Bacterial sexually transmitted infections in incarcerated populations: a systematic review and meta-analysis

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Summary

Background Bacterial sexually transmitted infections (STIs) are common among people in prison, a population identified by WHO as a key group to addressing the burden of sexually transmitted and blood-borne infections worldwide. To inform elimination efforts, we aimed to estimate the global prevalence of bacterial STIs (chlamydia, gonorrhoea, and syphilis) in prisons and other closed settings.

Methods We conducted a systematic review and meta-analysis by searching online databases (MEDLINE, Embase, Global Health, PsycInfo, CINAHL, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, Global Index Medicus, the Conference Proceedings Citation Index–Science, and the Conference Proceedings Citation Index–Social Sciences & Humanities) and reference lists for studies published from Jan 1, 2000, to Aug 5, 2025. We included peer-reviewed publications (scientific articles, conference abstracts, and technical reports) that reported on the prevalence of current chlamydia, current gonorrhoea, or current or previous syphilis infections, confirmed by validated diagnostic assays, among incarcerated populations (adolescents aged 10–19 years and/or adults aged >19 years). Two reviewers (GB and BH) independently assessed studies, extracted data, and evaluated the quality of studies using an adapted version of the Joanna Briggs Institute critical appraisal tool for prevalence studies. Pooled prevalence estimates for each bacterial STI were derived with use of generalised linear mixed-effects models, stratified by age group and, within each age group, by sex. Heterogeneity was quantified based on the I^2 statistic and χ^2 test. This systematic review and meta-analysis was registered with PROSPERO, CRD42023443370.

Findings The search generated 5237 records, of which 212, corresponding to 206 unique studies, met the eligibility criteria and were included. Of the 206 studies, 137 included adults only (n=425 215), 53 included adolescents only (n=342 762), and 16 included both (n=675 119). 190 (92·2%) studies were conducted in high-income or upper-middle-income countries. Across the 206 studies, data were available for 1 443 096 individuals (483 438 [33·5%] females, 901 188 [62·4%] males, and 58 470 [4·1%] sex not reported). The mean age was 33·6 years (SD 9·7) for adults and 15·6 years (1·1) for adolescents. Among female adults, the pooled prevalence of current chlamydia was 6·5% (95% CI 5·1–8·3; I^2=97·0%, p<0·0001; 15 582 crude infections in 166 767 females; 38 studies), the pooled prevalence of current gonorrhoea was 1·5% (0·8–2·7; I^2=97·2%, p<0·0001; 4424 crude infections in 167 953 females; 32 studies), and the pooled prevalence of current or previous syphilis was 5·9% (4·1–8·3; I^2=98·6%, p<0·0001; 5143 crude infections in 103 641 females; 59 studies). Among male adults, the corresponding estimates were 4·7% (3·7–6·0; I^2=94·4%, p<0·0001; 7101 crude infections in 128 380 males; 33 studies), 0·4% (0·2–1·1; I^2=98·4%, p<0·0001; 591 crude infections in 330 418 males; 23 studies), and 3·7% (2·8–5·0; I^2=99·4%, p<0·0001; 10 404 crude infections in 522 133 males; 61 studies), respectively. Among female adolescents, the pooled prevalence of current chlamydia was 16·8% (14·0–20·0; I^2=96·7%, p<0·0001; 31 206 crude infections in 221 350 females; 38 studies), the pooled prevalence of current gonorrhoea was 6·0% (4·5–7·9; I^2=89·3%, p<0·0001; 2053 crude infections in 39 949 females; 22 studies), and the pooled prevalence of current or previous syphilis was 1·9% (0·1–26·4; I^2=76·0%, p=0·0058; nine crude infections in 449 females; four studies). Among male adolescents, the corresponding estimates were 7·4% (6·3–8·8; I^2=97·0%, p<0·0001; 15 122 crude infections in 231 606 males; 29 studies), 2·0% (1·4–2·7; I^2=94·5%, p<0·0001; 1393 crude infections in 75 697 males; 17 studies), and 1·9% (0·5–6·5; I^2=24·7%, p=0·26; 11 crude infections in 596 males; three studies), respectively. The overall quality of studies was moderate (118 [57·3%] of 206 studies) or high (88 [42·7%] studies).

Interpretation The high prevalence of bacterial STIs in incarcerated populations, particularly among adolescents and females, highlights substantial public health gaps in bacterial STI prevention and treatment. Offering opt-out bacterial STI testing to all people in prison should be considered to accelerate elimination efforts.

Funding None.

Lancet Public Health 2026; 11: e44–60

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Introduction

In the past three decades, reported incident cases and disability-adjusted life-years of bacterial sexually transmitted infections (STIs) have increased substantially worldwide. According to estimates from the Global Burden of Disease study, *Chlamydia trachomatis*

Research in context

Evidence before this study

We conducted an extensive literature search across multiple databases (MEDLINE, Embase, Global Health, PsycInfo, CINAHL, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, Global Index Medicus, the Conference Proceedings Citation Index–Science, and the Conference Proceedings Citation Index–Social Sciences & Humanities) without language restrictions, to identify previous systematic reviews and meta-analyses on bacterial sexually transmitted infection (STI; defined as chlamydia, gonorrhoea, and syphilis) prevalence among incarcerated individuals from Jan 1, 2000, to Aug 5, 2025. We used the same search terms to identify primary studies in this current review. We identified several systematic reviews and meta-analyses, but all had notable limitations. The most relevant review, published in 2012, did not stratify prevalence estimates by age. Two other reviews broadly examined testing in non-clinical sites or underserved populations, including US correctional settings. Another was a global scoping review of the health problems of detained adolescents. Other reviews focused on specific bacterial STIs, subpopulations, or regions (eg, men, adolescents, Indigenous populations, US-only or Australian-only samples, or the Americas or Africa).

Added value of this study

To our knowledge, this analysis provides the most comprehensive global synthesis of bacterial STI prevalence estimates in prisons and other closed settings, among 1·4 million individuals across all WHO regions and World Bank income levels. Stratified by sex and age group, our estimates reveal marked disparities, with a substantial burden of bacterial STIs among adolescent and female populations, both of which are growing demographics in incarcerated settings globally. Our findings show a persistently high prevalence of bacterial STIs among people who are incarcerated, aligning with previous research. However, our estimates are more robust than those reported in 2012, as we did not collapse age groups, and we accounted for a broad range of study and sample characteristics in heterogeneity analyses and used updated methods to assess for influence and publication bias.

Implications of all the available evidence

The prevalence of bacterial STIs among people who are incarcerated has remained persistently high over the past two decades, underscoring critical gaps in prison health-care delivery. There is an urgent need to scale up bacterial STI testing upon admission to carceral settings, and throughout the incarceration period, and to expand bacterial STI treatment as part of a public health response to curb transmission. Further primary research on bacterial STI prevalence—particularly in carceral settings in low-income and middle-income countries—is also needed, along with improved reporting of diagnostic methods to inform evidence-based resource allocation. Additionally, robust implementation and evaluation research is required to inform testing and treatment strategies in prisons and other closed settings, as improved efforts in this priority population will be essential to achieving WHO's 2030 global sexually transmitted and blood-borne infection elimination targets. Finally, ensuring continuity of care within and beyond carceral settings is crucial to preventing bacterial STI transmission among people who are incarcerated and those in surrounding communities.

