Costs and operation management of community outreach program for tuberculosis in tribal populations in India

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Objective: To evaluate costs of an active case finding (ACF) program with tuberculosis (TB) treatment delivery and monitoring, which targeted a rural tribal population in India.

Method: A time and motion study was conducted to evaluate operations and workload. Costs from the program perspective were assessed using both the bottom-up and top-down costing methods, exclusive of routine TB care costs. The impact of ACF on routine TB laboratory workloads was measured based on the changes in available staff time per smear at nine designated microscopy centers before and after program implementation.

Results: A majority (53.2%) of the community health-care worker's time was spent in traveling to communities, with an average of 22 TB patients (95% CI 19.14–24.94) seen per day per person. Costs (at 2015 \$US rates) were US\$1.85–US\$2.42 per patient screened and submitting sputum, US\$2.51–US\$4.74 per person diagnosed with TB, and US\$22.52–US\$34.13 per TB patient completing treatment. Total smear volumes increased significantly after the ACF program, with more than a 15% reduction in available staff time per sputum smear test in most laboratories.

Conclusion: This low-cost, ACF program has the potential to be highly cost-effective in addressing gaps in TB care problems in rural India.

With an estimated 2.74 million people developing tuberculosis (TB) and 420 000 TB-related deaths in 2018, India is the single largest contributor to the global TB burden.¹ While steadily declining incidence (from 289 to 204 per 100 000) and mortality rates (56 to 32 per 100 000) since 2000¹ are attributable to the success of the Revised National Tuberculosis Control Programme (RNTCP), the TB epidemic in India is highly heterogeneous. Tribal communities often suffer from high TB prevalence and poor access to health services.^{2,3} As a result, more than half of India's designated 'tribal districts' report treatment coverage well below the 90% targets outlined in the Global Plan to End TB.⁴

To improve access to TB care in the *Saharia* communities living in the state of Madhya Pradesh, a community-based active case finding (ACF) and TB treatment delivery and monitoring program was implemented by *Asha Kalp*, beginning in July 2014, with funding support from the Stop TB Partnership's TB REACH initiative. ACF and treatment support ac-

tivities were implemented in two basic management units (BMUs) of Gwalior District (Dabra and District TB Centre Gwalior) where TB prevalence is nearly eight times higher than the average prevalence observed in contiguous areas. In the first year of operations, the program recorded a <50% increase in smear microscopy testing, an 84% increase in TB case notifications, and improvements in pre-treatment loss to follow-up and treatment success.⁵

Given the program's demonstration of its potential to address TB care accessibility in similar rural areas and tribal communities experiencing inadequate access to TB care by scaling up its operations, it is important to evaluate the program's operations and costs, and its impact on existing healthcare infrastructure. We used combined analyses to evaluate workload, operations, and costs of the program, and its impact on routine TB services.

METHODS

Asha Kalp operations

Between January and December 2015, the program screened 76 632 people for TB symptoms, transported 5658 people's sputum for smear microscopy testing, and provided treatment observation and support to a total of 1432 TB patients (832 smear-positive, 600 smear-negative). A total of 23 community health workers (CHWs) who already had access to a motor-bike were recruited from nearby villages and assigned to a defined catchment area to systematically visit homes and communal areas of the villages to provide TB education, screen, collect sputum samples, and deliver results and TB medication. CHWs were given a monthly travel and communication allowance, and performance-based payments based on quarterly treatment success rates reaching >80% among patients supported by individual CHWs.⁵

Time and motion study

A time and motion (TAM) study was conducted between February and April 2016, with three non-program personnel shadowing 12 CHWs. The CHWs were selected based on a representative range of performance and workloads—number of patients screened and treatment support—over 2 non-consecutive full working days. Before study initiation, CHWs were informed of the study and gave verbal consent to participate in the study. The duration of each categorized activity (developed from the pilot study), assessed as start and end time of continuous activity lasting more than 1 min

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KEY WORDS

active case finding; cost analysis; tribal population; tuberculosis; operation management

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measured by the observer's time device (e.g., mobile phones, wrist watch), was recorded using a standardized data collection form. Individual identifiers were coded by observers to ensure confidentiality. Based on the compiled TAM data, we assessed the per cent observed person-time for each activity (sum of observed person-time for each activity/total person-time in the data set) and the average time (the total observed person-time/the number of patients) spent in direct patient activities (patient screening, sputum collection, laboratory results review, and treatment delivery) to assess the workload and work patterns of the Asha Kalp operations.

