# Epidemiology of Sexually Transmitted Infections Among Offenders Following Arrest or Incarceration

Sarah E. Wiehe, MD, MPH, Marc B. Rosenman, MD, Matthew C. Aalsma, PhD, Michael L. Scanlon, MPH, and J. Dennis Fortenberry, MD, MS

*Objectives.* We sought to estimate rates of sexually transmitted infections (STIs) among criminal offenders in the 1 year after arrest or release from incarceration.

*Methods.* We performed a retrospective cohort study of risk of having a positive STI (chlamydia, gonorrhea, or syphilis) or incident-positive HIV test in the 1 year following arrest or incarceration in Marion County (Indianapolis), Indiana. Participants were 247 211 individuals with arrest or incarceration in jail, prison, or juvenile detention between 2003 and 2008.

*Results.* Test positivity rates (per 100 000 and per year) were highest for chlamydia (2968) and gonorrhea (2305), and lower for syphilis (278) and HIV (61). Rates of positive STI and HIV were between 1.5 and 2.8 times higher in female than male participants and between 2.7 and 6.9 times higher for Blacks than Whites. Compared with nonoffenders, offenders had a relative risk of 3.9 for chlamydia, 6.6 for gonorrhea, 3.6 for syphilis, and 4.6 for HIV.

*Conclusions.* The 1-year period following arrest or release from incarceration represents a high-impact opportunity to reduce STI and HIV infection rates at a population level. (*Am J Public Health.* 2015;105:e26–e32. doi:10.2105/AJPH.2015.302852)

At the end of 2011, more than 2.2 million adults and 70 000 juveniles were incarcerated in the United States, with an additional 4.8 million on parole or probation.[1,2] Adults and juveniles entering correctional facilities have high rates of sexually transmitted infections (STIs), including chlamydia, gonorrhea, syphilis, and HIV[3–12]; however, limited STI and HIV screening and testing services in jails and prisons make estimating the overall prevalence of STIs and HIV difficult.[13] Likewise, the arrested population, even when not detained, has increased risk of STIs.[14] It is likely that many incarcerated and arrested individuals infected with STIs or HIV are never tested or treated, and the burden of disease in this population is underestimated.

Despite extensive research documenting high rates of STIs and HIV among individuals who have interacted with the justice system,[15–22] there are few data on STI and HIV rates in the period following release from incarceration or following arrest ("postincarceration period").[15,23,24] A portion of prevalent STIs and HIV in the postincarceration period is expected to be from undiagnosed or untreated STIs and HIV acquired before or during incarceration, but offenders are also at high risk for acquiring new infections after release. Incarceration disrupts social and interpersonal relations, and individuals in the postincarceration period often engage in high-risk behaviors including unprotected sexual intercourse, concurrent sexual partnerships, and sex for money or drugs.[25–30] Regardless of when such infections are acquired (i.e., before, during, or after incarceration), a better understanding of STI and HIV rates and risk factors in the postincarceration period can inform clinical and public health interventions to reduce the burden of STIs and HIV among recent offenders, their sexual partners, and the communities to which they return.

The objective of this study was to estimate rates of STI, including chlamydia, gonorrhea, syphilis, and HIV diagnosis, and identify risk factors for test positivity among individuals within 1 year after any interaction with the justice system, including arrest or incarceration in Marion County (Indianapolis), Indiana.

## METHODS

We conducted a retrospective cohort study of adults and juveniles with any interaction with the justice system in Marion County, Indiana, including arrest, jail, prison, and juvenile detention (collectively we will refer to these individuals as "offenders"), to assess the test positivity of STIs and incident HIV in the 1-year period after arrest or incarceration. We defined incident HIV infection as the first recorded positive HIV test result. We obtained these data in collaboration with the Marion County Public Health Department, Indiana Department of Corrections, Marion County Courts including the Juvenile Division, Marion County Sheriff's Office, and the City of Indianapolis Department of Public Safety. Juveniles can be held in county-run detention centers or in jails during the preadjudication or predisposition period, depending on the seriousness of their criminal charge(s). We included data on positive STI and HIV test results between January 1, 2000, and May 14, 2009; data on arrest, juvenile detention, and juvenile or adult prison from January 1, 2000, to May 14, 2008; and data on jail from July 1, 2003, to May 14, 2008. Only positive STI or HIV test results were available in the data set. These data capture positive STI and HIV test results from the county. In addition to mandated reporting by clinical providers, Marion County Public Health Department actively seeks all positive results from laboratories where tests are performed.[31] We included all individuals in the criminal justice databases (selecting from the state prison data, only individuals living in Marion County) during the previously listed time periods in the study.