(chlamydia), *Neisseria gonorrhoeae* (gonorrhoea), and *Treponema pallidum* (syphilis) resulted in approximately 350 million new STI cases and more than 400 000 disability-adjusted life-years in 2019.[1] Although largely preventable and curable, untreated bacterial STIs can lead to severe complications such as pelvic inflammatory disease, adverse pregnancy outcomes, and infertility in women, and epididymitis, prostatitis, and urethral strictures in men, as well as increased susceptibility to other infections, including HIV, among both women and men.

WHO has identified people in prison and other closed settings as one of five key populations in the global response to sexually transmitted and blood-borne infections (STBBIs), with prisons and other closed settings defined as all places of detention within a country.[2] Individuals who are incarcerated are disproportionately affected by social determinants of health and housed in environments inherently prone to the transmission of STBBIs. Thus, the prevalence of STBBIs is higher in incarcerated populations than in the general population.[3–8] Globally, an estimated 11·5 million people are incarcerated each year.[9] High turnover and recidivism create fluid prison–community interactions and underscore the need for public health approaches that address disease transmission in these dynamic environments. To achieve the 2030 global STBBI elimination targets set by WHO, 90% of key populations should be screened and treated for gonorrhoea, and more than 95% for syphilis.[10,11]

Bacterial STIs remain understudied despite their disproportionate burden on people who are incarcerated. Previous reviews of bacterial STIs among incarcerated populations have had limited generalisability due to their focus on one infection, specific subpopulations, or a single jurisdiction.[12,13] Other findings were limited in scope due to language restrictions, lacked rigorous quality assessments or quantitative methods, or did not stratify findings by age.[14] Previous findings have also been synthesised descriptively rather than pooled quantitatively due to minimal data and the substantial heterogeneity of primary studies.[15] Hence, a comprehensive and updated meta-analysis of prevalence was needed. We aimed to synthesise evidence on the global

prevalence of three common bacterial STIs (chlamydia, gonorrhoea, and syphilis) in incarcerated populations. Given the high burden of bacterial STI in prisons and other closed settings, understanding their prevalence is critical for refining global estimates and informing testing and treatment practices, to ultimately advance bacterial STI elimination efforts both within and beyond carceral settings.

Methods

Search strategy and selection criteria

This systematic review and meta-analysis is reported in accordance with the PRISMA and MOOSE guidelines.[16,17] The protocol was registered with PROSPERO, CRD42023443370.

We conducted a systematic review of studies published between Jan 1, 2000, and Aug 5, 2025, that examined the prevalence of chlamydia, gonorrhoea, or syphilis among adolescents aged 10–19 years and adults older than 19 years who were incarcerated.[18] Electronic databases, namely MEDLINE, Embase, Global Health, PsycInfo, CINAHL, the Cochrane Database of Systematic Reviews, the Cochrane Central Register of Controlled Trials, Global Index Medicus, the Conference Proceedings Citation Index–Science, and the Conference Proceedings Citation Index–Social Sciences & Humanities, were searched using terms related to the three bacterial STIs and incarceration (appendix pp 22–24). Additionally, we manually reviewed reference lists of relevant papers identified in the searches. We did not set any language restrictions, and all non-English articles were translated using freely available online translation tools. We contacted the relevant study authors if additional data or clarifications were required.

We included peer-reviewed publications (scientific articles, conference abstracts, and technical reports) that reported original, primary research on the prevalence, number of cases, and number of individuals tested for any of the three bacterial STIs. Eligible studies had to use validated diagnostic assays to confirm current chlamydia or gonorrhoea infections, or current or previous syphilis infections, based on established and up-to-date clinical guidelines.[19] We set no restrictions on study design for primary research provided sufficient data were available to calculate prevalence estimates, but excluded non-peer-reviewed secondary publications, systematic reviews and meta-analyses, case studies, studies not reporting original data, and those which relied solely on self-reported data without concurrent biological test results. All carceral settings were included (eg, juvenile detention, prisons, and jails) except secure psychiatric forensic units. We sought summary estimates from the included studies.

One reviewer (GB) conducted the literature search, and two reviewers (GB and BLH) independently assessed the titles and abstracts of studies identified through the search strategy and additional sources. They also evaluated the full texts of studies after initial screening. Disagreements were resolved through referral to a third reviewer (NK).

Statistical analysis

Data were independently extracted by two reviewers (GB and BLH) in Covidence. Reviewers retrieved relevant information from eligible studies, including publication type (article, abstract, or report), publication year, geographical location, publication language, carceral setting (jail, prison, detention centre, immigration detention centre, or compulsory drug detention and rehabilitation centres), sample size, sex of participants (at birth), age statistics (mean, median, range, and IQR), and age group (adolescents and/or adults). Although all available descriptive statistics on age were recorded, we report the mean age and range of mean ages across studies, as mean age was most commonly provided. Data on race and ethnicity were infrequently reported and were therefore not collected. Additional data included study design (randomised controlled trial, cohort study, cross-sectional study, or case–control study), sampling method (target population, random sampling, stratified random sampling, convenience sampling, consecutive admissions or combination), participation rate, proportion sentenced versus on remand, median duration of incarceration at diagnosis, number of individuals tested, diagnostic tests used, proportion diagnosed with each bacterial STI, and proportion linked to care and/or treated. Duplicate publications were merged when they provided complementary information to consolidate all relevant data for analysis.

See Online for appendix

Following established methodology, samples that included both sexes and age groups but did not report data separately were categorised based on their overall composition. If one sex or age group comprised 90% or more of the sample, data were attributed to that group; otherwise, the sample was deemed as mixed.[20,21,22] For studies that reported separate data for males and females, or for adults and adolescents, the data were included in the analyses for both sex groups or both age groups. To conduct a comprehensive geographical analysis,[20] countries were classified according to the six WHO regions (ie, Africa, Americas, South-East Asia, Europe, Eastern Mediterranean, and Western Pacific).[23] Consistent with previous meta-analytical research on incarcerated populations, the Americas were further subdivided into North America and South and Central America, resulting in seven regions.[24] Income levels were structured using the World Bank classification (2024–25; ie, low, lower-middle, upper-middle, and high-income countries).[25]

Two reviewers (GB and BH) independently assessed the quality of the included studies using an adapted questionnaire based on the Joanna Briggs Institute critical appraisal tool for prevalence studies.[26] This tool,

previously used to assess bias in prison psychiatric research,[20,21] was adapted for infectious disease studies among incarcerated populations. The final version, comprising ten predefined questions with specific response options, yielded quality scores ranging from 0 to 10, which were categorised as low (scores of 0–3), moderate (scores of 4–7), and high (scores of 8–10; appendix pp 43–44).

