International Journal of Infectious Diseases 32 (2015) 111–117

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

Review

Tuberculosis control in prisons: current situation and research gaps

Masoud Dara [a,*], Colleen D. Acosta [a], Natalie V.S. Vinkeles Melchers [b], Haider A.A. Al-Darraji [c], Dato Chorgoliani [d], Hernan Reyes [e], Rosella Centis [f], Giovanni Sotgiu [g], Lia D'Ambrosio [f], Sarabjit S. Chadha [h], Giovanni Battista Migliori [f]

[a] Joint Tuberculosis, HIV/AIDS and Hepatitis Programme, Division of Communicable Diseases, Health Security, and Environment, World Health Organization, Regional Office for Europe, UN City, Marmorvej 51, Copenhagen, Denmark
[b] Academic Medical Center, Department of Global Health, University of Amsterdam Institute for Global Health and Development, Amsterdam Zuidoost, Netherlands
[c] Centre of Excellence for Research in AIDS (CERiA), University of Malaya, Kuala Lumpur, Malaysia
[d] International Committee of the Red Cross (ICRC), Bishkek, Kyrgyzstan
[e] International Committee of the Red Cross (ICRC), Geneva, Switzerland
[f] World Health Organization Collaborating Centre for Tuberculosis and Lung Diseases, Fondazione S. Maugeri, Care and Research Institute, Tradate, Italy
[g] Clinical Epidemiology and Medical Statistics Unit, Department of Biomedical Sciences, University of Sassari – Research, Medical Education and Professional Development Unit, AOU Sassari, Sassari, Italy
[h] International Union Against Tuberculosis and Lung Disease (The Union), South East Asia Office, New Delhi, India

ARTICLE INFO

Article history:
Received 19 November 2014
Received in revised form 12 December 2014
Accepted 16 December 2014

Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:
Tuberculosis
Prisons
MDR-TB
End TB Strategy
Xpert MTB/RIF
Research

SUMMARY

Background: Tuberculosis (TB) in penitentiary services (prisons) is a major challenge to TB control. This review article describes the challenges that prison systems encounter in TB control and provides solutions for the more efficient use of limited resources based on the three pillars of the post-2015 End TB Strategy. This paper also proposes research priorities for TB control in prisons based on current challenges.

Methods: Articles (published up to 2011) included in a recent systematic review on TB control in prisons were further reviewed. In addition, relevant articles in English (published 1990 to May 2014) were identified by searching keywords in PubMed and Google Scholar. Article bibliographies and conference abstracts were also hand-searched.

Results: Despite being a serious cause of morbidity and mortality among incarcerated populations, many prison systems encounter a variety of challenges that hinder TB control. These include, but are not limited to, insufficient laboratory capacity and diagnostic tools, interrupted supply of medicines, weak integration between civilian and prison TB services, inadequate infection control measures, and low policy priority for prison healthcare.

Conclusions: Governmental commitment, partnerships, and sustained financing are needed in order to facilitate improvements in TB control in prisons, which will translate to the wider community.

1. Introduction

Tuberculosis (TB) remains a major public health problem, posing specific challenges in numerous geographical areas, particularly in low- and middle-income countries (LMICs) where more than 80% of the global TB burden resides.[1] Additionally, with the current slow (2%) annual decline in TB incidence and the emergence of drug-resistant TB and TB/HIV co-infection, most LMICs will not meet the Millennium Development Goals (MDGs) for TB control by 2015 set by the United Nations.[1] Despite recently gained increased public and political awareness, TB remains a major infectious disease in prison systems, such as in Eastern Europe, for several reasons. These include, but are not limited to, the high prevalence of drug-resistant TB forms, i.e. multi- and extensively drug-resistant TB (M/XDR-TB),[1–14] and intravenous drug use among HIV-infected individuals, which makes prison populations more susceptible to the development of TB.[15]

Prisons are considered reservoirs facilitating *Mycobacterium tuberculosis* (MTB) transmission within their walls, as well as to the community at large. Transmission occurs through prison staff,

* Corresponding author. Tel.: +45 45 33 66 49.
E-mail address: daram@who.int (M. Dara).

http://dx.doi.org/10.1016/j.ijid.2014.12.029

visitors, and released inmates. The estimated prevalences of latent TB infection (LTBI) and active TB disease in prison systems are reported to be much higher than the average estimates in the general population, irrespective of the economic status and the population TB burden of the country.[16] In European prisons, the prevalence of TB is estimated to be up to 17 times higher than in the general population.[17] A similar epidemiological situation has been described in LMICs, including Bangladesh, Thailand, Ethiopia, and Brazil, where TB prevalence has been reported to be almost four-, eight-, seven-, and 64-times higher, respectively, among prisoners compared to the general population.[18–27] Factors known to contribute to the transmission of MTB strains and that hamper TB control are overcrowding, delayed case detection, poor contact detection, inadequate treatment of infectious cases, high turnover of prisoners, and poor implementation of TB infection control (IC) measures.[28,29] In addition, limited access to timely and quality health care services further exacerbate the situation.

In response to the continuing challenges facing the control of TB and M/XDR-TB, and as the current Global Plan to Stop TB (Stop TB Strategy) 2011–2015 is in its final year, the World Health Organization (WHO) has recently developed the post-2015 End TB Strategy with the goal to end the TB epidemic by 2035.[30] In order to define strategies that efficiently address the End TB Strategy targets, knowledge about solutions for improved TB control in prison systems is needed. In this review, we summarize published knowledge on the challenges of TB control in prison systems and discuss potential solutions, including research priorities for TB control in prisons, in relation to the three pillars of the End TB Strategy.