### Study Procedures

We linked individuals from criminal justice databases to public health records at an individual level with identifiers including first, middle, and last name (0.002% missing first name and 0.0002% missing last name); gender

(0.01% missing); month, day, and year of birth (0.1% missing); and social security number (16% missing). We performed linkage by using a probabilistic matching algorithm, which defines a probability that a specific pair of data entries is a true match.[32,33] We performed 5 independent probabilistic matches by using different combinations of the identifiers, in different levels of priority, to help alleviate the possibility that missing data in 1 identifier contributed to a missed true match. Three individuals manually reviewed the pair probabilities from each algorithm output (and the pairs of identifiers side by side) to identify a threshold probability above which was considered a true match. Given each reviewer's distinct threshold, the three collectively reviewed and discussed upper and lower thresholds, and then created additional criteria on which to run supplemental probabilistic matching processes. For example, these steps incorporated how common a first or last name was by race/ethnicity to sort matches among this subset. We ran matches separately for women with decreased emphasis on last name because of the possibility of name change with marriage, as done elsewhere.[34] We repeated the process, including manual validation by all 3 individuals, until we reached a consensus on a subset of true matches.

The resulting file of linked individuals identified many individuals who had criminal justice system involvement and positive tests for STI or HIV. A cross-sectional illustration of all positive STI and HIV data and all arrest or incarceration data for Marion County from 2003 to 2008 with the nexus indicating individuals present in both data sources revealed significant overlap (Figure A, available as a supplement to the online version of this article at http://www.ajph.org). The timing of STI or HIV diagnosis and arrest or incarceration is not reflected in this figure (i.e., test positivity could have occurred before, during, or after incarceration). We used dates of the offenders' arrest or release, and of positive STI and HIV tests performed within the 365 days afterward.

In some cases, within a single incarceration data source, 2 stay records for an individual had the same stay start date but different release dates (0.1% of all justice records). We merged these records to incorporate the shorter stay record into the longer. This phenomenon (same start date, different release date) occurred more often (12.0% of all justice records) when we considered arrest data and various incarceration sources (mostly jail) together. We dropped the corresponding arrest record so as not to double-count these individuals. Finally, depending on the analysis, we de-duplicated the criminal justice event-level data set to identify unique individuals per year (when not stratified by source) or unique individuals per source per year (when stratified by source), as our focus was on the number of individuals incarcerated and infected, rather than the total number of infections.

## Measures

We derived demographic characteristics, including age, gender, and race, from all data sources. We calculated age at first arrest or incarceration during the study period and age at first STI during the study period based on each patient's mode birth year (1.1% mismatched), after removing outliers (n = 3). We calculated history of arrest or incarceration and history of STI based on the 36 months before first arrest or incarceration during the study period. For gender and race, when demographic data did not match within a data source (over time) or between data sources, we chose the characteristic most prevalent (for the individual participant) per source and then in the most sources. Some data sources had limited or no ethnicity data, so we limited racial categories to White, Black, and other or missing for analyses.

The outcome measure for this study was test positivity for chlamydia, gonorrhea, syphilis, or incident HIV infection in the 365-day postincarceration period. The lack of this outcome in any individual does not imply lack of infection, as those with no positive STI or HIV test include individuals who tested negative as well as individuals not tested. The vast majority of chlamydia and gonorrhea assays were nucleic acid amplification tests on urine, cervical swab, or urethral swab specimens,[35,36] though the type of test was not always specified. When we interpreted chlamydia and gonorrhea test results within the database, we defined positivity according to standard clinical guidelines. We defined syphilis test positivity with the rapid plasma reagin test or venereal disease research laboratory test as an antibody titer less than 1:8.[37,38] We included only 1 positive syphilis test in the postincarceration period, to avoid potential double-counting of the same infection. We defined incident HIV infection as a positive enzyme-linked immunosorbent assay test with a confirmatory Western blot.