The primary outcomes for prevalence were defined as follows: (1) current *C trachomatis* infection for chlamydia, (2) current *N gonorrhoeae* infection for gonorrhoea, and (3) *T pallidum* infection, including current or previous infection, for syphilis. Current syphilis infection was based on the presence of both reactive non-treponemal and treponemal test results,[27] consistent with WHO standards requiring both for confirmation of current infection.[28] While our initial aim was to report current or prior syphilis prevalence separately, significant limitations in diagnostic reporting across studies necessitated their aggregation.

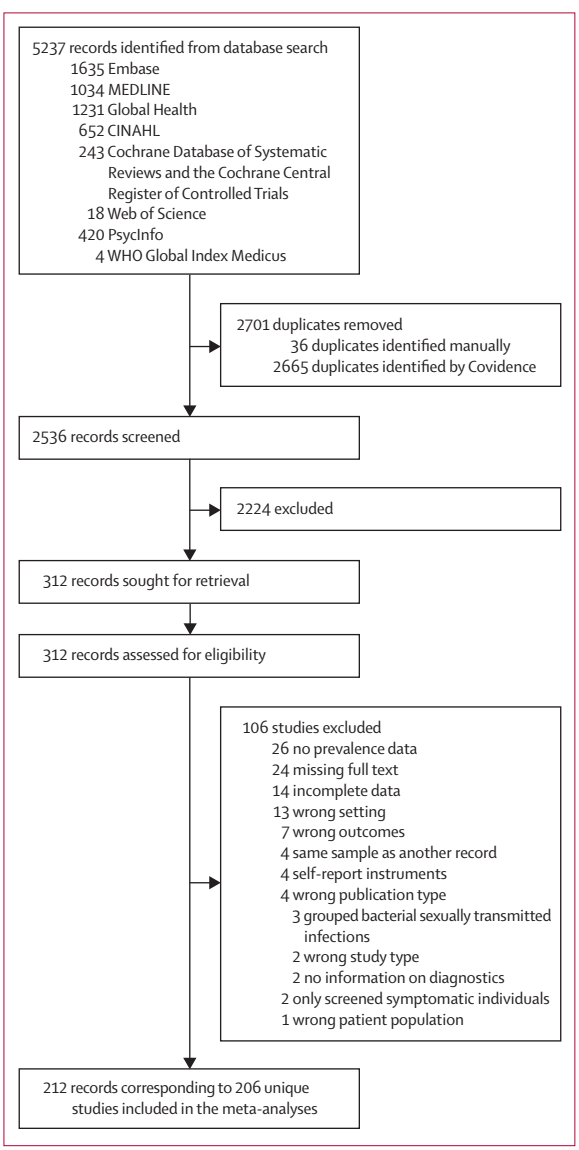

Figure 1: **Study selection**

Where raw prevalence data were unavailable, we converted pooled or transformed prevalence data into raw numbers to calculate prevalence estimates. For each of the three bacterial STIs, we calculated pooled prevalence estimates stratified by age group, and, within each age group, by sex. Prevalence estimates were pooled with use of generalised linear mixed-effects modelling, which applies a logistic regression approach with random effects for between-study variability.[29] Generalised linear mixed-effects models are particularly suited to pooling proportions,[30] offering greater accuracy and stability through logit transformation and maximum likelihood estimation, which bypass inverse-variance weighting. The 95% CIs were directly derived from the model.[31] Heterogeneity was quantified based on the I^2 statistic and χ^2 test, with an I^2 value greater than 75% suggesting substantial heterogeneity.[32] The p value threshold for significance for the χ^2 test was $p<0{\cdot}10$. By this approach, pooled estimates might differ from crude proportions, as they account for heterogeneity, sample size, and variance-stabilising transformations.[31] To minimise bias from extreme studies,[31] we re-estimated pooled effects excluding studies with 95% CIs entirely above or below the pooled 95% CI.[33]

We further assessed between-study heterogeneity in prevalence estimates using subgroup analyses and univariable mixed-effects meta-regression across predefined sample and publication characteristics. These characteristics included study size (number of participants as a continuous variable), country (elsewhere *vs* USA), sex group (separate *vs* mixed), country income level (low or middle *vs* high), population type (selected subgroup *vs* general), language (other *vs* English), study design (other *vs* cross-sectional), sampling method (consecutive or complete *vs* random or other sampling), setting (other *vs* prison or jail), and diagnostic approach (for gonorrhoea and chlamydia: other *vs* nucleic acid amplification test or PCR; for syphilis: other *vs* both non-treponemal and treponemal testing). This diverse sampling strategy aimed to improve the generalisability of findings to under-represented groups within carceral settings and was accordingly incorporated into sensitivity analyses. Additional factors were study quality score (analysed as both a continuous variable and dichotomised as high score *vs* low or moderate score), publication year (analysed as both a continuous variable and dichotomised as pre-2010 *vs* 2010 onwards, with this cutoff reflecting the introduction of key international guidelines and policy documents related to the surveillance and prevention of bacterial STIs in incarcerated populations, published after 2010),[34–37] and publication type (other *vs* journal article). Meta-regression was conducted only if at least ten studies were available per category.[38] Significant predictors ($p<0{\cdot}05$) were

incorporated into a multivariable meta-regression model to explain effect variation. P values for overall and moderator effects are based on Wald-type Z tests, whereas heterogeneity is assessed using Cochran's *Q* (χ^2 test).

Influence analysis was done to identify studies that, despite moderate effect sizes, disproportionately affected the overall results. Using the leave-one-out method, we repeated the meta-analysis *K* times, omitting one study at a time. Four influence diagnostic outputs were generated: a Baujat plot; influence diagnostics (including externally standardised residuals, DFFITS values, Cook's distance, covariance ratios, leave-one-out τ^2 and *Q* values, hat values, and study weights);[33] and leave-one-out meta-analysis results, sorted by effect size and I^2 value. Baujat plots are diagnostic tools used to identify studies that contribute disproportionately to heterogeneity in a meta-analysis. These plots display the relationship between each study's influence on the pooled effect estimate and its contribution to overall heterogeneity, as measured by Cochran's Q.[39]

Publication bias was assessed using a combination of statistical and visual methods.[31] Peters' regression was applied to examine the relationship between effect size and standard error,[40] serving as an alternative to Egger's test for continuous data.[41] Funnel plots are frequently used to assess publication bias, but can be misleading when pooling prevalence data.[42–44] We therefore used Doi plots, which relate normal quantiles to effect sizes for visual assessment, and the Luis Furuya-Kanamori index (known as the LFK index) for quantitative evaluation to minimise subjectivity.[45]

All statistical analyses were done in R (version 4.4.3) and R Studio (version 2025.05.1+513).

Role of the funding source

There was no funding source for this study.