2. Methods

Articles included in a recently published systematic review on TB control in prison services by Vinkeles Melchers et al.[31] were reviewed; these publications were dated up to June 2011. In addition, relevant articles in English were identified by searching PubMed and Google Scholar, with a temporal range of 1990 to May 2014. Studies were identified using combinations of the search terms "Tuberculosis or TB", "TB Control", "Management", "Public Health", "Prison* or Jail*", and "Prisoner* or Inmate*". Studies in languages other than English and studies published before 1990 were excluded. Articles were also excluded if they described challenges in TB control among populations other than prisoners (e.g., TB contact tracing in the community, health care workers). The selection of articles was based on their public health relevance to TB control in prisons. The references of selected articles were also evaluated to identify additional relevant publications. In addition, conference abstracts of the International Union Against Tuberculosis and Lung Diseases and publications from the WHO over the last 23 years were screened for relevant articles. A total of 637 citations and 332 abstracts were screened, resulting in the inclusion of 96 publications in this review. Because no systematic variables were extracted from the publications included, the challenges and solutions have not been rated on the quality and validity of the evidence.

3. Results and discussion: current evidence

Barriers to tackling TB in prisons are complex and linked strongly to other aspects of both the health and criminal justice systems, and with the cultural, historical, and economic situations of each country. These barriers are summarized in Table 1,[32] and are discussed below in relation to the three pillars of the End TB Strategy.

3.1. Pillar 1: Integrated, patient-centred care and prevention

3.1.1. Universal drug-susceptibility testing and systematic screening of contacts and high-risk groups

The lack of well-equipped laboratory facilities in prisons is well documented.[1,4,20,22,33,34] In addition, a systematic review found that approximately 21% of all studies reporting on TB screening in prisons described the lack of a well-organized health system,[31] potentially leading to the ongoing spread of TB to other prisoners, prison staff, visitors, and to the general population upon release from the prison.[23,35,36] In the absence of adequate diagnostic tools in the prison services, health professionals attempt to use the diagnostic capacity of the civilian sector through national TB programmes (NTPs), such as sputum smear microscopy, chest radiography, and sputum culture.[34] The use of diagnostic services external to the prison system may, however, lead to a delay in diagnosis due to a lack of coordination between the prison and the civilian sector laboratory networks.[17,37,38]

Another main challenge to TB diagnosis is the quality of the bacteriological services. Sputum smear microscopy is not always performed with quality control. Microscopes are poorly maintained, staff may lack quality training in the use of diagnostic tools,[22] and quality assurance including proficiency testing is rarely done.[22,39] The introduction of the GeneXpert MTB/RIF assay is considered an important breakthrough in the fight against TB and multidrug-resistant (MDR)-TB. For the first time, a molecular test is simple and robust enough to be introduced outside the conventional or reference laboratory setting, detecting TB and

Table 1
Key barriers to tackling TB in prisons according to the three pillars of the End TB Strategy

Pillar 1: Integrated, patient-centred care and prevention
Lack of laboratory capacity, insufficient quality control, and absence of new and improved diagnostic methods
Interrupted supply of quality medicines
Absence of an efficient mechanism for direct observation of treatment
Lack of adequate medical facilities
Lack of collaborative TB/HIV activities
Emerging drug resistance
Intravenous drug use among prison populations
Lack of drug substitution and needle exchange programmes
Lack of safer sex programmes for HIV prevention
Limited social support of vulnerable populations
Limited attention to comorbidities (HIV, hepatitis, psychiatric disease)
Weak integration between civilian and prison TB services, continuum of care for released prisoners
High incarceration rate
Pillar 2: Bold policies and supportive systems
Low priority that policymakers give to health care (including TB) within the prison system
Insufficient commitment of prison authorities to address TB prevention, control, and care
Unclear responsibilities of different ministries and health authorities
Stewardship of prison health, mismanagement of TB control in penitentiary institutions
Shortage of qualified and motivated human resources
Shortage of staff training/education and appreciation
Limited or poor patient education
Stigmatization of prisoners with TB
Lack of access to prisons by community representatives, NGOs, and organizations with the capacity to support the vulnerable population
Insufficient surveillance, supervision, monitoring, and evaluation systems
Inadequate IC measures due to overcrowding and/or organizational and legal challenges in the timely separation of patients
Pillar 3: Intensified research and innovation
Lack of funding
Lack of commitment by research institutes
Legal difficulties with research in prison systems

TB, tuberculosis; NGO, non-governmental organization; IC, infection control.

rifampicin-resistant TB as a proxy for MDR-TB.[40,41] The assay provides results directly from the sputum sample within 2 h and performs well, particularly in sputum smear-positive patients, with an overall sensitivity of 90.4% and specificity of 98.4%.[42] The GeneXpert MTB/RIF assay is suitable for use at the district and sub-district levels, including within the prison system, and should not be restricted to the central/reference laboratory level only.

The current availability of GeneXpert machines in prisons is unclear and this likely differs from country to country. Although testing with GeneXpert MTB/RIF does not require additional laboratory equipment, the sophisticated nature of the device requires care in handling, i.e., a stable and uninterrupted electrical or battery supply to avoid interruption of the procedure and subsequent loss of results, security against theft, adequate storage space for the cartridges, and dedicated staff to perform testing.[40] Addressing this challenge requires general health system strengthening,[5,6,43,44] including the prison sector and especially in LMICs. High-quality laboratory services with up-to-date biosafety measures,[19] updated and renewed detention centres[45] and TB prison hospitals, and continuous training programmes for both staff and prisoners should also be emphasized.[24,34,46]

3.1.2. Ensure equitable access to quality treatment for all people with TB, including drug-resistant TB, and to patient support

