

HIV and related infections in prisoners 1



Global burden of HIV, viral hepatitis, and tuberculosis in prisoners and detainees

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The prison setting presents not only challenges, but also opportunities, for the prevention and treatment of HIV, viral hepatitis, and tuberculosis. We did a comprehensive literature search of data published between 2005 and 2015 to understand the global epidemiology of HIV, hepatitis C virus (HCV), hepatitis B virus (HBV), and tuberculosis in prisoners. We further modelled the contribution of imprisonment and the potential impact of prevention interventions on HIV transmission in this population. Of the estimated 10·2 million people incarcerated worldwide on any given day in 2014, we estimated that 3·8% have HIV (389 000 living with HIV), 15·1% have HCV (1 546 500), 4·8% have chronic HBV (491 500), and 2·8% have active tuberculosis (286 000). The few studies on incidence suggest that intraprisn transmission is generally low, except for large-scale outbreaks. Our model indicates that decreasing the incarceration rate in people who inject drugs and providing opioid agonist therapy could reduce the burden of HIV in this population. The prevalence of HIV, HCV, HBV, and tuberculosis is higher in prison populations than in the general population, mainly because of the criminalisation of drug use and the detention of people who use drugs. The most effective way of controlling these infections in prisoners and the broader community is to reduce the incarceration of people who inject drugs.

Introduction

From the beginning of the AIDS epidemic in 1981, the association between HIV, tuberculosis, and prisons was apparent,¹ with HIV responsible for a steep rise in tuberculosis in US prison populations.² This is important because the prevalence of HIV in prisons in many countries is high, with one review reporting levels greater than 10% in 20 low-income and middle-income countries.³ Several factors have a role in the epidemics of HIV, tuberculosis, and related infections in prisons.⁴ Many individuals who are most likely to be incarcerated are at greatest risk of these infections, whether because of injection drug use for HIV and viral hepatitis or poverty and overcrowding for tuberculosis. Drug injection is common in prison inmates, ranging from 2% to 38% in Europe, 34% in Canada, and up to 55% in Australia, in stark contrast with the percentage in the general population, estimated at 0·3% in the European Union and 0·2% in Australia.⁵ Prisons provide many opportunities both for the spread⁴ and prevention of these infections.⁶

The situation is complicated further by the expansion of parallel prison systems for those suspected of drug use in at least 27 countries. These compulsory drug detention centres operate extrajudicially and often under the guise of drug treatment (panel 1).²⁰ Punishment and inhumane conditions are widespread, but evidence-based treatment for drug dependence and infectious diseases is rare or non-existent.^{7,21} However, prisons not only pose a threat to the health of people incarcerated within them. They also pose a risk to staff and to the population at large, because detainees are not a static population, but move around the prison system and back and forth from the outside world.

The risks particularly lie at the interface between prisons and society outside. In the USA, HIV incidence is highest

in detainees who were released and re-incarcerated compared with continuously incarcerated prisoners, people who inject drugs with no history of incarceration, and men who have sex with men (MSM; panel 2).⁴ The period immediately after release is especially risky for receptive syringe sharing, acquisition of HIV and hepatitis C virus (HCV), and mortality.^{29–32} Thus, the transition between the prison and community settings represents a high-risk

Key messages

- Prevalence of HIV, HCV, HBV, and tuberculosis is higher in prison populations than in the general population, mainly because of the criminalisation of drug use and the detention of people who inject or use drugs
- We strongly support the UN's 2012 call to close compulsory drug detention centres and expand voluntary, evidence-based treatment in the community
- Mathematical modelling suggests that incarceration and re-incarceration of people who inject drugs contributes to the overall HIV epidemic and a reduction in incarceration of this population will reduce the incidence of HIV
- Evidence-based prevention and treatment such as opioid agonist therapy and antiretroviral therapy can substantially reduce the incidence of HIV, HCV, and HBV, and reduce drug dependence in this population
- Responses to co-infection with HIV and tuberculosis should include an integrated, patient-centred model of prevention and care, with systematic screening of high-risk groups and equitable access to effective treatment
- The most effective way of controlling infection in prisoners and the broader community is to reduce mass incarceration of people who inject drugs

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This is the first in a **Series** of six papers on HIV and related infections in prisoners

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Panel 1: Compulsory drug detention centres

Some 27 countries detain drug users, or suspected drug users, in compulsory drug detention centres for the purpose of treatment or rehabilitation. In east and southeast Asia, an estimated 600 000 drug users are detained in roughly 1000 (mostly government-run) centres.⁷ In Latin America,^{8,9} and sub-Saharan Africa,^{10–12} an unknown number of individuals are detained in hundreds of faith-based and unregulated residential treatment centres. Abuses in these facilities include being shackled to trees and starved.¹³ Similar unregistered treatment centres operate in central Asia.¹⁴

Detainees are typically held in forms of administrative detention, often without due legal process, assessment of drug dependency, or informed consent. Evidence-based drug dependency treatment such as opioid agonist therapy is rarely provided,¹⁵ while physical abuse—including torture, forced prayer, forced exercise to sweat drugs out of the body, and manual labour (sometimes forced labour)—are common.¹⁶ Estimates of disease burden in compulsory drug detention centres are given in the appendix (p 31).

In Vietnam, one formerly detained child described punishment in a compulsory drug detention centre, where the staff beat him on the arm and back with a truncheon. He reported being held in a small punishment room for 3 months. Another ex-detainee served his 2-year sentence only to have it extended by 5 years with no reason given.¹⁶

In Cambodia, one former detainee reported having his head bashed against a wall until he lost consciousness.¹⁶ One child, detained in a compulsory drug detention centre in Cambodia, said he saw a doctor after he was beaten. After the doctor treated the child, the doctor told the child to not try and escape again.¹⁷ In Thailand, individuals detained in compulsory drug detention centres reported being beaten or made to roll on gravel as a punishment.¹⁸

Ex-detainees have limited or no access to health care. In China, one individual detained in Guangxi province reported that he was unable to continue taking his antiretroviral drugs once placed in (compulsory) detoxification. Another person, detained in Yunnan province, reported that many incarcerated people have tuberculosis and many acquire tuberculosis while incarcerated, yet there is no treatment.¹⁹

These unregulated and abusive forms of detention in the name of drug treatment do not meet minimum health or human rights standards and should be closed.

environment, especially for people with substance use disorders.³¹ This is important because, although an estimated 10·2 million people were incarcerated at any time in 2014, over 30 million individuals transition from prison to the community each year.³³ Prisons act as incubators for tuberculosis and HIV, because they are associated with higher levels of infection than in the surrounding populations,^{3,34} yet many countries have parallel and vertical systems, with fragmented policy responses to these interlinked issues—prisons, HIV, viral hepatitis, and tuberculosis—and interruptions of surveillance and treatment during transitions. This Series paper encourages a coordinated response by reviewing the global epidemiology of HIV, HCV, HBV, and tuberculosis in prison populations.^{35,36}

Disease burden in prisoners and detainees

We did a comprehensive review of studies of prevalence and incidence data on HIV, HCV, HBV, tuberculosis, and co-infection with tuberculosis and HIV in prisoners and detainees, published between Jan 1, 2005, and Nov 30, 2015, for 196 countries in 2015 (appendix p 2, 4).³⁷

See Online for appendix

We searched for studies with biological markers of each infection in general prisoners and in people who inject drugs, MSM, female sex workers, and transgender people, in prisons, jails, and compulsory drug detention centres.

