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Review Article

The Role of Private Doctor and Private-Public Mix Systems in Tuberculosis Detection in Developing Countries: A Systematic Review

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Abstract

Background: Despite the significant efforts in tuberculosis (TB) management, TB case detection remains a challenge in developing countries. Traditional methods such as Directly Observed Treatment Short-course (DOTS) have often underperformed, necessitating the implementation of the public-private mix (PPM) strategy in recent decades. However, varied PPM models yielded varied results across different countries. Hence, this systematic review assesses the effectiveness of various PPM models and seeks innovative strategies to enhance TB detection.

Methods: A systematic search was conducted using PubMed, Scopus, Embase, and Web of Science up to August 2024. Studies evaluating the efficacy of PPM models on TB case detection in developing countries were pooled. From the initial 731 potential studies, a total of 10 studies were finally included in this systematic review.

Results: The review identified a variety of PPM interventions, including mass campaigns, mobile screening units, home-based tracking, and digital CXR examination. These approaches significantly raised tuberculosis detection rates compared to control groups or previous years. Notably, private sector involvement and novel approaches, such as application-based tracking in Vietnam and mobile vans equipped with digital X-rays in India, yielded favorable results. However, the variation in effectiveness rate underscored the importance of personalized approaches based on local contexts.

Conclusion: PPM models, especially those with innovative techniques, significantly enhance TB case detection. Scaling up and modifying these strategies to various country circumstances is critical to meeting global TB reduction targets.

Keywords: Public-private mix; Tuberculosis; Developing countries; Systematic review

Introduction

Tuberculosis (TB) continues to be a major global health concern. As the leading cause of mortality from preventable and curable infection, TB causes more than (1). Five million deaths annually (1).

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Furthermore, approximately 10 million people develop active TB each year, with the highest burden seen in low- and middle-income countries. As a result, TB continues to hamper economic and social development, creating substantial health disparities. Approximately one-quarter of the world's population is estimated to be infected with latent TB, with 10% among them progressing to active TB. Interestingly, the global distribution of TB is highly concentrated in developing countries. According to the WHO, over two-thirds of all TB cases reside in eight countries: India, Tiongkok, Indonesia, Philippines, Pakistan, Nigeria, Bangladesh, and South Africa. Despite an ambitious global target to reduce TB incidence by 90% and TB-related mortality by 95% in 2035, detecting TB cases in developing nations continues to be a major challenge (1,2).

Various strategies, including Directly Observed Treatment Short-course (DOTS), have been implemented in high-burden countries (3), yet yielding suboptimal results. As a result, a novel concept of the public-private mix (PPM) approach was introduced in the late 1990s to enhance collaboration among healthcare workers, private sectors, and governmental/non-governmental organizations (GO/NGO) (4).

While the PPM model has shown success in several countries, its effectiveness varies greatly depending on the methodologies and local contexts of the respective country (5–7). These inconsistencies, coupled with outdated approaches, foster the need to review the current design to identify the most efficient approach for the PPM model in detecting TB cases, especially in developing countries where the health budget is often limited.

Hence, we aimed to evaluate the different PPM models across countries to identify strategies to enhance TB detection, particularly in developing countries. The findings from this systematic review are crucial for formulating evidence-based health policies in TB-endemic regions.

Methods

This review paper followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines.

Search strategy

A systematic search of the relevant studies was performed through PubMed, Scopus, Embase, and Web of Science up to August 2024. Details of the search strategy are available in Table 1.

Table 1: Details of the search strategy

PubMed	(("task force" OR "general practitioner" OR "physician")) AND (("TB screening" OR "tuberculosis screening" OR "TB detection" OR "tuberculosis detection" OR "tuberculosis diagnosis"))	285 articles
Scopus	(TITLE-ABS-KEY ("task force" OR "general practitioner" OR "physician")) AND (TITLE-ABS-KEY ("TB screening" OR "tuberculosis screening" OR "TB detection" OR "tuberculosis detection" OR "tuberculosis diagnosis"))	193 articles
Embase	('task force' OR 'general practitioner' OR 'physician') AND ('TB screening' OR 'tuberculosis screening' OR 'TB detection' OR 'tuberculosis detection' OR 'tuberculosis diagnosis')	200 articles
Web of Science	TS=("task force" OR "general practitioner" OR "physician") AND TS=("TB screening" OR "tuberculosis screening" OR "TB detection" OR "tuberculosis detection" OR "tuberculosis diagnosis")	53 articles
Total		731 articles