Although the Stop TB Strategy entails standardized supervised treatment and uninterrupted pharmaceutical supplies,[47,48] several prisons still encounter challenges in implementing supervised treatment,[38] the uncontrolled circulation and use of suboptimal quality TB drugs,[23,38,46,49] and TB/HIV treatment interactions in prisons with a high co-infection prevalence.[37] Some prisons report that the provision of an effective pharmaceutical supply may be in place, but that prisoners cannot afford treatment as they pay out-of-pocket for health services.[38,49] In addition, there are often other factors affecting treatment adherence in prisons. These may stem from a specific criminal culture among prisoners, the concern of being cured and then referred back to prisons with greater restriction, as well as the hierarchy among prisoners. Approximately 30% of the studies included in a recent systematic review described unsupervised treatment.[31] Therefore, TB control efforts should focus on the provision of effective treatment and/or increasing effectiveness of treatment to TB patients,[22,23,38,50] treatment adherence, and clinical case management.[19,35]

The high turnover of the prison population, between prisons and to the wider community, is a major challenge. This facilitates transmission and consequently the spread of both drug-sensitive and drug-resistant forms of TB.[19,23,51,52] Data from a systematic review identified that 31.2% of studies struggled with effective TB control due to loss to follow-up and a high turnover of prisoners.[31] Consequently, difficulties may be encountered in diagnosing and treating TB, leading to the further spread of infection to other prisoners, prison staff, and visitors.[23] In addition, approximately 26% of studies in the systematic review reported that TB control in prisons was hampered by a ban on the prisoners attending local clinics or hospitals for 'security reasons'.[31] Within most prison systems, the follow-up of released prisoners is limited or does not occur at all. In Eastern European countries, approximately 60–70% of prisoners are not referred to TB facilities after their release.[53]

3.1.3. Collaborative TB/HIV activities and the management of comorbidities

A core challenge to TB control in prison systems is dealing with the dual epidemics of HIV and TB, as well as other co-infections such as with hepatitis B or C virus. Given the impact that HIV has on TB cases and vice versa, coordination between TB and HIV programmes is vital.[54] However, this may be limited due to poor surveillance of HIV among prisoners with TB,[37] challenges in the diagnosis of TB among people living with HIV,[54,55] a lack of joint planning and mobilization for TB/HIV co-infection, and inadequate human resources capacity for managing TB/HIV.[56,57] In many prisons, the burden of HIV and hepatitis infections among TB patients may be unknown, as periodic surveys or sentinel surveillance are not performed and diagnostic testing and counselling of TB patients is not implemented in all settings.[56,58] Not all TB and HIV/AIDS programmes systematically coordinate plans for the management of dual infections. There is a lack of proper TB/HIV counselling and practice training for counsellors, and of public education and awareness programmes for voluntary HIV testing for individuals, resulting in TB patients not attending HIV clinics. A lack of awareness and education also increases stigmatization among prisoners, and the fear of HIV test results leads to HIV testing being refused.[57] Similar issues are seen for hepatitis and other co-morbidities frequently detected among prisoners. The epidemiological and clinical intertwining of other determinants such as excessive alcohol use or injecting drug abuse and chronic liver disorders (associated with hepatitis B or C virus) with TB places a high burden on the health of prisoners, and also after prisoners are discharged into the community.

Collaborative TB/HIV/hepatitis activities by NTPs and national HIV/AIDS programmes should prioritize prisons, where the prevalence of these infections is high. In addition, a coordinated system, supported by the ministries of health, welfare, and justice or interior, should implement a holistic approach to patients in correctional facilities. Furthermore, preventive activities, including wider health education (e.g. needle exchange or cleansing programmes, or safe sex), should be promoted in order to minimize the harms associated with high-risk behaviours.

3.1.4. Preventive treatment of persons at high risk

Despite the established evidence of the efficacy of isoniazid preventive therapy (IPT) in preventing TB among both HIV-infected and HIV-uninfected individuals, this intervention has not been fully explored in prisons. A systematic review of published reports showed that only 18 studies were designed to address the intervention in such settings.[59] IPT may effectively interrupt the progression of infection to active TB disease, but questions remain regarding whether IPT should be started in a facility with short imprisonment stays or in settings with high isoniazid resistance, and also which institution should take responsibility for the completion of IPT in the community once the prisoner is released.[19,60]

3.2. Pillar 2: Bold policies and supportive systems

3.2.1. Political commitment with adequate resources for TB care and prevention

Prison health services often have small budgets,[45,60,61] which, in addition to the lack of skilled and motivated manpower,[19,22,38] may jeopardize successful TB control programmes in prisons. Public health attention from donors and other stakeholders towards populations at risk of TB has increased in recent years following the emergence of HIV/AIDS, the more stringent application of human rights principles, health inequalities, and health governance.[62] Nevertheless, there are still challenges in TB control in prisons due to logistical complications, a lack of political commitment, and public indifference towards the prison population,[45] which undermine TB control programme efforts in prison systems.

Improved and strengthened political commitment, including sustainable funding,[38,39,52] is therefore strongly recommended.[31] The significance of ensuring adequate funding for TB control in prison systems is particularly important in Eastern Europe,

considering the increased need for MDR-TB diagnostics and treatment. Besides the external funding provided by donors (e.g., Global Fund, US Agency for International Development, International Federation of Red Cross and Red Crescent Societies, the World Bank, and bilateral donors), countries themselves should allocate more local resources in order to gain sustained TB control in prisons.[63] As part of building political commitment, it is essential to ensure that both legislation and national guidelines facilitate TB control in prisons. In particular, the following areas should have a supportive legal basis with minimum standards: (1) guidelines in line with NTPs, (2) a sufficient area per inmate to avoid overcrowding, (3) adequate nutrition, (4) comprehensive IC planning, (5) policies on the release of prisoners with TB and/or their transfer to other facilities, and (6) and integration/collaboration with health care services in the civil sector.[64]

Stewardship of prison health is defined as "all issues concerning governance and responsibility affecting the provision of prison health services of an agreed standard".[65] The question arising here is which ministry should ideally be responsible for the stewardship of health in prisons. This differs by country, and the general health of prisoners may come under the responsibility of the ministry of justice,[66] the ministry of health, or the ministry of internal affairs.[65] The WHO Regional Office for Europe Health in Prison Project (HIPP) provides overall guidance to improve prison health services.[65] Presently, the ministries of health are in charge of health in prisons in most settings.[65] In other settings, there is a need for close cooperation and collaboration between the ministries of health and the ministries responsible for prisons to plan common activities to improve TB control.

