Acta Scientific MEDICAL SCIENCES (ISSN: 2582-0931)

Volume 7 Issue 2 February 2023

Research Article

Combined Case Finding Strategies for Pulmonary Tuberculosis in Kampala City: A Cost Effectiveness Analysis

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Received: December 28, 2022

Published: January 18, 2023

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Abstract

Objective: This study aims to evaluate the cost-effectiveness of a combination of three strategies compared to Passive Case Finding (PCF) alone for TB case identification among high-risk communities in Kampala from provider's perspective.

Design: This was a cost effectiveness analysis where cost data and yield of TB cases for PCF alone and a combination of Passive Case Finding (PCF), Enhanced case finding strategies (ECF) and Household Contact Investigation (HCI) were collected among adults in highly-congested areas of Kampala. The main outcome was Incremental Cost Effectiveness Ratio representing the cost to detect an additional TB case identified.

Results: Based on Uganda TB program data, 4,755 pulmonary TB cases from 12,298 presumptive TB cases were identified through PCF alone in Kampala. The average cost for every presumptive tuberculosis case identified through PCF alone and PCF+HCI+ECF was US$895.80 and US$4909.90 respectively. The cost of detecting one additional TB case was US$8211.80 using PCF, ECF, and HCI compared to using PCF only. The Incremental Cost Effectiveness Ratio (ICER) was most sensitive to number of household contacts screened, number of TB cases identified through ECF and probability of having chronic cough.

Conclusion: The proportion of TB case yield of the combined strategies (PCF, ECF, and HCI) was twice as high as PCF alone. However, this was costlier making it less cost-effective compared to PCF alone based on the set threshold of twice Uganda's gross domestic product.

Keywords: Cost Effectiveness Analysis; Pulmonary Tuberculosis; Enhanced Case Finding; Household Contacts; Passive Case Finding

Abbreviations

CEA: Cost Effectiveness Analysis; CLF: Community Linkage Facilitator; DALY: Disability Adjusted Life Year; ECF: Enhanced Case Finding; HCI: Household Contact Investigation; NTLP: National Tuberculosis and Leprosy Control Program; PCF: Passive Case Finding; QALY: Quality Adjusted Life Year; WHO: World Health Organization

Introduction

Tuberculosis (TB) remains a major global health problem with approximately two billion patients [1]. The primary objective of TB programs is prompt identification and adequate treatment of new TB cases [2]. However, the global and country TB case notifications have been observed to be relatively stagnant over the past 10 years

[3]. The stagnant TB notification rates under Passive Case Finding (PCF) strategy call for innovative ways of finding more undetected TB cases among high-risk poor populations.

Active case finding (ACF) and Enhanced case finding (ECF) are strategies that have been suggested and implemented to increase TB case identification in high burden settings. ECF avails TB information to communities through publicity and health education. It also encourages self-presentation to medical services [4] and appropriate health-seeking behaviour when people experience symptoms of TB combined with on-site diagnostic services [5]. The ACF (including Household Contact Investigation(HCI)) and ECF are of considerable interest in TB control especially due to slow progress of current control strategies in reducing the TB incidence in HIV/AIDS high burden areas [6].

The National TB Control Program (NTLP) in Uganda implements PCF as the standard strategy for identification of index TB cases. Whilst case detection is the cornerstone of TB control strategy recommended by WHO, PCF strategy alone has been demonstrated to be insufficient for detection of all TB cases in high burden countries like Uganda [7-9].

Several studies have found various ACF strategies to be effective in identifying more undetected TB cases among high-risk communities [6,9-11]. However, there is minimal documented evidence about the cost effectiveness of ACF strategies including ECF. Thus, this study assessed the cost effectiveness of implementing a combination of PCF, ECF, and HCI compared to exclusive PCF, for identification of TB cases among high-risk communities in Kampala.

