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Review article

Age-Specific Global Prevalence of Hepatitis B, Hepatitis C, HIV, and Tuberculosis Among Incarcerated People: A Systematic Review

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A B S T R A C T

Purpose: This study aims to compare the global prevalence of hepatitis B, hepatitis C, HIV, and tuberculosis in incarcerated adolescents and young adults (AYAs) and older prisoners.
Methods: This study is a systematic review and meta-analysis of studies reporting the age-specific prevalence of each infection in prisoners. We grouped age-specific prevalence estimates into three overlapping age categories: AYA prisoners (<25 years), older prisoners (≥25 years), and mixed category (spanning age 25 years). We used random effects meta-analysis to estimate the relative risk (RR) of each infection in AYAs versus older prisoners.
Results: Among 72 studies, there was marked heterogeneity in prevalence estimates among AYA prisoners for all infections: hepatitis B (.4%–25.2%), hepatitis C (.0%–70.6%), HIV (.0%–15.8%), and active tuberculosis (.0%–3.7%). The pooled prevalence of HIV (RR = .39, 95% confidence interval .29–.53, I^2 = 79.2%) and hepatitis C (RR = .51, 95% confidence interval .33–.78, I^2 = 97.8%) was lower in AYAs than in older prisoners.
Conclusions: The prevalence of HIV and hepatitis C is lower in AYA prisoners than in older prisoners. Despite lower prevalence, acquisition begins early among incarcerated populations. There is an urgent need for targeted, age-appropriate prevention, treatment, and harm reduction measures in and beyond custodial settings to reduce the incidence of infection in these extremely vulnerable young people.

IMPLICATIONS AND CONTRIBUTION

Preventing incident HIV and hepatitis C infection in incarcerated adolescents and young adults will require both age-appropriate prevention, treatment, and harm reduction efforts in custodial settings, and increased investment in age-appropriate, evidence-based transitional programs to support continuity of health care between prison and community.

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The world prison population is growing at a rate in excess of general population growth and is currently at least 10.35 million, with several-fold more transitioning through these settings every year [1]. The age structure of this population at the global level is unknown, but in countries where data are publicly available, young people (aged <25 years) are markedly overrepresented [2–4] and, because they are typically incarcerated for shorter periods of time than their older counterparts, they tend to cycle through custodial settings more rapidly and thus form an even larger proportion of the "churn" through these settings [3]. Global data on detained adolescents are not available; however, it is evident that millions of adolescents and young adults (AYAs) cycle through custodial settings every year. The vast majority of these—greater than 90% in most countries where data are available—are male [4–6].

Age cutoffs for determining whether AYAs are incarcerated in juvenile justice facilities or adult prisons differ between countries, and some countries do not have a separate juvenile justice system. In the U.S., there is a further distinction between prisons (for sentences of more than 1 year) and jails (for persons awaiting trial or sentencing, or sentenced to less than 1 year). In the interests of brevity, throughout this manuscript we use the terms "prison" or "custodial setting" to describe all of these facilities, and "prisoners" to describe the people held in these facilities.

There is a high prevalence of HIV, viral hepatitis, and tuberculosis (TB) in prisoners compared with the corresponding non-incarcerated population. A recent systematic review estimated that the global prevalence of infection among prisoners was 4.8% for hepatitis B virus (HBV), 15.1% for hepatitis C virus (HCV), 3.8% for HIV, and 2.8% for active TB [7]. Prevalence estimates in that study were disaggregated by sex but not by age. The concentration of infectious disease among prisoners produces an imperative to both treat those infected and prevent transmission of infection to those at risk.

Young people in custodial settings are distinguished by a high prevalence of complex health-related needs, substance use, and sexual risk behaviour, typically set against a backdrop of trauma and entrenched social disadvantage including low education, unemployment and poverty, and increased risk of homelessness [8–12]. Studies of the prevalence of infectious disease in these incarcerated young people have never been synthesized, but there is good reason to suspect that the prevalence of infection in prisoners will vary according to age. In the general population, chronic viral hepatitis and HIV prevalence are higher in older age groups, as a result of both increased time spent at risk of infection and time spent at risk before the introduction of control measures in the 1990s and 2000s [13–15]. With improvements in treatment, those who are HIV infected are living longer, further contributing to higher HIV prevalence among older aged populations [15]. The prevalence of TB in the general population also varies with age, as a function of both the intensity of transmission and the age structure of societies [16]. In endemic settings, TB prevalence is generally lower among AYAs than among adults in middle age and the elderly [17], whereas in high-income countries, the age-related epidemiology of TB is tied to age-specific patterns of migration [16].