Selection criteria

Screening and data extraction processes were performed by two independent investigators (RDY, CUW) from eligible studies. Any disagreements were resolved by discussion and the involvement of the referee and a consensus was reached for all items. To investigate the role of private doctors, health volunteers, and PPM in tuberculosis case detection, the following inclusion criteria were applied: 1) experimental or interventional studies (cluster RCTs, cluster controlled trials, quasi-experimental studies, cohort), 2) evaluating the PPM or private healthcare outcomes with a comparison of the previous year to the intervention, or with the comparison of other districts/location as control, 3) evaluated the outcome of TB case detection, 4) conducted in developing countries or high-density of TB case, and 5) in English. Studies under the following criteria were excluded: 1) duplicate studies, 2) review, case report, letter to the editor, conference abstracts, commentary 3) no full-text studies, and 4) non-human studies. A PRISMA flow diagram will be used to document the selection process.

Data extraction

For studies meeting the eligibility criteria, the following information was extracted: author, publication year, study design, country, provider and intervention types, and outcomes. A standardized data extraction form will be used and will be converted to Microsoft Excel 2021.

Quality assessment

The quality of the included studies was evaluated using the Newcastle-Ottawa Scale (NOS). The NOS is designed to assess the quality of non-randomized studies across three components, including selection, comparability, and outcomes. Studies receiving 7-9 stars are considered high-quality. Those who received 4-6 stars are considered as moderate quality, while those who received 0-3 stars are interpreted as low-quality studies.

Data analysis

The included studies will be sorted according to the intervention type, health workers involved, and outcomes (new TB case detection, TB notifications, treatment initiation, and completed treatment). We evaluated the outcomes of the interventions pooled in this study and further provided evaluations according to the targets for global TB control.

Ethical considerations

This review did not require ethical considerations as it only included published articles available to the public.

Results

A total of 731 publications were initially retrieved from four databases (PubMed (n = 285) Web of Science (n = 53), EMBASE (n = 200), Scopus (n = 193)). A total of 347 duplicates were removed before screening, and 26 remaining studies were reviewed and carefully screened according to the eligibility criteria. Finally, ten studies evaluating the role of private doctors and public-private mix interventions in TB case detection were included in this systematic review. (4,6–14) (Fig. 1). It represents the identification of eligible studies using the PRISMA Flow Diagram.