Methods

This was a cost-effectiveness analysis study to compare exclusive PCF with pulmonary TB active case finding strategies (HCI and ECF, being piloted) co-existing with PCF from a provider's perspective. The study used mainly administrative secondary data sources from the TRACK Tuberculosis Activity Project (TRACK TB), National TB and Leprosy Program (NTLP) and Hospitals, as well as literature. The interventional data used for this analysis was generated from The TRACK TB project implemented in Kampala City by Management Sciences for Health, with the goal of drastically reducing TB prevalence in the City (which is known to be reporting the highest number of TB cases annually). This project piloted ECF in 2015 as one of the means to increase TB notification in the City, with a focus in areas with high risk of TB infection, especially highly congested areas like the slums, taxi parks and market areas.

This study considered data of adults from these high risk urban populations in Kampala city.

A time frame of one year was considered since this was a period for which the strategies were implemented.

Description of competing strategies

Passive case finding (PCF)

In this strategy, symptomatic persons that voluntarily access health care facilities are assessed and tested for TB using microscopy or GeneXpert (if HIV seropositive). The patient receives free services at public healthcare facility [28].

Additionally, a symptomatic presumptive TB patient produces at least two sputum samples (one on spot/immediate and another an early morning sample obtained before eating) were used for diagnostic purposes. Thus, there are costs borne by the health facility to provide a sputum container to a presumptive TB patient for the early morning sample as well as diagnostic costs using the microscopy/GeneXpert machine.

For purposes of this study, it was assumed that HIV-positive individuals were evaluated using GeneXpert machine, as per the NTLP guidelines [29].

Household contact investigation

Under this strategy, community linkage facilitators (CLFs) screen all household members of a TB index patient (smear positive who has been identified at a health facility) for TB symptoms; cough for more than two weeks, unexplained weight loss, haemoptysis, fevers and night sweats [12]. Individuals found with TB symptoms are requested to produce two sputum samples, which are collected by the CLF and delivered to an appropriate health facility for diagnosis. When ready, the results are returned to the CLF. Those whose sputum is found to be positive for *Mycobacterium Tuberculosis* are then linked to the nearest health facility for appropriate care.

The provider costs will include transport costs and work allowances for the CLF as well as provision of educational materials like catalogues, stationary and a bag which the CLF uses during the home visits. Costs incurred by the provider at the health facility level are the same as described above in the PCF strategy.

Enhanced case finding

This strategy involves health workers and CLFs setting up TB mass awareness camps in TB high-risk/burden areas, during which mobilization and sensitization of people, as well as subsequent screening for TB occurs [13]. The presumptive TB patient is left with a sputum container in which he/she will put the early morning sample.

The CLF then returns to the client (tested person) for an early morning sputum sample the following morning that is also taken for analysis. The results are then returned by the CLF to the patient and if found positive, are linked to an appropriate health facility for care. Costs incurred by the provider at the health facility level are the same as described in PCF strategy above. All diagnostic services are carried out at the health facility.

The provider incurs expenses on, but not limited to, hiring vehicles to transport outreach teams, public address systems, catalogues and stationery, allowances, tents and chairs for the outreach clinic, transportation costs for CLFs and sputum samples, communication between outreach teams and the patients, among others. The use of health workers here has a big cost impact to program implementation and the cost analysis since it raises the program costs while the use of CLFs is a less costly approach, though it may impact on the quality of work and outcomes in the community as CLFs are not trained health professionals.

Decision analytic model

A static decision analytic model was used to compare and analyse the different strategies, taking into consideration the activities involved in TB case identification. PCF was the reference strategy against which the other strategies were compared. A simplified illustration (Figure 1) and details of the model parameters are shown in the tables in the supplementary materials.

Figure 1: Decision analytic model.

The number of bacteriologically confirmed TB cases identified through a given strategy was the effectiveness measure used. This was the best effectiveness measure to inform program implementers on the cost-effective approaches to be used in order to identify more undetected TB cases in the community.