However, prisoners are not representative of the populations from which they are drawn, and are distinguished by both a relatively high prevalence of risk behaviors for bloodborne infection (e.g., injection drug use, unprotected sex, unsterile body modification practices) [18–20] and comparatively poor access to vaccination, harm reduction, and other preventive measures [21,22]. Few prison settings provide adequate access to infection control measures such as sterile injecting and tattooing equipment, or condoms, and outbreaks of infection in prison settings have been documented [7,21,23]. There is some evidence that these risk behaviors are more prevalent among young and male prisoners [18,24], such that one might expect the incidence of bloodborne infections to be particularly high among young, incarcerated men. This reality is an outcome of the criminalization of substance use globally [25].

Furthermore, among people who inject drugs, hepatitis C seroconversion typically occurs within a few years of initiating injecting [26,27], such that the prevalence of this infection may be similar in young and older prisoners, given the high prevalence of drug injection in prisoners [18]. In fact, some studies have reported a higher prevalence of HCV in young prisoners than in older prisoners [19], although others find that despite a higher prevalence of bloodborne virus (BBV) risk behaviors in young prisoners, the prevalence of HCV infection is lower, suggesting a possibly brief window for preventive intervention [28].

Prisons are also high-risk congregate settings that, particularly in the absence of routine screening, treatment, and infection control, are conducive to TB transmission [29]. This risk is further elevated in immunocompromised individuals, such as those living with HIV [30]. Given evidence that adolescents are at higher risk of progression to active TB after exposure than are adults [31], incarcerated youth may likewise be at comparatively elevated risk of incident TB infection. Whether or not this translates into a higher prevalence of TB infection among young people in prison settings remains unclear.

Incarcerated youth: a global health priority

The comparatively high prevalence of infection and associated risk behavior in prisoners makes effective prevention with this population—virtually all of whom return to the community—a public health priority [32]. To the extent that the prevalence of infection is lower in young prisoners than in older prisoners, the opportunity and imperative for prevention with these young people is proportionately greater. This notion of disproportionate benefit (the so-called triple dividend) was highlighted recently by the Lancet Standing Commission on Adolescent Health and Wellbeing, which both identified incarcerated adolescents as a highly vulnerable group, and identified a critical need for better data on the health of adolescents, particularly vulnerable adolescents [33,34]. Similarly, both the World Health Organization (WHO) and the United Nations have identified prisoners as a key population for HIV and viral hepatitis responses, and highlighted that young people often constitute an especially vulnerable subgroup of prisoners [35,36].

Through systematic review and meta-analysis, the aims of this study were to (1) compare the prevalence of hepatitis B, hepatitis C, HIV, and TB in incarcerated AYAs (aged <25 years) versus older prisoners (aged ≥25 years); and (2) compare the prevalence of each infection in incarcerated AYA males versus females. We hypothesized that there would be an age gradient in the prevalence of all infections, although this gradient would be less steep for HBV, given that vertical transmission is the key driver of HBV infection in many settings [37].

Methods

This study involves re-analysis of data collected for a systematic review of HBV, HCV, HIV, and TB prevalence in prisoners, published previously [7]. The authors of the original review systematically searched the peer-reviewed and gray literature for studies published between January 1, 2005 and November 30, 2015, reporting biologically confirmed estimates of each infection. Literature searches were supplemented by requests to relevant government agencies and researchers in the field. From more than 11,000 publications identified during the initial search and call for reports, 299 articles were identified that met the inclusion criteria and provided biologic estimates of at least one of the above infections. For each included study, the authors extracted information about the location, facility type, sample size, diagnostic method, overall prevalence, and prevalence by gender and at-risk subpopulation, where reported. The authors of the original paper did not extract age-specific prevalence estimates. Full details of the original search strategy are provided in Supplementary Appendix S1.

For the present study, we extracted age-specific data from all papers reporting age-specific prevalence for HBV infection (HBsAg), HCV seropositivity or infection (HCV-Ab or HCV-RNA), HIV infection (HIV-Ab), or active TB. Articles that did not provide any age-specific prevalence data were excluded. For the purposes of comparison, we collapsed extracted prevalence data into three age groups: AYAs (aged <25 years), older prisoners (aged ≥25 years), and mixed age groups (containing both young and older prisoners, e.g., age 20–30 years).