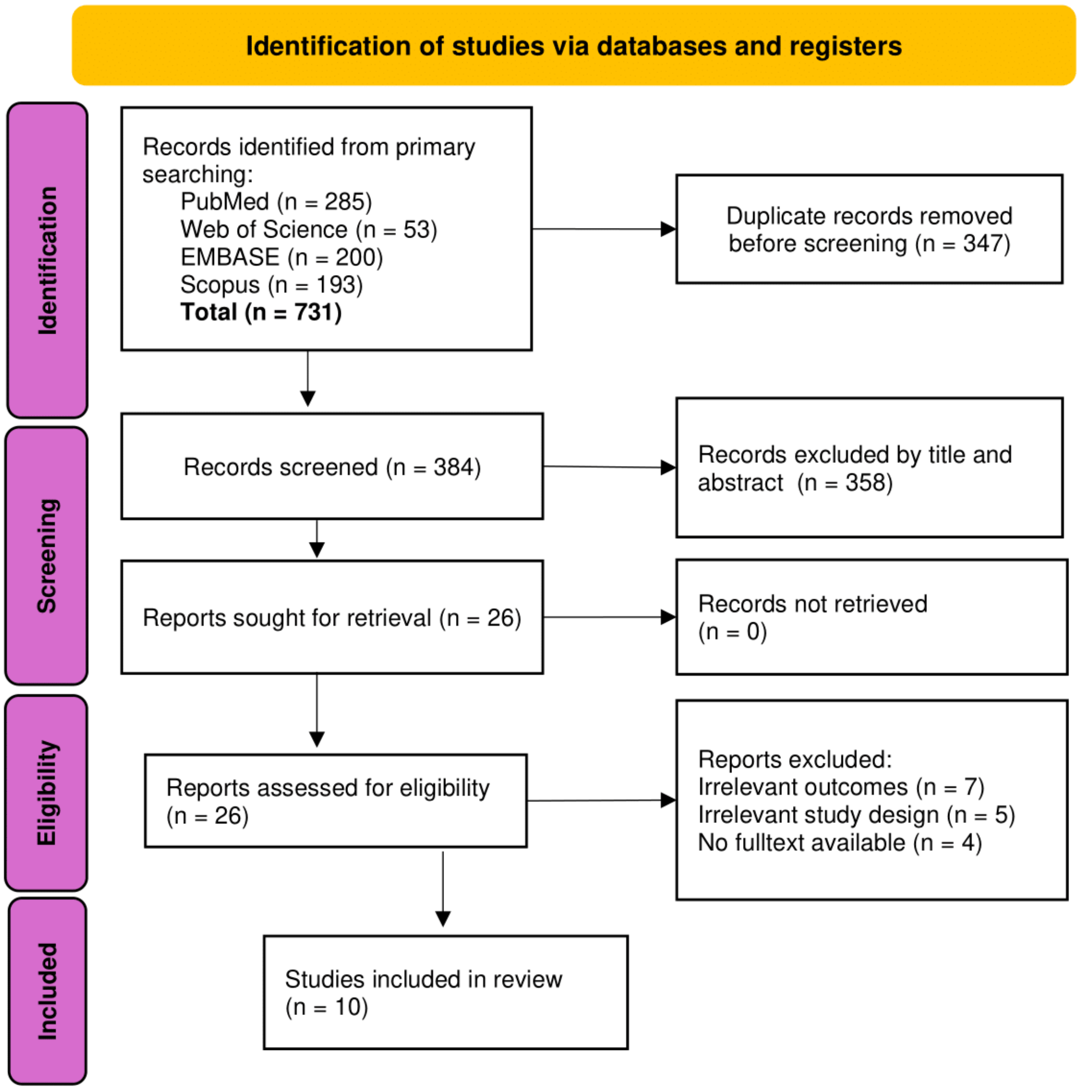

Fig. 1: PRISMA flow diagram

Characteristics of the Included Study

From the ten included studies, studies conducted prospectively dominated the overall study design pooled (n=4), followed by retrospective (n=2), cohort (n=1), quasi-randomized experimental (n=2), and mixed-methods study (n=1). Studies included were dominantly conducted in India (n = 3), followed by Pakistan (n=2), and one each for Peru, Nepal, Afghanistan, Uganda, and Vietnam. Approximately 80% of the included studies were conducted in Asia, while South America and Africa accounted for 10% of each of the remaining parts. Three of the included studies facilitated interventions by private healthcare providers, and the seven others by public-private mix interventions. All the included studies describe better TB case detection, notification, treatment initiation, and treatment completion compared to the controlled population or year before the intervention. The summary of the intervention and outcomes of each study are reported in Table 2.