Of 11000 publications identified, 299 met inclusion criteria for the meta-analysis of infections (appendix p 7). These data show substantial heterogeneity in disease burden across regions (figure 1).

Global estimates of prisoners with HIV, HCV, HBV, and tuberculosis infection

Of an estimated 10·2 million people incarcerated worldwide on any given day in 2013,²² we estimated the midpoint of the number infected was 389 000 with HIV (3·8%), 1 546 500 with HCV (15·1%), 491 500 with chronic HBV infection (4·8%), and 286 000 with active tuberculosis (2·8%; appendix pp 9, 15, 20, 24).

Overall, prevalence of all infections was substantially higher in prison populations than in surrounding communities, especially where there are generalised HIV epidemics, such as in sub-Saharan Africa,³⁸ and where there is a high prevalence of injection drug use, such as in eastern Europe and central Asia (figure 1, 2, appendix p 9).³⁹

HIV infection

Pooled estimated HIV prevalence in prisoners

74 of 196 countries³⁷ had HIV prevalence data in 2015 (200 datapoints) in prisoners (appendix p 8). The regions most affected were the two African regions (east and southern Africa and west and central Africa), which have a high prevalence in the general population, and the two European regions (eastern Europe and central Asia and west Europe), reflecting the over-representation of people who inject drugs in prison—a group with a high prevalence of HIV infection. Transmission via injection drug use also contributes to the HIV epidemic in the Middle East and north Africa and Asia Pacific regions.

While injection drug use is rare in the Caribbean and Latin America, HIV prevalence in prisoners is generally higher than in North America, possibly reflecting the concentrated epidemic of HIV in MSM⁴⁰ and cocaine users in Latin America.⁴¹

Female inmates had a slightly higher prevalence of HIV than male prisoners in six regions (both African regions, Asia Pacific, both European regions, and North America) and lower than male inmates in Latin America and the Middle East and north Africa (appendix p 9). Notable differences were found in west and central Africa, where the prevalence of HIV in women was almost double that of men (13·1% vs 7·1%), and in eastern Europe and central Asia, where it was almost three times higher than in men (22·1% vs 8·5%). HIV prevalence was higher in prisoners than in the general population in eastern Europe and central Asia (4·1% vs 0·5%) and western Europe (4·6% vs 0·2%).³⁸

HIV prevalence in imprisoned people who inject drugs

Of the 200 HIV datapoints, only 47 were related to people who inject drugs in 16 countries. Prevalence estimates from Iran ranged from 0·7% in 2002 to 18·2% in 2003 and fell to 2·3% in 2007. After two large outbreaks of HIV in prisons (panel 3), Iran increased opioid agonist therapy coverage from 100 to over 25 000 drug users, provided condoms and conjugal visits, and piloted six needle and syringe programmes in prisons from 2002.^{47,49} Australia's HIV infection prevalence of almost zero in people who inject drugs in and out of prison can be traced back to very early introduction of community-based needle and syringe programmes in 1986, which prevented an estimated 25 000 HIV cases in people who inject drugs.⁵⁸

Hepatitis C infection

Pooled estimated HCV prevalence in prisoners

46 of 196 countries had HCV prevalence data (171 datapoints; hepatitis C antibody) in prisoners from 2005 to 2015³⁷ (appendix p 8). HCV infection in prisoners is high worldwide, exceeding 10% in six regions (figure 1, 3, appendix p 15). This finding reflects the increased infectivity and earlier HCV entry into populations of people who inject drugs compared with HIV.⁵⁹

Epidemic patterns of HCV infection related to injection drug use persist in Europe. HCV prevalence estimates were high in the eastern Europe and central Asia region at 20·2% (95% CI 11·8–30·1), in west Europe at 15·5% (12·2–19·1), and in North America at 15·3% (13·1–17·7). Injection drug use is rare in the Caribbean, which probably accounts for the absence of HCV data (and possibly infection) in prison populations. In Latin America, HCV prevalence was 4·7% (3·1–6·7), also reflecting the low level of drug injection in this region. Insufficient data, particularly for female inmate populations, precluded gender comparisons of the prevalence of HCV.

HCV prevalence in imprisoned people who inject drugs

Of the 171 datapoints on HCV infection, only 53 related to people who inject drugs in 19 countries. As expected, the prevalence of HCV in imprisoned people who inject drugs was high or very high, ranging from 8% to 95%, most of which were above 40% (appendix p 28). Only six countries had multiple datapoints from which trends could be surmised. With ten datapoints, Iran showed a clear reduction in prevalence from 78·3% (2001) to 43·4% (2009).⁴⁹ No data were identified for HCV in people who inject drugs for either African regions or Latin America.

Hepatitis B infection

Pooled estimated HBV prevalence in prisoners

43 of 196 countries had HBV prevalence data (56 datapoints) in prisoners from 2005 to 2015 (figure 3, appendix pp 8, 20).³⁷ The prevalence of HBsAg in

Panel 2: Mass incarceration and the HIV epidemic in the USA

The US incarceration rate of 716 per 100 000 population is almost five times the global average of 146 per 100 000.²² This translates into 2·2 million people, or almost 1% of the US population behind bars on any given day in 2013. In the 1970s, this rate was a meagre 75 per 100 000. However, the Rockefeller Drug Laws, introduced in 1973, caused the incarceration rate to increase by five times in a decade.²³ Specifically designed to target heroin and crack cocaine users, these laws mandated lengthy minimum sentences for many drug offences, including the possession and sale of small quantities of drugs, which matched sentences for rape, assault, and robbery. These laws took account of previous offences and culminated in the three-strikes law (ie, three strikes and you are in for life), for minor, but multiple offences.

By 1985, drug offenders comprised one-third of all inmates in New York state. The burden of incarceration fell heavily on young black men, who were 40 times more likely to be incarcerated than their white peers, and Hispanic men, who were 30 times more likely to be imprisoned than their white peers. New York City's Rikers Island prison once had the largest concentration of HIV-positive people in the USA.

HIV prevalence is roughly three times higher in incarcerated individuals than in the general US population.²⁴ HIV prevalence in the state prisons of Florida, Maryland, and New York exceeds 3%, which is higher than the national prevalence of any country outside of sub-Saharan Africa.²⁵ At least one in six HIV-positive American people passes through a correctional centre each year.²³ HIV infection has been linked to a history of incarceration; however, proving the infection occurred in prison is difficult. Although cases of intraprisn HIV and HBV transmission have been recorded (panel 3), evidence suggests that most HIV-positive people were infected before prison entry. For people in detention with HIV infection, treatment outcomes have been good, but retention in treatment after release is more challenging.²⁶

The post-release period can also be especially dangerous for treatment interruptions, fatal and non-fatal overdose, and infection acquisition. The ALIVE study²⁷ reported that the risk of HIV transmission increases, rather than decreases, on release from prison. Incarceration plays a role in delaying recovery from drug dependence. Incarceration also has an impact on those in the community, most probably through the return of prisoners who have been released and are infectious, who have interruptions in antiretroviral treatment. The main risk behaviour for newly diagnosed, heterosexually acquired HIV infection in African-American women was having sex with a partner who had a history of incarceration.²⁸ The approach to drug policy and the mass incarceration of drug users in the USA is counterproductive, expensive, and increases the risk of HIV treatment interruption and subsequent transmission.²³

prisoners in west and central Africa was very high at 23·5% (95% CI 19·8–27·5)—the highest burden of all four types of infection and across the nine regions. High levels of chronic HBV infection were also reported in east and southern Africa (5·7%, 95% CI 2·9–9·4) and in eastern Europe and central Asia (10·4%, 1·9–24·6). In other regions, HBV prevalence was below 5% and unsafe injection drug use and unprotected sex remain important modes of transmission.⁶⁰

