A systematic review of tuberculosis detection and prevention studies in prisons

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Author contributions

ILH and LG conceived and designed the study. ILH performed the literature review. ILH, ATO and LG analysed and interpreted the data. ILH prepared the manuscript; ATO and LG finalised and approved the manuscript.

Abstract

Many studies have demonstrated that prisons are hotspots of tuberculosis disease and transmission. Despite this, it remains unclear which interventions are most effective at controlling tuberculosis in prisons. The objective of this study was to evaluate the study designs used to investigate tuberculosis control in prisons, and the efficacy of interventions undertaken. This systematic review included published studies which had the aim of reducing TB incidence or prevalence, or increasing the number of people screened for active pulmonary tuberculosis in incarcerated populations. 2,429 records were identified, 178 full-text articles were screened, and 17 studies were included. The majority of reports were before/after studies (7 of 17) or prospective non-comparative studies (5 of 17). The median study duration was 23 months (range 5–144). The most common intervention was the introduction of active case finding (10 of 17 studies) but the timing and methods varied. Comparable pre- and post-intervention outcome values were infrequently reported. It was therefore not possible to quantify the efficacy of interventions undertaken. Data from studies of tuberculosis control in prisons is limited by a lack of controlled interventions, reporting of pre-intervention methods, and comparable pre- and post-intervention outcomes. Prospective comparative trials of adequate duration to determine trends in incidence are necessary to understand which tuberculosis control interventions are effective in prisons.

Keywords

Jails, prisoners, infection control, mass screening, active case finding

Introduction

Tuberculosis (TB) in prisons is particularly difficult to control. The global median incidence rate of TB disease in prisoners is 23 times higher than the corresponding non-incarcerated population (Baussano et al., 2010) and up to 81 times higher in Eastern Europe (Aerts et al., 2006). Between 2015 and 2018, the TB incidence rate decreased by 6.3% across incarcerated and non-incarcerated populations globally (World Health Organization, 2019a), significantly short of the End TB milestone of a 20% reduction by 2020 (World Health Organization, 2015). Prison health must therefore be prioritised in order to progress towards making a TB-free world a reality (Reid et al., 2019).

There are at least 10.3 million people currently living in penal institutions globally (Institute for Criminal Policy Research, 2016). Prisoners are affected by a number of risk factors for TB infection and disease (World Health Organization, 2013). Homeless people, migrants, people from ethnic minorities and people with mental health illness disproportionately represent the demographic of prison populations (World Health Organization Regional Office for Europe, 2014). Recreational drug and alcohol use, smoking, HIV co-infection and malnutrition (a problem often augmented by imprisonment) further increase risk. Environmental conditions such as poor ventilation and overcrowding assist transmission. Institutional and societal barriers result in sub-optimal access to and uptake of healthcare. This leads to delayed diagnoses, inappropriate regimens and treatment interruption, facilitating the development of drug-resistant TB (World Health Organization Regional Office for Europe, 2014).

Prisons present a unique epidemiological environment for TB transmission. The magnitude of prevalent latent and active disease, the burden of individual risk factors, and the architectural and operational aspects each contribute to hyperendemic transmission in many institutions globally. It may not be appropriate to extrapolate what is known about TB control programmes

from other contexts to prison settings; different interventions may have different efficacies. The majority of evidence for the efficacy of control interventions has been obtained from healthcare settings but in general its quality has been assessed as very low (World Health Organization, 2019b).

TB control comprises a range of interventions which aim to reduce transmission and therefore an important focus is on detection of pulmonary disease. There are World Health Organization (WHO) guidelines on the management of TB in prisons which provide recommendations on control measures (Tuberculosis Coalition for Technical Assistance and International Committee of the Red Cross, 2009) but as requirements and resources vastly vary between prisons throughout the world, there are wide differences in implementation by individual countries and institutions.

The aim of this systematic review was to provide an overview of the types of study design adopted to determine the efficacy of TB control interventions in prison settings, and the type and efficacy of TB control interventions studied.