To assess the relative prevalence of each condition among AYA and older prisoners, we used random effects logistic regression, which accounts for interstudy variation, and incorporated inverse double arcsine square root to calculate the pooled relative risk (RR) estimates. The meta-analysis was restricted to studies reporting infectious disease estimates for both AYA and older prisoners. Prevalence estimates for the mixed age group were excluded from these analyses. Heterogeneity was assessed using the I^2 statistic, which describes the percentage of variation between studies that is due to heterogeneity rather than chance. In sensitivity analyses, we excluded studies of selected, high-risk samples from the meta-analysis. All analyses were conducted in StatsDirect version 3 (StatsDirect Ltd, Cheshire, UK).

Results

Of 299 publications included in the original study, 72 (24%) included age-specific prevalence estimates and were eligible for inclusion in this review (see Supplementary Figure S1). Consistent with the original study, we identified more age-specific prevalence estimates for HIV (n = 42) and HCV (n = 42) than for HBV (n = 13) or TB (n = 11). Several studies reported age-specific prevalence estimates separately for men and women [38–45], and one US study reported separate estimates for jail inmates and prison inmates [46]. There were 37 sets of prevalence estimates from studies of exclusively male samples, and 18 sets from exclusively female samples.

A large proportion of included studies were conducted in the WHO region of the Americas and the European region. No included studies pertaining to HBV, HCV, or HIV were identified from the Southeast Asian region. A small number of studies targeted specific risk groups, most often people who use or inject drugs [28,47–50]. One study [51] recruited from a dedicated unit for incarcerated men who have sex with men (MSM), and two studies recruited prisoners attending health services while incarcerated [52,53]. Detailed information regarding the included studies can be found in Supplementary Appendix S1 (Tables S1–S4).

Hepatitis B

There were 10 published estimates of the age-specific prevalence of HBV infection in prisoners. The prevalence among AYA prisoners was highest in studies conducted in Taiwan (24.5%) and Bulgaria (25.2%), and lowest in two studies from the U.S. (.4%, .7%; Table S1).

Hepatitis C

There were 42 sets of age-specific prevalence estimates for hepatitis C infection among incarcerated people, including 28 estimates specific to AYA prisoners (Table S2). The highest prevalence estimates for AYA prisoners came from a study of incarcerated young men who injected drugs in Iran (67.2%), and a study of incarcerated young women in Finland (70.6%).

HIV

There were 42 age-specific estimates of HIV prevalence among incarcerated people, including 33 specific to AYA prisoners (Table S3). Observed HIV prevalence was highest among AYA prisoners in Nigeria (13.3%) and Zambia (15.8%), among incarcerated young men who injected drugs in Iran (10.8%), among young MSM entering jail in the U.S. (11.6%), and among young women confined in labor camps in China (13.3%).

Active tuberculosis

There were 11 published sets of age-specific prevalence estimates for TB among prisoners, of which only 4 contained estimates specific to AYA prisoners (Table S4). Two studies identified no young prisoners with active TB in samples from facilities in Iran [54] and the U.S. [55]. In contrast, young prisoners in one facility in Cameroon had a prevalence of active TB of 3.7% [56], whereas active TB prevalence among young prisoners in a facility in Bangladesh [57] was observed at 1.1%.

Sex differences among incarcerated AYA

The majority of studies reported on samples comprised both men and women, although men were consistently the majority. There were 18 sets of age-specific prevalence estimates for incarcerated women and 37 sets for incarcerated men, of which 12 pertained specifically to incarcerated young women and 27 to incarcerated young men. The prevalence of chronic HBV infection among incarcerated young men ranged from 1.5% to 10.8%; the one study with an exclusively female sample [58] observed a prevalence of 8.3% (Figure S4). The prevalence of HCV infection ranged from 1.0% to 67.2% among incarcerated young men and from 3.4% to 70.6% among incarcerated young women (Figure S5). The prevalence of HIV infection was observed at .0%–13.3% among samples of incarcerated young men and across the same range for incarcerated young women (Figure S6). There were no sex-stratified estimates of the prevalence of active TB among samples of incarcerated youth.

