods

Study Design and Tools

Our multicountry cost analysis reflects DAT implementation projects funded by TB REACH Wave 6 (*13*). Our goal was to estimate capital and recurrent costs of DATs. We developed questionnaires and measurement tools to describe the current standard of care (without DATs) for treatment of drug-susceptible TB (DS-TB) and drug-resistant TB (DR-TB); document how the DATs used in each project were integrated into the local standard of care and what practice changes resulted from their introduction; and capture all cost components of the DAT used during each project, including all related interventions and practice changes. Participating programs were given a series of cost analysis questionnaires, available online (*14*) and were trained in their use via webinars. Our report is limited to cost analyses and does not address cost-effectiveness. During execution of each project, we collected data prospectively.

Study Populations

During 2018–2021, we enrolled eligible adolescents and adults receiving treatment for DS-TB and DR-TB in DAT implementation projects in Bangladesh, Haiti, Moldova, the Philippines, and Tanzania (Table 1). The projects were either 99DOTS (a technology-enabled supplement to enhanced DOT (https://www.99dots.org/About.html) medication sleeves or video-observed therapy (VOT; also referred to as video-supported therapy).

Cost Analyses

We performed a combination of bottom-up and top-down microcosting for 6 TB REACH (https://tbreach.org) DAT implementation projects. Seven other implementation projects pursued separate costing analyses, some of which have been published elsewhere (e.g., the Ugandan project [*15*]). Bottom-up costing applied to most cost components, but top-down microcosting incorporated total amounts spent for DAT platform/infrastructure, systems/data management and technical support, and training activities. Bottom-up microcosting involves a detailed enumeration of cost component data points obtained from the service provider to estimate unit costs (*16*,*17*). Top-down microcosting uses total costs for relevant elements and then prorates them to calculate unit costs (e.g., per patient treated, per service delivered) (*18*,*19*).

We conducted our analysis from the healthcare system perspective; hence, we did not tabulate costs borne by patients and their families. All costs were converted to 2022 US dollars by using the respective countries' inflation and exchange rates from the World Bank (*20*,*21*). Costs reflected project expenses reported by staff and were grouped into 2 categories: fixed and variable. Variable costs fell into 7 categories: 1) phones and accessories; 2) systems/data management; 3) mobile data use; 4) adherence monitoring by healthcare workers (HCWs) using the DAT platform; 5) HCW escalation/intervention in cases of nonadherence; 6) trainers; and 7) trainees. Two additional variable cost categories were specific to 99DOTS: 1) printing and shipping of medication sleeves, and 2) medication preparation (in case medication blister packs were not packaged within 99DOTS sleeves by the supplier). Fixed costs were those of the DAT platform and required infrastructure (Appendix, https://wwwnc.cdc.gov/EID/article/30/1/23-0427-App1.pdf).

For each project, we estimated total costs and then prorated them per person treated for TB. Because certain fixed costs (e.g., acquisition of the relevant platforms and computing infrastructure) can be substantial, we performed scenario analyses in which the DAT was scaled up to support more persons during treatment. In those scenarios, most variable costs remained unchanged, but we annuitized fixed technology costs as well as computer and phone purchases for HCWs and patients on the basis of a 5-year lifespan. We also explored scenarios in which fixed technology/platform introduction and maintenance costs would be shared across expanded user numbers (i.e., 2× study population, 5× study population, 10× study population, and 100× study population) while maintaining the same variable costs as previously estimated.

To situate the DAT costs relative to the local standard of care; we evaluated per-person costs for DATs compared with in-person DOT, accounting for each study setting (i.e., duration of treatment and salary/wages of the persons observing treatment). We supplemented this analysis by considering DOT costs from the existing literature. To capture the patient volumes at which DAT scale-up might become cost saving, we also performed a threshold analysis.

An additional scenario analysis accounted for the high fixed up-front costs, which can pose a substantial barrier to DAT adoption. In that scenario analysis, we assumed that the costs were covered separately by international donor funds. Thus, we excluded them from the analysis, which was therefore restricted to variable costs borne by the local TB program, including computer and phone purchases for HCWs and patients. We then compared those estimates with the cost estimates for DOT.

Results

During 2018–2021, the three 99DOTS projects enrolled a total of 2,091 patients: 719 in Bangladesh, 396 in the Philippines and 976 in Tanzania. During the same period, the 3 VOT projects enrolled a total of 505 patients: 87 in Haiti, 308 in Moldova, and 110 in the Philippines (Tables 1, 2; Appendix Tables 2–4, 6–9).

99DOTS

The estimated total costs of 99DOTS in the 3 implementation projects were $70,756 overall and $98 per person treated for DS-TB in Bangladesh, $47,074 overall and $119 per person in the Philippines, and $169,536 overall and $174 per person in Tanzania. Variable costs accounted for 79% of the total in Bangladesh, 70% in the Philippines, and 94% in Tanzania (Appendix Tables 3, 5, 6).

The main cost drivers for 99DOTS varied across project sites. Key components included adherence monitoring by personnel in Bangladesh (25% of costs), platform and infrastructure in the Philippines (29%), and systems/data management in Tanzania (34%).

For scenario analyses, we evaluated variation in per-person costs if 99DOTS were potentially scaled to larger numbers of persons receiving TB treatment and of their providers, while maintaining the same total fixed costs and the same variable costs per patient. When the number of persons served by the platform was increased 100-fold, we estimated a 39% decrease in cost per patient to $60 in Bangladesh, a 30% decrease to $83 in the Philippines, and an 8% decrease to $160 in Tanzania (Figure 1). In all scenario analyses, the most influential cost components remained the same (they all belonged to the variable cost category).

VOT

For the project in Haiti (DS-TB), estimated overall costs for VOT were $100,436 and costs per person treated were $1,154; for Moldova (all TB patients), $114,336 and $372; and for the Philippines (DR-TB),

Table 1. Implementation projects and participants in study of costs of digital adherence technologies for tuberculosis treatment support*

Country	DAT	Organization	Project description	Participants
Bangladesh	99DOTS†	icddr,b	Implementation of 99DOTS in private sector TB screening and treatment centers established by icddr,b under its social enterprise model in Dhaka	719 adults with DS-TB (mean age 34 y, SD 27) enrolled in the project, April 2019–July 2020.
Philippines	99DOTS	KNCV	A project to assess 99DOTS use in the private sector in the Philippines, where data suggest that 50% of patients in the country seek care	396 adults (>15 y) with DS-TB enrolled on 99DOTS at 3 private clinics based in metro Manila area, December 2018–June 2020.
Tanzania	99DOTS	KNCV	The project involved mining communities in Tanzania in 4 rural districts using 99DOTS with SMS-targeted educational messages and reminders. Patient dosing histories were used for counseling and for differentiated care (more intensive patient management)	976 adult miners (>15 y) with DS-TB from 11 public health facilities recruited at treatment initiation or during medication refill. 22 DOT nurses and 11 community health workers were engaged in the project, February 2019–June 2020.
Haiti	VOT	Health through Walls, Inc.	A project using VOT to improve TB treatment adherence and outcomes for current and former prisoners in Haiti	87 incarcerated persons with DS-TB enrolled in the project, February 2019–February 2020. The project used a commercial VOT platform.
The Philippines	VOT	Hermano (San) Miguel Febres Cordero Medical Education Foundation, Inc	A pilot study to determine feasibility and acceptability of VOT in a high-burden, resource constrained DR-TB clinic in the Philippines, where smartphone penetration is moderate and growing	110 adolescents and adults (>13 y) with DR-TB enrolled to use VOT at 6 DR-TB clinics. Everyone received a smartphone with the VOT application pre-installed and with SIM cards, December 2018–June 2021. The project used a commercial VOT platform.
Moldova	VOT	Centre for Health Policies and Studies	A pilot project to scale up a locally developed VOT application	173 adults with DS-TB and 135 adults with DR-TB enrolled on a locally developed VOT platform, April 2020–June 2021.

*Numbers indicate participants in the costing exercise; the overall parent study might have had more participants. CHW, community health worker; DAT, digital adherence technology; DR-TB, drug-resistant TB; DS-TB, drug-susceptible TB; KNCV, Koninklijke Nederlandse Centrale Vereniging tot bestrijding der Tuberculose; TB, tuberculosis; VOT, video-observed therapy; VST, video-supported therapy; SMS,short message service.
†https://www.99dots.org.

Table 2. Costs of digital adherence technologies for tuberculosis treatment support determined in study of costs of digital adherence technologies for tuberculosis treatment support*

	Variable costs, US$		Fixed costs, US$		Total costs, US$	
Adherence technology	Variable overall	Variable per patient	Fixed overall	Fixed per patient	Total overall	Total per patient
Observed project costs						
99DOTS†						
Bangladesh, n = 71	55,985	78	14,772	21	70,756	98
The Philippines, n = 396	33,173	84	13,901	35	47,074	119
Tanzania, n = 976	159,028	163	10,509	11	169,536	174
VOT						
Haiti, n = 87	69,287	796	31,149	358	100,436	1,154
Moldova, DS-TB, n = 173	34,248	198	18,429	107	52,677	304
Moldova DR-TB, n = 135	40,088	293	21,571	160	61,659	452
Moldova all TB, n = 308	74,336	242	40,000	130	114,336	372
The Philippines, n = 110	45,330	412	27,327	248	72,656	661
Project costs annuitized over the 5-y life span of servers and phones						
99DOTS						
Bangladesh, n = 719		60		21		81
The Philippines, n = 396		83		8.84		92
Tanzania, n = 976		160		3.61		163
VOT						
Haiti, n = 87		702		358		1,060
Moldova DS-TB, n = 173		151		21		172
Moldova DR-TB, n = 135		222		32		254
Moldova All TB, n = 308		185		26		211
The Philippines, n = 110		247		248		495

*DR-TB, drug-resistant TB; DS-TB, drug-susceptible TB; TB, tuberculosis; VOT, video-observed treatment.
†https://www.99dots.org.