Methods

Eligibility criteria

Included studies were those which describe an intervention in prison settings with the primary aim of either reducing the prevalence or incidence of active pulmonary TB, or increasing the proportion of prisoners who were screened for active pulmonary TB (henceforth referred to as TB disease). Studies whose focus was on detecting and managing latent TB were not included.

Prevalence studies without an intervention were not included. All study reports except case reports, review articles, conference proceedings and unpublished literature were included.

Articles in English, Spanish and French published since 1990 were included. The term 'prison' was applied to mean any place of detention, including pre-trial detention in adult and juvenile services (World Health Organization, n.d.). Studies of migrant detention centres were not included. The was no restriction by geographical location or size of prison, nor length of study. This PROSPERO-registered review (CRD42018116079) conformed to the PRISMA statement (Moher et al., 2009).

Search strategy and study selection

Articles were identified on the 7th November 2018 through electronic searches of MEDLINE, Embase, Global Health and Scopus databases (Appendix File 1). Records were automatically and manually deduplicated using EndNote™ X9 (Clarivate Analytics, USA). Abstracts were reviewed by a single reviewer to assess eligibility. If there was doubt over an article's relevance, the full text was obtained and assessed. If the full text of a potentially relevant article could not be obtained it was excluded.

Data extraction and outcomes

Data was extracted into an electronic database. Variables included: year of study, geographic location of study, funding source, type of prison, number of prisons in the study, number of occupants, capacity of prison, community TB incidence or prevalence, trial design, details of intervention, length of intervention, description of consent process for involvement in study, and pre- and post-intervention: prevalence, incidence or number screened for TB disease. The primary aims were to quantify the type of trial designs adopted to determine the efficacy of TB control interventions in prison settings, and to quantify the type and efficacy of each intervention studied.

Risk of bias and statistical techniques

The quality of evidence at the study level was assessed using the National Institutes of Health tool designed for quality assessment of before/after studies with no control group (National Institues of Health, n.d.). Due to the heterogeneity of populations, interventions and reporting of studies, meta-analysis was not performed.

Ethics approval

Ethics approval was not considered necessary by the authors because only fully anonymised published data was used.

Results

In total 17 articles, published between 1993 and 2018, were included in the analysis (Figure 1). One article was published in Spanish (Martin Sanchez et al., 1994) and the rest were in English. There were studies reported from every continent except Oceania (Table 1).

Setting characteristics

Every study was carried out in a prison setting; three studies additionally reported outcomes from a surrounding prison encampment (Maggard et al., 2015), drug treatment centres (Centers for Disease Control and Prevention, 1993) and TB dispensaries (Balabanova et al., 2006). Thirteen studies detailed their source of funding, which were from a mixture of national and international government agencies, the WHO, The Global Fund and non-governmental agencies.

The median number of prisons per study was 6 (range 1 – 70), with the median number of occupants 10,015 (range 300 – 92,517). Four studies reported their capacity; median occupancy was 232% (range 210% – 347%). Twelve studies reported corresponding general population incidence or prevalence values which were always lower than prison values.

Study characteristics

The majority of studies (14 of 17) were carried out as part of programmatic work rather than primarily as research (Table 2). Most study designs were generally either before/after (7 of 17), whereby it was unclear if data was collected prospectively or retrospectively, or prospective non-comparative intervention studies (5 of 17), whereby both pre- and post-intervention data was collected prospectively. There were no controlled intervention studies. The median length of study duration was 23 months (range 5-144 months). Consent procedures varied between studies and ranged from not describing whether consent was taken, describing that it was not deemed necessary, mandating testing or treatment, and seeking informed consent (Table 2). If consent was taken, none of these studies described the standard of care for those who declined to participate.

Intervention characteristics

Six of seventeen studies did not report pre-intervention TB control methods (Table 3). Interventions were generally composite, and the most common was the introduction of active case finding (10 of 17 studies). The timing varied but was most commonly at least on entry to prison (9 of 17 studies). The methods of active case finding were variable, consisting of different combinations of symptom-based screening, chest x-ray and sputum microscopy. Five studies introduced isolation for prisoners with TB. Other interventions included employing

more staff, improving staff training, using other prisoners as peer educators, improving laboratory services, contact tracing and HIV testing.