Results

Our search identified 5237 records. After duplicates were removed, 2536 records underwent title and abstract screening. Of these, 312 full-text scientific articles, conference abstracts, and technical reports were assessed, and 212 met the predefined eligibility criteria. 12 references,[46–57] corresponding to six unique studies, were merged, resulting in a total of 206 unique studies: 180 articles, 25 abstracts, and one report (figure 1).[8,46–256]

Of the 206 eligible studies, 114 reported on chlamydia,[46,49,56,61,63,65,66,70,71,73,76,78,79,81,83–86,89,91,93,94,96,97,102,104–106,108,109,112–114,122,126–138,140–142,146–152,154,156–162,164,166,169–175,177,180–184,186,187,190,192–194,203–206,209,212–214,218–221,223,227–229,231–233,238,241–243,245,247,249,252,254] 89 on gonorrhoea,[46–50,53,56,57,61,63,65,71,76,78,79,82,84–86,93,97,102,104–106,108,109,112–114,127–129,132–138,141,142,147–150,152,154,156,159–162,164,171,172,174,177,181,183,184,187,189,190,192–194,201,204–206,214,217–221,223,225,227,228,231,233,236–238,241–243,245,249,252,254] and 125 on syphilis.[8,48,51–60,62–65,67–69,72,74,75,77,79,80,82,87,88,90,92,94,95,97–101,103,105–107,110–112,115–121,123–125,132–137,139,143–145,149,150,153,155,156,160,162–165,167,168,172,176–179,181,182,185,188,189,191,195–200,202,207,208,210,211,214–216,219–226,228,230,231,234,235,238–240,242,244–248,250,251,253–256]

Study characteristics are summarised in the appendix (pp 4–21). By age group, 137 studies focused on adults, 53 on adolescents, and 16 included both age groups; however, 12 did not disaggregate data by age and were therefore classified as adult samples based on the predefined cutoff.[48,54,125,137,145,146,153,182,189,195,213,219] Across all studies, data were available for 1 443 096 individuals, of whom 483 438 (33·5%) were female, 901 188 (62·4%) were male, and 58 470 (4·1%) had unspecified sex. Overall, 137 studies included adults only (n=425 215), 53 adolescents only (n=342 762), and 16 included both (n=675 119). Mean age was 33·6 years (SD 9·7, range of study-level means 17·6–58·0) among adults and 15·6 years (1·1, 11·5–18·2) among adolescents.

The 206 studies spanned 43 countries, with the highest representation for North America (97 [47·1%] studies), including 88 (42·7%) studies in the USA. 46 (22·3%) studies were in South and Central America, primarily Brazil (32 [15·5%]). Most studies were conducted in high-income countries (133 [64·6%]) or middle-income countries (71 [34·5%], including 57 [27·7%] in upper-middle-income countries), with only two (1·0%) studies in low-income countries.

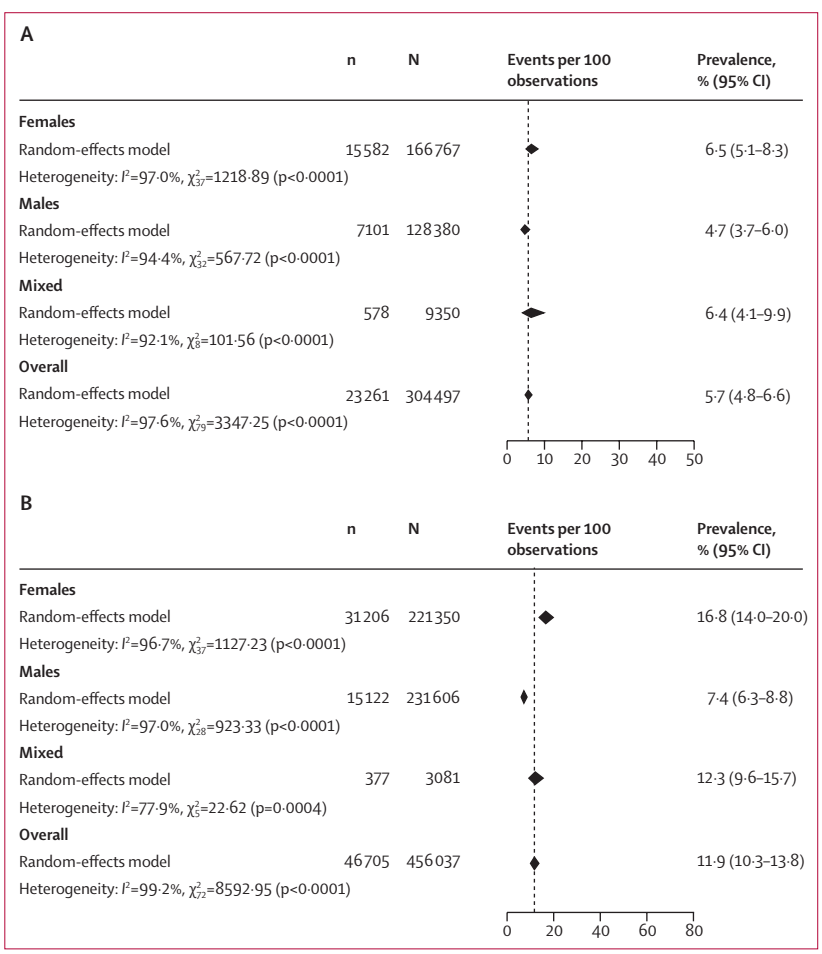

Figure 2: **Prevalence of current chlamydia infections in adult (A) and adolescent (B) incarcerated populations**
Pooled prevalence estimates were obtained by mixed-effects meta-analysis. The individual prevalence estimates by study and sex are shown in the appendix (pp 37–38). n=pooled number of cases. N=pooled total sample size.

Most of the 206 studies were conducted in jails or prisons (148 [71·8%] studies), with a substantial proportion of the remaining studies in adolescent detention centres (55 [26·7%]). Cross-sectional designs dominated (194 [94·2%] studies). Sampling strategies included convenience sampling (63 [30·6%] studies), total population sampling (48 [23·3%]), consecutive admissions to a carceral setting (47 [22·8%]), stratified random sampling (14 [6·8%]), a combination of methods (ten [4·9%]), and random sampling (nine [4·4%]). 15 (7·3%) studies did not report sampling methods. Both unselected samples (189 [91·7%] studies) and selected samples (17 [8·3%]) were included, the latter focusing on minority groups (six [2·9%]), men who have sex with men (four [1·9%]), people who use drugs (two [1·0%]), sex workers (two [1·0%]), individuals with HIV or tuberculosis (two [1·0%]), and pregnant individuals (one [0·5%]).

The meta-analysis results of chlamydia, gonorrhoea, and syphilis prevalence by WHO region and World Bank income group are provided in the appendix (pp 25–36).