Table 1
Relative risk of HBV, HCV, HIV, and TB infection among AYA prisoners (aged <25 years) versus older prisoners (aged ≥25 years)

Condition	No. of studies	RR (95% CI)	*p* Value	I^2 (95% CI)
HBV	3	.87 (.41–1.81)	.70	46.4% (.0%–83.7%)
HCV	15	.51 (.33–.78)	.002	97.8% (97.4%–98.1%)
HIV	25	.39 (.29–.53)	<.001	79.2% (69.7%–84.7%)
TB	3	.66 (.27–1.63)	.37	76.1% (.0%–90.7%)

Analyses are restricted to studies reporting infectious disease estimates for both AYA and older populations. Statistical analyses were conducted in StatsDirect 3 using a meta-analysis with random effects that incorporates inverse double arcsine square root to calculate the pooled relative risk estimates. Given the expected heterogeneity between studies, all meta-analyses were performed using random effects models, which account for interstudy variation. Heterogeneity was assessed using the I^2 statistic, which describes the percentage of variation between studies that is due to heterogeneity rather than chance.
AYA = adolescent and young adult; CI = confidence interval; HCV = hepatitis C virus; HBV = hepatitis B virus; RR = relative risk; TB = tuberculosis.

Relative risk of infection in AYA and older prisoners

We used random effects logistic regression to assess the relative prevalence of each infection among AYA and older prisoners. Based on data from 25 studies, we estimated that the risk of HIV infection among AYA prisoners was 39% of that among older prisoners (RR = .39, 95% confidence interval .29–.53, I^2: 79.2%). Based on data from 15 studies, we estimated that the risk of HCV infection among AYA prisoners was 51% of that among older prisoners (RR = .51, 95% confidence interval .33–.78, I^2: 97.8%). Point estimates for HBV and TB (each based on three studies) were also less than one, but were not statistically significant at $p < .05$ (Table 1, Figures 1–4). Sensitivity analyses, excluding studies of high-risk samples for HCV (n = 3) and HIV (n = 3), produced similar findings (Table S5, Figures S2 and S3).

Discussion

This systematic review identified 72 publications reporting age-specific prevalence estimates for hepatitis B, hepatitis C, HIV, and/or TB among prisoners. We hypothesized that the prevalence of each infection would be lower among AYA prisoners than among older prisoners. We found that HIV and HCV—the most prevalent infections in this population, transmitted primarily through drug injection using contaminated injecting equipment (and, in the case of HIV, unsafe sex)—were more prevalent in older prisoners than in AYA prisoners. We observed no statistically significant difference between age groups in the prevalence of either HBV or TB. There was substantial heterogeneity between studies in the prevalence of each infection, consistent with evidence that incarcerated populations both reflect and amplify the prevalence of infection in the surrounding community [59]. Nevertheless, given the high prevalence of infection in incarcerated AYA, effective responses in these settings are critical to the health of young people at the population level, particularly in countries with a high incarceration rate, such as the U.S. [60].

As both HIV and HCV seroconversion are irreversible, our finding that seroprevalence rose with age is perhaps unsurprising, although at least one study has reported a higher prevalence of HCV infection in younger prisoners [19]. Given mounting evidence of injecting risk behavior [18] and associated incident HIV and HCV infection in prisons [61–65], coupled with inadequate coverage of evidence-based preventive measures such as needle and syringe programs and opioid agonist therapy in these settings [21], our findings point to an urgent need to scale up harm and demand reduction measures for incarcerated AYA who inject drugs to prevent another generation of vulnerable young people from acquiring life-threatening, costly infections. In settings where HIV infection is concentrated in MSM, increased access to

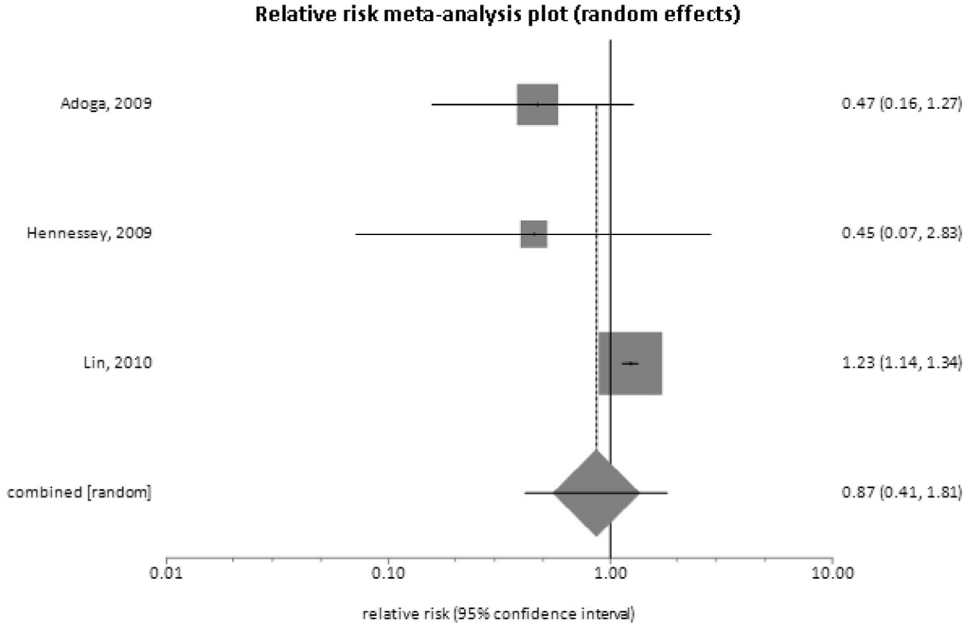

Figure 1. HBV in young versus older prisoners (mixed group excluded).