HBsAg prevalence in prisoners relative to the general population

The burden of HBV in the general population is highest in sub-Saharan Africa, with a meta-analysis estimate of HBsAg prevalence at 8·8%, which was primarily attributed to vertical transmission from mother to child,

low HBV vaccine coverage (including birth dose), and unsafe medical products and procedures.⁶¹ In Australia, the prevalence of HBsAg was 2·3% in prison and 1·0% in the community.⁶²

HBsAg prevalence in imprisoned people who inject drugs

Of the 56 HBV datapoints, 24 related to people who inject drugs in ten countries. Iran and Australia were the only countries with multiple datapoints (appendix p 28). In Iran, HBV prevalence was significantly and positively associated with the frequency and duration of imprisonment.⁴⁹ Despite a reduction in the proportion of Australian prisoners reporting injection drug use, evidence of HBV infection remains high in

prison entrants, with many unaware of their infection status.⁶²

Tuberculosis and co-infection with HIV

Prevalence of active tuberculosis and co-infection with HIV in prisoners

Estimates of active tuberculosis in prison populations were higher than in the general population in almost all settings, with investigators of one study, from the Dourados prison in Brazil, estimating that prevalence of tuberculosis was 40 times higher than in the general population.⁶³

25 of 196 countries reported tuberculosis prevalence data (46 datapoints) and 17 of 196 countries prevalence data on co-infection with HIV and tuberculosis (25 datapoints) in prisoners from 2005 to 2015 (figure 4, appendix pp 8, 27).³⁷ In the three regions with the highest prevalence of HIV and viral hepatitis, active tuberculosis was also common (appendix pp 24, 27): 5·3% (95% CI 2·1–10·0) in east and southern Africa, 2·9% (2·4–3·6) in west and central Africa, and 4·9% (1·8–9·3) in eastern Europe and central Asia. In the African regions, active tuberculosis infection was associated with overcrowding, high inmate turnover, and increased frequency or duration of incarceration.^{64–66} Disease burden was lower in other regions, though only one study was identified in the Middle East and north Africa, two in the western European region, and none in the Caribbean.

A systematic review⁶⁷ found that the incidence of tuberculosis is 23 times higher in prison populations than in the general community, and that the prevalence of drug-resistant tuberculosis is also substantially higher. Increased prevalence of HIV infection exacerbates the effect of incarceration on tuberculosis incidence, highlighting the importance of a coordinated approach to prevent and treat these two infections.³⁴ Important for tuberculosis control in prisons is case-finding to ensure early detection and treatment, case isolation and infection control measures,

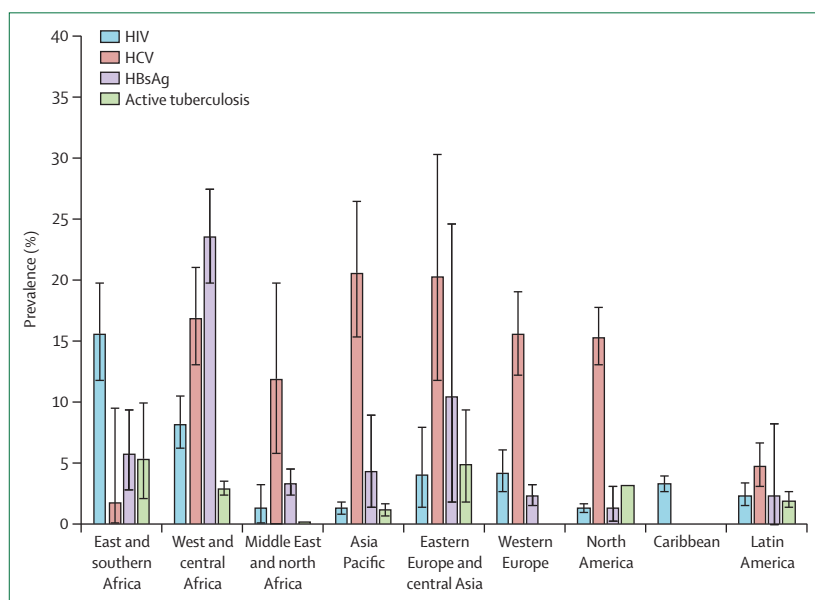


Figure 1: Regional prevalence of HIV, hepatitis C, HBsAg, and active tuberculosis in prisoners, published between 2005 and 2015

HCV=hepatitis C antibodies.

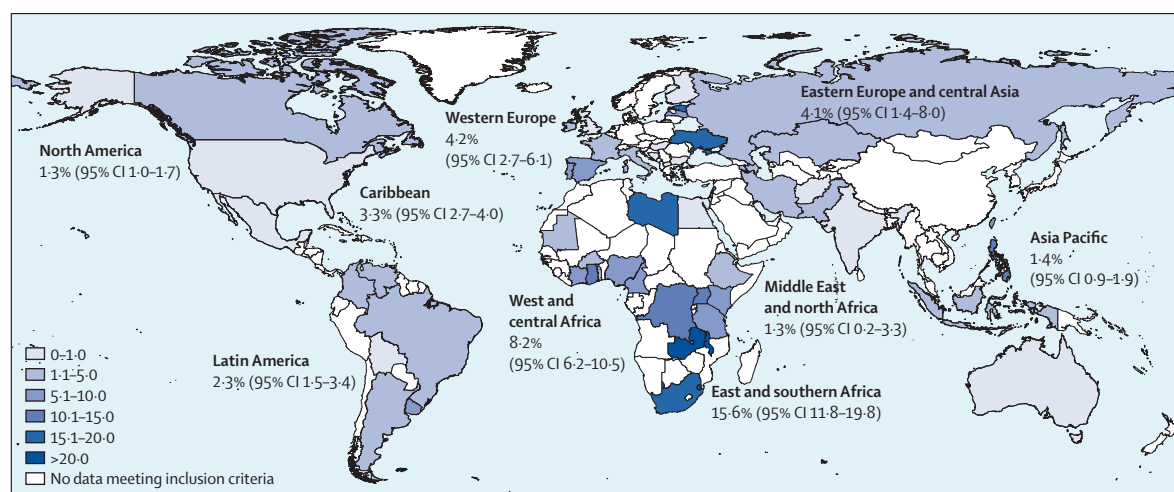


Figure 2: Global and regional burden of HIV in prison inmates, published between 2005 and 2015

initiation of tuberculosis treatment followed soon after by HIV treatment, and treatment of latent tuberculosis infection, especially in patients with HIV.