## Analyses

We restricted all analyses to dates of arrest or release in the time frame July 1, 2003, to May 14, 2008, to account for the period for which data were available from all sources (referred to as "study period"). We calculated descriptive statistics by using demographic characteristics at first arrest or incarceration during the study period, criminal justice history, and STI history. We calculated annual chlamydia, gonorrhea, syphilis, and HIV positivity rates (per 100 000 individuals) by demographic characteristics and justice system category (arrest, jail, adult prison, juvenile detention, and juvenile prison). We did not include positive test results before or during incarceration. We counted a positive HIV test in the study period among individuals with no previous positive HIV test based on clinical data dating back to 1996, and we excluded subsequent positive HIV tests in analyses to avoid double-counting HIV infection.

We also calculated annual STI and HIV positivity rates among all individuals in Marion County who had not been arrested or incarcerated ("non-offenders") by excluding those who had been arrested or incarcerated that year from county population-level data. We calculated STI and HIV positivity among non-offenders for the same period (July 1, 2003, to May 14, 2008) and averaged to calculate an annual rate, as done for calculations of STI and HIV positivity among offenders. We calculated population denominators by using mean annual values from the 2005–2008 American Community Survey data.[39]

We compared STI and HIV positivity rates by calculating relative risks (RRs), attributable risk percentages (AR%s), and population attributable risk percentages (PAR%s) by using STI positivity data for offenders versus non-offenders. We assessed significance with 95% confidence intervals (CIs). We only included individuals once per year for RR, AR%, and PAR% calculations. For example, if an

individual was incarcerated multiple times in 1 year and had 1 chlamydia infection in that year, this individual was only included as 1 person with chlamydia infection in calculating the rate among offenders with at least 1 chlamydia infection that year.

## RESULTS

From 2003 to 2008, 247 211 unique individuals were arrested or incarcerated in Marion County, Indiana, and we included these for analyses. This cohort was disproportionately male (67%) and Black (38%; Table 1), compared with the Marion County population (male: 49%; Black: 25%). Recent offenders were also younger than the general population. Individuals who had a history of both incarceration and STI before the study period were younger at baseline (23 years) compared with those with either only a history of incarceration (31 years) or only a history of STI (26 years). Approximately half had been arrested and 39% had been to jail at least once before incarceration during the study period. The mean and median numbers of interactions with the justice system, among those with at least 1 interaction, were 1.9 and 1, respectively. Among those who were detained, the median length of stay was 4 days (interquartile range = 2–30 days). Twenty-two percent had a previous positive test result for chlamydia, 11% for gonorrhea, and 3% for syphilis.

### Annual Positivity Rates of STI and HIV Among Offenders

Rates of STI and incident HIV in the 1 year following arrest or incarceration were higher than for nonoffenders, but rates varied by demographic characteristics and type of detention facility (Table 2). Rates were highest for chlamydia (2968 per 100 000) and for gonorrhea (2305 per 100 000), and lower for syphilis (278 per 100 000) and HIV (61 per 100 000).

Rates were between 1.5 to 2.8 times higher among women compared with men and 2.7 to 6.9 times higher among Blacks compared with Whites. By age, rates of chlamydia and gonorrhea were highest among individuals aged 15 to 19 years, and rates of syphilis were highest among individuals aged 45 to 54 years. The highest rates for incident HIV were among individuals aged 20 to 44 years. Individuals incarcerated in juvenile detention and juvenile prison facilities had higher rates of chlamydia and gonorrhea in the postincarceration period than did individuals from adult correctional facilities (Table 3). Compared with individuals from adult prisons and jails, individuals who were arrested but not detained had higher annual test positivity rates for chlamydia, gonorrhea, and syphilis.

### Infection Rate Comparisons Between Offenders and Nonoffenders

Recent offenders had similar demographic patterns but higher STI and HIV positivity rates across all groups compared with nonoffenders (Table 4). Recent offenders had higher risk for chlamydia (RR = 3.9; AR% = 74), gonorrhea (RR = 6.6; AR% = 85), syphilis (RR = 3.6; AR% = 72), and HIV (RR = 4.6; AR% = 78). Among offenders, women had higher rates of all STIs compared with men, whereas among nonoffenders, women had lower rates of syphilis and HIV compared with men. The relative risks of White offenders to nonoffenders was higher (chlamydia = 3.6; gonorrhea = 6.7; HIV = 3.4) compared with the relative risks of Black offenders to nonoffenders (chlamydia = 2.6; gonorrhea = 3.8; HIV = 1.5) except for syphilis. The STI relative risks of offenders to nonoffenders younger than 14 years is particularly noteworthy (chlamydia = 45.3; gonorrhea = 79.3; syphilis = 52.0). The low RR and AR% among offenders compared with nonoffenders aged 20 to 24 years was likely attributable to the high proportion of male offenders in this age group that masked the risk among offenders. This finding prompted post-hoc analyses stratified by both gender and age for the group aged 15 to 24 years. This revealed high RR and PAR% for male juveniles aged 15 to 19 years.