Costing

Ingredients approach was used for this study where all the resources used for the delivery of the strategies were quantified and valued [14].

Cost estimates were largely grouped into fixed and variable costs (as well as direct medical and direct non-medical costs) regarding expenditures on ECF, HCI and PCF-related activities. The cost items on PCF included; 1) Program costs like Personnel costs, costs for administration, supervision, among others; 2) Direct Medical Costs like costs for Consumables as well as costs of tests (AFB smear test and GeneXpert test).

Variable costs also included costs for Airtime, evaluation meetings for ECF, SDA, transport allowances for Health workers and community linkage facilitators during ECF, Cost of materials/ items used during ECF, Costs incurred during trainings for CLFs for ECF, Costs for mobilisation of members of the public to attend ECF activities, Cost of materials/items used during HCI, Costs incurred during evaluation meetings for HCI, Opportunity costs incurred by the patient during HCI, Transport refund for CLFs during HCI. HCI fixed variable costs included items like IEC materials, while HCI variable costs included transport refund for Home visits for CLFs during HCI, costs incurred during evaluation meetings for HCI, and Materials. On the other hand, ECF Fixed costs included; costs to purchase log back bags for the community support team, IEC materials, tents, chairs, tables and sputum carrier box, operations space (in square feet).

Capital costs were annualized and discounted at 3% per year [15], with useful estimates obtained from the WHO tables. Cost data from previous years were adjusted for inflation to 2015 costs [16] and converted to US$ (using the conversion annual average rate of US$1.00=UGX 3,240.65) [17]. It represents changes in price and of all goods and services purchased for consumption by urban households. Shared costs were not included in the analysis.

A discount rate was not applied to the costs because a one-year analytic horizon for this study was used.

Data analysis

Data was entered into and analysed using TreeAge Pro Suite (TreeAge Software, Williamstown, MA) version 2017. A decision threshold of three times the per capita Gross Domestic Product (GDP) for Uganda (US$696.4) [18] was considered, following standard benchmarks proposed in the international panel on cost-effectiveness analysis [19].

Sensitivity analyses

Deterministic one-way and two-way sensitivity analyses were done to ascertain the robustness of study results. Baseline cost estimates were halved and doubled while the probabilities were reduced or increased by 20% to establish the parameter ranges [20,21].

Ethical approval

Ethical approval and clearance for the study was sought from the Makerere University School of Public Health Higher Degrees, Research and Ethics Committee. In addition, written informed consent as sought and obtained from the study participants for the cases where primary data was collected.

Results

We estimated the number of people at high risk of TB infection in Kampala to be 1,387,430, based on estimated from the data from NTLP and Uganda Bureau of Statistics. A total of 12,298 and 12,915 presumptive TB cases were identified by PCF alone and PCF, ECF, and HCI respectively.

Costs

The average costs per presumptive TB case were higher for PCF, ECF, and HCI (US$4,909.91) compared to PCF alone (US$895.79). The cost components were for communication and facilitation at US$25,889.87 (20.7%) and US$24,058 (19.3%) respectively. This is indicative of the high communication intensity required for PCF, ECF, and HCI. The total estimated PCF costs for diagnosis of Pulmonary TB was US$44.44 (using Microscopy and GeneXpert techniques) per patient. Of this, 89.2% (US$39.65) were direct medical costs and 10.8% (US$4.79) were the associated program costs.

The total costs spent on ECF and HCI program activities were US$110,671.04, of which US$ 2,995.57 was spent on fixed

costs and US$107,675.47 was spent on variable costs (details in Supplementary material for details).

Effectiveness

The number of pulmonary TB cases was lower in the PCF strategy compared to PCF, ECF, and HCI (4755 vs 5,120); representing a proportion of bacteriologically confirmed TB cases being lower with the PCF strategy (10.6%) compared to the PCF, ECF, and HCI (23.55%).