Studies investigating HIV and tuberculosis co-infection are of two types (appendix p 27). The first study type measures HIV and tuberculosis co-infection in all prisoners, which typically finds prevalence estimates that are less than 10% of the prison population, ranging from 1·6% (Zambia) and 5·1% (South Africa) in east and southern Africa to 0·3% (Guinea) and 8·9% (Nigeria) in west and central Africa. The figures were less than 1% in studies from Latin America and western Europe. The second type of study measures HIV prevalence in inmates with tuberculosis infection and vice versa. Studies of HIV in individuals with tuberculosis done in Africa typically report a prevalence of 40% and higher (Burkina Faso 75%, Uganda 57%, Zambia 45·8%, and South Africa 42–58%). Prevalence estimates of tuberculosis in people with HIV infection tend to be lower (Burkina Faso 20%, Ethiopia 47%, and Malaysia 17%; appendix p 27).

Incidence of HIV, HCV, HBV, and tuberculosis in prisoners

Few incidence studies were found on HIV (three countries), HCV (four), HBV (two), and tuberculosis (14; appendix p 32). Spain had detailed annual HIV incidence data from 2000 to 2014 that revealed a steady decline from 0·70% to 0·04% per year over 14 years.⁶⁸ A large prospective study of hepatitis C incidence in prisons in Australia reported an annual incidence of 14·1%,⁶⁹ which was high compared with Scotland (0·9%),⁷⁰ the USA (0·4%),⁷¹ and Spain (1·7%).⁷²

Of the 14 countries with tuberculosis data, only seven had multiple incidence rates. Countries that had a decrease in incidence were Colombia,^{73,74} Argentina,⁷⁵ Hong Kong,⁷⁶ Macedonia,⁷⁷ and Romania.⁷⁸ An increase in tuberculosis cases in prison was observed in the USA (figure 5).⁷⁹

The potential effect of increased incarceration on tuberculosis in Europe and central Asia was modelled.³⁴ For each percentage point increase in incarceration rates, there was a corresponding increase in tuberculosis incidence of 0·34% (population attributable risk; 95% CI 0·10–0·58, $p<0\cdot01$). Mathematical modelling of tuberculosis transmission in Ukraine further suggests that incarceration contributes to 75% of new tuberculosis infections in people who inject drugs.⁸⁰

Infectious disease prevalence in key populations HIV, HCV, HBV, and tuberculosis in imprisoned MSM, female sex workers, and transgender people

Estimates of infectious diseases in key populations who become imprisoned (eg, MSM, female sex workers, and transgender people) are less frequently reported than in people who inject drugs. In 2008, HIV prevalence in Ghana in imprisoned female sex

Panel 3: Outbreaks of infectious diseases in prisoners

One of the first recognised HIV outbreaks occurred in a Bangkok prison in 1988.⁴² The outbreak was only detected once infected inmates were released and HIV in people who inject drugs escalated from 2% to 43% over the course of several months. An investigation revealed that HIV incidence in prison was very high at 35 per 100 person-years.^{43,44} In Lithuania, a policy of segregation saw a prisoner who was seroconverting to HIV infection housed with individuals who were HIV negative. At least 284 prisoners were identified as infected with HIV in a few months, which doubled the number of diagnosed HIV cases in Lithuania.^{3,45} Two outbreaks in Russian prisons saw more than 400 (of 1824) prisoners infected in Nizhnekamsk and 260 inmates infected in the Tatarstan region in 2001.^{3,46} Large outbreaks have occurred in prisons in Iran and Ukraine, with hundreds of prisoners infected.^{47,48} Iran increased opioid agonist therapy places from 100 to over 25 000, provided condoms and conjugal visits, and piloted six needle and syringe programmes in prison from 2002.^{47,49} Small HIV outbreaks have even occurred in areas where prevalence was very low, such as in Australia (four prisoners) and Scotland (ten prisoners), which also had intraprisn hepatitis B virus (HBV) transmission.^{50–52} In 2000, two Australian prisoners were caught sharing syringes and an investigation found that four inmates had acquired hepatitis C virus infection, but none had acquired HIV in prison.⁵³

In the USA, Georgia's state prison system recorded an outbreak of seven cases of hepatitis B in 2000 and 2001, which were attributed to sex. 52% of 907 susceptible inmates who completed a questionnaire reported at least one risk behaviour for hepatitis B virus infection (including 48% who reported tattooing, sharing a razor [8%], having sex [4%], or injecting drugs [2%]). HBV vaccination was offered only to inmates in the dormitory where the outbreak originated, leaving over 90% of inmates potentially at risk. In the second outbreak, an audit of prison medical records revealed 41 (72%) of 57 HBV cases had occurred in prison. Routine HBV vaccination was recommended for all new prisoners.^{54–56}

In 2006, two ex-inmates in the USA were diagnosed with tuberculosis sparking an investigation.⁵⁷ Despite one inmate having prolonged symptoms and abnormal chest radiographs, he went undiagnosed while incarcerated. Of 910 exposed inmates who were tested, 53 inmates (5·8%) had newly positive tuberculin skin tests. This included 11 (of 204) new cases of tuberculosis who had been released and re-incarcerated. Of 485 prison employees tested, ten (2·1%) were identified as tuberculin skin test converters.

Although the study of the transmission of these infections prospectively in prison populations has been challenging, these outbreaks illustrate the role that prisons might play in continuing these epidemics beyond the prison wall. It is good public health policy to screen at-risk new prisoners for infectious diseases and to provide inmates with free, easy, and confidential access to prevention programmes such as opioid agonist therapy, antiretroviral therapy, condoms, and HBV vaccination to reduce the risk of outbreaks.⁶

workers ($n=73$) was 11% and 8·9% in MSM ($n=403$).⁸¹ HIV prevalence in imprisoned MSM was 43·8% in Nigeria ($n=32$ in 2009), 2·6% in Iran ($n=113$), and 5·5–34·0% in the USA.^{82–90} The only study of transgender prisoners was done in Argentina, in which half of transgender prisoners (six of 11 people) were HIV positive.⁷⁵ US studies provided estimates of HIV prevalence in female sex workers from 2·0% to 5·6%.^{89,91}

Imprisoned MSM in the USA and Iran had high levels of exposure to HCV (50%)^{82,92} compared with imprisoned MSM in Nigeria (12·5%).⁸³ Imprisoned MSM had high levels of HBV in Ghana (40·2%)⁸¹ and Nigeria (56·3%).⁸³ Female sex workers in Ghana also had high levels of HBV infection at 37·0%.⁸¹