Cost analysis

Costs were assessed as economic costs using the service provider perspective and were limited to the services provided by Asha Kalp—house to house screening, sputum collection for smear microscopy at designated microscopy centers (DMCs), and TB patient management (test result follow-up and provision of treatment support). Routine TB care by the RNTCP (e.g., drug cost) were thus excluded from our analysis. Costs were evaluated as cost/patient using both bottom-up (resource input usage data from observed usage at the service provider level by activity) and top-down (overall program costs allocated based on number of patients associated with each major activity) methods.⁶ In the bottom-up method, costs were allocated based on the results of the TAM study and the estimated number of repeated daily activities associated with each patient type managed (patients screened, sputum tested, and under treatment observation and support). Costs associated with indirect patient activities (e.g., travel, administrative work, breaks, etc.) were apportioned based on the distribution of patient volumes reported for each direct patient activity reported in the TAM study. In the top-down method, the total annual operations cost of the program was divided by the number of patients managed in the program's service delivery.

All data on overhead, capital assets (e.g., office space, motor bikes), human resources (inclusive of fringe benefits), and recurrent materials costs were obtained from a review of the complete program operational expenditure for the 2015 calendar year and review of market-based estimates. Costs were expressed in 2015 \$US based on the average United Nations official exchange rate.⁷

Evaluation of laboratory workloads

To assess the impact of the program on routine TB services, we collected data on laboratory operations (staffing levels as assessed as the number of full-time staff available for TB, and total numbers of sputum smear tests performed and presumptive TB patients investigated) during the 3-year period (2013–2015) from the nine DMCs collaborating with the program. We first pooled the data from all nine laboratories to assess overall changes in TB workloads based on 1) the total number of smear microscopy tests performed, 2) the average number of slides per DMC, and 3) the average available person-time to process one smear microscopy test. Total available laboratory staff person-time was calculated based on 267 operational days per year (5.5 working days per week and excluding 19 official government holidays), and the total number of full (8 h per day) and part time (4 h per day) laboratory staff. These figures were further estimated for reduced operations at 70% and 90% capacity to test for uncertainties in laboratory operations in the region. To identify high-workload DMCs, we used 20 smear slides/day/technician as the threshold (translating as 24 min per sputum smear test performed).⁸

As part of the program evaluation of the ACF, the study received approval from the District Administration and the Stop TB Partnership.

FIGURE 1 Daily composition of community healthcare worker's activities for the Asha Kalp program.

As the study only used the financial and aggregate program data, which do not include individual patient information, ethics approval was not required.

RESULTS

During the TAM study, we followed 196 people who were screened and followed-up for sputum collection, 9 people for diagnostic results delivery, and 278 people with TB who were visited for treatment observation and support. CHWs spent the majority (53.2%) of an 8 h working day in traveling (on motorbike) between communities, patient households and DMCs, covering a median distance of 50.35 km (interquartile range [IQR] 34.0–68.5) per working day and 4.71 km (IQR 3.15–8.35) between two locations (e.g., between communities). CHWs spent approximately 12.0% and 8.9% of total observed time on administrative and laboratory-based activities, including the registration and submission of sputum samples and TB drug dispensing (Figure 1).