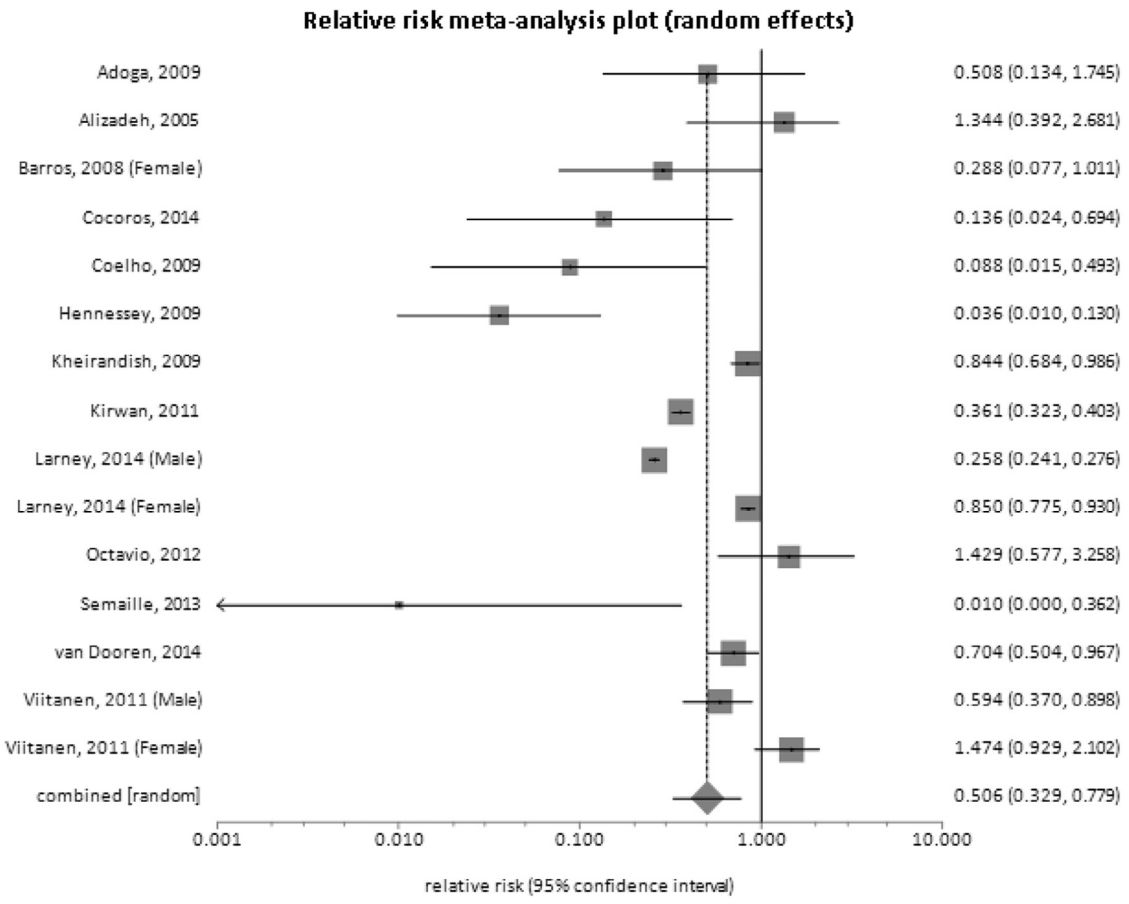

Figure 2. HCV in young versus older prisoners (mixed group excluded).

condoms and pre-exposure prophylaxis, coupled with decriminalization of same-sex behavior, are also important elements of effective prevention [66,67].