$72,656 and $661. Variable costs accounted for 69% of the total in Haiti (DS-TB), 65% in Moldova (all TB patients), and 62%, in the Philippines (DR-TB) (Appendix Tables 6–8).

The largest cost component in Haiti was associated with systems/data management and technical support, which together accounted for 54% of the total. VOT platform and infrastructure accounted for 35% of the total cost in Moldova and 38% in the Philippines.

For the scenario analysis, when the number of persons served by the same platform was increased 100-fold, we estimated a 31% decrease in cost with per-person costs falling to $800 in Haiti (DS-TB), 12% falling to $185 in Moldova (all TB patients), and 50% falling to $151 in the Philippines (DR-TB) (Figure 2). In that scenario, the largest cost component in Haiti (DS-TB) remained systems/data management and technical support at 91%; adherence monitoring then accounted for 55% of the total per patient cost in Moldova (all TB patients) and 88% in the Philippines.

99DOTS Versus DOT

The 99DOTS projects were conducted in settings in which TB treatment is ordinarily observed by health facility workers, community health workers, or family members. Program personnel estimated that 30% of patients would continue traditional DOT after the introduction of 99DOTS in Bangladesh, 20% in the Philippines, and 0 in Tanzania. Such persons included those receiving TB retreatment, persons without access to a mobile phone, persons residing outside the clinic's catchment area, hospitalized patients, persons with extrapulmonary TB receiving ≥12-month treatment regimens, and persons unwilling to provide consent. From the Tanzania healthcare system perspective, DOT itself does not imply healthcare system costs, and hence DOT costs to the healthcare system are not offset by use of 99DOTS because treatment support is ordinarily provided (unpaid) by family members.

In a threshold analysis, we explored the patient volumes required for 99DOTS to be cost saving when compared with DOT. In Bangladesh, when we used study DOT cost estimates, 99DOTS was associated with a $7 increase per patient enrolled; when we used DOT costs published elsewhere, the incremental cost was $45 (*22*). We estimated that an increase of >47% in patient volumes from the study population would render 99DOTS cost saving. In the Philippines, 99DOTS was cost saving with existing patient volumes according to study DOT cost estimates and those published elsewhere (*23*). In Tanzania, there was no possibility of healthcare system cost savings with 99DOTS compared with DOT because DOT relied on family members at no cost to the healthcare system.

For the scenario in which fixed costs are paid by donors, 99DOTS was cost saving in Bangladesh and the Philippines. In that scenario, TB programs would be able to support treatment for $60 per patient by using 99DOTS compared with $74 per patient by using DOT in Bangladesh, $83 compared with $176 in the Philippines, and $160 compared with $0 per patient in Tanzania.

VOT versus DOT

Program personnel estimated that 15% of persons treated for TB would remain on traditional DOT after the implementation of VOT in Haiti, 10% in Moldova, and 50% in the Philippines (Table 3). Use of VOT in Haiti was associated with $646 additional cost per patient compared with study DOT cost estimates and $1,011 compared with published DOT cost estimates (*25*). In Moldova, VOT was cost-saving with existing patient volumes according to our own DOT cost estimates; 77% of the DS-TB and 75% of the DR-TB study populations actually enrolled would have been sufficient to generate cost savings in Moldova. In Bangladesh and the Philippines, VOT costs per patient exceeded those for DOT even with all fixed costs excluded, meaning that expanding the number of patients covered by VOT (i.e., economies of scale for fixed costs) could not result in savings.

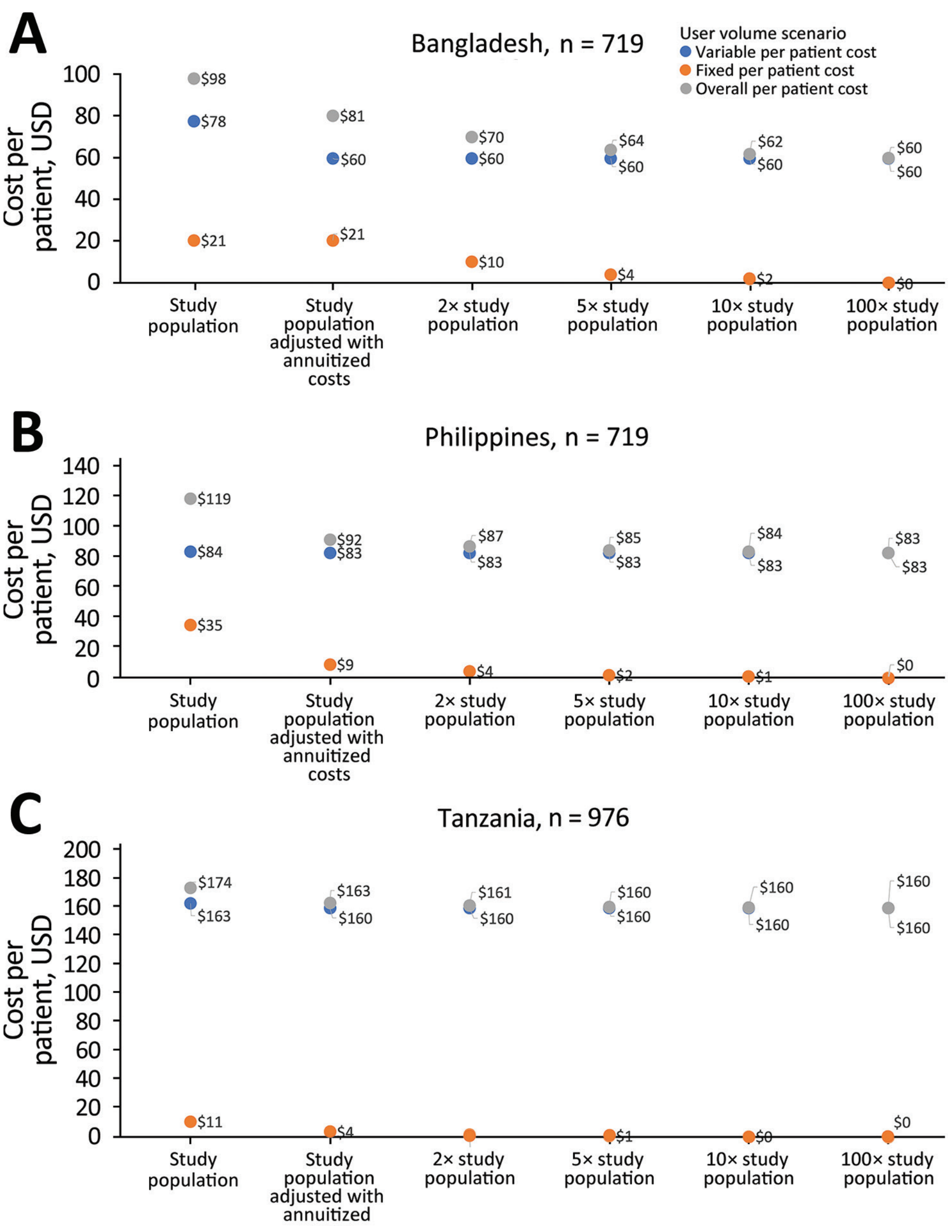

Figure 1. Directly observed tuberculosis therapy scale-up scenario analysis for 3 countries: A) Bangladesh; B) the Philippines; C) Tanzania. In each scenario, fixed technology/platform introduction and maintenance costs are shared across expanded user numbers (i.e., 2× study population, 5× study population, 10× study population, and 100× study population) while maintaining the same variable costs.