Direct patient activities accounted for a combined 25.5% of the total daily workload (screening and diagnostic visits at 11.4% and DOTS care at 14.1%), with an average of 22 patients visited/CHW workday (95% confidence interval [CI] 19–25). CHWs spent respectively 4.6 (95%CI 4.0–5.2) and 5.9 (95%CI 4.1–7.6) min/patient for initial and follow-up screening visits (both visits may include spot and morning sputum collection), 24.2 (95%CI 12.2–46.3) min/patient for delivering bacteriologic diagnosis results (including treatment initiation), and 5.0 (95%CI 4.5–5.5) min/treatment observation and support.

Per patient cost for screening, sputum testing, TB detection, and treatment support differed based on the method used. Top-down cost estimates were consistently higher than bottom-up estimates. The cost of initial screening (single visit to identify people with presumptive TB) ranged between US\$0.42 and US\$0.73/person screened (respectively for bottom-up vs. top-down). Collection of spot and morning sputum samples required two additional home visits and costs were estimated to be between US\$1.85 and US\$2.42/person. When an individual had either bacteriologically positive or clinically diagnosed TB, two or more additional visits (a total of ≥ 5 visits) were necessary, with the unit cost/person detected with TB ranging between US\$2.51 and US\$4.47, depending on the type of TB (respectively smear-positive vs. smear-negative). Overall, TB patients identified and supported by the program required a total of 45 independent visits

FIGURE 2 Changes in workload for smear microscopy between 2013 and 2015 at district microscopy centers where the Asha Kalp program submitted sputum samples. A) TB laboratory workloads evaluated as average daily testing volume and laboratory staff time available to perform one sputum smear microscopy test between 2013 and 2015. B) Change in laboratory staff time available to perform one sputum smear microscopy test at each district microscopy center between 2013 and 2015.* Negative percentage indicates reduction in time available to perform one sputum smear microscopy test in 2015 compared to 2013.

by CHWs until the end of successful first-line TB treatment, which incurred a cost of US\$22.52–US\$34.13/patient.

After the program was implemented in the region, there was an increase of >20% (11.15 to 13.33 tests) in the average number of smear microscopy tests/day at the DMCs working in collaboration with the program. This translated into an overall 16% decrease (five of nine DMCs experienced $\geq 15\%$ reduction) in available person-time to process one smear microscopy test (33.1 to 27.7 min) between 2013 and 2015 (Figure 2). Four of nine DMCs experienced high workloads above the WHO-recommended level (<24 min/smear microscopy test),⁸ an increase from two before the start of program operations. Shuklhari and Bhitarwar DMCs were the two most affected DMCs, with >40% (36.4 to 11.5 min) and 60% (82.2 to 29.1 min) reduction in available person-time/smear microscopy test between 2013 and 2015.

DISCUSSION

Using multiple methods, our study provides several important insights on costs, scalability, and impact on routine laboratory operations of an ACF and treatment support program operating in re-

remote communities with limited access to TB care services. As illustrated by the activity-based time estimates of tasks performed by CHWs in the field, direct human resource costs and operation efficiencies were major factors influencing the costs of the program. Likewise, the economics and scalability of similar programs in other settings will likely depend heavily on labor costs and the degree of optimization in service delivery routes and coverage. Furthermore, given the dramatic increase in workloads seen at the DMCs after the program began operations, our study underscores the importance in streamlining overall TB care cascade in the region when implementing similar ACF programs.

Given the resource-intensive nature of ACF, the cost to implement and the cost-effectiveness of additional services are at the center of the debate over ACF strategies.^{9,10} In this study, we demonstrate that the program is a low-cost operation that has the potential to effectively address significant gaps in routine TB service delivery in remote tribal settings in India. At less than US\$0.50/person screened and US\$20.82/person completing TB treatment, this program's costs are well below the operational costs reported for other ACF programs.^{9,11–13} Furthermore, consideration should be given to the higher per patient costs reported for TB service delivery models in less restricted settings in India—treatment delivery provided through the public sector (US\$30–US\$40/patient)¹⁴ or private sector engagement models (US\$18–US\$19/patient).¹⁵ Our results strengthen the economic case that programs similar to the one implemented by Asha Kalp can address the gaps in case finding and treatment management in the remote and under-served areas of India.