The analysis of current chlamydia prevalence included 114 studies, with a pooled population comprising 760 534 individuals who were incarcerated, of whom 304 497 were adults (65 studies),[56,57,63,65,66,70,71,73,78,79,91,93,97,102,105,106,108,112,122,126,129,131,133–135,137,141,146,149–151,156,159–162,164,169–172,177,181,182,184,186,187,194,213,214,218–221,223,227,229,233,238,242,243,245,247,252,254] and 456 037 were adolescents (53 studies).[46,47,49,50,61,71,73,76,81,83–86,89,96,104,109,113,114,127,128,130–132,136,138,140,147,148,151,152,154,157,158,166,173–175,180,183,190,192,193,203–206,209,212,228,231,232,241,242,249] Four studies reported separate data for adults and adolescents and were included in both age groups.[71,73,151,242] Among the population of 304 497 adults, 166 767 (54·8%) were females (38 studies), 128 380 (42·2%) were males (33 studies), and 9350 (3·1%) were from mixed-sex samples (nine studies). The overall pooled estimate for chlamydia prevalence in adults was 5·7% (95% CI 4·8–6·6; I^2=97·6%, p<0·0001), based on a crude number of current infections of 23 261. When stratified by sex, current prevalence was 6·5% (5·1–8·3; I^2=97·0%, p<0·0001; 15 582 crude infections) in females, 4·7% (3·7–6·0; I^2=94·4%, p<0·0001; 7101 crude infections) in males, and 6·4% (4·1–9·9, I^2=92·1%, p<0·0001;

	Adults			Adolescents		
	Chlamydia: β (SE), p value	Gonorrhoea: β (SE), p value	Syphilis: β (SE), p value	Chlamydia: β (SE), p value	Gonorrhoea: β (SE), p value	Syphilis: β (SE), p value
Study size, number of participants (continuous)	0·00001 (0·00), p=0·23	–0·00001 (0·00), p=0·012	–0·00001 (0·00), p=0·022	–0·000005 (0·00), p=0·28	–0·00002 (0·00), p=0·30	NA
Year of publication (continuous, in calendar years)	–0·01 (0·01), p=0·33	0·02 (0·03), p=0·60	0·01 (0·02), p=0·47	0·01 (0·01), p=0·70	0·004 (0·02), p=0·82	NA
Year of publication: <2010 *vs* ≥2010	0·15 (0·17), p=0·37	0·26 (0·48), p=0·59	–0·21 (0·25), p=0·40	–0·30 (0·18), p=0·091	–0·24 (0·25), p=0·35	NA
Type of publication: other *vs* journal article	NA	NA	0·13 (0·34), p=0·70	0·54 (0·25), p=0·031	0·54 (0·29), p=0·073	NA
Country: elsewhere *vs* USA	–0·02 (0·17), p=0·89	–0·19 (0·49), p=0·70	0·71 (0·25), p=0·0061	NA	NA	NA
Sex group: separate *vs* mixed	NA	NA	0·21 (0·30), p=0·48	NA	NA	NA
Country income level: low or middle *vs* high	NA	–0·20 (0·67), p=0·77	1·02 (0·21), p=0·0001	NA	NA	NA
Population: selected subgroup *vs* general	NA	NA	0·73 (0·40), p=0·065	NA	NA	NA
Language: other *vs* English	NA	NA	0·71 (0·34), p=0·038	NA	NA	NA
Study design: other *vs* cross-sectional	NA	NA	NA	NA	NA	NA
Sampling method: consecutive or complete *vs* random or other sampling	0·003 (0·17), p=0·99	0·34 (0·49), p=0·49	–0·34 (0·23), p=0·14	0·07 (0·17), p=0·71	0·27 (0·26), p=0·30	NA
Setting: other *vs* prison or jail	NA	NA	NA	NA	NA	NA
Diagnostics: other *vs* nucleic acid amplification test or PCR (gonorrhoea and chlamydia) or other *vs* non-treponemal and treponemal testing (syphilis)	–0·26 (0·19), p=0·19	–0·15 (0·48), p=0·75	–0·08 (0·23), p=0·71	0·15 (0·21), p=0·46	–0·04 (0·26), p=0·89	NA
Study quality: score (continuous)	0·01 (0·06), p=0·90	–0·05 (0·15), p=0·72	0·10 (0·07), p=0·14	–0·09 (0·06), p=0·14	–0·01 (0·10), p=0·92	NA
Study quality: high score *vs* low or moderate score	0·07 (0·17), p=0·67	–0·43 (0·48), p=0·37	0·30 (0·22), p=0·19	–0·11 (0·18), p=0·56	NA	NA

Results are from mixed-effects linear meta-regression models. For categorical variables, β (regression coefficient) represents the difference in prevalence between the group shown and the reference group (ie, the second group in each comparison); for continuous variables, β represents the change in prevalence associated with a 1-unit increase in the predictor. Statistical significance was defined as p<0·05. NA=not applicable (analysis not be conducted due to an insufficient number of studies, ie, <10 studies in at least one category).

Table: **Univariable meta-regression results by age group for each bacterial sexually transmitted infection**

578 crude infections) in mixed-sex samples (figure 2A, appendix p 37).

Among the population of 456 037 adolescents, 221 350 (48·5%) were females (38 studies), 231 606 (50·8%) were males (29 studies), and 3081 (0·7%) were from mixed-sex samples (six studies). The overall pooled estimate for current chlamydia prevalence in adolescents was 11·9% (10·3–13·8; I^2=99·2%, p<0·0001), based on 46 705 crude infections. Current prevalence was 16·8% (14·0–20·0; I^2=96·7%, p<0·0001; 31 206 crude infections) in females, 7·4% (6·3–8·8; I^2=97·0%, p<0·0001; 15 122 crude infections) in males, and 12·3% (9·6–15·7; I^2=77·9%, p=0·0004; 377 current infections) in mixed-sex samples (figure 2B, appendix p 38). In univariable meta-regression, publication type was associated with the reported chlamydia prevalence, whereby studies of other publication types reported higher prevalence than journal articles (β=0·54, SE=0·25; p=0·031; table). No other significant findings were observed in the meta-regression analyses.

Current gonorrhoea prevalence was assessed in 89 studies, with a pooled population comprising 622 759 individuals who were incarcerated, of whom 504 033 were adults (57 studies),[48,53,56,57,63,65,71,78,79,82,93,97,102,105,106,108,112,129,133–135,137,141,142,149,150,156,159–162,164,171,172,177,181,184,187,189,194,201,214,217–221,223,225,227,233,236–238,242,243,245,252,254] and 118 726 were adolescents (33 studies).[46,47,49,50,61,71,76,84–86,104,109,113,114,127,128,132,136,138,147,148,152,154,174,183,190,192,193,204–206,228,231,241,249] One study provided separate estimates for both age groups.[71] Among the population of 504 033 adults, 167 953 (33·3%) were females (32 studies), 330 418 (65·6%) were males (23 studies), and 5662 (1·1%) were from mixed-sex samples (nine studies). The overall pooled prevalence of gonorrhoea in adults was 1·0% (95% CI 0·6–1·7; I^2=98·1%, p<0·0001), based on a crude number of current infections of 5183. When stratified by sex, current prevalence was 1·5% (0·8–2·7; I^2=97·2%, p<0·0001; 4424 crude infections) in females, 0·4% (0·2–1·1, I^2=98·4%, p<0·0001; 591 crude infections) in males, and 2·2% (0·7–6·4; I^2=97·5%, p<0·0001; 168 crude infections) in mixed-sex samples (figure 3A, appendix p 39). Among adults, univariable meta-regression indicated a small but statistically significant decrease in reported gonorrhoea prevalence with increasing study size (β=–0·00001, SE=0·00; p=0·012; table). No other significant predictors were identified in the meta-regression analysis.