Table 2: Characteristics of the included studies

Study	Country	Intervention type	Outcomes
Ullah et al., 2021(4)	Pakistan	Comparing the following PPM models: solo general practitioner (GP) (PPM-1), Non-Governmental-Organization (NGO) model (PPM-2), private hospital model (PPM-3), and Parastatal model (PPM-4)	The PPM model was responsible for 25% of the Pakistan national TB case notifications. Treatment success rates varied: solo general practitioners and NGOs achieved 94-95%; private hospitals reached 82%, while Parastatals managed fewer than 50% successfully.
Wippel et al., (12)	Peru	Mixed-methods model assessing patient's pathway analysis in PPM models	Among private providers, 43% offered smear microscopy, 13% had radiography, and none provided TB treatment. In contrast, public sector facilities provided 100% smear microscopy, 26% radiography, and 99% treatment.
Sah et al., (6)	Nepal	Mass screening in hospital outpatient by engaging health volunteers at the cough screening desk (CSD) and referring the clinical examination to the physician	The intervention led to over a 10% increase in TB case detection. Areas that received intervention experienced a 17% rise in bacteriologically confirmed TB cases and a 10% increase in overall TB cases. Control areas only reached 4% and 2% rise in the abovementioned outcomes, respectively.
Ford et al., (7)	India	Mobile vans equipped with digital CXR are scheduled to detect TB cases in peripheral health institutes.	There was an 11.67% increase in new smear-negative TB cases from 2015 to 2016 ($p = 0.036$). From 2017 to 2018, the intervention scaled up to 13 and 16 districts, conducting 6268 and 8021 CXR examinations.
Hamim et al.,(8)	Afghanistan	DOTS program in urban TB	The private sector contributed 19.7% of new case detection. Positivity rates for TB in public facilities ranged from 18.9-4.8% annually, while in private facilities varied from 25.8% to 27.4% in the same years.
Joloba et al., (9)	Uganda	Training for laboratory and postal workers in strengthening sputum referrals to detect MDR-TB	Improvements of the specimen referral system led to over >10-fold increase in MDR-TB sputum referrals, with 94% of specimens arrived the national laboratorium within the target time.
Khan et al., (5)	Pakistan	- Engaging the private sector to conduct a mass campaign for those developing TB symptoms in private healthcare facilities - Mobile-phone-based screening for visitors of the outpatient department	TB case notification in intervention areas doubled from 2010 to 2011 compared to control areas. At Indus Hospital, pulmonary TB notifications increased by 3·77-fold for adults and 7·32-fold for pediatrics.
Khatana et al., (10)	India	Home-based contact tracing by the Medical Officer of TB-Unit (MO-TC of TB Unit)	The intervention group found that 4.51% of contacts had active pulmonary TB, compared to 1.18% in the control group. Initial contact participation was 70.74% and remained at 59.53% at six-month follow-ups.
Thu et al., (11)	Vietnam	(i) Active facility-based screening of all adults for TB symptoms (and chest x-ray (CXR) for those with symptoms) by trained and incentivized providers, with on-site diagnostic testing or transport of sputum samples, (ii) a mobile application to reduce dropout in the care cascade and (iii) enhanced follow-up care by community health workers.	Around 0.7% of outpatient visitors showed symptoms or CXR abnormalities indicative of TB; 81% were tested, and 34.4% were diagnosed with TB. Of these, 95% started treatment and 93% achieved successful outcomes.
Kumar et al., (13)	India	Training in microscopy-based TB detection to all large private sector laboratories, and educated private physicians on the importance of microscopy for TB diagnosis.	The private sector was responsible for 17% of new TB case detections, with an annual increase of 21% in new AFB-positive cases.

Quality of the included studies

The quality of the included studies was rated using NOS for non-randomized studies. All of the included studies received 7-9 stars in the NOS quality assessment, indicating studies included in this meta-analysis are high-quality studies (Table 3).

Table 3: Quality Assessment of Included Studies

Reference	Representativeness of the Exposed Cohort (1)	Selection of the Non-exposed Cohort (1)	Ascertainment of Exposure (1)	Demonstration that Outcome of Interest was not Present at the Start of the Study (1)	Comparability of Cohorts based on Design or Analysis (2)	Assessment of Outcome (1)	Was Follow-up Long Enough for Outcomes to Occur (1)	Adequacy of Follow-up of Cohorts (1)	Total
Ullah et al., 2021 (4)	1	1	1	1	1	1	1	1	8
Wippel et al., 2024 (12)	1	1	1	1	1	0	0	1	6
Sah et al., 2021 (6)	1	1	1	1	2	1	0	1	9
Ford et al., 2019 (7)	1	1	1	1	2	0	1	1	9
Hamim et al., 2023 (8)	1	1	1	1	1	1	1	1	9
Joloba et al., 2016 (9)	1	1	1	1	2	1	0	1	9
Khan et al.,2012 (5)	1	1	1	0	1	1	1	1	8
Khatana et al., 2019 (10)	1	1	1	1	1	1	1	1	9
Thu et al., 2020 (11)	1	1	1	1	1	1	1	1	9
Kumar et al.,2005 (13)	1	1	1	1	1	1	0	0	7