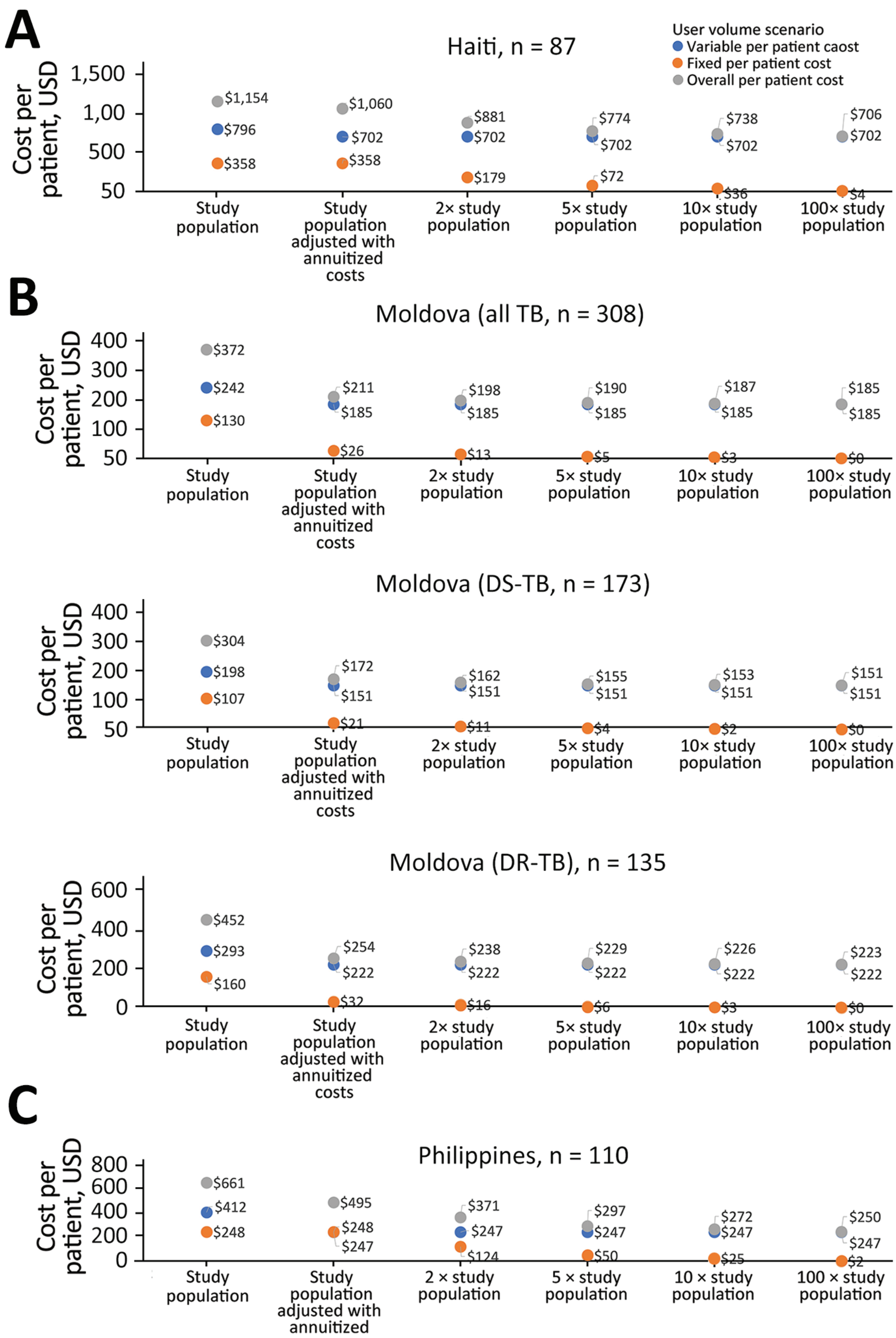

Figure 2. Video-observed tuberculosis therapy scale-up scenario analysis for 3 countries: A) Haiti; B) Moldova; C) the Philippines. In each scenario, fixed technology/platform introduction and maintenance costs are shared across expanded user numbers (i.e., 2× study population, 5× study population, 10× study population, and 100× study population) while maintaining the same variable costs. All TB, all TB patients; DR-TB, drug-resistant TB; DS-TB, drug-susceptible TB; TB, tuberculosis.

For the scenario in which fixed costs are covered by donors, VOT was cost saving in Moldova but not in Haiti or the Philippines. In that scenario, TB programs would be able to support treatment with VOT for $702 per patient compared with $414 per patient with DOT in Haiti, $151 compared with $336 in Moldova (DS-TB), $222 compared with $504 in Moldova (DR-TB), $185 compared with $427 in Moldova (all TB patients), and $247 compared with $17 per patient in the Philippines.

Discussion

Our cost analysis for 2 DATS covered a wide range of settings with diverse populations, socioeconomic conditions, and TB epidemiology. Implementation costs, particularly infrastructure and training costs, were substantial when limited to a small number of persons with TB. However, if the DAT programs are scaled up to cover larger numbers of persons, the healthcare system cost per treatment course would fall and could become less expensive than paid in-person DOT.

The same infrastructure can be stretched only so far; a better knowledge of its capacity will be essential for understanding cost and budgetary effects of DAT expansion. Moving forward, it will also be useful to account for potential cost savings to the healthcare system, to the extent that in-person DOT is reduced and especially for potential cost savings to persons and families affected by TB.

Among the strengths of our analysis are a diversity of real-world settings, reflective of those in which TB care is provided, and the use of carefully gathered microcosting data. We explicitly considered scenarios in which user volume could be expanded to better harness the necessary technical infrastructure. However, the numbers of persons with TB included in these projects varied, and the project settings were not always representative of the available resources and infrastructure in some places where persons with TB obtain care. According to questionnaire responses from local project personnel, DOT visits were substantially longer in the Philippines and Bangladesh than at the other project sites. Nonetheless, those data provide relevant insights for managers and policy makers considering adding those technologies to their TB treatment programs.

We did not evaluate effectiveness of the DATs, which has been addressed in other related publications; an analysis of the feasibility and acceptability of DATs in the TB REACH projects is forthcoming (*26*). Limitations of the technologies themselves have been recognized: for example, messages received or not received by the 99DOTS platform do not necessarily equate with medication ingestion or lack thereof (*27*,*28*). Hence, direct comparisons of DAT and DOT costs are only appropriate to the extent that clinical outcomes with the DAT in question are similar to or better than standard care; we explicitly did not address that point in our analysis. Our study considered only economies of scale resulting from sharing of fixed infrastructure and equipment costs by more users. We did not have specific information as to how variable costs (e.g., HCW time, phones, and data charges) might fall with increased user numbers (e.g., greater HCW efficiency, discounted phones, and data with larger bulk purchasing). Clearly, any reductions in variable costs at scale would be relevant to providers and payers.

Of note, we did not evaluate costs or savings for patients and family members with regard to constraints such as missed work hours or childcare needs, which may be mitigated when in-person DOT is replaced by digital treatment support. Other studies have highlighted the value of such savings in the DAT context (*29*,*30*).

Among the limitations to our comparison of DATs with DOT, the total estimated cost for DOT was

Table 3. Digital adherence technologies compared with directly observed therapy costs*

Cost	99DOTS sites, US$: Bangladesh, healthcare facility	99DOTS sites, US$: Philippines, health care facility	99DOTS sites, US$: Tanzania, home	VOT sites, US$: Haiti, prison	VOT sites, US$: Moldova, health facility: DS-TB	VOT sites, US$: Moldova, health facility: DR-TB	VOT sites, US$: Moldova, health facility: All TB	VOT sites, US$: Philippines, healthcare facility or home
Crude estimate for DOT cost for the standard of care derived from the costing tool								
Hourly wage of person offering DOT support	0.83	1.40	0.00	4.60	11.20	11.20	11.20	2.88
Duration of DOT visit, min	45	45	0	45	15	15	15	2
Total per patient cost								
DOT cost from study data	74	176	0	414	336	504	427	17
DOT cost from the literature	36 (*22*)	155 (*23*)	89 (*24*)	49 (*25*)				166 (*23*)
Annuitized cost of DAT	81	92	163	1,060	172	254	211	495
Variable DAT costs only	60	83	160	702	151	222	185	247
Incremental per patient cost for the DAT versus standard of care								
Study data as comparator†	7	–84	163	646	–164	–250	–216	478
Prior published data as comparator‡	45	–63	74	1,011	–	–	–	329
Incremental per patient cost for the DAT using variable costs only versus standard of care, assuming fixed costs are already sunk								
Study data as comparator†	–14	–93	160	288	–185	–282	–242	230
Prior published data as comparator‡	24	–72	71	653	–	–	–	81

*DAT, digital adherence technologies; DOT, directly observed therapy; –, no prior published data available for comparison.
†Negative incremental costs indicate savings for the DAT relative to standard of care.
‡There is no available literature documenting the cost of DOT in Moldova; therefore, we did not calculate incremental costs when published literature was the comparator.

based on the reported staff time cost per DOT visit multiplied by the number of DOT visits expected for a complete course of treatment (perfect attendance). However, for 99DOTS and VOT, we included only the costs of the actual calls made and videos sent. On the other hand, we had explicit microcosting information, which enabled us to include the cost of escalation (additional phone calls and home visits) in the case of suboptimal adherence detected with the DATs. We did not have such granular data available for escalation costs in the event of suboptimal adherence during DOT. Similarly, we did not include DOT training costs because we did not have data for those.

The high costs of DATs, especially VOT, are driven largely by up-front infrastructure costs such as computing equipment and phones, initial configuration, and software licensing (Appendix Table 3). For Haiti and Moldova, where the cost of purchasing phones accounted for a substantial portion of the per patient cost, the loan of phones to patients or their use of personal phones would drastically lower the cost of implementing VOT. The per-patient cost was notably higher in Haiti because of higher hardware cost at the beginning of the project; there was a learning curve when evaluating whether tablets or phones were best suited for the intervention.

Asynchronous VOT offsets some recurrent costs associated with synchronous VOT and improves flexibility by allowing persons with TB to record medication ingestion within an agreed range of time, even if they did not have internet access at that moment (*31*). Similarly, the use of compressed video files can lower data-use costs. Less worker time is needed if the recordings are reviewed at higher playback speed or if computer-assisted recognition of pill swallowing is used (*32*; J.N. Sekandi, unpub. data, https://doi.org/10.2139/ssrn.4074672). However, those adaptations may not be sufficient to make VOT easily accessible to TB programs in low- and lower middle-income countries. Our scenario analysis suggests that the initial capital investment would have to be covered by donor funds for this technology to become cost saving to local TB programs in these settings.

Global DAT initiatives for TB are addressing the infrastructure cost burden by improving market access, procurement mechanisms, and supply chains (*33*). Our study complements this work by carefully documenting capital and operating expenditures, allowing for better planning and decisions by TB treatment programs (*34*). Our cost estimates for 99DOTS are similar to those from other TB programs that have used this technology (*15*,*35*). A recent study from the United States estimated that VOT was less expensive than in-person DOT provided by healthcare staff (*29*) for both the healthcare system and for persons with TB and their families. The extent that DATs offload HCWs from in-person observation will reduce their net cost.