Because virtually all young prisoners return to the community after a relatively short period of incarceration, and given evidence of rapid relapse to drug injection after release from custody [68], achieving sustained reductions in infection for these young people will require continuous support during and after their transition back to the community, including through uninterrupted provision of opioid agonist therapy for those who are opioid dependent [59,69–71]. Furthermore, given evidence that incarceration precipitates increased injecting risk behavior [72] and reduces adherence to ART among those who are HIV positive [73,74], efforts to minimize the incarceration of at-risk young people are important to preventing the further spread of infection [25,75]. Among studies presenting sex-specific estimates, high HIV or HCV seroprevalence was more often observed among young women than young men, consistent with previous findings that incarcerated women have a particularly high prevalence of HIV and HCV infection, driven largely by a higher prevalence of injection drug use and higher rates of unsafe injecting practices, primarily in the context of intimate relationships [76,77].

We found comparatively few studies that reported age-specific prevalence estimates for HBV or TB, and no evidence that the prevalence of these infections was different among incarcerated AYAs and older prisoners. HBV prevalence among incarcerated young people from high HBV prevalence settings is largely determined by control of mother to child transmission at the time they were born, whereas among prisoners from low prevalence countries, HBV prevalence is more likely to reflect transmission via sexual behavior and injecting drug use [14,78]. The HBV vaccine was introduced in the late 1980s; however, global coverage of the three-dose schedule is currently estimated at 83% and coverage of the birth dose at only 39% [79]. In some settings, the current cohort of incarcerated youth will be fully vaccinated, whereas in countries that have only recently implemented national HBV vaccination programs, it will be some time before fully vaccinated cohorts begin entering the prison system. Free hepatitis B vaccination for all prisoners is recommended as part of the United Nations Office on Drugs and Crime "comprehensive package" for responding to HIV and other infections in prison settings [80].

The comparative dearth of studies on HBV among prisoners compared with those on HCV is notable. Although HCV is more common among people who inject drugs due to much lower rates of spontaneous clearance, HBV presents an equal threat to the health of those who do develop chronic infection. In addition, HBV in an adult from an endemic area may represent an infection acquired at birth, which HCV rarely does; thus even a young adult with HBV may have lived with the infection for multiple decades and may be at high risk of progression to advanced liver disease in the near future. The burden of HBV among AYA