Study outcomes

Nine of seventeen studies did not report pre-intervention values (Table 4). Of studies which did report pre- and post-intervention values, these were often non-comparable and lacked important detail, such as the number of prisoners in the population, the rate of population turnover, and the proportion screened. Outcomes reported as incidence or prevalence were often ambiguous. Overall, studies tended to report descriptive rather than statistical analyses.

Risk of bias

Across all studies there was a high risk of bias principally due to the nature of the study designs; before/after and non-comparative, generally with very few pre- and post-intervention years of data (with a median study length of 23 months). Such designs are likely to be affected by multiple unmeasured confounders, including changes in population TB incidence, changes in community detection and management of TB, and differences in prisoner characteristics between the two time periods. None of these potential confounding variables were discussed, reported, or considered in the analyses. The population (denominator) of the prisons and the proportion tested was infrequently described, and the demographics of the prisoners were not reported by any study.

Discussion

This systematic review summarises the study designs and quality of studies that have been undertaken to assess the efficacy of TB control interventions in prisons. Seventeen studies were included from a spectrum of low- to high-income countries. Every study reported very high TB prevalence or incidence values; these varied considerably between studies, likely due to differences in the TB burden and detection practices between studies. In line with the global situation, the burden of TB was considerably higher within prisons compared to that of the surrounding non-incarcerated population.

Before/after and non-comparative studies (with combinations of retrospective and prospective data collection) were the most common type of study design reported. There were no controlled comparison studies. Because of the nature of non-comparative study designs, particularly those where data collection was in part or wholly retrospective, multiple unmeasured confounding factors are likely to exist. This severely limits the ability to understand causal associations between interventions and outcomes. Many of the studies did not report pre-intervention control methods nor comparable pre/post-intervention outcome values. The prison population (i.e. the denominator) was rarely reported, which further precludes estimating the burden of infections and the effectiveness of interventions. Furthermore, the median duration of the included studies was 23 months which is too short to determine whether the apparent effect of a TB control intervention could be casual and sustainable.

Accurate, publicly available estimates of the TB burden in individual prisons do not exist. Numerous barriers to conducting good-quality studies in prison settings result in underestimation of TB incidence rates (Rieder et al., 2011). Overcrowding and high turnover

of inmates results in difficulty providing accurate denominator data and thus prevalence and incidence estimates. Tracking prisoners as they are moved through different institutions is very difficult, even those enrolled in TB care, and can result in treatment interruption. Operational procedures designed to prioritise safety can make conducting research in prison settings very challenging. Furthermore, prisoners represent a particularly vulnerable group of people which makes participation in research more challenging. Knowledge of how to plan and conduct studies which pay due regard to important ethical considerations could be facilitated by provision of international best practice guidance.

The question is how these barriers are best overcome to design studies which allow an accurate estimation of intervention efficacy or impact. In well designed, prospective non-comparative before/after studies, confounding is very difficult to avoid even if appropriate statistical analysis (such as a quasi-experimental interrupted-time series analyses) were applied. With several years of pre- and post-intervention data, these methods can provide good-quality evidence of causal associations. Other designs include cluster randomised control trials (randomised at the level of individual prisons) or step-wedge trials (which may be deemed more ethically appropriate).

In terms of estimating prevalence, it has been suggested that prisoners diagnosed within the first three months of entry should be considered prevalent at entry (i.e. they have acquired their infection from the community) and should not be included in incidence estimates (Rieder et al., 2011). Repeated cross-sectional prevalence surveys are frequently used to determine trends over time, however these values are affected by the proportion of new entrants among all inmates present in the prison at the time of the survey (which, if done at entry, is more likely

to detect people with TB). Length of stay therefore also influences prevalence estimates. Ideally the incidence rate should be used to estimate new infections; those who are no longer at risk of developing TB (those who are already diagnosed with TB) should be excluded from the person-time at risk. Of course, this relies on accurate recording of the date of entry and exit from the prison (excluding the first three months of incarceration) and thus every effort should be made to record this data.