3.2.2. Engagement of communities, civil society organizations, and public and private care providers

Prisoners belong disproportionately to population groups already at high risk of TB (e.g., people who abuse substances, the homeless, migrants from high endemic areas, and other marginalized groups stricken by poverty with little or no access to healthcare), which may partially explain the high prevalence of TB in these settings.[25,28,67] Education and counselling are fundamental to improving patient adherence to treatment. In some settings, community representatives engage inmates in health education and prepare them for treatment follow-up after their release from prison. However, it is clear that prison health services alone may not be able to fully respond to the TB situation in most settings; therefore working in partnership on different levels needs to be encouraged. Prison health services should collaborate closely with other sectors, including civil society and community representatives and health services outside prisons, in order to share diagnostic facilities and improve the referral and support of patients. Prison systems should also partner various ministries on a political level, NGOs, donors, and health experts for improved public awareness and knowledge-sharing.

3.2.3. Infection control

Many prisons worldwide are overcrowded, well beyond their official capacity.[68] Overcrowded prisons facilitate the spread of mycobacterial strains, as prisoners are in close contact with one another, often for 12 h or more each day without access to fresh air. In some countries, the living conditions of prisoners are poor: spaces in prison cells of less than one square meter per person, bunks stacked three tiers high, and prisoners sleeping in turn, even during daytime hours when they have access to an outside area, or they are kept in isolation cells for long periods without spending time outside at all.[53,68]

Overcrowding, poor ventilation, and prolonged confinement inside cells are all factors conducive to the transmission of airborne infections. Poor ventilation may be due to inadequate prison infrastructure (e.g., lack of windows, no mechanical ventilation), or caused by the prisoners themselves covering the windows to block cold air from entering the room in cold climates, or by hanging clothes on the bars. The lack of mechanical ventilation systems is another major risk factor for contracting TB.[45] Furthermore, many prisoners may be heavy smokers, adding to the unhealthy environment of overcrowded cells.[68]

Overcrowding leading to significantly higher rates of TB transmission in prisons also has implications for rates of TB in the community. Using longitudinal TB and cross-sectional MDR-TB data from 26 Eastern European and Central Asian countries, Stuckler et al.[28] found that each percentage increase in incarceration rate related to an increased TB incidence of 0.34% (population attributable risk, 95% confidence interval 0.10–0.58%, $p < 0.01$), after controlling for several confounders. Conversely, a reduction in custodial sentencing would impact favourably on risk reduction of TB and MDR-TB in the general population.[69]

In light of the challenge of overcrowding associated with increased rates of TB in both the prison and community setting, TB IC is a fundamental element for improved TB control.[70] TB IC is a combination of measures aimed at minimizing the risk of MTB transmission and includes the early and rapid identification of individuals with suspected or known TB, separation of prisoners according to their TB disease type, and effective treatment of infection or disease,[69,71] building design or engineering methods to improve ventilation, disinfecting of the air, and the use of protective measures for staff and visitors in contact with TB patients. TB IC is also a fundamental element of Pillar 2 of the post-2015 End TB Strategy.[30] A list of IC measures to be conducted in prisons in consideration of these factors is summarized in Table 2.[72]

3.3. Pillar 3: Intensified research and innovation

One of the three main pillars of the End TB Strategy includes research. With the current 2% decline in TB incidence, the MDGs for TB control will not be met by 2015.[73] The need to develop new technologies to accelerate TB control resulted in the launch of the TB Research Movement, with the development of a roadmap for global TB research as its main objective.[73,74] Despite its impact on public health, TB control in prisons has been given a low priority by national health authorities worldwide, particularly in LMICs. This is reflected negatively in the fund allocation, and consequently in research output.[75–77] A recent review of published documents describing TB research priorities showed that 33 documents were published from 1998 to 2010 describing the importance of research on new medicines and diagnostics.[78] None of the documents retrieved directly addressed TB research in prisons.

Table 2
Summary of infection control measures to be conducted in prisons

- Preventing the spread of infection from the community to prison by intensified TB screening of new or transferred prisoners and preparing special blocks 'Quarantine' or cells (to be used for 1–2 weeks) for new or transferred prisoners
- Preventing TB infection among prisoners (transmission from one TB prisoner to other prisoners) or to prison staff by conducting a contact investigation for TB suspects and cases, improving infection control (e.g., implementing organizational, administrative, and environmental interventions) in prisons, and using IC for prisoners
- Preventing infection of family members and the community by a released prisoner or prison staff by examining prisoners before release and examining prison staff regularly
- Isolation measures for TB cases and/or suspects when patients are screened or diagnosed within the prison system

TB, tuberculosis; IC, infection control.