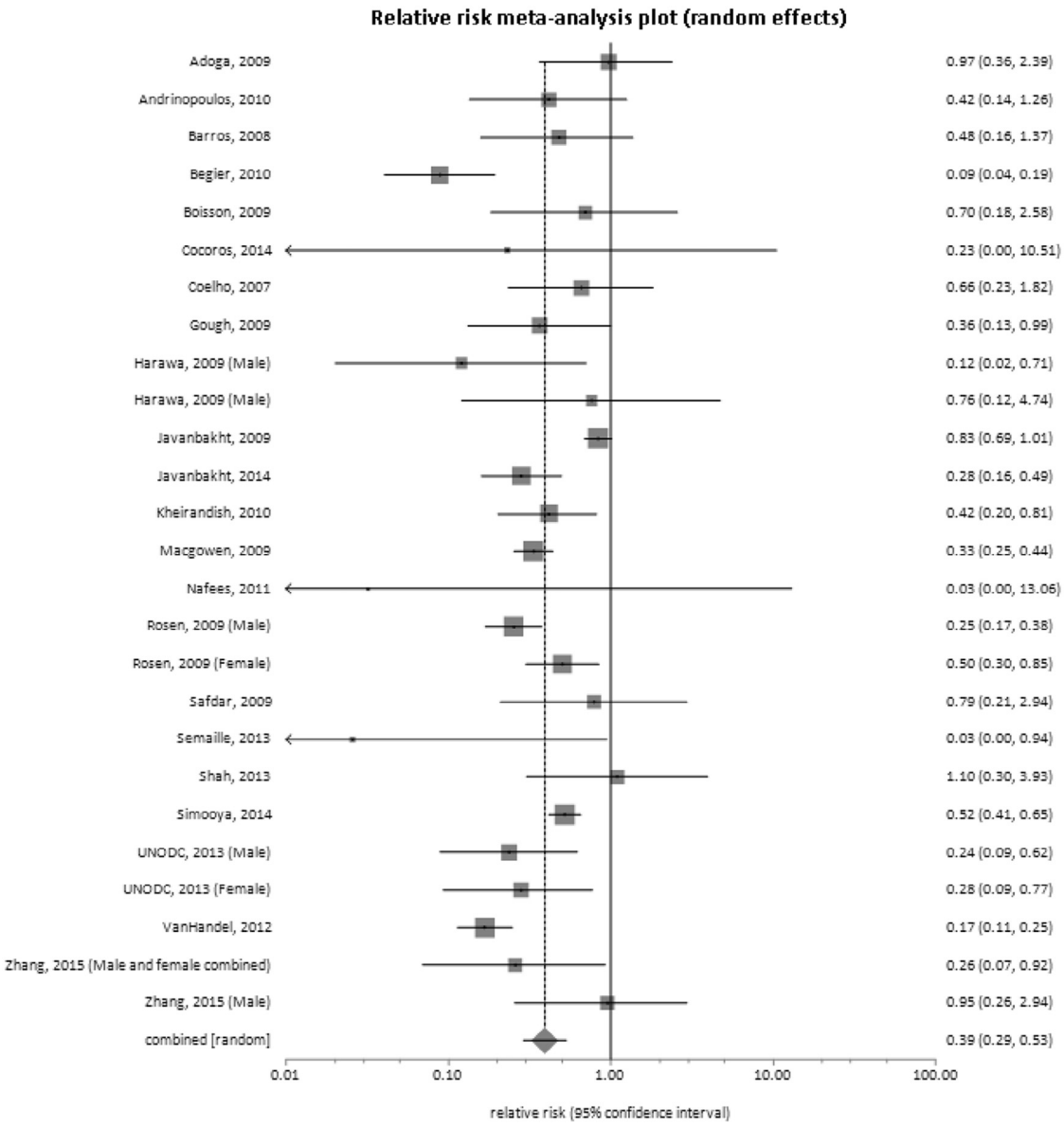

Figure 3. HIV in young versus older prisoners (mixed group excluded).

prisoners, particularly those living in high prevalence countries, merits increased attention. Increased vaccination coverage for young people who experience incarceration, particularly in endemic areas, should be a priority [59].

Documented TB prevalence among people over the age of 15 years in the general population in endemic countries varies markedly by setting, but is very rarely in excess of 1% of the population [81]. The prevalence estimates reported here demonstrate a very substantial burden of disease in prisoners compared with the general public, including among incarcerated youth in the studies from Cameroon [56] and Bangladesh [57]. Although TB prevalence is generally lower among young people in the general population, we found no age gradient in the prevalence of this infection in prison. One possible explanation for this finding is that, whereas BBV infections are often acquired in the community before incarceration, active TB among prisoners will very often reflect recent transmission. In many prison settings, access to diagnosis and treatment for TB is limited, as is capacity to isolate those who are infected. Prison overcrowding is a widespread problem, but is often particularly acute in low- and middle-income countries where TB is endemic [29,82,83]. The incarceration of young people in adult prisons is likely to expose them to markedly higher risks of TB infection and disease than they would face in the community [29]. Therefore, efforts to prevent the incarceration of young people in these settings—particularly those who are more vulnerable to infection due to HIV-related immunosuppression—may reduce the incidence of TB in vulnerable AYAs.

Chronic hepatitis, HIV, and TB contribute significantly to the global burden of disease [84], and typically have profound implications for the life expectancy and life choices of young people who acquire these infections. Obtaining reliable epidemiological

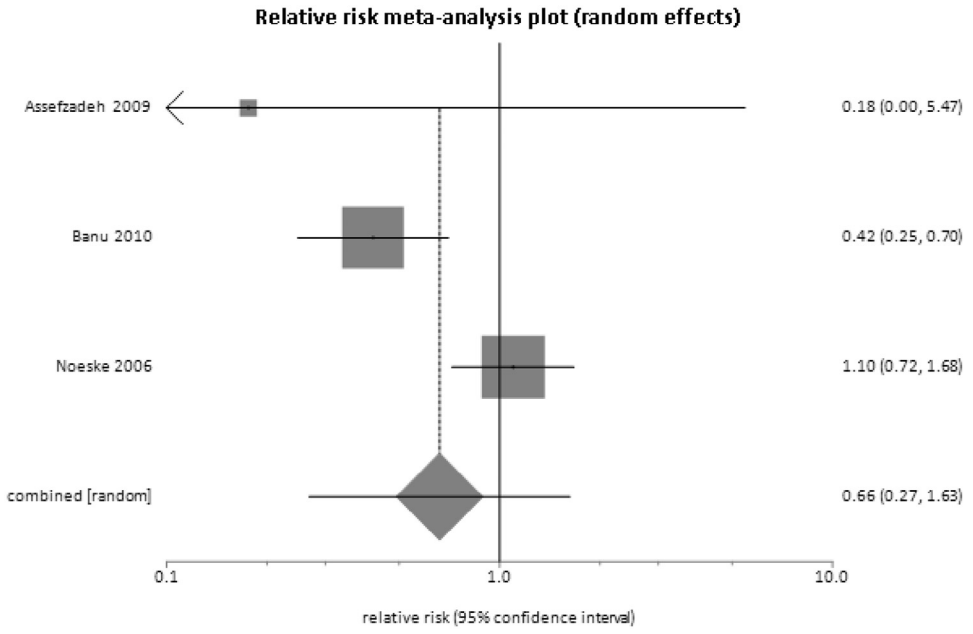

Figure 4. TB in young versus older prisoners (mixed group excluded).