The most common intervention was the introduction of active case finding, with varied timing, frequency and diagnostic algorithms. Active case finding in high-risk groups is recommended by the WHO, a recommendation for which there is unfortunately very low-quality evidence (World Health Organization, 2009). Decisions on when and how to screen for active TB depends on the epidemiological situation (TB burden, physical prison environment) and the availability of resources in the prison health system. The sensitivity and specificity of diagnostic algorithms remains unknown in prison populations, and specific methods of active case detection are left to the discretion of individual countries. Despite a paucity of evidence regarding the effectiveness of screening at entry compared with annual mass screening, the WHO recommends that active case finding should include both screening at entry and annual mass screening if resources permit (Tuberculosis Coalition for Technical Assistance and International Committee of the Red Cross, 2009). Exit screening is recommended when treatment and follow up after release can be ensured.

Despite the overall limitations with study designs, many of these studies provided a rich discussion of the implementation or improvement of prison TB control programmes. For example, several studies describe in detail how they implemented educational programmes in

their prisons, often by using prisoners as 'peer educators' to spread messages about TB symptoms and even to identify prisoners who may be unwell (Harries et al., 2004; Maggard et al., 2015; Zishiri et al., 2015). Other studies describe how they built labs or linked their prison to regional laboratory services to increase diagnostic capacity (Cunha et al., 2018; Maggard et al., 2015; Mallick et al., 2017; Nateniyom et al., 2004), or procured chest x-ray equipment to increase the number of prisoners able to be screened (Puisis et al., 1996; Sanchez et al., 2013). Others described strengthened links to community services so that prisoners could be appropriately followed up after release from prison (Farhoudi et al., 2018; Klopf, 1998).

It is well established that prisons are a 'hot-spots' or reservoirs of TB and there is growing evidence of 'spill-over' or transmission to the surrounding community (Mabud et al., 2019; Sacchi et al., 2015; Warren et al., 2018). Interaction between prisoners and the non-incarcerated population, including prison staff and visitors, is ubiquitous during incarceration. Further opportunities for transmission occur when prisoners move between institutions and following release. The risk of transmission to surrounding communities adds to the strength of the argument to increase efforts to control TB in prisons, and targeting high-risk groups such as prisoners might provide an efficient way to reduce community transmission (Mabud et al., 2019). However, it should be explicitly emphasised that the rate of TB in prisons presents a major human rights issue for prisoners themselves. The argument should rather be centred around the urgent necessity to ensure prisoners have access to healthcare which is of the same standard as that available for non-incarcerated people, as outlined by the United Nations Standard Minimum Rules for the Treatment of Prisoners (United Nations Office on Drugs and Crime, 2015). All aspects of prison healthcare should be fully integrated with TB services, and screening, treatment and ongoing support for common illnesses such as blood-borne viruses,

nutritional problems and mental health should be streamlined (World Health Organization Regional Office for Europe, 2014).

Limitations

Many of the included studies were conducted a relatively long time ago, and the burden of TB and the control practices in these contexts are likely to have since changed. There are a broad range of TB services provided between countries, so caution should be applied when generalising practices and findings to other institutions, even within the same country. By limiting inclusion to reports published in academic journals, other sources of relevant data are likely to be missed. Individual countries' national TB programmes or Ministries of Justice collect programmatic longitudinal data of this nature; however, it is usually not be publicly available. Although such data may be subject to the same biases and confounding discussed, with several years of data collected using consistent methods, this data is likely to provide insight into changes in trends associated with the introduction of various interventions.

Conclusions

This review highlights the paucity of available data on the effectiveness of TB control interventions in prison settings using robust study methods. There is an urgent need for effective prison TB control programmes globally, and for good-quality data to evaluate their efficacy. Data to determine the efficacy of different control methods is currently limited by poor reporting of prison population and turnover estimates, and problematic study designs which are subject to multiple confounding effects. As a result, it remains unclear which control interventions are most efficacious in different settings. More rigorous study designs could take the form of cluster or step-wedge randomised control trials. Although the current evidence is

298 limited, active case finding is likely to be the most effective control strategy, and could be
299 implemented at entry, exit, and during periodic mass screening campaigns.