Cost effectiveness of the TB case finding strategies

The incremental cost-effectiveness ratio (shown in Table 1) comparing PCF, ECF, and HCI to PCF alone was US$8,211.8 per TB case identified. This means that the program incurred US$8,211.8 for every additional TB case identified through PCF, ECF, and HCI compared to PCF alone. The analysis further revealed that no strategy was clearly dominated by the other.

Strategy	Cost	Incr. Costs	Eff.	Incr. Eff.	Avg. CE	ICER
PCF	9,521.1	0	10.63	0	895.8	0
PCF, ECF, and HCI	115630.0	106108.9	23.55	12.92	4909.9	8211.8

Table 1: Cost-effectiveness results table comparing PCF, ECF, and HCI to PCF alone.

Abbreviations: Incr. – Incremental, Eff. – Effectiveness, Avg. CE - Average Cost Effectiveness Ratio.

Sensitivity analysis

One-way sensitivity analysis revealed that the model was most sensitive to the probability of having chronic cough, and number of HCI contacts screened (see Supplementary material for details). However, the ICER was most sensitive to number of HCI contacts screened (Figure 2).

Figure 2: A Tornado diagram showing variations in selected key population parameters.

The most influential cost parameters noted (substantially increased the ICER) included; cost of the materials used during HCI, cost of doing the GeneXpert test, cost of the IEC materials for ECF, the opportunity costs, and overall PCF costs (Figure 3).

Figure 3: A Tornado diagram showing variations in selected key cost parameters.

PCF, ECF, and HCI became the dominated strategy at the probability value of having chronic cough of 0.835. The Two-way sensitivity analysis noted that two model parameters were the most sensitive; that is, the cost of PCF with the probability of having chronic coughs (see Supplementary material for details).

Discussion

We performed cost-effectiveness analysis comparing PCF, ECF, and HCI with PCF-alone in the identification of Pulmonary TB cases among high-risk communities in Kampala. At an incremental cost of US$ 8,211.8 per TB case identified, the PCF, ECF, and HCI combination was noted not to be cost-effective.

To our knowledge, this is one of the first studies that have evaluated the cost-effectiveness of a combination of PCF, ECF, and HCI strategies. These findings give an insight of the impact of PCF, ECF, and HCI as well as the cost implications, when considering adding TB active case finding to the existing PCF, especially in a relatively similar incremental manner [22].

Yield of pulmonary TB cases

The PCF, ECF, and HCI produced a marginally higher yield of TB cases compared to PCF alone. This mirrors the added value of combining ECF and HCI with the standard PCF TB case identification and notification in high-risk populations since PCF alone is more likely to be accessed by sicker individuals with a higher probability of TB disease [22,23]. Thus, the benefits of PCF, ECF, and HCI cannot just be underestimated.

In South Africa, a study used an existing mobile HIV testing service using a nurse-run and counsellor-supported clinic in Cape Town as the model for ECF. It was demonstrated that community-based active TB case finding had a high uptake and yield of diagnoses among high-risk TB/HIV populations [22]. Findings from this study in Cape Town were comparable to our study findings.

Another study based on community ACF was conducted in a poor urban settlement in Cambodia, with targeted use of microscopy and GeneXpert techniques. It reported a yield of 737 TB cases, and

29% increase in case notification. However, an analysis of cost-effectiveness of this community-based strategy was lacking [24]. In addition, the authors recommended community-wide TB screening supplementary to passive case detection for similar TB-endemic settings. It's important to note that the yield of TB cases from PCF, ECF, and HCI may often be context specific, depending on TB and HIV prevalence, TB control services, as well as the specificity and sensitivity of the screening tool used [12]. In this study, the higher yield of TB cases in PCF, ECF, and HCI could be partly explained by the on-going efforts by Government of Uganda to increase access to GeneXpert machines in order to improve TB diagnosis in public healthcare facilities in Kampala [12].