As cost estimates differ based on the methods used,⁶ our dual costing approach provide complementary insights on the costs associated with ACF operations. The gaps in cost estimates from our bottom-up (assessed based on TAM data captured when the program operations were highly optimized) and top-down method likely portray the costs associated with 'real world' efficiency gaps. This 'gap' is highly sensitive and inversely associated with the service volumes (screening vs. diagnostic vs. treatment; see Table). Given that the process of implementation and efficiencies of ACF operations vary according to local geographic, population, and TB epidemiologic factors, monitoring the costs of ACF programs using this dual costing approach will be of value in understanding the efficiency gaps in the program operations.

The successes in ACF operations often coincides with an increased utilization and workload at the TB laboratories, as more people with presumptive TB who would otherwise not have sought care undergo diagnostic evaluation. In our study, we observed changes in workloads at four of nine DMCs resulting in higher workloads than those recommended by the WHO.⁸ While this further underlines the importance of program operations as CHWs link people to TB care, the sudden increase in workloads beyond existing laboratory capacity poses a concern that may potentially negate the benefits of the ACF program (e.g., crowding and high workloads, resulting in staff burnout, impacting timely delivery of diagnosis and treatment in the routine program). As Asha Kalp's communication with the regional RNTCP shows, it will be critical for current and future ACF programs to closely engage with TB programs to streamline case-finding efforts with diagnostic and treatment capacity.

Our study is not free of limitations in methodology and interpretation of the results. We only assessed costs incurred by the program (costs of drugs, routine clinic visits, diagnostics, and patient-incurred expenses were excluded) and data were limited to the 2015 fiscal year. As such, our cost estimates should be inter-

TABLE A summary of cost analysis of the Asha Kalp program by resource type and method of allocation (bottom-up or top-down)

Key services/activities	Screening visit	Diagnostic visits			Treatment	
		Sputum collection 2015 \$US	Smear-positive (or no TB) 2015 \$US	Smear-negative TB (including EPTB) 2015 \$US	Smear-positive TB 2015 \$US	Smear-negative TB 2015 \$US
Total visits to the patient, <i>n</i>	1	3	4	6	44	46
Costing method: bottom-up						
Types of resources,						
Overhead	0.09	0.57	0.89	1.60	5.43	6.14
Motorbike	0.21	0.64	0.85	1.28	10.03	10.45
Human resources	0.11	0.64	0.76	1.29	7.06	7.08
Travel	0.08	0.23	0.30	0.46	3.57	3.72
Screening	0.03	0.08	0.13	0.18	0.98	1.31
Laboratory	0.00	0.33	0.33	0.65	0.98	0.52
TB treatment support	0.00	0.00	0.00	0.00	1.54	1.54
Cost per patient type	0.42	1.85	2.51	4.17	22.52	23.67
Costing method: top-down						
Patients, <i>n</i>	70974	5658	832	600	832	600
Total cost allocation	37007	5900	434	626	2867	
Total motorcycle costs	15142	2414	178	256	7100	5120
Cost per patient type	0.73	2.42	3.79	4.74	33.18	34.13

TB = tuberculosis; EPTB = extra-pulmonary TB.

puted only as an incremental cost to routine TB program services. We were only able to conduct a TAM study towards the end of the program, when operations were likely optimized, and did not have information on implementation, nor data on day-to-day operation statistics (staffing and service delivery). Given that costs depend largely on operations and service volumes, we expect that the time allocation for travel and non-patient-related activities may have been greater than we observed in our study. Likewise, future studies and ACF programs should track daily and periodic operational statistics to monitor workload and costs to capture variabilities in costs of their operations. This will increase transparency and generalizability of the ACF program that can be useful in evaluating potential scale-up of same or similar programs in other settings. Furthermore, we were only able to ecologically assess the impact of the program on routine laboratory workloads. It is therefore difficult to ascertain whether the increases in DMC workloads were due to the program's operations or other routine TB program operational factors (e.g., absenteeism and/or prolonged or interim shortage of staff, increase in routine patients, etc.). Likewise, additional data on routine program operations may be needed to adequately monitor and assess the impact of the ACF program on the capacity of the routine TB services.