Among demographic groups with high arrest and incarceration rates, PAR%s were high, particularly for chlamydia and gonorrhea among men and younger adults. The PAR%s were also high for older adults, women, and Whites, subsets who have lower rates of arrest and incarceration. The PAR%s for HIV among women (30%) and for chlamydia and gonorrhea among men (37% and 38%, respectively) were particularly high.

## DISCUSSION

Individuals who were recently arrested or released from incarceration had high rates of test positivity for STI and incident HIV. Demographic factors associated with increased STIs and HIV risk were similar among offenders and nonoffenders in Marion County

**TABLE 1—Cohort Characteristics: 247 211 Individuals With Arrest or Incarceration in Jail, Prison, or Juvenile Detention: Marion County, Indiana, 2003–2008**

| Characteristic | % or Mean ±SD |
|---|---|
| Race | |
| White | 54 |
| Black | 38 |
| Other or missing | 8 |
| Gender | |
| Male | 67 |
| Female | 33 |
| Age, y | |
| 7–17 | 10 |
| 18–24 | 32 |
| 25–34 | 28 |
| 35–44 | 18 |
| 45–54 | 9 |
| 55–64 | 2 |
| 65–100 | 1 |
| Missing | 1 |
| Age at baseline, y | 29.7 ±11.7 |
| Age of first offense during the study period, y | 30.5 ±11.5 |
| Age of first STI during the study period, y | 26.0 ±10.7 |
| History of offense | |
| Adult DOC | 12 |
| Juvenile DOC | 2 |
| Jail | 39 |
| Arrest | 49 |
| Juvenile detention | 6 |
| History of STI | |
| Chlamydia | 22 |
| Gonorrhea | 11 |
| Syphilis | 3 |
| HIV | 0 |

*Note.* DOC = department of corrections; STI = sexually transmitted infection.

**TABLE 2—Annual Sexually Transmitted Infection and HIV Positivity Rates per 100 000 Individuals of Offenders Recently Released and Nonoffenders: Marion County, Indiana, 2003–2008**

| Characteristic | Offenders Recently Released | | | | Nonoffender Population | | | |
|---|---|---|---|---|---|---|---|---|
| | Chlamydia | Gonorrhea | Syphilis | HIV | Chlamydia | Gonorrhea | Syphilis | HIV |
| Total | 2 968 | 2 305 | 278 | 61 | 759** | 350** | 77** | 13** |
| Race | | | | | | | | |
| White | 1 421 | 846 | 70 | 32 | 394** | 126** | 44* | 9** |
| Black | 4 331 | 3 678 | 482 | 86 | 1 635** | 969** | 152** | 57 |
| Gender | | | | | | | | |
| Male | 1 984 | 1 788 | 182 | 50 | 342** | 302** | 86** | 23** |
| Female | 5 393 | 3 227 | 512 | 74 | 1 124** | 396** | 69** | 5** |
| Age, y | | | | | | | | |
| ≤ 14 | 3 128 | 1 579 | 89 | 30 | 69** | 20** | 2** | 0** |
| 15–19 | 7 019 | 4 079 | 146 | 30 | 3 629** | 463** | 44** | 9 |
| 20–24 | 4 531 | 3 231 | 142 | 64 | 5 613** | 2 189** | 141 | 37 |
| 25–34 | 2 277 | 2 017 | 259 | 64 | 1 373** | 740** | 128** | 25** |
| 35–44 | 850 | 1 153 | 361 | 65 | 251** | 258** | 124** | 28* |
| 45–54 | 414 | 595 | 366 | 34 | 75** | 121** | 85** | 15 |
| 55–100 | 145 | 248 | 280 | 10 | 13** | 24** | 80** | 4 |
| Gender–age (y) group | | | | | | | | |
| Male 15–19 | 5 414 | 3 609 | 97 | 27 | 750** | 391** | 27* | 9 |
| Female 15–19 | 12 130 | 5 608 | 305 | 38 | 6 683** | 2 077** | 64** | 10 |
| Male 20–24 | 3 426 | 2 795 | 106 | 73 | 2 745** | 1 845** | 117 | 72 |
| Female 20–24 | 8 602 | 4 837 | 275 | 33 | 8 232 | 2 703** | 175 | 20 |