However, local factors also further shape overall costs, such as the cost of internet and SMS (short message service), the DAT and platform used, specific infrastructure used and patient population served, labor costs, varying nature of services, and treatment duration. Barriers beyond internet connectivity and infrastructure include restricted availability, accessibility, and affordability of some technologies for persons in resource-limited areas and, similarly, the availability and affordability of technical personnel needed to support the TB clinics (*26*,*36*). Hence, real-world cost, effectiveness, and implementation data from high TB-incidence, lower-income settings will remain paramount.

In conclusion, advances in the usability and acceptability of DATs, coupled with widespread internet access and mobile phone use, make them viable tools for person-centered adherence support. However, economic evaluations are limited to date. Our analysis suggests that 99DOTS may be affordable to TB programs in diverse settings, particularly if used at scale. VOT appears less affordable for lower-income countries, although costs for both technologies could be reduced if the same infrastructure and hardware could support more patients, and both technologies would be cost saving should their fixed cost be covered by international donor funds. Our work is a step toward future cost-effectiveness analysis of DATs as more clinical outcome data become available.

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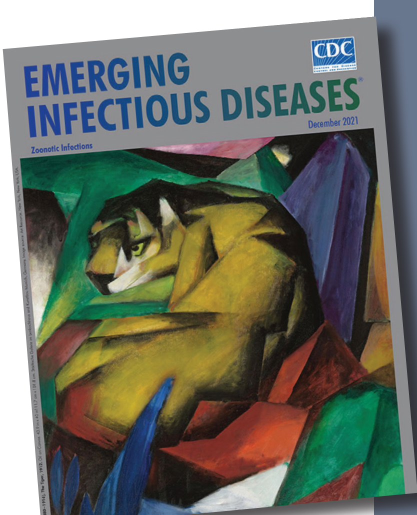

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etymologia revisited

Trichinella spiralis

[tri kuh neh′ luh spr a′ luhs]

Trichinella is derived from the Greek words *trichos* (hair) and *ella* (diminutive); *spiralis* means spiral. In 1835, Richard Owen (1804–1892) and James Paget (1814–1899) described a spiral worm (*Trichina spiralis*)–lined sandy diaphragm of a cadaver. In 1895, Alcide Raillet (1852–1930) renamed it as *Trichinella spiralis* because *Trichina* was attributed to an insect in 1830. In 1859, Rudolf Virchow (1821–1902) described the life cycle. The genus includes many distinct species, several genotypes, and encapsulated and nonencapsulated clades based on the presence/absence of a collagen capsule.

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Costs of Digital Adherence Technologies for Tuberculosis Treatment Support, 2018–2021

Appendix

99DOTS tool and data

Appendix Table 1. Costing tool - 99DOTS

Cost components	Details/Formula *
Project and respondent information	
1. Name of the project	Text
2. Country	Text
3. Name of respondent	Text
4. Position of respondent	Text
5. e-mail of respondent	Text
6. Phone	Text
7. Local currency used in the country	Text
8. Date the questionnaire was filled	YYYY - MM - DD
9. Was anything donated to the project? (e.g., equipment, technical support, training sessions offered as donations, etc.)	Yes, No
10. List detailed items and services that were donated to the project	Text
Population	
I. Number of patients who used 99DOTS during the project	N
a) Phone and accessories	For patients
A1. Number of phones that were purchased	N
A2. Unit cost of phone purchased	$
A3. Number of SIM cards that were purchased	N
A4. Unit cost of SIM card	$
A5. Number of charger or solar batteries that were purchased	N
A6. Unit cost of charger or solar batteries	$
A7. Number of phone lines provided with airtime	N
A8. Total cost for airtime per phone line for the entire duration of the project	$
A9. Total cost of phones (includes phone, SIM card and airtime)	(A1*A2) + (A3*A4) + (A5*A6) + (A7*A8)
Per patient cost for phone and accessories	A9/I
b) Platform / infrastructure costs	
B1. Initial configuration/customization costs (setting up phonelines and or platform at sites)	$
B2. Type of configuration (portable, toll-free or SMS)	Text
B3. Total fixed cost of renting toll free phone lines / SMS line or any other system used to support 99DOTS platform for the entire duration of the project	$
Per patient fixed cost of the platform/infrastructure	(B1 + B3)/I
c) Medication sleeves	
C1. Total cost of 99DOTS medication sleeve printing (including secondary packaging, labels, etc.)	$
C2. Total cost for shipping of 99DOTS medication sleeves (including customs, etc.)	$
Per patient cost for medication sleeves	(C1+C2)/I
d) Medication Preparation	
D1. Typical amount of time to wrap and prepare one medication medication sleeve (in minutes)	Minutes
D2. Type of staff wrapping medication	Job Category
D3. Wage of staff (per hour)	$
D4. Cost of labor for wrapping per medication sleeve (Total time for wrapping an medication sleeve)	D1*D3/60

Cost components	Details/Formula *
D5. Number of medication sleeves required per patient for the entire duration of treatment	N
Per patient preparation cost for entire duration of treatment	D4*D5
e) 99DOTS Calls/SMS costs	
E1. Average number of calls/SMS made by a patient to 99DOTS during the entire duration of treatment	N
E2. Amount the project paid per call/SMS made by a patient to 99DOTS	$
E3. Per patient call/SMS to 99DOTS cost for entire duration of treatment	E1*E2
E4. Average number (per patient) of 99DOTS reminder/education SMS sent by the system for missed doses	N
E5. cost the project has to pay per 99DOTS system SMS	$
E6. per patient cost of 99DOTS adherence reminders for the entire duration of treatment	E4*E5
Total per patient cost (TO AND FROM) 99DOTS system call/SMS for entire duration of treatment	E3 + E6
f) Adherence monitoring by HCW using 99DOTS platform	
F1. Type of HCW who does adherence monitoring using 99DOTS platform	Job Category
F2. HCW wage (per hour)	$
F3. Typical amount of time (in min) spent by HCW monitoring adherence on the platform per patient (duration of project)	N
Per patient cost of 99DOTS adherence monitoring	F3*F2/60
g) Systems, Data management and technical support	
G1. Amount spent for staff working on data management for 99DOTS platform (salaries paid for support of DAT platform)	$
G2. Number of days that technical support was provided, or number of times specific technical services were provided (beyond initial setup)	N
G3. Cost per day or per activity reported in G2	$
G4. Total cost of technical support for 99DOTS platform	G2*G3
G5. Amount paid for health facility hardware (laptops, desktop, or tablet computer to track adherence)	$
G6. Payments made for monthly plans for technical services such as data plans and phone plans for HCW and health facility	$
Per patient cost for Systems, Data management and technical support	(G1 + G4 + G5 + G6)/I
h) Escalation in case of non-adherence and HCW response	(improve adherence)
Escalation related phone calls:	
H1. Number of patients who required follow up by phone as part of adherence escalation procedure	N
H2. Average number of phone calls made by HCW per patient (for entire duration of the project)	N
H3. Average HCW time per call (in minutes) required to speak to a patient who requires adherence follow up	minutes
H4. Total time (in minutes) spent by HCW with patients on a phone for adherence follow up	H1*H2*H3
H5. Type of HCW who usually makes phone calls	Job Category
H6. Average HCW wage (per hour)	$
H7. Additional fees associated with phone call follow up (per call)	$
H8. Total cost for Phone calls	(H4*H6/60min) + (H1*H2*H7)
Escalation related Home Visits:	
H9. Number of patients who required a home visit as part of escalation procedure	N
H10.Average number of home visits per individual who requires home visits	N
H11.Amount of time per visit (including travel)	minutes
H12. Total time (in minutes) spent by HCW on home visits for patients who required adherence follow up	H9*H10*H11
H13.Type of HCW doing home visit	Job Category
H14.HCW wage (per hour)	$
H15.Additional costs for HCW per visit (e.g., Travel/transport costs, incentives, etc.)	$
H16. Total cost for home visits	(H12*H14/60) + (H9*H10*H15)
Per patient cost for escalation activity	(H8 + H16)/I
i) DAT Training for HCWs *(Trainee costs)*	List up to three
1st Category of HCW trained	Job Category 1
I1.1 Number of Category 1 trained	N
I1.2 Typical amount of time for training (in minutes) (per HCW in category 1)	Minutes
I1.3 Total time in minutes for training all HCW in category 1	I1.1*I1.2
I1.4 HCW wage (per hour)	$
I1.5 Total cost for training all HCW in category 1	I1.3*I1.4/60
2nd Category of HCW trained	Job Category 2
I2.1 Number of Category 2 trained	N
I2.2 Typical amount of time for training (in minutes) (per HCW in category 2)	Minutes
I2.3 Total time in minutes for training all HCW in category 2	I2.1*I2.2
I2.4 HCW wage (per hour) (category 2)	$
I2.5 Total cost for training all HCW in category 2	I2.3*I2.4/60
3rd Category of HCW trained	Job Category 3
I3.1 Number of Category 3 trained	N
I3.2 Typical amount of time for training (in minutes) (per HCW in category 3)	Minutes