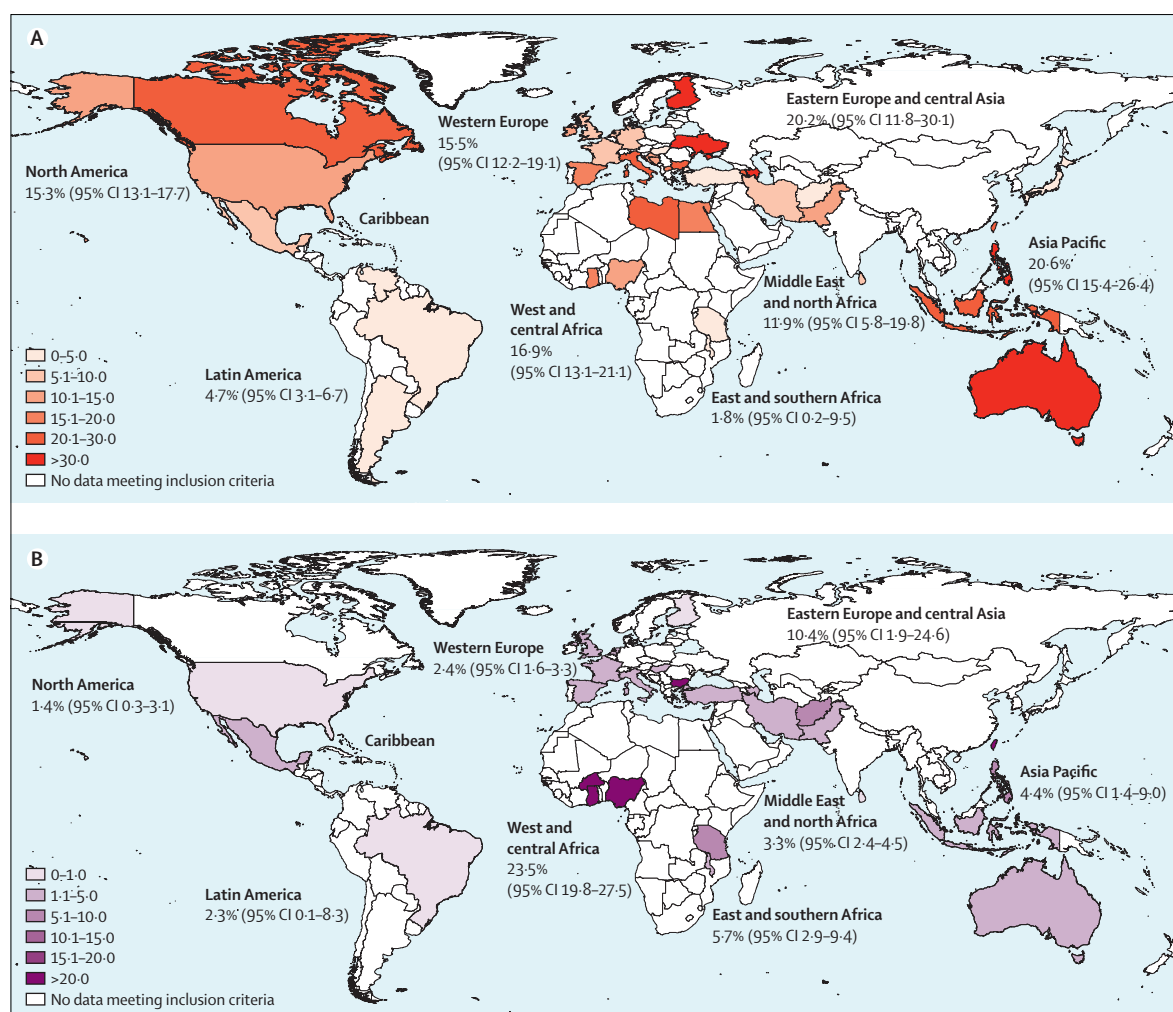


Figure 3: Global and regional prevalence of viral hepatitis in prison inmates, published between 2005 and 2015
(A) Prevalence of HCV antibodies. (B) Prevalence of HBsAg.

Prevalence of HIV, HCV, and HBV in compulsory drug detention centre detainees in China, Taiwan, Vietnam, and Iran

In 2012, an estimated 235 000–600 000^{7,20} drug users were detained for compulsory drug treatment in over 1000 compulsory drug detention centres.²⁰ While the number of compulsory drug detention centres remained the same, the numbers of drug users detained in those centres had increased by 2015. In China, HIV prevalence ranged from 0.2% to 9.5% in general detainees and was 10.3% in people who inject drugs, whereas HCV prevalence was 44% in general detainees (appendix p 31). In Taiwan, HIV prevalence was 6.9% in general detainees and 25.5% in people who inject drugs in detention. Viral hepatitis was also common with HCV prevalence estimated at 30.5% in general detainees and 89.6% in people who inject drugs; HBsAg prevalence was estimated at 16.9% in general detainees and 16.7% in people who inject drugs in detention. In Vietnam, HIV prevalence was 19.8% and

HCV prevalence was 76.9% in people who inject drugs in detention. Iran reported that 24.4% of detained people who inject drugs were HIV positive, 80% were anti-HCV antibody positive, and 5.8% were HBsAg positive (appendix p 31).

Mathematical modelling of HIV transmission and prevention in people who inject drugs

We modelled the contribution of incarceration and re-incarceration on HIV incidence in people who inject drugs and examined the effects of a reduced rate of incarceration, introduction of prison-based opioid agonist therapy followed by post-release opioid agonist therapy, and post-release antiretroviral treatment retention on HIV incidence.

In our model, the increased risk for HIV transmission was captured by behaviour change in people who inject drugs who temporarily receptively share syringes in prison and a combination of interruption of antiretroviral treatment and behaviour change in people who inject

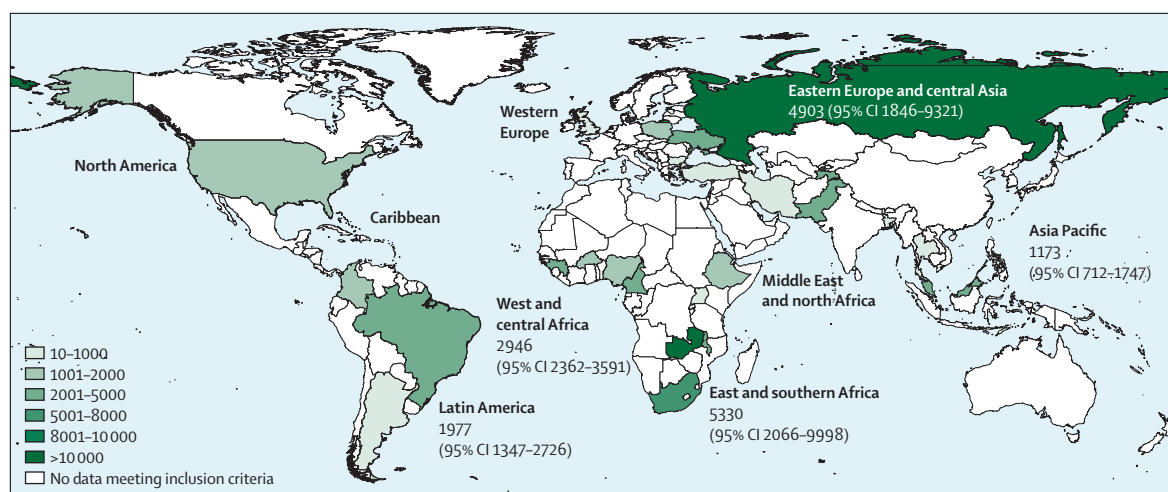


Figure 4: Global and regional prevalence of active tuberculosis in prison inmates, published between 2005 and 2015
Data are per 100 000.