Incremental cost-effectiveness ratio

An incremental cost effectiveness analysis was performed from the provider's perspective that revealed a cost of $8,211.8 per extra TB case identified from the community. These findings demonstrate that PCF, ECF, and HCI for identifying and detecting a pulmonary TB case in the community was quite much costly and offered marginal benefit compared to exclusive PCF. Hence, this suggests that the former offers marginal benefit in terms of yield of TB cases but at a much larger cost, than three times the national GDP.

There are limited studies that have evaluated the cost-effectiveness of TB active case finding strategies [25]. To the best of our knowledge, our study is the first to conduct a cost effectiveness evaluation of PCF, ECF, and HCI strategy in this setting. Sekandi and colleagues conducted a cost-effectiveness comparing PCF alone to combinations of PCF+HCI or PCF+ACF. They found that PCF and HCI was cost effective) [9].

Another study done in Cambodia found that PCF+ACF program was highly cost effective when compared to PCF alone at an estimated US$330 per DALY averted or US$5300 per death averted [11]. This study is different from ours because it compared a combination of two strategies excluding ECF and also used DALYs as the outcome measure.

It is important to note that, the cost effectiveness of PCF, ECF, and HCI programs is context-specific [11]. Whereas these findings might not suggest cost effectiveness of PCF, ECF, and HCI in similar Sub-Saharan African settings, second stage filters and other issues like social factors, availability/functionality of the infrastructure and resources for those contexts ought to be considered since they substantially affect the generalizability of the concept [22,26]. Furthermore, a study done in South Africa reported a cost of US$1,117 per TB case detected [22], which was relatively lower compared to the findings in this study. This could have been due to contextual issues like Infrastructure as eluded to above.

Sensitivity analysis

Uncertainty analysis about the true parameter values of the data was done using both one-way and two-way sensitivity analyses. The model's Incremental Cost Effectiveness Ratio (ICER) was generally robust in both one-way and two-way sensitivity analyses. However, the probability of having chronic cough and the number of HCI contacts screened were the most influential parameters (due to the underlying influence of the TB prevalence and TB transmission intensity).

TB prevalence has a substantial impact on the cost-effectiveness of TB ACF programs [4,11].

This study has some limitations. We considered an intermediate outcome without accounting for future benefits that would accrue from ACF and ECF. This decision was informed by the most relevant information needed by our audience; the TB providers for policy decision making. Using terminal outcomes such Quality adjusted Life Years (QALYs) is the recommended gold standard [27].

Conclusion

The current study provides preliminary evidence that implementation of PCF combined with HCI and ECF is effective for detecting additional cases of active TB in Kampala, Uganda. The effectiveness of PCF, ECF, and HCI was more than two times higher than that of PCF alone. However, in the context of limited resources, the combination of PCF, ECF, and HCI is not cost-effective given the high cost of detecting each additional case not cost effective for identifying TB cases in this high-burden low-resourced setting.

Ethics, Consent and Permissions

Ethical approval and clearance for the study was sought from the Makerere University School of Public Health Higher Degrees, Research and Ethics Committee, TRACK TB Project, Kampala Capital City Authority, the health facilities' administrators and staff.

Consent for Publication

Not applicable.

Availability of Data and Materials

All the data generated or analyzed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Funding

Direct funding for this study was availed by the German government through the DAAD scholarship.

Authors' Contributions

AS designed and conceptualized the study, wrote the model and conducted data collection. AS and VK conducted analyses. AS wrote the first draft of the manuscript. AS, VK, SK and JS made substantial contributions during the study conceptualisation, design and participated in manuscript writing. All authors read and approved the final manuscript.

Acknowledgements

Funding for this work was provided by the German government through the DAAD scholarship. The authors sincerely thank the staff of USAID funded TRACK TB project under Management Sciences for Health, especially Dr. Deus Lukoye, the study respondents, and Health facility administrators for their support throughout the study.

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