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Table 1 Setting characteristics of individual studies

Reference	Country	Funding	Type of facility	Number of facilities	Urban or rural	Total number of occupants	Capacity (%)	General population values
Centers for Disease Control and Prevention, 1993*	USA	Centers for Disease Control and Prevention	Prison, drug treatment centres	6	-	10,015	-	-
Martin Sanchez, 1994	Spain	-	Prison	1	-	280–320	-	-
Puisis, 1996	USA	-	Prison	1	Urban	8,789	-	Prison incidence 6 times higher than general population
Klopf, 1998	USA	New York State Department of Health, New York State Division of Parole	Prison	70	Urban	69,000	-	-
Harries, 2004	Malawi	Department for International Development (UK), Norwegian Agency for International Cooperation, Royal Netherlands Tuberculosis Association	Prison	12	-	26,118	-	Prison incidence 6-7 times higher than general population incidence of 80/100,000
Nateniyom, 2004	Thailand	WHO, government of Thailand, TB Patient Foundation of Thailand	Prison	16	-	32,937	-	General population incidence 54/100,000
Balabanova, 2006*	Russia	Department for International Development (UK)	Prison, TB dispensaries and hospitals	2	-	-	-	-
Assefzadeh, 2009	Iran	-	Prison	1	Urban	1,000–1,400	-	Prison prevalence 113 times higher than regional province
Sanchez, 2013	Brazil	Coordination of Management in Penitentiary Health of the Secretary of State for the Penitentiary Administration of Rio de Janeiro, International Cooperation Program - National Institute of Health and Medical Research	Prison	1	Urban	1,429	-	Prison incidence 33 times higher than general population
Zishiri, 2015	South Africa	The Global Fund	Prison	4	-	20,700	-	-
Banu, 2015	Bangladesh	Government of the People's Republic of Bangladesh	Prison	1	Urban	8,000–10,000	2,600 (308–385%)	Prison prevalence 21 times higher than general population
Maggard, 2015*	Zambia	TB REACH (Stop TB Partnership), United States Centres for Disease Control and Prevention, Elizabeth Glaser Pediatric AIDS Foundation	Prison, encampments	6	Urban	4,700	-	Prison prevalence 18 times higher than general population prevalence of 0.35%
Paiao, 2016	Brazil	Foundation for the Development of Teaching, Science and Technology of the State of Mato Grosso do Sul, Ministry of Education, Brazilian National Research Council, Fogarty Global Health Equity Scholars Program	Prison	12	Urban	7,221	2,920 (247%)	Incidence <40/100,000 in general population
Degner, 2016	USA	None	Prison	7	-	92,517	-	Prison incidence 2.33 times higher than general population incidence of 2.96/100,000
Mallick, 2017	India	Department for International Development (UK), government programmatic funding	Prison	28	-	19,473	9,267 (210%)	Prison incidence 23 times higher than general population incidence of 217/100,000
Farhoudi, 2018	Iran	WHO (the Global Found), United Nations Office on Drugs and Crime in Iran	Prison	1	-	-	-	Prison incidence 10 times higher than general population
Cunha, 2018	Brazil	-	Prison	35	-	14,904	216%	Prevalence 25.3 times lower risk in general population

* Data from publications where the population includes groups other than prisoners. '-' denotes data not available. The general population values are as reported in the references (no other source was used).

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Table 2 Study design of individual studies