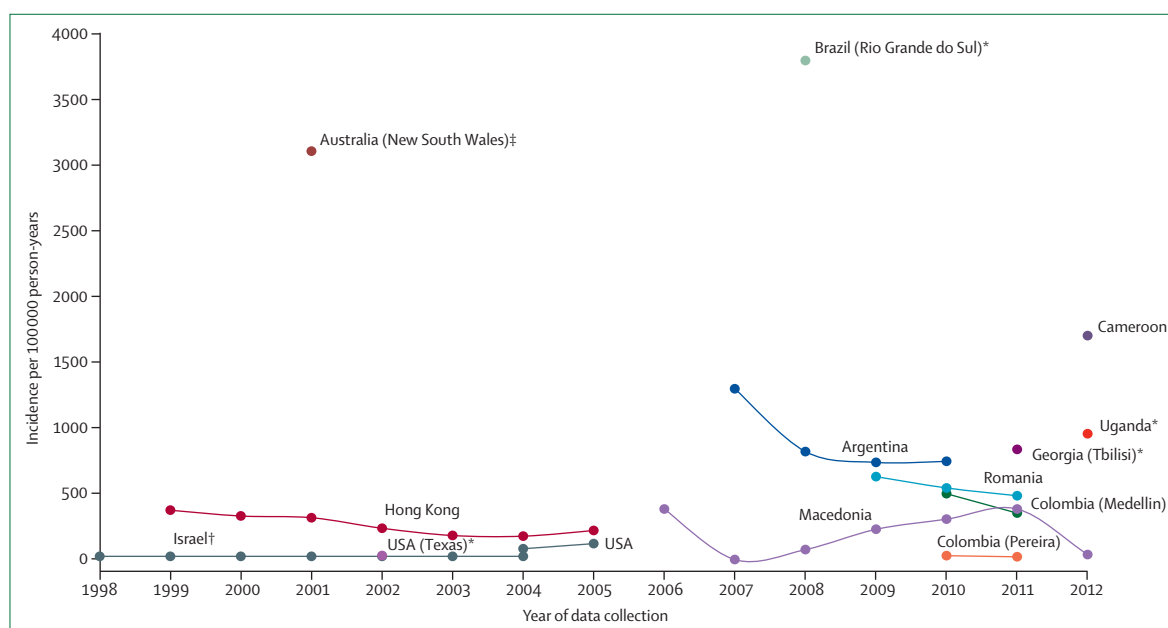


Figure 5: Incidence of tuberculosis in prisons and closed settings

*Cumulative over this period. †Average over this period. ‡Estimated annual risk 1996–2001.

drugs who temporarily receptively share syringes during transient post-release period, which was assumed to last between 1 and 6 months (panel 4, appendix p 33). We quantified the contribution of discontinuation of antiretroviral treatment and temporary syringe sharing to cumulative HIV incidence in people who inject drugs for varying proportions of people who continue this high-risk behaviour for a transient period after release (figure 6). Antiretroviral treatment discontinuation was shown to contribute to less than 5% of cumulative HIV incidence during the epidemic, from epidemic onset to 2015 (figure 7A). This small contribution of discontinuation of antiretroviral treatment to HIV

incidence was due to the small proportion of HIV cases discontinuing antiretroviral treatment at a given time and the short duration of discontinuation.

Specifically, our results show that for people who inject drugs from communities with high HIV prevalence (over 20%), the relative contribution of antiretroviral treatment discontinuation to HIV transmission varies from 0.12% (95% credible interval [CrI] 0.02–0.62) to 0.15% (0.02–1.0), which depends on whether individuals who engage in temporary syringe sharing behaviour only do so during incarceration or continue to do so after release (figure 7A). In communities with moderate HIV prevalence (5–20%), the relative contribution of antiretroviral

Panel 4: Mathematical model for HIV transmission in people who inject drugs

To assess the fundamental dynamics that govern the interplay between HIV transmission in people who inject drugs in the community and in prison around the world, we developed a deterministic compartmental model of drug injection transmission of HIV in the general community and incarcerated populations (figure 6). Individuals were structured in the model according to their HIV infection history, disease progression, and antiretroviral treatment status (1=susceptible, 2=acute infection, 3=latent infection with CD4 cell count ≥ 350 cells per μL , 4=latent infection with CD4 cell count < 350 cells per μL , 5=pre-AIDS with elevated viraemia, 6=AIDS, 7=initiated antiretroviral treatment with CD4 cell count ≥ 350 cells per μL , 8=initiated antiretroviral treatment with low CD4 cell count or pre-AIDS, 9=initiated antiretroviral treatment with AIDS), incarceration status (1=currently incarcerated, 2=recently released [in the past 6 months], 3=previously incarcerated, 4=never incarcerated), and drug injection risk behaviour (1=people who do not inject drugs, 2=people who inject drugs who do not share syringes, 3=people who inject drugs who share syringes, 4=people who inject drugs and share syringes temporarily). As our analysis focused on HIV epidemics in people who inject drugs, we only considered injection drug use as transmission mode. Rather than focusing on a specific setting, we considered a wide range of scenarios by stratifying the rates of HIV transmission in people who inject drugs into communities with moderate HIV prevalence in people who inject drugs (ranging from 5% to 20%), and communities with high HIV prevalence in people who inject drugs (over 20%).⁹³ Our model accounted for the elevated frequency of needle sharing in prison as well as discontinuation of antiretroviral treatment during a transitory period after prison release.^{31,94–97} We parameterise our model using epidemiological and clinical data from the scientific literature about HIV infectiousness, disease progression, demographic, injection drug behaviour data on the incarcerated population, proportion of people who inject drugs, syringe sharing in and out of prison, and incarceration history in people who inject drugs and people who do not share syringes (appendix p 33). To address empirical uncertainty regarding model parameters, we used a Bayesian inference approach to fit our model to epidemiological data of HIV prevalence in people who inject drugs in and out of prisons and HIV incidence in prison.

Given the scarcity of data on the impact of this post-release behaviour change on HIV transmission, we did a sensitivity analysis to evaluate the contribution of the frequency of post-release needle sharing and percentage discontinuation of antiretroviral treatment on HIV incidence in people who inject drugs in the community and in prison. We denoted people who inject drugs who share syringes while incarcerated as temporary sharers, a proportion of whom share for a transient duration after release, but not beyond. This post-release transient period of temporary syringe sharing and antiretroviral treatment discontinuation was assumed to vary between 1 and 6 months.^{31,95}

Finally, we used the fitted model to evaluate the impact of demand reduction programmes, such as prison-based opioid agonist therapy followed by post-release retention, reduced rates of incarceration for non-violent drug users, and antiretroviral treatment retention in care post-release for curtailing HIV incidence in people who inject drugs. Consistent with empirical studies, we assumed that people who inject drugs who continue opioid agonist therapy after incarceration have a 20% (95% CI 10–30) reduced risk of re-incarceration while they are given treatment.⁹⁸

treatment discontinuation varies from 0·10% (0·01–1·1) to 0·23% (0·03–3·3), which also depends on whether individuals who engage in temporary sharing behaviour only do so while incarcerated (figure 7A). The contribution of temporary syringe sharing to HIV transmission varies from 7·0% (0·1–41·6) to 12·0% (0·5–51·8) in communities with high HIV prevalence, and from 5·8% (0·2–31·7) to

21·1% (0·4–53·0) in communities with moderate prevalence (figure 7B). The contribution of temporary syringe sharing to HIV transmission was higher in communities with lower HIV prevalence than in communities with high HIV prevalence (figure 7B).