Cost components	Details/Formula *
I3.3 Total time in minutes for training all HCW in category 3	I3.1*I3.2
I3.4 HCW wage (per hour) (category 3)	$
I3.5 Total cost for training all HCW in category 3	I3.3*I3.4/60
I4. Total cost for training	I1.5 + I2.5 +I3.5
Per patient training cost	I4/III
j) Additional training costs *(Trainer costs)*	
Choose the training scenario for your project	
Scenario I: training was provided by individuals who were paid for each training session	
J1. Most common job category of staff providing the training sessions for HCW on how to use the 99DOTS	Job category (trainer)
J2. Typical amount of time spent by a trainer on training (including preparation and delivery) (in hours)	Hours
J3. Approximate hourly salary of someone doing training (trainer)	$
J4. Number of trainers	N
J5. Total trainers' wage directly related to 99DOTS training	J2*J3*J4
Scenario II: training was conducted by an outside organization or paid as a package	
J6. Total trainers' cost	$
J7. Additional expenditures related to training (including travel, training venue, subsistence for trainers and trainees, etc. but not time spent by, or salary paid to trainers or trainees)? Specify in column C and enter the cost in column C	$
Per patient cost of running training sessions (not including time for HCW who are being trained)	IF Scenario I: (J5 + J7)/III IF Scenario II: (J6 + J7)/III
Total per patient cost for 99DOTS is the SUM of the following categories	Per patient cost for phone and accessories Per patient fixed cost of the platform/infrastructure Per patient cost for medication sleeves Per patient preparation cost for entire duration of treatment Total per patient cost (TO AND FROM) 99DOTS system call/SMS for entire duration of treatment Per patient cost of 99DOTS adherence monitoring Per patient cost for Systems, Data management and technical support Per patient cost for escalation activity Per patient training cost Per patient cost of running training sessions (not including time for HCW who are being trained)

*Text in blue Indicates calculated fields. N = Numeric.

Appendix Table 2. Cost components for 99DOTS across the three study populations

Cost components	Bangladesh	The Philippines	Tanzania
Population			
I. Number of patients who used 99DOTS during the project	719	396	976
a) Phone and accessories			
A1. Number of phones that were purchased	22	0	0
A2. Unit cost of phone purchased	$354.58	$0	$0
A3. Number of SIM cards that were purchased	22	296	0
A4. Unit cost of SIM card	$11.79	$1.00	-
A5. Number of charger or solar batteries that were purchased	0	0	0
A6. Unit cost of charger or solar batteries	$0.00	-	-
A7. Number of phone lines provided with airtime	10	0	0
A8. Total cost for airtime per phone line for the entire duration of the project	$70.74	-	-
A9. Total cost of phones (includes phone, SIM card and airtime)	$8,767.63	$296.00	-
Per patient cost for phone and accessories	$12.19	$0.75	-
b) Platform / infrastructure costs			
B1. Initial configuration/customization costs (setting up phonelines and or platform at sites)	$ 10,304.5	$ 13,000.0	$8,736.3
B2. Type of configuration (portable, toll-free or SMS)	-	toll-free SMS	-
B3. Total fixed cost of renting toll free phone lines / SMS line or any other system used to support 99DOTS	$4,467.2	$901.3	$1,772.8
Per patient fixed cost of the platform/infrastructure	$20.54	$35.10	$10.77
c) Medication sleeves			
C1. Total cost of 99DOTS medication sleeve printing (including secondary packaging, labels, etc.)	$4,922.33	$13,000	$3,628
C2. Total cost for shipping of 99DOTS medication sleeves (including customs, etc.)	$70.74	$370.00	$6,120.00
Per patient cost for medication sleeves	$ 6.94	$33.76	$9.99

Cost components	Bangladesh	The Philippines	Tanzania
d) Medication Preparation			
D1. Typical amount of time to wrap and prepare one medication sleeve (in minutes)	2	1	1
D2. Type of staff wrapping medication	Research	TB nurse	Nurse
D3. Wage of staff (per hour)	$1.36	$1.59	$1.09
D4. Cost of labor for wrapping per medication sleeve (Total time for wrapping an medication sleeve)	$0.05	$0.03	$0.02
D5. Number of medication sleeves required per patient for the entire duration of treatment	35	24	24
Per patient preparation cost for entire duration of treatment	$1.58	$0.64	$0.44
e) 99DOTS Calls/SMS costs			
E1. Average number of calls/SMS made by a patient to 99DOTS during the entire duration of treatment	180	128	99
E2. Amount the project paid per call/SMS made by a patient to 99DOTS	$0.00	$0.01	$0.03
E3. Per patient call/SMS to 99DOTS cost for entire duration of treatment	-	$1.02	$3.27
E4. Average number (per patient) of 99DOTS reminder/education SMS sent by the system for missed doses	50	53	190
E5. cost the project has to pay per 99DOTS system SMS	$0.01	$0.01	$0.03
E6. per patient cost of 99DOTS adherence reminders for the entire duration of treatment	$0.59	$0.42	$5.70
Total per patient cost (TO AND FROM) 99DOTS system call/SMS for entire duration of treatment	$0.59	$1.45	$8.97
f) Adherence monitoring by HCW using 99DOTS platform			
F1. Type of HCW who does adherence monitoring using 99DOTS platform	Research	TB nurse	Nurse
F2. HCW wage (per hour)	$1.36	$1.59	$1.09
F3. Typical amount of time (in min) spent by HCW monitoring adherence on the platform per patient	1080	504	60
Per patient cost of 99DOTS adherence monitoring	$24.41	$13.36	$1.09
g) Systems, Data management and technical support			
G1. Amount spent for staff working on data management for 99DOTS platform (support of DAT platform)	$1,459.01	$1,639.21	$38,137.50
G2. Number of days that technical support was provided, or times specific technical services provided	35	15	6
G3. Cost per day or per activity reported in G2	$56.14	$74.50	$2,652.42
G4. Total cost of technical support for 99DOTS platform	$1,965.04	$1,117.50	$15,914.52
G5. Amount paid for health facility hardware (laptops, desktop, or tablet computer to track adherence)	$8,253.00	$449.00	$3,971.00
G6. Payments made for monthly plans for technical services such as data plans and phone plans for HCW	$589.50	$4.81	$143.48
Per patient cost for Systems, Data management and technical support	$17.06	$8.11	$59.60
h) Escalation in case of non-adherence and HCW response			
Escalation related phone calls:			
H1. Number of patients who required follow up by phone as part of adherence escalation procedure	17	31	736
H2. Average number of phone calls made by HCW per patient (for entire duration of the project)	10	1	9.92
H3. HCW time per call (in minutes) required to speak to a patient who requires adherence follow up	10	2	1
H4. Total time (in minutes) spent by HCW with patients on a phone for adherence follow up	1,700	62	7,304
H5. Type of HCW who usually makes phone calls	Research	TB nurse	Nurse
H6. Average HCW wage (per hour)	$1.36	$1.59	$1.09
H7. Additional fees associated with phone call follow up (per call)	$0.00	-	-
H8. Total cost for Phone calls	$38.42	$1.64	$132.69
Escalation related Home Visits:			
H9. Number of patients who required a home visit as part of escalation procedure	40	95	495
H10.Average number of home visits per individual who requires home visits	0	2	4
H11.Amount of time per visit (including travel)	180	45	120
H12. Total time (in minutes) spent by HCW on home visits for patients who required adherence follow up	-	8,550	237,600
H13.Type of HCW doing home visit	Research	Volunteer	Volunteers
H14.HCW wage (per hour)	$1.36	-	-
H15.Additional costs for HCW per visit (e.g., Travel/transport costs, incentives, etc.)	$1.77	$2.30	$1.79
H16. Total cost for home visits	-	$437.00	$3,544.20
Per patient cost for escalation activity	$0.05	$1.11	$3.77
i) DAT Training for HCWs *(Trainee costs)*			
1st Category of HCW trained	Research	TB nurse	Doctors
I1.1 Number of Category 1 trained	7	5	29
I1.2 Typical amount of time for training (in minutes) (per HCW in category 1)	1,440	300	600

Cost components	Bangladesh	The Philippines	Tanzania
I1.3 Total time in minutes for training all HCW in category 1	10,080	1,500	17,400
I1.4 HCW wage (per hour)	$1.36	$1.59	$2.40
I1.5 Total cost for training all HCW in category 1	$227.78	$39.75	$696.00
2nd Category of HCW trained	volunteer	Midwife	Clinicians
I2.1 Number of Category 2 trained	0	2	16
I2.2 Typical amount of time for training (in minutes) (per HCW in category 2)	0	300	600
I2.3 Total time in minutes for training all HCW in category 2	-	600	9,600
I2.4 HCW wage (per hour) (category 2)	-	$1.20	$1.09
I2.5 Total cost for training all HCW in category 2	-	$720.00	$10,464
Category of HCW trained	Research	TB Doctor	Nurses
I3.1 Number of Category 3 trained	1	3	56
I3.2 Typical amount of time for training (in minutes) (per HCW in category 3)	1,440	300	600
I3.3 Total time in minutes for training all HCW in category 3	1,440	900	33,600
I3.4 HCW wage (per hour) (category 3)	$3.12	$3.27	$1.09
I3.5 Total cost for training all HCW in category 3	$4,499.06	$2,943.00	$36,624
I4. Total cost for training	$4,726.85	$3,702.75	$47,784
Per patient training cost	$6.57	$9.35	$48.96
j) Additional training costs *(Trainer costs)*			
Choose the training scenario for your project	Scenario I	Scenario I& II	Scenario II
Scenario I: training was provided by individuals who were paid for each training session			
J1. Most common job category of staff providing the training sessions for HCW on how to use the 99DOTS	Research	IT	-
J2. Typical amount of time spent by a trainer on training (including preparation and delivery) (in hours)	40	240	-
J3. Approximate hourly salary of someone doing training (trainer)	$25.35	$6.00	-
J4. Number of trainers	6	3	-
J5. Total trainers' wage directly related to 99DOTS training	$6,083.64	$4,320.00	-
Scenario II: training was conducted by an outside organization or paid as a package			
J6. Total trainers' cost	-	$144.00	-
J7. Additional expenditures related to training (including travel, training venue, subsistence for trainers and trainees, etc. but not time spent by, or salary paid to trainers or trainees)? Specify in column C and enter the cost in column C	-	$788.00	$29,409.94
Per patient cost of running training sessions (not including time for HCW who are being trained)	$8.46	$15.25	$30.13
Total per patient cost for 99DOTS	$98.41	$118.88	$173.70

*Text in blue Indicates calculated fields - indicates non applicable components. N = Numeric.