*$P < .05$; **$P < .01$; $P$ values for difference between offenders and nonoffenders.

and in the United States, with individuals who were young, female, and of minority race at greatest risk.[40] The risk of syphilis was particularly high among Black and female offenders, and the high prevalence of STI among juvenile offenders is noteworthy but consistent with previous research.[17,41–43] With respect to the differences by race, it is important to consider these findings in the context of disproportionately increased representation of minorities in the justice system and decreased representation in the health care system.[44,45]

Although we did not have access to sexual behavior data, studies suggest that individuals practice high-risk sexual behaviors after release that put them at greater risk for STI and HIV.[46–48] Two small prospective studies among 178 men released from prison[23] and 190 women released from jail[24] found that 26% of men tested positive for chlamydia, gonorrhea, trichomoniasis, syphilis, or hepatitis C, and 10% of women tested positive for chlamydia, gonorrhea, or trichomoniasis at 6 months after release. A population-based study among 2136 Baltimore, Maryland, residents found that self-reported incarceration in the past year was associated with a positive test for STI among men and women; however, the association was not statistically significant after controlling for sociodemographic characteristics and drug use.[15] Our study adds to the limited literature on postincarceration STI and HIV and provides some of the most robust data on postincarceration rates of chlamydia, gonorrhea, syphilis, and incident HIV infection in a major metropolitan area.

**TABLE 3—Annual Positivity Rates per 100 000 Individuals of Sexually Transmitted Infection and HIV by Incarceration Source 1 Year After Release: Marion County, Indiana, 2003–2008**

| Incarceration Source | Chlamydia | Gonorrhea | Syphilis | HIV |
|---|---|---|---|---|
| Adult prison | 1871 | 2137 | 245 | 38 |
| Arrest | 3141 | 2276 | 329 | 53 |
| Jail | 2542 | 2295 | 239 | 57 |
| Juvenile prison | 9290 | 6193 | 191 | . . . |
| Juvenile detention | 6868 | 3345 | 108 | 31 |

Corrections-based STI and HIV services vary significantly by setting and geographic location,[13,49,50] though there is a comprehensive Centers for Disease Control and Prevention monograph on HIV testing implementation in correctional settings.[51] In our setting, individuals entering prison facilities were universally screened for HIV, and studies show that acquisition of HIV infection within prison is rare.[52,53] Therefore, in this study, HIV positivity following release from prison likely reflects infections acquired after release.

In jail and juvenile detention settings, HIV testing is available but individuals must ask to be tested or must opt in to testing programs; therefore, for those released from jail or detention, we are less confident about when HIV infection occurred. For chlamydia, gonorrhea, and syphilis, testing in all settings (i.e., prison, jail, and juvenile detention) is provided by an opt-in system. Furthermore, short stays limit the opportunity for delivering services in jail settings, and those who are arrested but not detained may have limited access to testing and treatment services through the justice system.

Our findings support using interaction with the justice system, whether for arrest or incarceration, as an indicator for STI and HIV screening in subsequent clinical interactions, to detect and treat infections acquired before, during, or after arrest or incarceration. We recommend that more linkages be created between the public health and justice systems. This might include opt-out testing and active follow-up for individuals released from incarceration (i.e., through probation and parole agencies) as well as in correctional facilities. Moreover, resources are needed to improve testing rates among recent arrestees. This could be accomplished through partnerships with pretrial services agencies or law enforcement agencies that operate facilities in which offenders are detained briefly immediately following arrest, such as was successfully done for juvenile arrestees.[54]