To identify the contribution of each model parameter to the variability of temporary syringe sharing to HIV transmission, we calculated the partial rank correlation coefficients (PRCCs), which quantify the magnitude of increase or decrease of the value of an outcome measure predicted by the model as a given input model parameter varies.⁹⁹

PRCCs indicated that the effect of temporary syringe sharing increases with the rate of re-incarceration for people who inject drugs, the proportion of people who inject drugs who share syringes in prison, and the risk of HIV transmission per episode of syringe sharing (appendix p 41). Conversely, the effect of temporary syringe sharing decreases with the proportion of people who inject drugs who share syringes outside prison, the mortality rate of people who inject drugs who do not have HIV, and the proportion of people who inject drugs and have never been incarcerated (appendix p 41). Given that the rate of first incarceration in people who inject drugs was defined as a non-monotonic functional relationship between the average non-HIV mortality rate for people who inject drugs and the proportion of people who inject drugs who have never been incarcerated (appendix p 33), we deduced from the PRCC results that the rate of first incarceration has a substantial contribution to the effect of temporary syringe sharing. However, that effect could not be captured by the PRCC analysis because of the non-monotonic relationship.

We assessed the effectiveness of three interventions in reducing HIV incidence after 5 years of initial implementation: the incarceration rate of people who inject drugs, prison-based opioid agonist therapy followed by post-release retention, and prison-based opioid agonist therapy followed by post-release opioid agonist therapy combined with antiretroviral treatment retention. We showed that lowering incarceration rates (both first-time incarceration and re-incarceration) by 10–50%, corresponding to a 4·6% (95% CrI 2·6–6·6) to 25·9% (16·9–35·4) reduction of incarcerated people who inject drugs over 5 years, could potentially reduce community-wide cumulative HIV incidence in people who inject drugs by 0·9% (–0·1 to 3·6) to 7·6% (0–26·5) over a 5-year period in communities with high HIV prevalence, and by 1·1% (0·1–3·1) to 15·4% (1·4–29·9) in communities with moderate HIV prevalence (appendix p 42). We found that prison-based opioid agonist therapy followed by post-release retention in treatment during the transitory period of elevated risk behaviour could reduce cumulative HIV incidence by 1·6% (95% CrI 0·1–7·3) for a 20% coverage and by 12·0% (1·4–45·3) as an upper bound of complete (100%) coverage in communities with high HIV prevalence. In

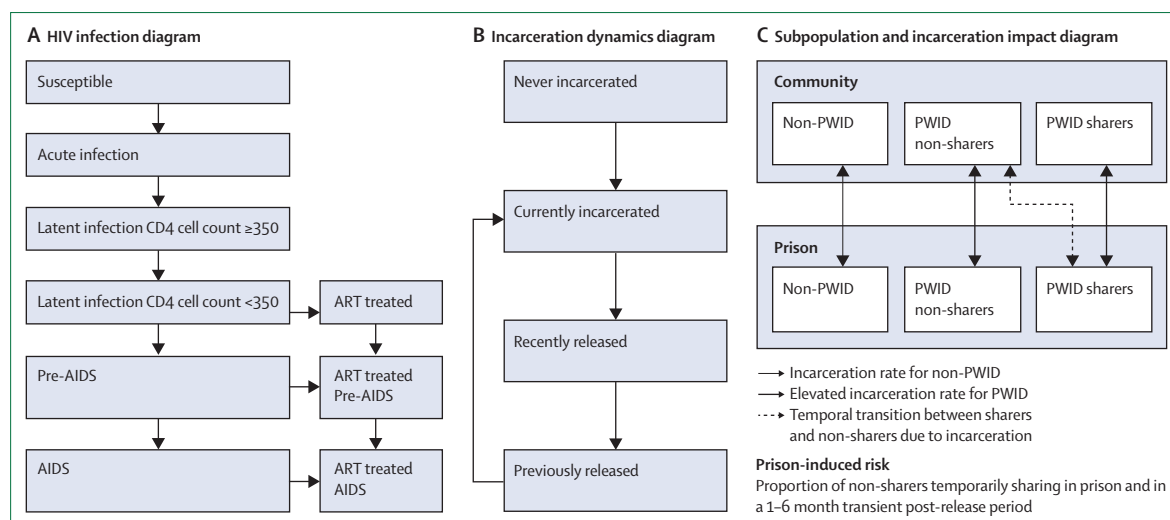


Figure 6: Deterministic compartmental model of drug injection transmission of HIV in the general community and incarcerated populations
 ART=antiretroviral therapy. PWID=people who inject drugs.

communities with moderate HIV prevalence, the reduction in HIV incidence is predicted to vary from 3.9% (0.9–13.4) for 20% coverage to 28.5% (9.4–57.5) for complete coverage (appendix p 42). Combining opioid agonist therapy with post-release antiretroviral treatment retention could achieve a further reduction of HIV incidence ranging from 0.3% to 1.8% in communities with high HIV prevalence and from 0.7% to 4.2% in communities with moderate HIV prevalence as coverage is expanded from 20% to 100% (appendix p 42).

Our estimates of the contribution of incarceration to HIV transmission and the potential effect of interventions depends on the general HIV prevalence in communities of people who inject drugs, which varies substantially between and within countries (figure 7, appendix p 42). Our results show that prison-based opioid agonist therapy followed with post-release retention could be an effective strategy for the reduction of HIV in people who inject drugs, at least in the short term (appendix p 42). Lowering the rate of incarceration of people who inject drugs might be effective in reducing HIV transmission in addition to opioid agonist therapy. The contribution of incarceration and effectiveness of intervention were higher in communities of lower HIV prevalence, where transmission because of incarceration is most substantial relative to that in the community, compared with communities with high HIV prevalence.

Summary of findings

This Series paper provides clear evidence that the findings, replicated in many individual studies, that higher prevalence of HIV in individuals who are detained than in the population from which they arise, is almost universal. However, it also shows that the detailed epidemiology of HIV in people who are detained varies

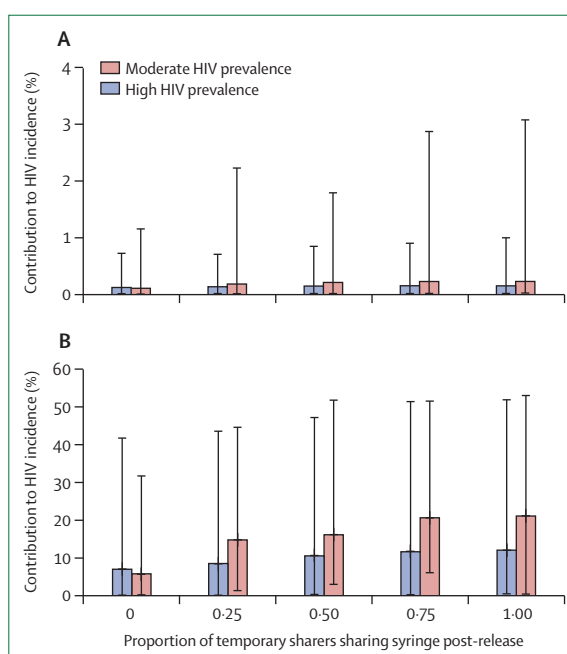


Figure 7: Contribution of antiretroviral therapy discontinuation and temporary sharers to cumulative HIV incidence in people who inject drugs
 (A) Contribution of ART discontinuation. (B) Contribution of temporary sharers. Contribution accounts for transmission in prison and during the transitory period of elevated risk behaviour after release from prison. Contributions were evaluated relative to the scenario of no antiretroviral therapy discontinuation or no temporary sharers, and were assessed for a varying proportion of temporary sharers who share syringes after incarceration versus those who only share syringes while incarcerated, from epidemic onset to 2015. Bars show median (middle cross line) and range of contribution estimated for different HIV epidemics modelled (error bars show upper and lower 95% credible interval). Prevalence of HIV in people who inject drugs was varied from 5–20% (moderate prevalence communities) and 20–60% (high prevalence communities).

considerably, reflecting the disease burden, the dominant mode of transmission in the population as a whole, and the role of incarceration. In most regions of the world, HIV prevalence is higher in detained women than detained men. However, although we have shown great variation in the pattern of HIV infection in prisons, the ability to draw general conclusions is limited by the scarcity of data, with data in some regions restricted to one or a few countries. The studies that do exist are often restricted to individual prisons (even subgroups of detainees in them) and are heterogeneous in reporting quality.