Appendix Table 3. Total costs of 99DOTS during the implementation projects

Cost in USD	Bangladesh	The Philippines	Tanzania
Number of patients who used 99DOTS during the project	(n = 719)	(n = 396)	(n = 976)
Variable costs	$55,985	$33,173	$159,028
Phone and accessories	$8,768	$296	$0
Medication sleeves	$4,993	$13,370	$9,748
Medication preparation	$1,137	$252	$426
99DOTS Calls/SMS costs	$424	$573	$8,752
Adherence monitoring by HCW using 99DOTS platform	$17,547	$5,289	$1,064
Systems, Data management and technical support	$12,267	$3,211	$58,167
Escalation in case of non-adherence and HCW response	$38	$439	$3,677
DAT training for HCWs (Trainee costs)	$4,727	$3,703	$47,784
Additional training costs (Trainer costs)	$6,084	$6,040	$29,410
Fixed costs	$14,772	$13,901	$10,509
Platform / infrastructure costs	$14,772	$13,901	$10,509
Total overall cost of 99DOTS	$70,756	$47,074	$169,536

Appendix Table 4. Per person costs of 99DOTS during the implementation projects, without and with annuitization of capital costs§

Country	Project site			With costs annuitized over the 5-y life span of servers and phones		
	Bangladesh	The Philippines	Tanzania	Bangladesh	The Philippines	Tanzania
Number of patients who used 99DOTS during the project	(n = 719)	(n = 396)	(n = 976)	(n = 719)	(n = 396)	(n = 976)
Variable per patient cost	$78	$84	$163	$60	$83	$160
Per patient cost for phone and accessories *	$12	$0.75	$0.00	$3.51	$0.75	$0.00
Per patient cost for medication sleeves	$6.94	$34	$10	$6.94	$34	$10
Per patient medication preparation cost for entire duration of treatment	$1.58	$0.64	$0.44	$1.58	$0.64	$0.44
Total per patient cost of 99DOTS system call/SMS (TO AND FROM) for the entire duration of treatment	$0.59	$1.45	$8.97	$0.59	$1.45	$8.97
Per patient cost of 99DOTS adherence monitoring	$24	$13	$1.09	$24.4	$13	$1.09
Per patient cost for systems, Data management and technical support	$17	$8.11	$60	$7.88	$7.20	$56
Per patient cost for escalation activity	$0.05	$1.11	$3.77	$0.05	$1.11	$3.77
Per patient training cost for HCWs	$6.57	$9.35	$49	$6.57	$9.35	$49
Per patient cost of running training sessions (not including time for HCW who are being trained)	$8.46	$15	$30	$8.46	$15	$30
Fixed per patient cost*#	$21	$35	$11	$21	$8.84	$3.61
Total per patient cost of 99DOTS	$98	$119	$174	$81	$92	$163

§Totals from rounded totals.
*Equipment cost annuitized over a 5-y life span (phones, tablets and computers).
#Fixed cost consists of fixed cost of the platform/infrastructure.

VOT tool and data

Appendix Table 5. Costing tool - VOT

Cost components	Details/Formula *
Project and respondent information	
1. Name of the project``	Text
2. Country	Text
3. Name of respondent	Text
4. Position of respondent	Text
5. e-mail of respondent	Text
6. Phone	Text
7. Local currency used in the country	Text
8. Date the questionnaire was filled	YYYY - MM - DD
9. Was anything donated to the project? (e.g., equipment, technical support, training sessions offered as donations,etc.)	Yes, No
10. List detailed items and services that were donated to the project	Text
Population	
I. Type of patients (DS-TB or DR-TB)	Text
II. Length of a full course of treatment (in months)	N
III. Number of patients who were followed using DAT during the project	N
a) Phone and accessories	
A1. Number of phones that were purchased	N
A2. Unit cost of phone purchased	$
A3. Number of SIM cards that were purchased	N
A4. Unit cost of SIM card	$
A5. Number of charger or solar batteries that were purchased	N
A6. Unit cost of charger or solar batteries	$
A7. Number of phone lines provided with airtime	N
A8. Total cost for airtime per phone line for the entire duration of the project	$
A9. Total cost of phones (includes phone, SIM card and airtime)	(A1*A2) + (A3*A4) + (A5*A6) + (A7*A8)

Cost components	Details/Formula *
Per patient cost for phone and accessories	A9/III
b) Data	
B1. Average size of a video recording in Megabytes (MB)	N
B2. Cost per MB of data	$
B3. Total number of video calls/recordings made by all patients in the project	N
B4. Total cost for data for all patients	B1*B2*B3
Per patient cost for data	B4/III
c) Platform / infrastructure costs	
C1. Total amount spent on software license (if applicable) for the entire duration of the project	$
C2. Initial Configuration costs (setting up VDOT platform in country)	$
C3. Total amount spent to develop a VDOT software or platform for a project not using an already existing system	$
Per patient fixed cost of the platform/infrastructure	(C1 + C2 + C3)/III
d) Adherence monitoring by HCW using VDOT platform	
Routine adherence monitoring using VDOT	
D1. Type of HCW who does adherence monitoring using VDOT platform	Text
D2. HCW wage (per hour)	$
D3. Typical amount of time (in min) spent by HCW monitoring adherence on the platform per patient (duration of project)	N
D4. Per patient cost of VDOT routine adherence monitoring	D3*D2/60
Video recordings viewing	
D5. Type of HCW who usually views video recordings	Text
D6. HCW wage (per hour)	$
D7. Average number of minutes per patient per recording	N
D8. Average number of recordings made by a patient in the project	B3/III
D9. Per patient average amount of time (in minutes) of recordings over the course of treatment	D7*D8
D10. Per patient cost of viewing video recordings	D9*D6/60
Per patient cost of VDOT adherence monitoring (routine + viewing of recordings)	D4 + D10
e) Systems, Data management and technical support	
E1. Amount spent for staff working on data management for VDOT platform (salaries paid for support of DAT platform)	$
E2. Number of days that technical support was provided or number of times specific technical services were provided (beyond initial setup)	N
E3. Cost per day or per activity reported in E2	$
E4. Total cost of technical support for VDOT platform	E2*E3
E5. Amount paid for health facility hardware (laptops, desktop or tablet computer to track adherence)	$
E6. Payments made for monthly plans for technical services such as data plans and phone plans for HCW and health facility	$
Per patient cost for Systems, Data management and technical support	(E1 + E4 + E5 + E6)/III
f) Escalation in case of non-adherence and HCW response	
Escalation related phone calls:	
F1. Number of patients who required follow up by phone as part of adherence escalation procedure	N
F2. Average number of phone calls made by HCW per patient (for entire duration of the project)	N
F3. Average HCW time per call (in minutes) required to speak to a patient who requires adherence follow up	minutes
F4. Total time (in minutes) spent by HCW with patients on a phone for adherence follow up	F1*F2*F3
F5. Type of HCW who usually makes phone calls	Job Category
F6. Average HCW wage (per hour)	$
F7. Additional fees associated with phone call follow up (per call)	$
F8. Total cost for Phone calls	(F4*F6/60min) + (F1*F2*F7)
Escalation related Home Visits:	
F9. Number of patients who required a home visit as part of escalation procedure	N
F10.Average number of home visits per individual who requires home visits	N
F11.Amount of time per visit (including travel)	minutes
F12. Total time (in minutes) spent by HCW on home visits for patients who required adherence follow up	F9*F10*F11
F13.Type of HCW doing home visit	Job Category
F14.HCW wage (per hour)	$
F15.Additional costs for HCW per visit (e.g., Travel/transport costs, incentives, etc.)	$
F16. Total cost for Home visits	(F12*F14/60) + (F9*F10*F15)
Per patient cost for escalation activity	(F8 + F16)/III
g) DAT Training for HCWs (Trainee costs)	
1st Category of HCW trained	Job Category 1
G1.1 Number of HCW trained	N
G1.2 Typical amount of time for training (in minutes) (per HCW in category 1)	Minutes
G1.3 Total time in minutes for training all HCW in category 1	G1.1*G1.2