Table 3
Priorities for research related to TB control in prisons

Epidemiological research
Actual burden of TB (drug-susceptible and drug-resistant strains) and TB/HIV in prisons worldwide
Best tools to measure the TB burden
Social determinants of TB infection and transmission inside prisons
Prevalence of LTBI in high-burden countries
Impact of scaling up current preventive regimens on TB prevalence in prisons
Contribution of TB in prison to TB transmission in the community (attributable risk)
Operational (health services) research
Best operational model to enhance case-finding and its impact on mortality and transmission in prisons
Definition of optimal algorithms for the diagnosis of all forms of active TB and the best model to rule out TB among high-risk groups (particularly the HIV-infected)
Barriers to achieving treatment adherence and strategies to improve treatment management particularly after prisoner release after a short detention
Impact of individual infection control methods and proper cost-effective methods for its implementation
Cost-effectiveness studies of the scaling-up of TB/HIV and MDR-TB services in prisons
Best model to integrate TB/HIV/STD services
Proper reporting and recoding system suitable for prisons
Diagnostics
New point of care, same-day diagnostic tool to diagnose active TB
Rapid tests for diagnosing drug-resistant TB
Feasibility, impact, and cost-effectiveness of new automated nucleic acid amplification tests (e.g. GeneXpert) for use in prisons in remote and/or resource-limited settings, particularly for new arrival screening
Optimal and cost-effective modelling for diagnosing LTBI and active TB
Developing a proper diagnostic tool to differentiate between LTBI and active TB, particularly among HIV-infected prisoners
Treatment
Newer and safer TB medications to combat the growing epidemic of TB and M/XDR-TB in prisons
Shorter treatment regimens to treat LTBI and active TB
Effectiveness and safety of currently available LTBI treatment regimens in correctional settings vis-à-vis the high prevalence of blood-borne co-infections (i.e., HIV, HCV, HBV)
Safety, efficacy, and cost-effectiveness of new shorter LTBI regimens (e.g., combination of isoniazid and rifapentine once weekly for 12 weeks)
Optimal time to start ARV and exploration of possible drug–drug interactions with newer TB medications

TB, tuberculosis; LTBI, latent tuberculosis infection; MDR, multidrug-resistant; STD, sexually transmitted disease; M/XDR-TB, multi- and extensively drug-resistant TB; HCV, hepatitis C virus; HBV, hepatitis B virus; ARV, antiretroviral.

In order to better allocate economic and human resources, it is important to adequately estimate the burden of disease and the risk of developing TB in prison.[79] Given the difference in dynamics and population, guidelines outlining TB research priorities need to be developed specifically for correctional institutions.[76] The areas for research to be addressed in relation to prisons, as listed in Table 3, are of high priority.[74,75,78] There are still concerns about conducting studies among vulnerable populations, including prisoners, and ethical considerations related to prisoners need to be addressed properly when conducting research in these settings.

4. Conclusions

Currently, a complex range of activities is required to tackle the alarming situation of TB, M/XDR-TB, and TB/HIV control in prisons. The requirements for enhanced TB control in prisons are good governance, clear strategies to diagnose and treat TB patients, adherence to internationally established IC policies, and the performance of cost-effectiveness analyses to evaluate screening procedures and other control strategies. Released prisoners with active TB disease need to be followed-up by health authorities in the civilian sector and NTP-based local health centres, or organizations collaborating with NTPs. To minimize the interruption of treatment for released prisoners, implementation of the following interventions is recommended: (1) discharge or referral planning, (2) post-release follow-up, and (3) notification of unplanned releases and monitoring of referrals. If NTPs or ministries of health are responsible for TB control in the prison system, the establishment of follow-up mechanisms is probably more likely to occur, and gaps between public health and prisons are less likely to exist.

In addition, it is crucial to prepare effective plans for human resource development covering entire processes, such as basic education (in- and pre-service), retraining, on-the-job training, supervision, career development, salary scales, job descriptions, and enhanced IC measures. Although the directly observed therapy strategy (DOTS) has been declared the most cost-effective health strategy available by the World Bank, there is still work to be done to improve general TB management among prisoners. It is argued that if there is a failure to implement TB control successfully in prisons, it will affect prison and public health services dramatically in the near future, due to increased numbers of cases within the prison services and community, as well as higher numbers of M/XDR-TB and/or TB/HIV cases. New tools, such as the GeneXpert MTB/RIF, should be implemented in central prison hospitals, or facilities where prisoners receive TB treatment.

Although we are entering an exciting period of innovation, e.g. introduction of GeneXpert MTB/RIF and new medicines like delamanid and bedaquiline,[41,80,81] TB control in prisons remains a neglected priority. In addition, the increased cost of new drugs (USD 900 and USD 3000 for bedaquiline in LMICs and high-income countries, respectively, for a 6-month course)[82] and the resources needed for pharmacovigilance and the management of side effects, remain a barrier to utilization, particularly in the prison sector where resources are even more limited. No real improvement can be facilitated without clear commitment from national governments and partnerships and sustained financing, in line with the End TB Strategy. In order to achieve this, the principle "good prison health is good public health"[83] needs to be fully recognized.

Conflict of interest: Dr Haider Al-Darraji receives funding from the University of Malaya High Impact Research Grant (HIRGA-E000001-20001). The authors have no competing interests and no funders had a role in the development or writing of this review.

References

1. World Health Organization. Global tuberculosis report 2013. WHO/HTM/TB/2013. 11. Geneva: WHO; 2013.
2. Stop TB. Partnership. The global plan to stop TB 2011-2015: transforming the fight towards elimination of tuberculosis. WHO/HTM/STB/2010. 2. Geneva: WHO; 2010.
3. Raviglione M, Marais B, Floyd K, Lönnroth K, Getahun H, Migliori GB, et al. Scaling up interventions to achieve global tuberculosis control: progress and new developments. *Lancet* 2012;**379**:1902–13.
4. Dara M, Chadha SS, Vinkeles Melchers NV, Melchers NV, van den Hombergh J, Gurbanova E, et al. Time to act to prevent and control tuberculosis among inmates. *Int J Tuberc Lung Dis* 2013;**17**:4–5.
5. Skrahina A, Hurevich H, Zalutskaya A, Sahalchyk E, Astrauko A, van Gemert W, et al. Alarming levels of drug-resistant tuberculosis in Belarus: results of a survey in Minsk. *Eur Respir J* 2012;**39**:1425–31.
6. Migliori GB, Dara M, de Colombani P, Kluge H, Raviglione MC. Multidrug-resistant tuberculosis in Eastern Europe: still on the increase? *Eur Respir J* 2012;**39**:1290–1.
7. Migliori GB, Sotgiu G, Lange C, Centis R. Extensively drug-resistant tuberculosis: back to the future. *Eur Respir J* 2010;**36**:475–7.
8. Jenkins HE, Plesca V, Ciobanu A, Crudu V, Galusca I, Soltan V, et al. Assessing spatial heterogeneity of multidrug-resistant tuberculosis in a high-burden country. *Eur Respir J* 2013;**42**:1291–301.
9. Ahuja SD, Ashkin D, Avendano M, Banerjee R, Bauer M, Bayona JN, et al. Multidrug resistant pulmonary tuberculosis treatment regimens and patient outcomes: an individual patient data meta-analysis of 9,153 patients. *PLoS Med* 2012;**9**: e1001300.