There are several reasons for the scarcity of data. First, many countries with the highest disease burden have very weak systems for health research and surveillance. Second, where health systems in prisons are organisationally separate from systems serving the general population, capacity that exists in prison systems might be deployed elsewhere. Consistent with the UN's Mandela Rules, the WHO recommends that prisoner health care be consistent with community standards of care, and under the direction of the ministry of health.¹⁰⁰ Third, secrecy and fear of exposing human rights abuses might cause governments to be unwilling to permit studies in their prisons, or if they are done, researchers are often prohibited from published results.^{101,102} Compulsory drug detention centres are a particular concern. In 2012, 12 UN agencies called for their immediate closure¹⁵ and since then, international funding for compulsory drug detention centres has stopped. However, they remain in operation in several regions, although largely hidden from those undertaking HIV surveillance.⁷

A particular problem is the scarcity of data on women detainees, even though they comprise about 10% of prison populations, they are more likely to have a substance abuse disorder, and are less likely to receive treatment than male prisoners.¹⁰³

Most studies are cross-sectional, providing only snapshots of the situation at a particular moment in time. Cross-sectional studies, however, fail to capture the dynamic nature of the prison population, because the number of individuals passing through prisons each year can be up to three times higher than the estimated prison census. This discrepancy causes an especially important gap in our knowledge, given the role that the transition in and out of prison has in interruption of both antiretroviral treatment and opioid agonist therapy, with implications for both transmission and the emergence of drug-resistant HIV and tuberculosis infections.¹⁰⁴

So what should be done to address the problem of HIV and related infections in prisons? One obvious response is to reduce the prison population, as our model showed. Measures that can reduce the population in detention include evidence-based treatment in and out of prison. Non-violent drug offenders and especially women¹⁵ should particularly be offered treatment, as an alternative, where appropriate.¹⁰⁵ Our model further showed that

opioid agonist therapy given in prison can reduce HIV transmission within prison and reduce post-release HIV transmission.

Other infectious diseases might also be mitigated in prison settings. Interferon-free HCV therapies using direct-acting antiviral agents are rapidly becoming available and HCV treatment as prevention strategies, particularly in the prison setting, are now feasible.¹⁰⁶ These treatments can produce 90–95% rates of HCV eradication.¹⁰⁷

Routine screening and vaccination for HBV in prison settings¹⁰⁸ is likely to produce considerable savings to the broader health system through prevention of cirrhosis of the liver and hepatocellular carcinoma,¹⁰⁹ even though only around 5% of adults infected with HBV develop chronic infection¹¹⁰ because of the comparatively high prevalence in prison settings. Such programmes should be linked to a wider strategy to reduce HBV infection in countries where it is prevalent, through early childhood immunisation. A safe and efficacious vaccine for HBV has existed since 1986.¹¹¹

A review of the evidence base for the management of tuberculosis and HIV and tuberculosis co-infection in prisons provides a useful framework including universal drug susceptibility testing, systematic screening of contacts in high-risk groups, access to high-quality treatment, and adequate coordination.¹¹² Other specific measures include identification, isolation, and treatment of patients who are infected with tuberculosis as early as possible. In many countries, prisoners with symptoms suggestive of tuberculosis experience long delays in obtaining a diagnosis.¹¹³ Isolation of infectious prisoners is rare; many prisoners who are isolated might not receive treatment, and conditions are frequently appalling.¹¹⁴

Tuberculosis treatment completion rates in prisoners are often low, exacerbated by their movement within and in and out of the prison system. Prisoners in eastern Europe are unlikely to receive adequate treatment for HIV and tuberculosis.⁸⁰ A study in Uganda found a default treatment prevalence of 12% in people staying in the same prison and 53% for those transferred to another prison, and 81% of prisoners who were on treatment and released were subsequently lost to follow-up.¹¹⁵

Pooled estimates of HIV prevalence and incidence, collected for the purpose of this review, were used to develop and calibrate a model for people who inject drugs for HIV transmission in and out of prison. Given that our focus was the evaluation of the contribution of incarceration to injection-related HIV transmission in people who inject drugs and the potential effect of interventions on the HIV epidemic in people who inject drugs, we did not address sexual, tattoo-related, or mother-to-child transmission of HIV. Inclusion of these transmission routes would further increase the predicted effect of the interventions considered by accounting for the substantial indirect benefits to people who do not

inject drugs. Another limitation of our modelling analysis is the fact that the model was not developed for a specific setting; rather we investigated a range of plausible scenarios. This approach resulted in large uncertainty about model parameter values and model outcomes. Additionally, our model assumed constant antiretroviral treatment coverage during the course of the epidemic, which does not capture the effect of increased antiretroviral treatment coverage on HIV transmission. However, the effect of this assumption was mitigated by using a wide range of values for antiretroviral treatment coverage. Finally, our model was restricted to inmates who inject heroin, because most research and prevention has focused on these individuals.

Conclusion

We found a consistently higher prevalence of HIV, HCV, HBV, and tuberculosis in prisoners than in the general population across all regions and especially in imprisoned people who inject drugs.^{38,61,116} Interventions to prevent, identify, and treat these infections in prisons are poorly implemented, particularly in low-income and middle-income countries and in populations such as people who inject drugs, where care and treatment remain challenging in community settings. Investment in surveillance infrastructure is needed to improve country-level data on the prevalence of these infections and to inform policy and programmatic responses. This is particularly important in regions where injection drug use is increasing and the burden of HIV is already high. Mass incarceration of people who inject drugs is a key driver of the ever-growing population of prisoners. Decriminalising drug use and possession or providing alternatives to imprisonment for people who use drugs, and ensuring access to opioid agonist therapy, tuberculosis treatment, and antiretroviral treatment for prisoners will reduce the burden of these infections in the world's prison population.

Contributors

KD and CB developed the manuscript concept. ALW led the comprehensive search and data extraction and did the meta-analysis. KD developed the initial draft of the manuscript. BM wrote the sections on imprisonment data. BM and ALW calculated the number of inmates with each infection. JJA wrote the Compulsory Drug Detention Centres section. LM provided a revised structure for the manuscript, edited it, and addressed reviewers' comments. MH analysed and wrote the section on incidence data. ALW, AG, MN-m, KD, and FLA conceived of the mathematical modelling analysis. MN-m conducted the mathematical modelling, and MN-m and AG wrote the modelling section. MM wrote the section on tuberculosis data and provided the final edit. SAK wrote the section on hepatitis B data. RC wrote the section on hepatitis C data. All authors had full access to the data, reviewed and edited the manuscript, and take responsibility for its integrity and the accuracy of the analysis.

Declaration of interests

We declare no competing interests.

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