Cost components	Details/Formula *
G1.4 HCW wage (per hour)	$
G1.5 Total cost for training all HCW in category 1	G1.3*G1.4/60
2nd Category of HCW trained	Job Category 2
G2.1 Number of HCW trained	N
G2.2 Typical amount of time for training (in minutes) (per HCW in category 2)	Minutes
G2.3 Total time in minutes for training all HCW in category 2	G2.1*G2.2
G2.4 HCW wage (per hour) (category 2)	$
G2.5 Total cost for training all HCW in category 2	G2.3*G2.4/60
3rd Category of HCW trained	Job Category 3
G3.1 Number of HCW trained	N
G3.2 Typical amount of time for training (in minutes) (per HCW in category 3)	Minutes
G3.3 Total time in minutes for training all HCW in category 3	G3.1*G3.2
G3.4 HCW wage (per hour) (category 3)	$
G3.5 Total cost for training all HCW in category 3	G3.3*G3.4/60
G4. Total cost for training	G1.5 + G2.5 +G3.5
Per patient training cost	G4/III
h) Additional training costs (Trainer costs)	
Choose the training scenario for your project	
Scenario I: training was provided by individuals who were paid for each training session	
H1. Most common job category of staff providing the training sessions for HCW on how to use the DAT	Job category (trainer)
H2. Typical amount of time spent by a trainer on training (including preparation and delivery) (in hours)	Hours
H3. Approximate hourly salary of someone doing training (trainer)	$
H4. Number of trainers	N
H5. Total trainers' wage directly related to VDOT training	H2*H3*H4
Scenario II: training was conducted by an outside organization or paid as a package	
H6. Total trainers' cost	$
H7. Additional expenditures related to training (including travel, training venue, subsistence for trainers and trainees, etc. but not time spent by or salary paid to trainers or trainees)? Specify in column C and enter the cost in column C	$
Per patient cost of running training sessions (not including time for HCW who are being trained)	IF Scenario I: (H5 + H7)/III IF Scenario II: (H6+H7)/III
Total per patient cost for VDOT is SUM of the following categories	Per patient cost for smart phone Per patient cost for data Per patient fixed cost of the platform/infrastructure Per patient cost of VDOT adherence monitoring by HCW Per patient cost for Systems, Data management and technical support Per patient cost for escalation activity Per patient cost for HCW training Per patient trainers' cost

*Text in blue Indicates calculated fields. N = Numeric.

Appendix Table 6. Cost components for VOT across the four study populations

Cost components	Haiti	Moldova (All)	Moldova (DS-TB)`	Moldova (DR-TB)	the Philippines
Population					
I. Type of patients (DS-TB or DR-TB)	DS-TB	All	DS-TB	DR-TB	DR-TB
II. Length of a full course of treatment (in months)	6	6 and 9	6	9	9
III. Number of patients who were supported using VOT during the project	87	308	173	135	110
a) Phone and accessories					
A1. Number of phones that were purchased	40	200	92	108	131
A2. Unit cost of phone purchased	$69.0	$110.0	$110.0	$110.0	$97.7
A3. Number of SIM cards that were purchased	60	140	65	75	111
A4. Unit cost of SIM card	$2.0	-	-	-	$0.8
A5. Number of charger or solar batteries that were purchased	0	-	-	-	90
A6. Unit cost of charger or solar batteries	$0.0	-	-	-	$1.8
A7. Number of phone lines provided with airtime	60	384	177	207	54
A8. Total cost for airtime per phone line for the entire duration of the project	$118.0	$27.8	$27.8	$27.8	$47.8
A9. Total cost of phones (includes phone, SIM card and airtime)	$9,960.0	$32,663.7	$15,048.8	$17,614.9	$15,635.7

Cost components	Haiti	Moldova (All)	Moldova (DS-TB)`	Moldova (DR-TB)	the Philippines
Per patient cost for phone and accessories	$114.5	$106.05	$86.99	$130.48	$142.1
b) Data					
B1. Average size of a video recording in Megabytes (MB)	60	30	30	30	-
B2. Cost per MB of data	$0.0	$0.0	$0.0	$0.0	-
B3. Total number of video calls/recordings made by all patients in the project	12,194	43,027	19,823	23,204	29,700
B4. Total cost for data for all patients	$731.6	$1,837.3	$846.46	$990.80	$0.0
Per patient cost for data	$8.4	$5.97	$4.89	$7.34	$0.0
c) Platform / infrastructure costs					
C1. Total amount spent on software license (if applicable) for the entire duration of the project	$31,149.0	-	-	-	$27,326.7
C2. Initial Configuration costs (setting up VDOT platform in country)	-	-	-	-	-
C3. Total amount spent to develop a VDOT software or platform for a project not using an already existing system	-	$40,000.0	$18,428.8	$21,571.2	-
Per patient fixed cost of the platform/infrastructure	$358.0	$129.87	$106.52	$159.79	$248.4
d) Adherence monitoring by HCW using VDOT platform					
Routine adherence monitoring using VDOT					
D1. Type of HCW who does adherence monitoring using VDOT platform	Field staff	Assistant	Assistant	Assistant	Nurse
D2. HCW wage (per hour)	$2.7	$11.0	$11.0	$11.0	-
D3. Typical amount of time (in min) spent by HCW monitoring adherence on the platform per patient (duration of project)	701	540	360	540	-
D4. Per patient cost of VDOT routine adherence monitoring	$31.5	$80.46	$66.00	$99.00	$0.0
Video recordings viewing					
D5. Type of HCW who usually views video recordings	Officer	Assistant	Assistant	Assistant	Nurse
D6. HCW wage (per hour)	$1.7	$11.0	$11.0	$11.0	$2.9
D7. Average number of minutes per patient per recording	0.3	2	2	2	10
D8. Average number of recordings made by a patient in the project	140.2	139.70	114.59	171.88	270.0
D9. Per patient average amount of time (in minutes) of recordings over the course of treatment	42.0	279	229	171.88	2,700.0
D10. Per patient cost of viewing video recordings [#]	$1.2	-	-	-	$132.7
Per patient cost of VDOT adherence monitoring (routine + viewing of recordings)	$32.7	$80.46	$66.00	$99.00	$132.7
e) Systems, Data management and technical support					
E1. Amount spent for staff working on data management for VDOT platform (salaries paid for support of DAT platform)	$34,200.0	-	-	-	-
E2. Number of days that technical support was provided or number of times specific technical services were provided (beyond initial setup)	220	160	74	86	-
E3. Cost per day or per activity reported in E2	$55.0	$28.5	$28.5	$28.5	-
E4. Total cost of technical support for VDOT platform	$12,100.0	$4,560.0	$2,100.88	$2,459.12	$0.0
E5. Amount paid for health facility hardware (laptops, desktop or tablet computer to track adherence)	$7,500.0	$650.0	$299.47	$350.53	$2,257.2
E6. Payments made for monthly plans for technical services such as data plans and phone plans for HCW and health facility	$0.0	$1,920.0	$884.58	$1,035.42	-
Per patient cost for Systems, Data management and technical support	$618.4	$23.15	$18.99	$28.48	$20.5
f) Escalation in case of non-adherence and HCW response					
Escalation related phone calls:					
F1. Number of patients who required follow up by phone as part of adherence escalation procedure	-	32	15	17	42
F2. Average number of phone calls made by HCW per patient (for entire duration of the project)	-	21	21	21	50
F3. Average HCW time per call (in minutes) required to speak to a patient who requires adherence follow up	-	5	5	5	15
F4. Total time (in minutes) spent by HCW with patients on a phone for adherence follow up	-	3,360	1,548	1,812	31,500
F5. Type of HCW who usually makes phone calls		Assistant	Assistant	Assistant	Nurse
F6. Average HCW wage (per hour)	-	$11.00	$11.00	$11.00	$2.95
F7. Additional fees associated with phone call follow up (per call)	-	-	-	-	-
F8. Total cost for Phone calls	$0.0	$616.0	$284.8	$332.20	$1,549
Escalation related Home Visits:					
F9. Number of patients who required a home visit as part of escalation procedure	-	0	0	0	18

Cost components	Haiti	Moldova (All)	Moldova (DS-TB)`	Moldova (DR-TB)	the Philippines
F10.Average number of home visits per individual who requires home visits	-	0	0	0	6
F11.Amount of time per visit (including travel)	-	0	0	0	240
F12. Total time (in minutes) spent by HCW on home visits for patients who required adherence follow up	-	-	-	-	25,920
F13.Type of HCW doing home visit	-	Assistant	Assistant	Assistant	-
F14.HCW wage (per hour)		$11.0	$11.0	$11.0	$3.2
F15.Additional costs for HCW per visit (e.g., Travel/transport costs, incentives, etc.)					
F16. Total cost for Home visits	$0.0	$0.0	$0.0	$0.0	$1,385.1
Per patient cost for escalation activity	$8.6	$2.00	$1.64	$2.46	$26.7
g) DAT Training for HCWs (Trainee costs)					
1st Category of HCW trained		Doctors	Doctors	Doctors	Nurse
G1.1 Number of HCW trained	-	43	43	43	6
G1.2 Typical amount of time for training (in minutes) (per HCW in category 1)	-	300	300	300	120
G1.3 Total time in minutes for training all HCW in category 1	-	12,900	12,900	12,900	720
G1.4 HCW wage (per hour)	-	$15.0	$15.0	$15.0	$2.9
G1.5 Total cost for training all HCW in category 1	$0.0	$3,225	$3,225	$3,225	$35.4
2nd Category of HCW trained		Assistant	Assistant	Assistant	Staff
G2.1 Number of HCW trained	-	53	53	53	8
G2.2 Typical amount of time for training (in minutes) (per HCW in category 2)	-	420	420	420	240
G2.3 Total time in minutes for training all HCW in category 2	-	22,260	22,260	22,260	1,920
G2.4 HCW wage (per hour) (category 2)	-	$11.0	$11.0	$11.0	-
G2.5 Total cost for training all HCW in category 2	$0.0	$4,081	$4,081	$4,081	$0.0
3rd Category of HCW trained	-	N/A	N/A	N/A	Nurse
G3.1 Number of HCW trained	-	-	-	-	4
G3.2 Typical amount of time for training (in minutes) (per HCW in category 3)	-	-	-	-	240
G3.3 Total time in minutes for training all HCW in category 3	-	-	-	-	960
G3.4 HCW wage (per hour) (category 3)	-	-	-	-	$2.9
G3.5 Total cost for training all HCW in category 3	$0.0	$0.0	$0.0	$0.0	$2,832
G4. Total cost for training	$1,201	$7,306	$3,366	$3,940	$2,867
Per patient training cost	$13.8	$23.72	$19.46	$24.93	$26.1
h) Additional training costs (Trainer costs)					
Choose the training scenario for your project					
Scenario I: training was provided by individuals who were paid for each training session					
H1. Most common job category of staff providing the training sessions for HCW on how to use the DAT	-	-	-	-	Doctor
H2. Typical amount of time spent by a trainer on training (including preparation and delivery) (in hours)	-	-	-	-	8
H3. Approximate hourly salary of someone doing training (trainer)	-	-	-	-	$30.8
H4. Number of trainers	-	-	-	-	1
H5. Total trainers' wage directly related to VDOT training	$0.0	$0.0	$0.0	$0.0	$246.2
Scenario II: training was conducted by an outside organization or paid as a package					
H6. Total trainers' cost	-	-	-	-	-
H7. Additional expenditures related to training (including travel, training venue, subsistence for trainers and trainees, etc. but not time spent by or salary paid to trainers or trainees)? Specify in column C and enter the cost in column C	-	-	-	-	$7,034.62
Per patient cost of running training sessions (not including time for HCW who are being trained)	$0.0	$0.0	$0.0	$0.0	$64.0
Total per patient cost for VDOT is SUM of the following categories	$1,154.4	$371.22	$304.49	$452.48	$660.5