Among the population of 118 726 adolescents, 39 949 (33·6%) were females (22 studies), 75 697 (63·8%) were males (17 studies), and 3080 (2·6%) were from mixed-sex samples (six studies). The overall pooled estimate of current gonorrhoea prevalence in adolescents was 3·5% (2·7–4·4; I^2=96·6%, p<0·0001), based on 3517 crude infections, with estimates of 6·0% (4·5–7·9; I^2=89·3%, p<0·0001; 2053 crude infections) in females, 2·0% (1·4–2·7; I^2=94·5%, p<0·0001; 1393 crude infections) in males, and 2·3% (1·7–3·1; I^2=0·0%, p=0·47; 71 crude infections) in mixed-sex samples (figure 3B, appendix p 40). All heterogeneity analyses indicated no significant differences in the reported prevalence of current gonorrhoea infections across the analysed characteristics (table).

The prevalence of current or previous syphilis was reported in 125 studies, encompassing a total of 694 350 individuals who were incarcerated. Of these, 117 studies reported on 692 923 adults[8,48,51–60,62–65,67–69,72,74,75,77,79,80,82,87,88,90,92,94,95,97–101,103,105–107,110,112,115–121,123,125,133–135,137,139,143–145,149,150,153,155,156,160,162–165,167,168,172,176,177,179,181,182,185,188,189,195–200,202,207,208,210,211,214–216,219–226,230,234,235,238–240,242,244–248,250,251,253–256] and eight studies reported on 1427 adolescents.[111,124,132,136,178,191,228,231] Among the population of 692 923 adults, 103 641 (15·0%) were females (59 studies), 522 133 (75·4%) were males (61 studies), and 67 149 (9·7%) were from mixed-sex samples (23 studies). The overall pooled prevalence of syphilis in adults was 4·5% (95% CI 3·6–5·6, I^2=99·3%, p<0·0001), based on a crude number of current or previous infections of 17 172. Stratified by sex, the prevalence of current or

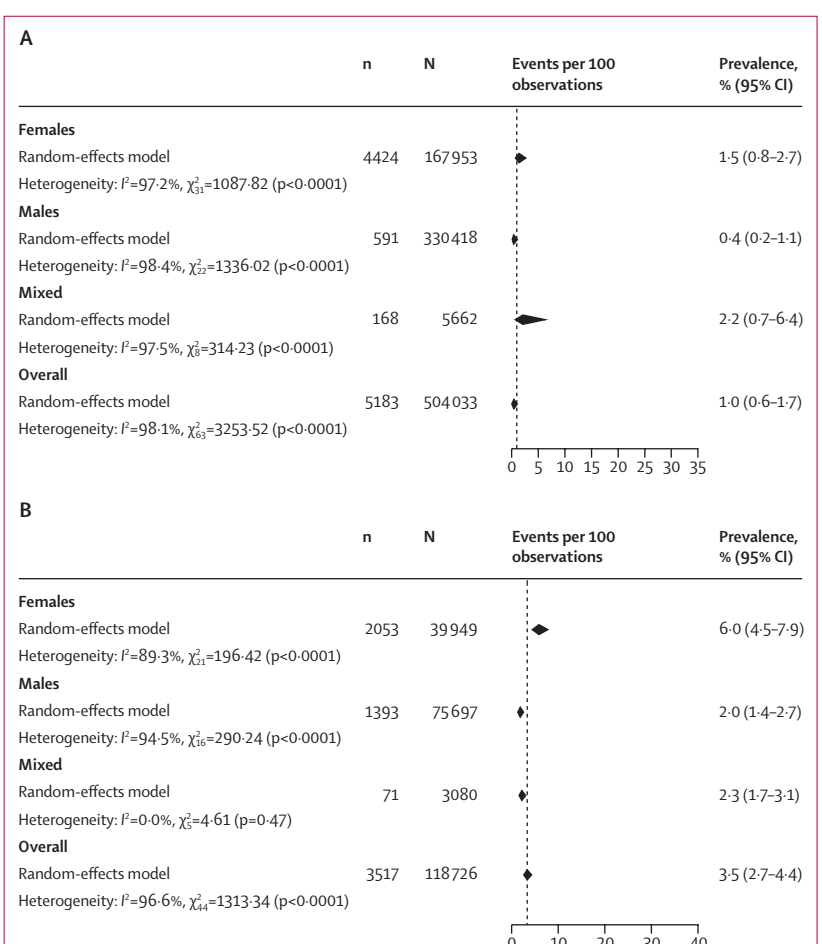

Figure 3: **Prevalence of current gonorrhoea infections in adult (A) and adolescent (B) incarcerated populations**
Pooled prevalence estimates were obtained by mixed-effects meta-analysis. The individual prevalence estimates by study and sex are shown in the appendix (pp 39–40). n=pooled number of cases. N=pooled total sample size.

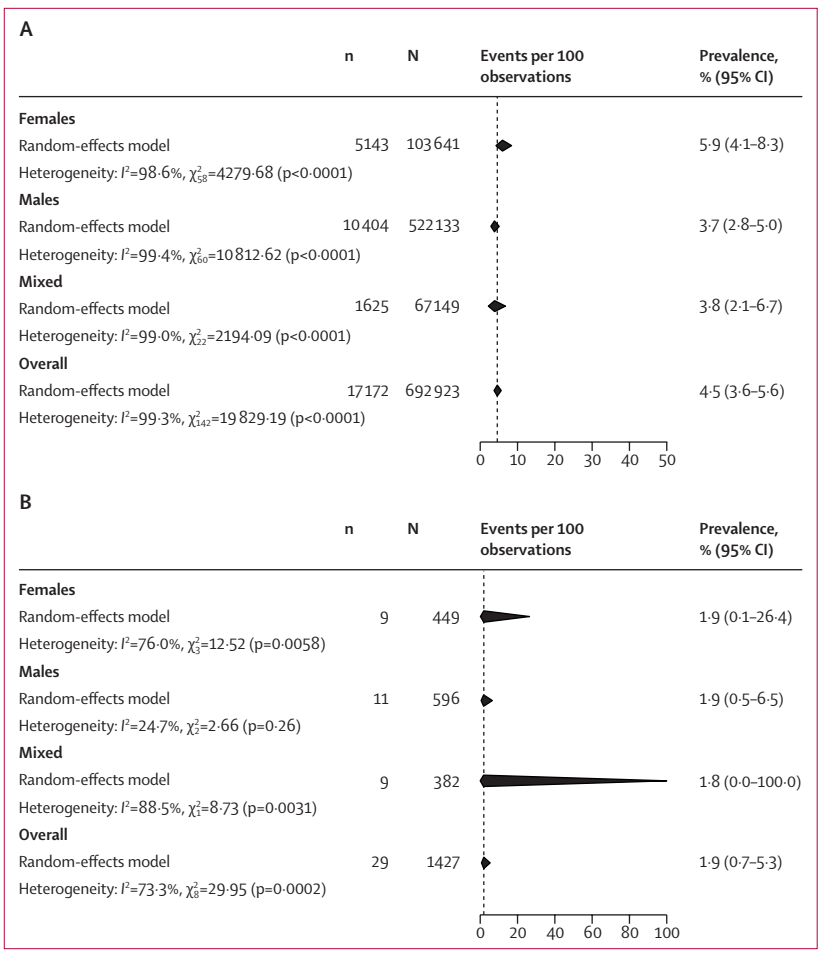

Figure 4: **Prevalence of current or previous syphilis infections in adult (A) and adolescent (B) incarcerated populations**