Reference	Research or programmatic	Trial design	Study duration (months)	Type of consent
CDC, 1993	Programmatic	Before/after	12	-
Martin Sanchez, 1994	Research	Before/after	12	-
Puisis, 1996	Programmatic	Before/after	23	-
Klopf, 1998	Programmatic	Before/after	60	Mandated testing and treatment (by New York State Public Health Law). Latent treatment optional but highly recommended.
Harries, 2004	Programmatic	Before/after	56	-
Nateniyom, 2004	Programmatic	Prospective non-comparative intervention	35	Not described (although passive detection).
Balabanova, 2006	Programmatic	Prospective non-comparative intervention	29	-
Assefzadeh, 2009	Programmatic	Before/after	15	-
Sanchez, 2013	Research	Prospective non-comparative intervention	24	Informed consent for participation to study. No description of pathway of care for those not participating.
Zishiri, 2014	Programmatic + research	Prospective non-comparative intervention	5	Ethics review board felt informed consent not necessary; this was an evaluation of implementation without an a priori research question or other procedures.
Banu, 2015	Programmatic + research	Prospective non-comparative intervention	52	Written consent for participation in study. Not described if screening optional or possible for those not enrolled in study. Doesn't report how many refused to consent.
Maggard, 2015	Programmatic	Before/after (prospective with retrospective pre-values)	12	Mandatory TB testing for prisoners (deemed standard of care), voluntary for community. HIV testing voluntary.
Paião, 2016	Research	Prospective non-comparative intervention with descriptive cohort	23	Written informed consent required for participation. Referred for free treatment if positive (HIV, TB, latent TB). No description of pathway of care for those not participating.
Degner, 2016	Programmatic	Retrospective before/after	144	-
Mallick, 2017	Programmatic	Before/after	12	Not described (although passive detection).
Farhoudi, 2017	Programmatic	Non-comparative intervention	8	Verbal and written informed consent provided by prisoners. Does not detail consent for what (testing, treatment or participation in educational activities).
Cunha, 2018	Programmatic	Retrospective before/after	84	Not required (secondary data).

'-' denotes data not available.

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Table 3 Intervention characteristics of individual studies

Reference	Pre-intervention TB control	Intervention	Summary of screening intervention	Diagnostic algorithm	Isolation
CDC, 1993	-	Active screening, HIV testing, staff training, data management system developed	Active (unknown when)	Skin test → further evaluation (not detailed what)	No
Martin Sanchez, 1994	Active screening (medical review at entry then Mantoux - may be some time after initial screening). CXR for all positive skin tests. If CXR suspicious, sputum sent for smear, culture and if necessary DST. HIV testing offered.	Mantoux at time of screening on entry (rather than delayed)	Active (entry)	Symptoms + skin test → CXR → sputum (smear, culture, DST)	No
Puisis, 1996	Active on entry. Symptom questionnaire and skin testing, with CXR if reactive.	Introduction of CXR to entry screening process	Active (entry)	Symptoms + CXR → sputum (culture)	Yes (already in place)
Klopf, 1998	-	Active screening, contact tracing, isolation, latent TB testing, HIV testing, more staff employed, education, community links for follow up. Staff also screened.	Active (entry + at least yearly)	Skin test (+ CXR on entry) → sputum (smear, culture) + CXR	Yes
Harries, 2004	-	Active screening, awareness campaign using prisoner peers, more staff employed, monitoring and evaluation	Active (entry) + passive	Symptoms → sputum (smear) ± CXR	No
Nateniyom, 2004	Passive. Patients taken to hospital for diagnosis, treated in hospital if severe. Family purchased and administered medications. No specific isolation, therapy not observed, no reporting system.	Passive detection strengthened, labs established, staff employed, isolation, monitoring and evaluation, DOTS established	Passive	Symptoms → sputum (smear) → ± CXR	Yes
Balabanova, 2006	-	Implementation of DOTS programme	Unknown	Unknown	No
Assefzadeh, 2009	Passive	Active screening, isolation, directly observed therapy, provision of high-protein diet, education, contact tracing to patients' families, prophylaxis to paediatric contacts under 6.	Active (unknown when)	Symptoms → sputum (smear ± culture) ± CXR	Yes
Sanchez, 2013	Passive. Supervised treatment.	Active screening, mobile CXR unit introduced	Active (entry + already incarcerated) + passive	Symptoms + CXR → sputum (smear, culture, DST)	No
Zishiri, 2014	-	Active screening, HIV screening, management in hospital (assume isolation), contact tracing, more staff employed, peer educators, monitoring and evaluation.	Active (entry + at least yearly) + passive	Symptoms → sputum (GeneXpert)	Yes
Banu, 2015	Passive. Smear microscopy for diagnosis without culture or DST.	Active screening (on entry and already incarcerated), isolation	Active (entry + already incarcerated)	Symptoms → sputum (smear, culture, DST)	Yes
Maggard, 2015	Screening practices not detailed (assume passive). No specific infection control, isolation involved placement in a 'sick cell' with people with mental health illness and HIV. No onsite TB diagnostics.	Active screening, isolation in 1 site, HIV testing, more staff employed, awareness campaign by prison peers, labs built	Active (entry + already incarcerated + community)	Symptoms + sputum (smear, culture, DST) or symptoms + sputum + CXR (different sites)	Yes (only in 1 prison)
Paiao, 2016	Passive. Smear and culture for diagnosis.	Active screening, latent TB testing, HIV testing	Active (already incarcerated) + passive	Symptoms + TST → sputum (smear, culture)	No
Degner, 2016	Active on entry. Symptom questionnaire, examination and skin testing. CXR if reactive or symptoms, placed in isolation until confirmed no infection or until treatment completed. If diagnosed with latent TB, latent therapy given. Contact tracing.	Use of CXR for screening instead of skin testing	Active (entry)	Symptoms + CXR → treatment or PPD + sputum	Yes (already in place)
Mallick, 2017	No systematic efforts of TB control (assume non-systematic passive).	Passive detection more systematically implemented, awareness campaign and education, monitoring and evaluation, strengthened links with labs	Passive	Symptoms → sputum (smear)	No
Farhoudi, 2017	-	Active screening, directly observed therapy, education, more staff, improved transport of samples, isolation, monitoring and evaluation, links with community follow up	Active (unknown when)	Unknown	No
Cunha, 2018	No bacteriologic diagnostics. Otherwise not described.	Diagnostic services and lab management	Unknown	Unknown	No