CONCLUSION

In this study, we provided a range of evidence on costs and factors influencing the operations of an ACF and treatment support program targeting a rural, neglected population in India. Despite being highly resource-intensive, given the program's operational context and its innovative approach to effectively reach people missed by existing TB services, this program clearly demonstrates economic feasibility. Nevertheless, close cooperation with the routine TB program and continued monitoring of the factors influencing variabilities in costs and operations will be critical in ensuring increased adoption and scalability of this program.

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Objectif : Evaluer le coût d'un programme de recherche active des cas (ACF) avec la fourniture et le suivi d'un traitement de tuberculose (TB) ciblant une population rurale tribale en Inde.

Méthode : Une étude de temps et de production a été réalisée afin d'évaluer les opérations et la charge de travail. Le coût (2015 \$US) a été évalué en utilisant à la fois la méthode de coût ascendante et descendante selon la perspective du programme, à l'exclusion du coût des soins de TB de routine. L'impact de l'ACF sur les charges de travail de routine des laboratoires TB a été mesuré en se basant sur les modifications du temps de personnel disponible par frottis dans neuf centres de microscopie désignés avant et après la mise en œuvre du programme.

Résultats : Une majorité (53,2%) du temps des travailleurs de santé

communautaire a été dépensée en trajets vers les communautés, avec une moyenne de 22 (IC 95% 19,14–24,94) patients TB vus chaque jour par personne. Les coûts ont été de 1,85–2,42\$ par patient dépisté et ayant soumis des crachats, de 2,51–4,74\$ par personne ayant eu un diagnostic de TB et de 22,52–34,13\$ par patient TB achevant le traitement. Le volume total des crachats a augmenté significativement après le programme ACF, avec plus de 15% de réduction du temps disponible du personnel pour chaque examen de frottis dans la plupart des laboratoires.

Conclusion : Ce programme d'ACF à faible coût a le potentiel d'être très rentable en répondant aux problèmes de traitement de la TB dans l'Inde rurale.

Objetivo: Determinar los costos de un programa de búsqueda activa de casos (ACF) de tuberculosis (TB) con suministro de tratamiento y seguimiento, dirigido a una población tribal rural en la India.

Método: Se llevó a cabo un estudio de tiempos y movimientos, con el fin de analizar las operaciones y la carga de trabajo. Los costos se evaluaron (en USD del 2015) mediante métodos de determinación de costos ascendentes y descendentes, desde la perspectiva del programa, con la exclusión de los costos ordinarios de la atención de la TB. El impacto de la ACF sobre la carga ordinaria en los laboratorios de TB se midió en función de la modificación del tiempo de trabajo del personal disponible para cada baciloscopia en nueve centros de microscopía escogidos, antes y después de la ejecución del programa.

Resultados: La mayor parte del tiempo de los agentes comunitarios

de salud (53,2%) se invertía en los desplazamientos hacia las comunidades; se atendió un promedio de 22 pacientes con TB por día y por persona (IC 95% 19,14–24,94). Los costos oscilaron entre 1,85 USD y 2,42 USD por cada paciente evaluado que aportó muestra de esputo; entre 2,51 USD y 4,74 USD por persona diagnosticada con TB; y entre 22,52 USD y 34,13 USD por cada paciente con TB que completó el tratamiento. El volumen global de las baciloscopias aumentó de manera considerable después del programa de ACF y se observó una disminución superior al 15% en el tiempo de trabajo del personal disponible por cada baciloscopia en la mayoría de los laboratorios.

Conclusión: Este programa de ACF de TB, de bajo costo, podría ser sumamente costo-efectivo para abordar las brechas de los problemas de atención de la TB en zonas rurales de la India.