Intervention models

The intervention models in included studies to optimize new TB cases detection varied according to healthcare systems and countries where the interventions were conducted. The most common approach was performed in Nepal and Pakistan and involved systematic screening in hospital outpatient departments by healthcare volunteers using a "cough scoring" or questionnaire system, followed by referral to a general practitioner or pulmonologist. (5,6). In India, two different approaches were pooled in different studies, from a mobile van equipped with digital CXR and active case finding through home-based intervention (7,10). Other impactful interventions were done in Pakistan through self-referral encouragement through mass campaigns and advertisements, while application-based screening and reporting were done in Vietnam (11). Training for postal and laboratory workers was done in Uganda to strengthen the sputum referrals suggestive of MDR-TB, and urban DOTS was done in a rural part of Afghanistan (8,9). Another study in Pakistan compared four different methods of PPM models, including 1) the solo general practitioner model, 2) the Non-Governmental Organization TB care facility model, 3) the private hospital model, and 4) the Parastatal model (4). Finally, a study in Lima, Peru highlighted the role of private healthcare providers in detecting TB cases (12).

Tuberculosis detection outcomes from the intervention model

All of the included studies reported higher case detection compared to the control or year before the intervention. The case detection has contributed substantially to the national case notification, ranging from 19.7% in Afghanistan to 25% in Pakistan (4,8). Compared to the controlled population, higher TB case detection is found in the intervention group, for over than two times (5). From home-based intervention model in India (10), a higher positivity rate was found among the intervention population (4.51%) compared to the controlled population (1.18%). Interestingly, after training 724 healthcare and postal staff members covering 72% of districts in Uganda to strengthen sputum referral to reduce multidrug-resistant (MDR)-TB cases, the referral of MDR-TB sputum experienced an increase by more than 10-fold within the three years of intervention (9).

Lessons learned from previous findings were highlighted by interlinking the role of private sectors and healthcare workers in TB case detection. Such an approach was done in India by engaging the private health sector by promoting self-referral to those presumptive of TB through a mass campaign, which resulted in two-fold case detection (5). Interestingly, in Uganda, the training for postal and laboratory workers led to over a tenfold increase in MDR-TB sputum referrals, addressing the diagnostic service and delivery delay gaps without new laboratory construction, as all the sputum was delivered to Uganda National TB Reference Laboratory (NTRL). This improvement yielded a transport system to conduct Uganda's national MDR-TB survey, which is substantially crucial for the national MDR-TB treatment program (9).

Proactively identifying tuberculosis cases is necessary, particularly for individuals who are unaware of TB symptoms. One possible approach involves systematic screening of visitors at the hospital's outpatient department using a "cough scoring" system, as successfully demonstrated in Nepal and Pakistan (5,6). Interestingly, more than a third of the newly detected TB cases were identified through this organized screening method. Despite the positivity rate of this detection method varying according to the patient's symptoms and the presence of other pulmonary diseases, screening for individuals with productive cough in the hospital's outpatient department is recommended, particularly in areas with a high TB case burden. Most of the included study involves healthcare volunteers performing the "cough scoring" and referring the patients for confirmatory diagnosis through sputum tests or chest X-ray evaluations by the general practitioner or pulmonologist, in which all the processes were done in the same hospital (5,6).

The innovative approach in PPM methodology, such as application-based screening and reporting, resulted in successful TB detection and treatment outcomes in Vietnam (11). This approach not only improved TB recording and reporting, but also reduced potential transmission to the healthcare workers, which could increase the participation of healthcare personnel in this proposed model. Moreover, the application utilized in this model is linked to the national TB information and management system, facilitating electronic referrals of suspected or confirmed TB patients to healthcare facilities. Another advantage of the online-based intervention is its ability to notify every diagnosed TB patient, improving the tracking and follow-up system that enhances treatment initiation and completion. This innovative approach in Vietnam achieved a 95% treatment initiation rate and 93% success rate for treatment outcomes (11).

An intriguing public-private partnership (PPP) initiative in TB detection took place in India with the designed mobile van equipped with digital CXR named "TB free Haryana". This approach has been scaled up due to its significantly successful result in increasing case detection for smear-negative TB cases that show radiographic signs of TB appearance. By 2018, a total of 8021 CXRs had been done across 16 districts, proving its feasibility in the field settings (7).

Comparison of intervention models

When comparing private to public healthcare facilities, significant discrepancies were found in TB positivity rates. In Afghanistan (2018), positivity rates were reported to be higher in private facilities compared to public facilities. Private facilities reported a 27.4% positivity rate, whereas public facilities had a positive rate of 4.8% in the same year (8).