data is a first essential step in developing evidence-based responses, and funding them at a scale proportional to need. Our findings add support to calls for more, better, and more consistent data on the health of young people, particularly vulnerable groups such as those exposed to the criminal justice system [33,35].

Limitations

This study provided the first comprehensive review of published, age-specific prevalence estimates of bloodborne viral infections and active pulmonary TB among prisoners. The reviewed studies spanned a wide variety of detention settings, including prisons, jails, labor camps, youth detention facilities, and compulsory drug treatment facilities, although remarkably few studies of detained juveniles were identified. Further research on the health status of detained juveniles, particularly in low- and middle-income settings, should be a priority.

We observed substantial heterogeneity in prevalence estimates between studies; this is to be expected given the diversity of geographical and epidemiological settings of included studies. Strategies for preventing and responding to these infections are likely to differ markedly between settings; however, consideration of these differences was beyond the scope of this review. A large proportion of studies was conducted in upper middle- or high-income countries from the European region and the region of the Americas, and only one study was identified from the Southeast Asian region [57]. Among the 299 studies identified in the original systematic review [7], those reporting age-disaggregated prevalence estimates were disproportionately from high-income countries (56% of studies with age-disaggregated data vs. 46% of those without). Our findings may not generalize to low-income countries, and further research in these settings is urgently required.

We also observed significant heterogeneity in estimates of the RR of infection between AYA and older prisoners. As such, our meta-analysis findings should be interpreted with caution, although inspection of forest plots suggests that this heterogeneity is largely a function of variation in the magnitude rather than the direction of RR estimates: in other words, the finding that HCV and HIV infection were less prevalent among AYA was reasonably consistent, although the extent to which the prevalence of infection was lower in young prisoners varied between studies.

Some studies recruited high-risk samples; however, exclusion of these in sensitivity analyses had minimal impact on our estimates. Other studies may have only or preferentially tested symptomatic individuals; prevalence estimates in these studies may have been inflated. Screening algorithms for TB were inconsistent, with different studies using different combinations of symptom screening, chest x-ray, and microbiologic testing. This is consistent with the greater challenge of mass TB screening due to the absence of a high-performance, gold-standard test. No study attempted to identify patients with extrapulmonary TB, which constitutes more than 30% of disease in some countries [85]—as such, the prevalence estimates for TB presented here will underestimate the true burden of disease. Several studies only provided microbiologic testing to participants who reported TB symptoms, which is known to reduce case detection, as up to 30% of people with pulmonary TB may be asymptomatic [86].

The present study was able to include only one in four studies from the original review (i.e., those that included age-disaggregated prevalence estimates) and, among these, heterogeneity in age categories hampered data synthesis. This is a perennial problem for meta-analysis and a well-recognized challenge for research on AYA health [33,87]. One possible solution for future research is to employ individual patient data meta-analysis, in which primary data are reanalyzed in a coordinated fashion, to increase data harmonization and potentially permit inclusion of additional studies [88].

In conclusion, the prevalence of HIV and hepatitis C among incarcerated AYAs is high, but lower than among older prisoners. Given the high background prevalence of infection, persistence

of BBV risk behaviors, and inadequacy of infection control measures, prisons are extremely high-risk settings for the transmission of infection for these young people. As a primary measure, every effort should be made to reduce incarceration of AYAs, and to prevent incarceration for substance use and substance use disorders [25]. The window of opportunity for preventing infection in incarcerated AYA is likely brief and will require both age-appropriate prevention through adoption of evidence-based harm reduction measures and rapid scale-up of in-prison treatment for HIV and HCV, and associated conditions such as opioid dependence and mental disorder [75]. There is good evidence for both the effectiveness and the acceptability of these responses, but uptake remains poor in many settings. Given that most AYAs spend a relatively short time in custody before returning to the community, improved continuity of care between prison and community is also essential to reducing the incidence of infection, and associated morbidity and mortality, in these highly vulnerable young people.

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Appendix: Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jadohealth.2017.09.030.

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