10. Migliori GB, Sotgiu G, Gandhi NR, Falzon D, DeRiemer K, Centis R, et al. Drug resistance beyond extensively drug-resistant tuberculosis: individual patient data meta-analysis. *Eur Respir J* 2013;**42**:169–79.
11. Floyd K, Hutubessy R, Kliiman K, Centis R, Khurieva N, Jakobowiak W, et al. Cost and cost-effectiveness of multidrug-resistant tuberculosis treatment in Estonia and Russia. *Eur Respir J* 2012;**40**:133–42.
12. Sotgiu G, Ferrara G, Matteelli A, Richardson MD, Centis R, Ruesch-Gerdes S, et al. Epidemiology and clinical management of XDR-TB: a systematic review by TBNET. *Eur Respir J* 2009;**33**:871–81.
13. Zhao Y, Xu S, Wang L, Chin DP, Wang S, Jiang G, et al. National survey of drug-resistant tuberculosis in China. *N Engl J Med* 2012;**366**:2161–70.
14. Post FA, Grint D, Werlinrud AM, Panteleev A, Riekstina V, Malashenkov EA, et al. Multi-drug-resistant tuberculosis in HIV positive patients in Eastern Europe. *J Infect* 2014;**68**:259–63.
15. El-Bassel N, Shaw SA, Dasgupta A, Strathdee SA. Drug use as a driver of HIV risks: re-emerging and emerging issues. *Curr Opin HIV AIDS* 2014;**9**:150–5.
16. World Health Organization. Tuberculosis control in prisons: a manual for programme managers. WHO/HTM/TB/2013.6. Geneva: WHO; 2000.
17. Aerts A, Hauer B, Wanlin M, Veen J. Tuberculosis and tuberculosis control in European prisons. *Int J Tuberc Lung Dis* 2006;**10**:1215–23.
18. Jittimanee SX, Ngamtrairai N, White MC, Jittimanee S. A prevalence survey for smear-positive tuberculosis in Thai prisons. *Int J Tuberc Lung Dis* 2007;**11**:556–61.
19. Chiang CY, Hsu CJ, Hsu PK, Suo J, Lin TP. Pulmonary tuberculosis in the Taiwanese prison population. *J Formos Med Assoc* 2002;**101**:537–41.
20. Banu S, Hossain A, Uddin MK, Uddin MR, Ahmed T, Khatun R, et al. Pulmonary tuberculosis and drug resistance in Dhaka central jail, the largest prison in Bangladesh. *PLoS One* 2010;**5**:e10759.
21. United Nations. Millennium Development Goals Indicators. The official United Nations site for the MDG Indicators. Available at: http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=617 (accessed June 11, 2014).
22. Abebe DS, Bjune G, Ameni G, Biffa D, Abebe F. Prevalence of pulmonary tuberculosis and associated risk factors in Eastern Ethiopian prisons. *Int J Tuberc Lung Dis* 2011;**15**:668–73.
23. Abrahão RM, Nogueira PA, Malucelli MI. Tuberculosis in county jail prisoners in the western sector of the city of São Paulo, Brazil. *Int J Tuberc Lung Dis* 2006;**10**:203–8.
24. Sanchez A, Gerhardt G, Natal S, Capone D, Espinola A, Costa W, et al. Prevalence of pulmonary tuberculosis and comparative evaluation of screening strategies in a Brazilian prison. *Int J Tuberc Lung Dis* 2005;**9**:633–9.
25. Reyes H, Coninx R. Pitfalls of tuberculosis programmes in prisons. *BMJ* 1997;**315**:1447–50.
26. Coninx R, Eshaya-Chauvin B, Reyes H. Tuberculosis in prisons. *Lancet* 1995;**346**:1238–9.
27. Aerts A, de Haller R. DOTS and DOTS plus: what's in a name. *Int J Tuberc Lung Dis* 2001;**5**:879–80.
28. Stuckler D, Basu S, McKee M, King L. Mass incarceration can explain population increases in TB and multidrug-resistant TB in European and central Asian countries. *Proc Natl Acad Sci U S A* 2008;**105**:13280–5.
29. Baussano I, Williams BG, Nunn P, Beggiato M, Fedeli U, Scano F. Tuberculosis incidence in prisons: a systematic review. *PLoS Med* 2010;**7**:e1000381.
30. World Health Organization. Draft global strategy and targets for tuberculosis prevention, care and control after 2015. Report by the Secretariat. Sixty-seventh World Health Assembly. WHO; March 14, 2014. Available at: http://apps.who.int/gb/ebwha/pdf_files/WHA67/A67_11-en.pdf?ua=1. (accessed December 11, 2014).
31. Vinkeles Melchers NV, van Elsland SL, Lange JM, Borgdorff MW, van den Hombergh J. State of affairs of tuberculosis in prison facilities: a systematic review of screening practices and recommendations for best TB control. *PLoS One* 2013;**8**:e53644.
32. Moller L, Gatherer A, Dara M. Barriers to implementation of effective tuberculosis control in prisons. *Public Health* 2009;**123**:419–21.
33. Stop TB Partnership. The Global Plan to Stop TB. Available at: http://www.stoptb.org/global/plan/ (accessed November 21, 2012).
34. Nyangulu DS, Harries AD, Kang'ombe C, Yadidi AE, Chokani K, Cullinan T, et al. Tuberculosis in a prison population in Malawi. *Lancet* 1997;**350**(9087):1284–7.
35. Kazi AM, Shah SA, Jenkins CA, Shepherd BE, Vermund SH. Risk factors and prevalence of tuberculosis, human immunodeficiency virus, syphilis, hepatitis B virus, and hepatitis C virus among prisoners in Pakistan. *Int J Infect Dis* 2010;**14**(Suppl 3):e60–6.
36. Butler T, Levy M. Mantoux positivity among prison inmates—New South Wales, 1996. *Aust N Z J Public Health* 1999;**23**:185–8.
37. Habeenzu C, Mitarai S, Lubasi D, Mudenda V, Kantenga T, Mwansa J, et al. Tuberculosis and multidrug resistance in Zambian prisons, 2000-2001. *Int J Tuberc Lung Dis* 2007;**11**:1216–20.
38. Aerts A, Habouzit M, Mschiladze L, Malakmadze N, Sadradze N, Menteshashvili O, et al. Pulmonary tuberculosis in prisons of the ex-USSR state Georgia: results of a nation-wide prevalence survey among sentenced inmates. *Int J Tuberc Lung Dis* 2000;**4**:1104–10.
39. Banda HT, Gausi F, Harries AD, Salaniponi FM. Prevalence of smear-positive pulmonary tuberculosis among prisoners in Malawi: a national survey. *Int J Tuberc Lung Dis* 2009;**13**:1557–9.
40. World Health Organization. Rapid implementation of the Xpert MTB/RIF diagnostic test. Technical and operational "How-to". Practical considerations. WHO/HTM/TB/2011.2. Geneva, WHO; 2011.
41. Weyer K, Mirzayev F, Migliori GB, Van Gemert W, D'Ambrosio L, Zignol M, et al. Rapid molecular TB diagnosis: evidence, policy making and global implementation of Xpert MTB/RIF. *Eur Respir J* 2013;**42**:252–71.