CXR: chest x-ray; DST: drug-sensitivity testing; DOTS: Directly Observed Therapy Short-Course; TST: tuberculin skin test. '-' denotes data not available.

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Table 4 Outcomes of individual studies

Reference	Pre-intervention values	Post-intervention outcomes
CDC, 1993	-	98.2% eligible screened with skin testing, 96.5% skin test reaction read. 90.9% referred for follow up medical examination. 85.2% were evaluated.
Martin Sanchez, 1994	85.1% screening process completed when skin testing deferred	96.4% when skin testing performed immediately at screening
Puisis, 1996	46,711/62,000 (75%) of inmates screened; 66% results read; 0.04% prevalence active of TB (26 people). Mean time to isolation if active TB: 17.6 days.	126,608 screened, 249 cases, incidence rate 197/100,000. Mean time to isolation if active TB: 2.3 days.
Klopf, 1998	Incidence 225/100,000. Skin test conversions (1993) of inmates: 2.4%; staff: 1.7%.	Incidence of active TB 61/100,000 (73% reduction). Skin test conversions (1997) of inmates: 1.1%, staff: 0.2%.
Harries, 2004	5% prevalence	Average annual case notification incidence rate smear-positive TB 518/100,000. 8% diagnosed on entry, 92% already incarcerated.
Nateniyom, 2004	-	Number of people diagnosed: year 1=348 (prevalence 1,056/100000), year 2=490, year 3=574.
Balabanova, 2006	-	640 patients diagnosed in the prison sector. Overall 85.4% (786/920) of newly diagnosed and recruited patients were treated according to the WHO protocol (non-prisoner and prisoner).
Assefzadeh, 2009	Prevalence 136/100,000	768 prisoners examined, prevalence 910/100,000 (7 patients with TB).
Sanchez, 2013	Incidence rate 8,686/100,000	97.7% of total prisoner population screened. Initial screening prevalence: 6.0%. Second systematic screening prevalence: 2.8%. Prevalence from screening at entry: 1st year 2.8%; 2nd year 2.9%. Incidence rate of cases identified passively: 1st year 42/1000 person-years; 2nd year 19/1000 person-years.
Zishiri, 2014	-	7,426 inmates screened, estimated as 55% of overall screening target. Prevalence 2.7% (201 cases). 93% initiated on treatment.
Banu, 2015	-	Screened 60,585; 42,367 (70%) on entry and 18,218 (30%) current inmates. Diagnosed 466. Prevalence of mass screening for those incarcerated 2,227/100,000. Number of new diagnoses declined during study: 49 in first quarter to 8 in last quarter.
Maggard, 2015	-	Screened 7,638/7,700; diagnosed 491, prevalence 6.4%.
Paiao, 2016	-	Prevalence of active TB at first screening: 0.7%, 1.8% over first year. Baseline skin test positive 21%, 25.7% conversions after 1 year.
Degner, 2016	Incidence rate 26.7 per 100,000 person-years (8 diagnoses). Mean time to isolation if active TB: 44.4 days.	Incidence rate 105.7 per 100,000 person-years (37 diagnoses). Mean time to isolation if active TB: 5.2 days.
Mallick, 2017	Incidence rate 568/100,000	Incidence rate 784/100,000 (TB case notification rate increased by 38%, 124 diagnoses).
Farhoudi, 2017	-	Active case finding is responsible for 98.4% of case finding.
Cunha, 2018	Prevalence rate 480/100,000 (358 diagnoses). Smear tested 82.7%; cultured 55.0%; DST 36.6%.	Prevalence rate 972.9/100,000 (654 diagnoses). Smear tested 92.9%; cultured 81.8%; DST 47.4%.