**TABLE 4—Relative Risks, Attributable Risk Percentages, and Population Attributable Risk Percentages of Offenders Compared With Nonoffenders: Marion County, Indiana, 2003–2008**

| | Relative Risk | | | | Attributable Risk Percentage | | | | Population Attributable Risk Percentage | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Chlamydia | Gonorrhea | Syphilis | HIV | Chlamydia | Gonorrhea | Syphilis | HIV | Chlamydia | Gonorrhea | Syphilis | HIV |
| Total | 3.9 | 6.6 | 3.6 | 4.6 | 74 | 85 | 72 | 78 | 17 | 28 | 15 | 20 |
| Race | | | | | | | | | | | | |
| White | 3.6 | 6.7 | 1.6 | 3.4 | 72 | 85 | 37 | 71 | 13 | 25 | 3 | 12 |
| Black | 2.6 | 3.8 | 3.2 | 1.5 | 62 | 74 | 69 | 34 | 18 | 28 | 23 | 7 |
| Gender | | | | | | | | | | | | |
| Male | 5.8 | 5.9 | 2.1 | 2.2 | 83 | 83 | 53 | 54 | 37 | 38 | 12 | 13 |
| Female | 4.7 | 8.2 | 7.4 | 14.4 | 79 | 88 | 86 | 93 | 11 | 19 | 17 | 30 |
| Age, y | | | | | | | | | | | | |
| ≤ 14 | 45.1 | 79.2 | 52.0 | . . . | 98 | 99 | 98 | . . . | 34 | 47 | 37 | 100 |
| 15–19 | 1.9 | 8.8 | 3.3 | 3.3 | 48 | 89 | 70 | 70 | 10 | 49 | 22 | 22 |
| 20–24 | 0.8 | 1.5 | 1.0 | 1.7 | ND | 32 | 1 | 42 | ND | 11 | 0 | 16 |
| 25–34 | 1.7 | 2.7 | 2.0 | 2.5 | 40 | 63 | 51 | 60 | 9 | 21 | 14 | 19 |
| 35–44 | 3.4 | 4.5 | 2.9 | 2.3 | 70 | 78 | 66 | 56 | 20 | 26 | 16 | 12 |
| 45–54 | 5.5 | 4.9 | 4.3 | 2.2 | 82 | 80 | 77 | 55 | 21 | 19 | 17 | 7 |
| 55–100 | 11.1 | 10.4 | 3.5 | 2.4 | 91 | 90 | 71 | 59 | 11 | 10 | 3 | 2 |
| Gender–age (y) group | | | | | | | | | | | | |
| Male 15–19 | 7.2 | 9.2 | 3.6 | 3.0 | 86 | 89 | 72 | 67 | 54 | 61 | 33 | 28 |
| Female 15–19 | 1.8 | 2.7 | 4.7 | 3.8 | 45 | 63 | 79 | 74 | 5 | 9 | 19 | 15 |
| Male 20–24 | 1.2 | 1.5 | 0.9 | 1.0 | 20 | 34 | ND | 1 | 75 | 83 | 76 | 88 |
| Female 20–24 | 1.0 | 1.8 | 1.6 | 1.7 | 4 | 44 | 36 | 42 | 19 | 30 | 66 | 53 |

*Notes.* ND = not defined.

For designing and implementing interventions, it is critical to understand where offenders are accessing care in community-based settings[55,56]; however, we did not have data on the location where recent offenders were tested for STI and HIV. A few studies have shown that emergency departments are a common access point for this population, especially for offenders with HIV and substance abuse issues,[57–59] and may represent an important setting in which to increase STI and HIV testing and treatment. A lack of health insurance, suspension from Medicaid benefits, and irregular sources of care among offenders likely lead to reduced access to primary care and STI and HIV testing services.[60,61] More data are needed on points of clinical interaction with this population and, if they do access care, on if they are being appropriately screened and treated for STI and HIV.

## Limitations

There are several limitations of this study. First, our data only included positive STI and HIV test results from the year after arrest or incarceration. It is unclear how many individuals were tested in our cohort, and depending on the positivity rate among those tested or untested and whether these proportions were different by those recently arrested or incarcerated, the difference between groups could either be accentuated or attenuated. There are also possible biases in our comparison of STI and HIV positivity among offenders and nonoffenders because of differences in testing rates, access to testing services, and likelihood of capturing positive test results. It is important to point out, however, that among a population for whom annual chlamydia screening for sexually active young women is recommended and monitored as a quality measure,[62,63] young women aged 15 to 19 years who had been arrested or incarcerated had significantly higher rates of positive tests compared with nonoffending women, though those aged 20 to 24 years did not.