Pooled prevalence estimates were obtained by mixed-effects meta-analysis. The individual prevalence estimates by study and sex are shown in the appendix (pp 41–42). n=pooled number of cases. N=pooled total sample size.

previous syphilis was 5·9% (4·1–8·3; I^2=98·6%, p<0·0001; 5143 crude infections) in females, 3·7% (2·8–5·0; I^2=99·4%, p<0·0001; 10 404 crude infections) in males, and 3·8% (2·1–6·7; I^2=99·0%, p<0·0001; 1625 crude infections) in mixed-sex samples (figure 4A, appendix p 41). In the subgroup analyses, syphilis prevalence among adults was higher in low-income and middle-income countries (LMICs; 6·9%, 5·2–9·0) than in high-income countries (2·6%, 2·0–3·5; p<0·0001), higher outside the USA (5·3%, 4·1–6·7) than within the USA (2·7%, 1·8–4·0; p=0·0030), and higher in studies published in other languages (8·1%, 5·7–11·5) than English (4·1%, 3·3–5·2; p=0·0009). The univariable meta-regression analyses confirmed these differences (country income level, low or middle *vs* high: β=1·02, SE=0·21, p=0·0001; country, elsewhere *vs* USA: β=0·71, SE=0·25, p=0·0061; and language, other *vs* English: β=0·71, SE=0·34, p=0·038; table). Additionally, increasing study size was associated with slightly lower prevalence (β=–0·00001, SE=0·00, p=0·022). In multivariable meta-regression adjusting for income level, country, language and study size, prevalence remained higher in LMICs (β=1·04, SE=0·27, p=0·0002).

Among the population of 1427 adolescents, 449 (31·5%) were females (four studies) , 596 (41·8%) were males (three studies), and 382 (26·8%) were from mixed-sex samples (two studies). From the limited number of studies on syphilis in adolescents in custody, the overall prevalence of current or previous syphilis was estimated at 1·9% (95% CI 0·7–5·3; I^2=73·3%, p=0·0002), based on 29 crude infections. When stratified by sex, the prevalence of current or previous syphilis was 1·9% (0·1–26·4; I^2=76·0%, p=0·0058; nine crude infections) in females, 1·9% (0·5–6·5; I^2=24·7%, p=0·26; 11 crude infections) in males, and 1·8% (0·0–100·0; I^2=88·5%, p=0·0031; nine crude infections) in mixed-sex samples (figure 4B; appendix p 42). Due to the small number of studies, heterogeneity analyses could not be performed for this group. The results of subgroup analyses by WHO region and World Bank income group were also limited by the small number of studies (appendix pp 35–36).

Sensitivity analyses using basic outlier removal identified several outlying studies across the adult and adolescent samples for each bacterial STI; however, their exclusion did not substantially alter the pooled prevalence estimates (appendix pp 53–57). Studies were flagged as outliers on the basis of large standardised residuals and substantial contributions to between-study heterogeneity. Influence analyses, which assess the impact of individual studies on model fit, identified two influential studies for chlamydia in adults,[91,221] one for chlamydia in adolescents,[204] one for gonorrhoea in adults,[48,53] and one for syphilis in adults[116] (appendix pp 58–85).

The overall quality of studies was moderate (118 [57·3%] of 206 studies) or high (88 [42·7%] studies; appendix pp 45–52). When including quality score in meta-regression analyses, we identified no consistent overarching bias associated with lower quality studies (table). Evidence of publication bias, as indicated by Doi plot asymmetry, was observed for studies of syphilis in adults (t=3·79, p=0·0002). No such evidence was found for the other populations examined (appendix pp 86–91).

Discussion

This systematic review and meta-analysis summarises the global prevalence of bacterial STIs among 1·4 million people in prison and other closed settings. We found a high prevalence of chlamydia, gonorrhoea, and syphilis, which potentially reflects both sexual behaviours that increase the risk of bacterial STIs, and poor access to bacterial STI testing and treatment in carceral and community settings. The overall prevalence of chlamydia was higher than both gonorrhoea and syphilis, in keeping with global trends.[257] Furthermore, the pooled prevalence estimates for chlamydia and gonorrhoea were higher among adolescents than adults,

and the pooled prevalence of each bacterial STI was higher among females than males. These findings, which confirm the higher prevalence of bacterial STIs in carceral settings than in surrounding communities,[258] and the strong association between incarceration and STIs, support WHO recommendations for routine STBBI testing for people in prison and other closed settings.[259]

Given the high prevalence of bacterial STIs among adolescents, opt-out screening for chlamydia, gonorrhoea, and syphilis, should be offered, at minimum, to all individuals aged 19 years or younger upon admission to carceral settings globally. Adolescents in juvenile facilities are more likely to be sexually active than age-matched individuals in the general population,[260] and studies have shown that the prevalence of chlamydia and gonorrhoea in juvenile detention centres is higher than the prevalence among adolescents not involved in the criminal justice system.[261] A recent US systematic review supported these findings,[15] leading to age-based recommendations for bacterial STI screening for people in carceral settings by the US Centres for Disease Control and Prevention.[19] We found that the pooled prevalence of syphilis in adolescents was lower than in adults; however, fewer than 1500 adolescents (only 29 positive cases) contributed data to our analysis of syphilis prevalence, potentially leading to an underestimation or over-estimation of true prevalence. Thus, although our findings support bacterial STI testing for all people in prison and other closed settings, for countries that do not perform routine testing in this key population, adolescents who are incarcerated should be prioritised for chlamydia, gonorrhoea, and syphilis screening given shared risk factors and disease syndemics, unless local youth detention centre data consistently show low yield.