DST: drug-sensitivity testing; TST: tuberculin skin test. '-' denotes data not available.

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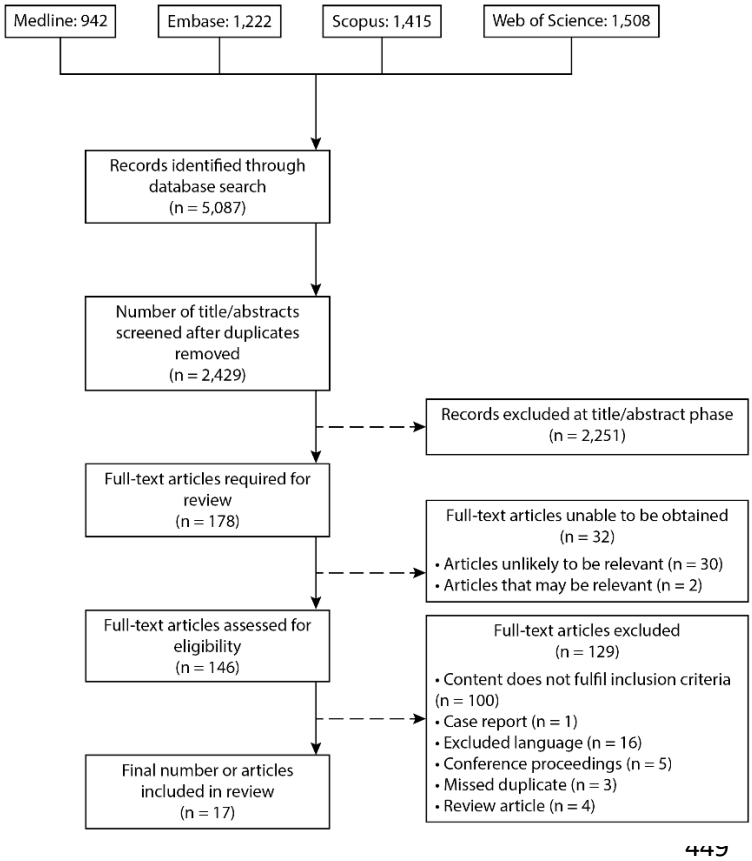

450 **Figure 1** Study selection flow chart

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Figure captions

In order of reference in manuscript

Appendix file 1: Complete search strategy for MEDLINE, Embase, Global Health and Scopus databases

Figure 1: Study selection flow chart

Table 1: Setting characteristics of individual studies

Table 2: Study design of individual studies

Table 3: Intervention characteristics of individual studies

Table 4: Outcomes of individual studies