*Text in blue Indicates calculated field. N = Numerics. - indicates non applicable components

[#]D10 was intentionally removed from Moldova study because it would have double counted the per patient cost of VDOT adherence monitoring

Appendix Table 7. Total costs of VOT at project sites

Cost in USD	Haiti	Moldova DS-TB	Moldova DR-TB	Moldova (All TB)	The Philippines
Number of patients who used VOT during the project	(n = 87)	(n = 173)	(n = 135)	(n = 308)	(n = 110)
Variable cost	$69,287	$34,248	$40,088	$74,336	$45,330
Phone and accessories	$9,960	$15,049	$17,615	$32,664	$15,636
Data	$732	$846	$991	$1,837	$0
Adherence monitoring by HCW using VOT platform	$2,845	$11,418	$13,365	$24,783	$14,601
Systems, Data management and technical support	$53,800	$3,285	$3,845	$7,130	$2,257
Escalation in case of non-adherence and HCW response	$750	$284	$332	$616	$2,934
DAT Training for HCWs (Trainee costs)	$1,201	$3,366	$3,940	$7,306	$2,867
Additional training costs (Trainer costs)	$0	$0	$0	$0	$7,035
Fixed cost	$31,149	$18,429	$21,571	$40,000	$27,327
Platform / infrastructure	$31,149	$18,429	$21,571	$40,000	$27,327
Total overall cost of VOT	$100,436	$52,677	$61,659	$114,336	$72,656

Appendix Table 8. Per person VOT costs

	Project population				
Country	Haiti	Moldova DS-TB	Moldova DR-TB	Moldova (All TB)	The Philippines
Number of patients who used VOT during the project	(n = 87)	(n = 173)	(n = 135)	(n = 308)	(n = 110)
Variable per patient cost	$796	$198	$293	$242	$412
Per patient cost for phone and accessories*	$114	$87	$130	$106	$142
Per patient cost for data	$8.41	$4.89	$7.34	$5.97	$0.00
Per patient cost of VOT adherence monitoring	$33	$66	$99	$80	$133
Per patient cost for systems, Data management and technical support	$618	$19	$28	$23	$21
Per patient cost for escalation activity	$8.62	$1.64	$2.46	$2.46	$27
Per patient training cost	$14	$19	$25	$24	$26
Per patient cost of running training sessions (not including time for HCW who are being trained)	$0.00	$0.00	$0.00	$0.00	$64
Fixed per patient cost*#	$358	$107	$160	$130	$248
Total per patient cost of VOT	$1,154	$304	$452	$372	$661
	Project costs annuitized over the 5-y life span of servers and phones				
Country	Haiti	Moldova DS-TB	Moldova DR-TB	Moldova (All TB)	The Philippines
Number of patients who used VOT during the project	(n = 87)	(n = 173)	(n = 135)	(n = 308	(n = 110)
Variable per patient cost	$702	$151	$222	$185	$247
Per patient cost for phone and accessories*	$89	$40	$60	$49	$49
Per patient cost for data	$8.41	$4.89	$7.34	$5.97	$0.00
Per patient cost of VOT adherence monitoring	$33	$66	$99	$80	$133
Per patient cost for systems, Data management and technical support	$549	$19	$28	$23	$21
Per patient cost for escalation activity	$8.62	$1.64	$2.46	$2.46	$27
Per patient training cost	$14	$19	$25	$24	$5.2
Per patient cost of running training sessions (not including time for HCW who are being trained)	$0.00	$0.00	$0.00	$0.00	$13
Fixed per patient cost*#	$358	$21	$32	$26	$248
Total per patient cost of VOT	$1,060	$172	$254	$211	$495

*Equipment cost annuitized over a 5-y life span (phones, tablets and computers).
#Fixed cost consists of fixed cost of the platform/infrastructure, and the cost of systems, data management and technical support.

Effectiveness and standard of care (DOT) visit schedules

Appendix Table 9. Effectiveness

Country	DAT	Study description	Effectiveness of DAT arm	Reference
Bangladesh	99DOTS	Implementation study of 99DOTS in private sector TB screening and treatment centers established by icddr,b under its social enterprise model in Dhaka. Total TB incidence 375,000	Overall adherence: 96% of prescribed doses taken	(*1*)

Country	DAT	Study description	Effectiveness of DAT arm	Reference
The Philippines	99DOTS	The study was designed to assess 99DOTS use in the private sector in the Philippines, where data suggests 50% of patients in the country seek care. Total TB incidence 741,000	Overall adherence: 94% of prescribed doses taken #	(*2*)
United Republic of Tanzania	99DOTS	The study was done in mining communities in Tanzania in four districts and four regions. The intervention involves (i) provision of medication in 99DOTS sleeves, (ii) delivery of reminders via SMS to patients, (iii) dosing histories used for counselling and for differentiated care (more intensive patient management), and (iv) targeted educational messaging based on adherence and risk factors via SMS or IVR. Total TB incidence 132,000	Measured concordance with urine testing 95% of doses reported using 99DOTS were confirmed by urine testing . This concordance was highest (98%) in patients who were in their first 2 mo of treatment. §	(*3*)
Haiti	VOT	A feasibility, acceptance, persistence, accuracy and sustainability study of VOT for prisoners in a low-income country Total TB incidence 18,000	Median adherence of 85.7% of doses taken, but limited to the 65 patients who completed treatment	(*4*)
The Philippines	VOT	This pilot study aimed to determine feasibility and acceptability of VOT in a high-burden, resource constrained DR-TB clinic in the Philippines where smartphones penetration is moderate and growing. Total TB incidence 741 000	Good adherence was defined as ingestion of >90% of prescribed doses. Observed doses: Males VOT 86.2% Status quo 80.7% Females VOT 86.8% Status quo 81.4%	(*5*)
Republic of Moldova	VOT	A pilot study to scale up locally developed VOT technology/program. Total TB incidence 2,600	Overall: 89% adherence to TB treatment * DS-TB 92% DR-TB 85%	(*6*)

#Adherence Using 99DOTS calls as a proxy for adherence resulted in a 94% sensitivity using a urine test for isoniazid metabolites (IsoScreen) as the reference standard.
§Similar urinalysis approach used in Tanzania to that in the Philippines to assess adherence.
DAT; Digital adherence technology. DR-TB; drug resistant TB. DS-TB; drug susceptible TB. Icddr,b; International Centre for Diarrheal Disease Research, Bangladesh. KNCV; Koninklijke Nederlandse Centrale Vereniging tot bestrijding der Tuberculose. TB; Tuberculosis. VOT; video-observed treatment
*Adherence was measured by the proportion of days that a person with TB was observed ingesting medication during the planned treatment period

Appendix Table 10. DOT schedules and duration in the study settings – from the costing tool

	99DOTS sites			VOT sites			
Schedule and duration	Bangladesh	The Philippines	Tanzania	Haiti	Moldova DS-TB	Moldova DR-TB	The Philippines
Crude estimate for DOT cost for the standard of care - derived from the costing tool							
Duration of TB treatment (in months)	6	6	6	6	6	9	9
Frequency of nurse visits (for clinical purposes)	3	6	16	6	6	9	9
Frequency of physician visits (for clinical purposes)	2	6	6	6	6	9	36
Proportion on DOT	100%	100%	100%	100%	100%	100%	50%
Number of days DOT	120	168	120	120	120	180	180
Location of DOT - during the study	Health facility	Health facility	Home based	Prison	Health facility	Health facility	Health facility or Home
Hourly wage of person offering DOT support	$0.83	$1.40	$0.00	$4.60	$11.20	$11.20	$2.88
Duration of DOT visit - in minutes	45	45	0	45	15	15	2

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