In terms of comparing PPM models, a study conducted in Pakistan divided the interventions into four subgroups, 1) the solo general practitioner model, 2) the Non-Governmental Organization TB care facility model, 3) the private hospital model, and 4) the Parastatal model were employed and assessed retrospectively. These interventions were conducted in 92 different districts across Pakistan, even resulted in 25% of Pakistan's TB case notifications. This study revealed that the PPM model resulted in a significantly greater case detection compared to the non-PPM approach. Interestingly, from the four approaches implemented, the first (general physician) and second (NGO) models achieved 94-95% of successful treatments, higher compared to the private hospitals model (82%) and Parastatals (<50%) (4).

Discussion

Managing tuberculosis burden in densely populated areas remains a challenge, especially in developing countries (1,2,14). Despite the establishment of global and national TB programs, tuberculosis detection remains suboptimal, strengthening its status as the leading cause of mortality from curable infection globally (1). The public-private mix (PPM) strategy, introduced in the 1990s, was designed to help developing countries meet global targets of detecting at least 70% of tuberculosis cases (2,4).

Findings from a recent review revealed that active case finding by engaging the private sector yielded a significantly higher TB detection rate compared to a year before the intervention or among the controlled population (15,13). This was achieved through multiple modalities, including but not limited to mass campaigns for self-referral, mobile applications, home-based interventions, national data reporting, and training for community workers to improve sputum referral. Despite the varied properties of the PPM approach according to the respective nation's medical system (17–19), findings from this study suggested the necessity of scaling up active case finding using the PPM intervention approach to improve tuberculosis case detection and reduce its burden.

The process of diagnosing and treating tuberculosis cases involves multiple steps, including identifying symptoms, collecting and transporting specimens for TB detection, conducting additional examinations (e.g., chest X-ray (CXR)), reporting results, ensuring treatment initiation and continuation, and reducing the risk of transmission. Any insufficiencies or delays at any of these steps can lead to poor health outcomes, loss of follow-up in patients' care, delayed treatment, drug resistance, and increased TB transmission among the community. Hence, the PPM approach, especially in developing countries, plays a crucial role in accelerating and optimizing any of the abovementioned steps.

Engaging the private sector has substantially improved TB case detection in every mentioned study. Discrepancies of positive rates in TB screening were demonstrated in Afghanistan when comparing private and public healthcare facilities. In 2018, private healthcare facilities reported a 27.4% positivity rate, compared to 4.8% in public healthcare facilities (8). This discrepancy could have happened for several reasons. First, patients with tuberculosis were more often referred to private clinics for screening; hence, those screened at private clinics are probably presumptive of having tuberculosis. Secondly, most tuberculosis cases found in public health facilities were incidental, before the referral by "cough screening" by health volunteers.

Several challenges and areas for improvement were identified in the abovementioned interventions. First, in strengthening sputum referrals, providing appropriate protection for shipping and laboratory personnel must be prioritized (10). This can be achieved through establishing standardized specimen packaging which ensures the safety of healthcare workers and the general community. Secondly, even with improved case detection through mobile vans with digital CXR or home-based active contact tracing, major concerns are given to the treatment initiation and completion for those detected at home, especially when the healthcare facilities are far away (15-17). Hence, it is recommended to initiate anti-tuberculosis drugs as soon as a case is identified in the field.

Third, continuous monitoring and re-orientation for health volunteers must be prioritized to keep their commitment to completing the interventions (17,18). Additional training and financial incentives should be considered to boost their active participation in this proposed model (19,20). Fourth, education and counseling from the volunteers play a crucial role in overcoming patients' hesitancy in providing sputum samples and initiating TB treatment. For those living far from healthcare facilities, extended DOTS center staff participation in monitoring patients' treatment compliance is suggested (21).

Conclusion

The PPM approach, regardless of the intervention model, is associated with a higher TB case detection than in the controlled population. In the observed countries, models involving general practitioners and NGOs had the highest success, especially when coupled with technological aids such as application-based reporting and mass campaigns in collaboration with NGOs, even outperforming hospital-based detection alone. The innovative approach demonstrated higher success than the traditional door-to-door approach. Hence, PPM models with innovative, country-specific strategies should be scaled up to achieve global TB targets for case detection.

Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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Conflict of Interest

All authors in this study declare no conflict of interest.

Data availability statement

All data related to this systematic review is available within the manuscript and supplementary materials.

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