42. Chang K, Lu W, Wang J, Zhang K, Jia S, Li F, et al. Rapid and effective diagnosis of tuberculosis and rifampicin resistance with Xpert MTB/RIF assay: a meta-analysis. *J Infect* 2012;**64**:580–8.
43. Kirwan DE, Cárdenas MK, Gilman RH. Rapid implementation of new TB diagnostic tests: is it too soon for a global roll-out of Xpert MTB/RIF? *Am J Trop Med Hyg* 2012;**87**:197–201.
44. Schnippel K, Meyer-Rath G, Long L, MacLeod W, Sanne I, Stevens WS, et al. Scaling up Xpert MTB/RIF technology: the costs of laboratory- vs. clinic-based roll-out in South Africa. *Trop Med Int Health* 2012;**17**:1142–51.
45. Vieira AA, Ribeiro SA, de Siqueira AM, Galesi VM, dos Santos LA, Golub JE. Prevalence of patients with respiratory symptoms through active case finding and diagnosis of pulmonary tuberculosis among prisoners and related predictors in a jail in the city of Carapicuíba, Brazil. *Rev Bras Epidemiol* 2010;**13**:641–50.
46. Mor Z, Adler A, Leventhal A, Volovic I, Rosenfeld E, Lobato MN, et al. Tuberculosis behind bars in Israel: policy making within a dynamic situation. *Isr Med Assoc J* 2008;**10**:202–6.
47. Veen J, Migliori GB, Raviglione M, Rieder HL, Dara M, Falzon D, et al. Harmonisation of TB control in the WHO European region: the history of the Wolfheze Workshops. *Eur Respir J* 2011;**37**:950–9.
48. Tadolini M, Migliori GB. The WHO strategy for TB control and elimination. In: Lange C, Migliori GB, editors. *Tuberculosis; European Respiratory Society Monograph 58. Sheffield, United Kingdom*. 2012. p. 242–53.
49. Shah SA, Mujeeb SA, Mirza A, Nabi KG, Siddiqui Q. Prevalence of pulmonary tuberculosis in Karachi juvenile jail, Pakistan. *East Mediterr Health J* 2003;**9**:667–74.
50. Adib SM, Al-Takash H, Al-Hajj C. Tuberculosis in Lebanese jails: prevalence and risk factors. *Eur J Epidemiol* 1999;**15**:253–60.
51. GGD. Jaarverslag 2009 Tuberculoseonderzoek in penitentiaire inrichtingen. Netherlands: GGD; 2010. Available at: http://www.ggdkennisnet.nl/?file=64&m=1309267100&action=file.download (accessed December 11, 2014).
52. Carbonara S, Babudieri S, Longo B, Starnini G, Monarca R, Brunetti B, et al. Correlates of *Mycobacterium tuberculosis* infection in a prison population. *Eur Respir J* 2005;**25**:1070–6.
53. Dara M, Grzemska M, Kimerling ME, Reyes H, Zagorskiy A. Guidelines for control of tuberculosis in prisons. Tuberculosis Coalition for Technical Assistance and International Committee of the Red Cross. Geneva: Red Cross; 2009. Available at: http://pdf.usaid.gov/pdf_docs/PNADP462.pdf (accessed December 11, 2014).
54. Martín Sánchez V, Alvarez-Guisasola F, Caylá JA, Alvarez JL. Predictive factors of *Mycobacterium tuberculosis* infection and pulmonary tuberculosis in prisoners. *Int J Epidemiol* 1995;**24**:630–6.
55. McLaughlin SI, Spradling P, Drociuk D, Ridzon R, Pozsik CJ, Onorato I. Extensive transmission of *Mycobacterium tuberculosis* among congregated, HIV-infected prison inmates in South Carolina, United States. *Int J Tuberc Lung Dis* 2003;**7**:665–72.
56. World Health, Organization. WHO policy on collaborative TB/HIV activities. Guidelines for national programmes and other stakeholders. WHO/HTM/TB/2012.1. Geneva: WHO; 2012.
57. Njozing BN, Edin KE, San Sebastián M, Hurtig AK. Voices from the frontline: counsellors' perspectives on TB/HIV collaborative activities in the Northwest Region, Cameroon. *BMC Health Serv Res* 2011;**11**:328.
58. World Health Organization. Joint United Nations Programme on HIV/AIDS. Guidance on provider-initiated HIV testing and counselling in health facilities. Geneva: WHO; 2007.
59. Al-Darraji HA, Kamarulzaman A, Altice FL. Isoniazid preventive therapy in correctional facilities: a systematic review. *Int J Tuberc Lung Dis* 2012;**16**:871–9.
60. Tulsky JP, White MC, Dawson C, Hoynes TM, Goldenson J, Schecter G. Screening for tuberculosis in jail and clinic follow-up after release. *Am J Public Health* 1998;**88**:223–6.
61. Sanchez A, Larouzé B, Espinola AB, Pires J, Capone D, Gerhardt G, et al. Screening for tuberculosis on admission to highly endemic prisons? The case of Rio de Janeiro State prisons. *Int J Tuberc Lung Dis* 2009;**13**:1247–52.
62. The Global Fund to Fight AIDS, Tuberculosis and Malaria. The Global Fund Strategy 2012-2016: investing for impact. Global Fund; 2011. Available at: http://www.theglobalfund.org/en/about/strategy/ (accessed December 11, 2014).
63. Lee D, Lal SS, Komatsu R, Zumla A, Atun R. Global fund financing of tuberculosis services delivery in prisons. *J Infect Dis* 2012;**205**(Suppl 2):S274–83.
64. WHO, KNCV, UNION, DH Prison Health. Status Paper on Prisons and Tuberculosis. Geneva: WHO; 2007. Available at: http://www.euro.who.int/__data/assets/pdf_file/0004/69511/E89906.pdf (accessed December 11, 2014).
65. World Health Organization. Stewardship of prison health: a WHO guidance document. The draft 2012. Geneva: WHO; 2012.
66. Todrys KW, Amon JJ. Criminal justice reform as HIV and TB prevention in African prisons. *PLoS Med* 2012;**9**:e1001215.
67. Larouzé B, Sánchez A, Diuana V. Tuberculosis behind bars in developing countries: a hidden shame to public health. *Trans R Soc Trop Med Hyg* 2008;**102**:841–2.
68. International Centre for Prison Studies. Guidance Note 4: dealing with prison overcrowding. London: ICPS; 2011. Available at: http://www.prisonstudies.org/images/news_events/gn42ndedv2.pdf (accessed December 11, 2014).
69. Stern V. Sentenced to die? The problem of TB in prisons in Eastern Europe and Central Asia.. London: International Centre for Prison Studies; 1999.
70. Bick JA. Infection control in jails and prisons. *Clin Infect Dis* 2007;**45**:1047–55.