Our findings also support gender-informed public health planning and responses for women and girls who are incarcerated. Females in prison and other closed settings had a higher prevalence of all bacterial STIs compared with males, irrespective of age. Females typically serve shorter sentences than males in prison and other closed settings. Movement in and out of carceral settings can affect vulnerability to infectious diseases, suggesting that public health responses should consider mobility as a driver of STBBI transmission.[262] Females also have a high burden of inter-related and mutually amplifying health conditions related to violence, substance use, and HIV.[263–265] Furthermore, females who are incarcerated have a high prevalence of trauma secondary to childhood abuse or gender-based violence, which are associated with sexual behaviours (including sex work), as well as mental health and substance use disorders.[266,267] Our findings suggest that females who are incarcerated should be offered opt-out bacterial STI screening on admission to carceral settings, considering that this can lead to high treatment uptake,[268] thereby interrupting transmission cycles. Trauma-informed services could encourage females to participate, and offering other services concurrently, including mental health services, might help to address the health and social needs of this population.[24,269,270]

We also identified an increased prevalence of syphilis among adults in LMICs compared with those in high-income countries. However, similar differences were not observed for the other bacterial STIs across subgroups, despite general population estimates suggesting otherwise—whereby more than 90% of bacterial STI cases occur in LMICs.[28,271] This difference likely reflects the modest research conducted and published on bacterial STIs in LMICs,[272] potentially leading to an underestimation of true bacterial STI prevalence.[273] Our findings highlight the urgent need to improve bacterial STI testing and reporting for people in carceral settings in LMICs. Although syndromic management (treating STIs based on patients' signs and symptoms, rather than laboratory-confirmed diagnoses) remains the primary approach in many prisons in LMICs, due to limited and expensive diagnostic testing, this can lead to both missed diagnoses and overtreatment, as bacterial STIs are often asymptomatic.[273]

Effective primary and secondary prevention programmes are needed for both people in carceral settings and for marginalised groups, such as people who use drugs and sex workers in the community, who are over-represented in carceral settings. Innovative service delivery models should be developed to engage these groups effectively.[2] Such models should include interventions to ensure engagement with testing, sex education, and access to harm reduction services, including condoms, dental dams, and pre-exposure and post-exposure prophylaxis for HIV. Cost-effectiveness studies are also needed to establish the optimal frequency of bacterial STI screening post-admission, given that high-risk behaviours might be prevalent during incarceration. Comprehensive screening to include other STIs (eg, HIV and viral hepatitis) should also be considered given the presence of co-occurring infections among people who are incarcerated.[4] Meaningful involvement of people with lived experience of incarceration is essential to inform future research and the development, implementation, and evaluation of bacterial STI services. Finally, effective prevention, diagnosis, and treatment of bacterial STIs will likely have the additional benefit of minimising the transmission and impact of antimicrobial resistance, particularly for *N gonorrhoeae*.[274]

Several limitations of this analysis should be acknowledged. First, inconsistencies in the reporting of diagnostic assays limited the precision of bacterial STI prevalence estimates. This was particularly relevant for syphilis, for which the specific diagnostic test—whether non-treponemal or treponemal—was often unspecified. Thus, we could not always assess diagnostic accuracy or distinguish between current and previous syphilis, as done in previous meta-analyses.[27] Future research should report infection status (ie, current *vs* previous; treated *vs* untreated)

in addition to specifying the diagnostic test used. Second, limited reporting of participant characteristics, particularly age and sex, occasionally required classification according to the predominant age group (adolescent and adult) or sex (female and male) when pooling prevalence estimates. Although this approach ensured consistency, it might have reduced the granularity of the results. Third, substantial heterogeneity was observed across studies and most age and sex groups for all bacterial STIs, likely reflecting differences in detention practices, health-care infrastructure, and environmental factors across prisons and other closed settings.[22] However, subgroup and meta-regression analyses identified few sample or publication characteristics to explain this variability. Nevertheless, sensitivity analyses were generally consistent with the main findings. Fourth, despite efforts to contact authors of primary studies with unavailable raw prevalence data, responses were limited. Consequently, we occasionally had to convert pooled or transformed prevalence data into raw numbers to calculate prevalence estimates. Fifth, although our literature search was extensive and included studies from all seven modified WHO regions, only two eligible studies were conducted in low-income countries. This finding further reinforces the under-representation of LMICs in prison health research,[272,275–277] and highlights the urgent need for high-quality research on bacterial STIs in low-resource settings, where more than two-thirds of the global incarcerated population reside.[9] Sixth, given that our included studies covered only a fraction of the total incarcerated population over 25 years, and that most data were cross-sectional, we were limited to pre-2010 versus post-2010 comparisons, highlighting the need for longitudinal analyses to better understand temporal trends in bacterial STI prevalence. Seventh, race and ethnicity were rarely reported, preventing further disaggregation. Finally, we were unable to generate specific estimates for high-risk groups in carceral settings, such as people living with HIV, people who use drugs, and sex workers, due to insufficient data. These subpopulations are particularly vulnerable to bacterial STIs, underscoring the need for further targeted research to guide evidence-based interventions and policy responses.

In conclusion, the global prevalence of chlamydia, gonorrhoea, and syphilis in incarcerated populations remains high, particularly among adolescent and female populations. Investment is needed to improve sexual health services in the community and reach populations who experience incarceration. In addition, offering opt-out testing and treatment to all people in prison and other closed settings is likely required to achieve the 2030 STBBI elimination goals set by WHO.

Contributors

GB and NK conceptualised the review. GB, SL, and NK planned the analysis. GB conducted the literature search and, with BLH, independently did all the screening and data extraction stages. NK resolved any disagreements over inclusion. GB conducted the formal analysis, drafted tables, and interpreted the findings with NK. GB and BLH accessed the data and verified it with NK. GB drafted the paper, and NK provided initial feedback. BLH, SL, EP, and ACS reviewed, revised, and approved the final manuscript. NK provided overall supervision. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Declaration of interests

SL has received advisory board fees from Gilead Sciences. ACS reports investigator-initiated research funding to her institution from the US National Institute on Drug Abuse and the National Institute of Allergy and Infectious Diseases, the US Health Resources and Services Administration, the Gates Foundation, Health through Walls, and the Southside Medical Centre (Atlanta), all outside of this work. ACS also reports consulting fees from St Joseph's Mercy Care, the Medical Association of Georgia, and the Canadian Network on Hepatitis C, and support for attending meetings and/or travel from Canadian Network on Hepatitis C, the Infectious Disease Society of America, Health through Walls, and the World Health Association. NK reports investigator-initiated research funding from Gilead Sciences, AbbVie, and ViiV Healthcare, and speaker fees from AbbVie, all outside this work. NK also participates on the Data Safety Monitoring Board of the Canadian Institutes of Health Research Pan-Canadian Network for HIV and Sexually Transmitted and Blood Borne Infections Clinical Trials Research. All other authors declare no competing interests.

Data sharing

Data are based on the results of published studies that are cited in this Article, listed in the appendix (pp 4–21), and available online. The protocol for this systematic review and meta-analysis is available online at https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=443370.

Acknowledgments

NK acknowledges support from a career award from the Fonds de recherche Québec – Santé (Junior 2). GB received a McGill Centre for Viral Disease (MCVD) Summer Undergraduate Research Fellowship award (2025). We acknowledge the McGill Centre for Viral Disease and the McGill Interdisciplinary Initiative in Infection and Immunity for supporting this award. We are grateful to the study teams that conducted the included studies, and to all study participants involved.

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