71. Sotgiu G, D'Ambrosio L, Centis R, Bothamley G, Cirillo DM, De Lorenzo S, et al. TB and M/XDR-TB infection control in European TB reference centres: the Achilles' heel? *Eur Respir J* 2011;**38**:1221–3.
72. World Health, Organization. WHO policy on TB infection control in health-care facilities, congregate settings and households. WHO/HTM/TB/2009. 419. Geneva: WHO; 2009.
73. Lienhardt C, Espinal M, Pai M, Maher D, Raviglione MC. What research is needed to stop TB? Introducing the TB Research Movement. *PLoS Med* 2011;**8**:e1001135.
74. World Health Organization. An international roadmap for tuberculosis research: towards a world free of tuberculosis. Geneva: WHO; 2011.
75. O'Grady J, Hoelscher M, Atun R, Bates M, Mwaba P, Kapata N, et al. Tuberculosis in prisons in Sub-Saharan Africa—the need for improved health services, surveillance and control. *Tuberculosis (Edinb)* 2011;**91**:173–8.
76. Basu S, Stuckler D, McKee M. Addressing institutional amplifiers in the dynamics and control of tuberculosis epidemics. *Am J Trop Med Hyg* 2011;**84**:30–7.
77. World Health Organization. Literature review on tuberculosis in prisons. Geneva: WHO; 2008 .
78. Rylance J, Pai M, Lienhardt C, Garner P. Priorities for tuberculosis research: a systematic review. *Lancet Infect Dis* 2010;**10**:886–92.
79. Dara M, Acosta CD. Tuberculosis prevention and control. Do we know enough? *Int J Tuberc Lung Dis* 2014;**18**:758–9.
80. Gler MT, Skripconoka V, Sanchez-Garavito E, Xiao H, Cabrera-Rivero JL, Vargas-Vasquez DE, et al. Delamanid for multidrug-resistant pulmonary tuberculosis. *N Engl J Med* 2012;**366**:2151–60.
81. Diacon AH, Dawson R, von Groote-Bidlingmaier F, Symons G, Venter A, Donald PR, et al. 14-day bactericidal activity of PA-824, bedaquiline, pyrazinamide, and moxifloxacin combinations: a randomised trial. *Lancet* 2012;**380**:986–93.
82. Vassall A. Cost-effectiveness of introducing bedaquiline in MDR-TB regimens—an exploratory analysis. London School of Hygiene and Tropical Medicine; 2013. Available at: http://who.int/tb/challenges/mdr/CEA_bdqreport_final.pdf (accessed December 11, 2014).
83. Reyes H. Multi-drug resistant TB in prisons. *World Med J* 2010;**56**:6–10.