Second, we were not able to differentiate among infections acquired before, during, or after arrest or incarceration. Undoubtedly, there were infections acquired before arrest or incarceration that were identified following arrest or release (misclassification of when the infection occurred). Even so, our findings are relevant for public health and suggest that (1) opt-in testing programs are not effectively testing and treating STI in detention settings, and (2) individuals are at high risk for STI and HIV in the immediate period following release or arrest. This inability to pinpoint the timing of infection may influence our results for syphilis, in that we did not compare the postincarceration titer with previous titers. We may also have included individuals with false-positive serology results. Still, as almost all individuals with titers less than 1:8 in the postincarceration period (including those with previously treated syphilis) may be at high risk and will need follow-up titers in any event, we include the analyses of syphilis, subject to this limitation.

Third, in-and-out migration could have led to missed diagnoses for individuals tested and

diagnosed outside Marion County, Indiana.[39] If mobility were higher among offenders, this might falsely decrease identified infections, thus biasing our findings toward the null. We also recognize that HIV and chlamydia screening (in various settings including correctional facilities) may have increased during the study period, as a result of Centers for Disease Control and Prevention recommendations and other public health initiatives. However, we are not aware of any new programs during the study years that were designed specifically to increase STI or HIV screening during the postincarceration period. In addition, though we omitted individuals with residential addresses outside Marion County within the prison data source, we may have inadvertently included nonresidents in the other county-specific offender data sources.

Finally, we do not know whether all individuals were appropriately linked. Missing or incorrect data, the use of aliases, or legal name changes particularly among married women may reduce the sensitivity and specificity of record linkages and lead to missed matches. Although probabilistic matching remains the gold standard, we cannot rule out potential biases if the degree of missingness is associated with STI and HIV risk.

## Conclusions

The year following arrest or release from incarceration represents a high-impact opportunity to reduce STI and HIV infection rates at a population level, and interaction with the justice system may be a useful clinical indicator for STI and HIV screening. ■

## About the Authors

*Sarah E. Wiehe, Marc B. Rosenman, and Michael L. Scanlon are with Children's Health Services Research, Department of Pediatrics, Indiana University School of Medicine, Indianapolis. Sarah E. Wiehe and Marc B. Rosenman are also with Regenstrief Institute Inc, Indianapolis. Matthew C. Aalsma and J. Dennis Fortenberry are with Section of Adolescent Medicine, Department of Pediatrics, Indiana University School of Medicine.*

*Correspondence should be sent to Sarah Wiehe, MD, MPH, 410 W 10th St, HS1000, Indianapolis, IN 46202 (e-mail: swiehe@iu.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.*

*This article was accepted July 25, 2015.*

## Contributors

S. E. Wiehe had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. S. E. Wiehe led the origination of study design and the acquisition, analysis, and interpretation of data, and contributed significantly to the drafting and revision of the article. M. B. Rosenman and M. C. Aalsma contributed significantly to the origination of study design, analysis, and interpretation of data and the critical revision of the article for important intellectual content. M. L. Scanlon contributed significantly to the interpretation of data, provided administrative and technical support, and led the drafting of the article. J. D. Fortenberry contributed significantly to the origination of study design, the analysis and interpretation of data, and critical revision of the article for important intellectual content. All authors read and approved the final draft of the article.

## Acknowledgments

The design and conduct of this study was supported by a grant (R21AI084060) to S. E. Wiehe from the National Institute of Allergy and Infectious Diseases.

This work would not have been possible without the collaboration of many partner agencies and individuals. We would like to acknowledge and thank the Marion County Sheriff's Office, especially Lt Col Louis Dezelan, Ron Meadows, and Mark Reynolds (jail data); Marion County Courts, Juvenile Division, especially Judge Marilyn Moores, Gael Deppert, and Jason Melchi (juvenile detention data); Marion County Courts and the City of Indianapolis Department of Public Safety, especially former Director Straub, Lauren Magee Hanley, Mike McConaha, and Jean Ritsema (arrest data); Indiana Department of Corrections, especially Amanda Copeland, Katie Knutson, and Aaron Garner (adult and juvenile prison data); and Marion County Health Department, especially Janet Arno, MD, and Coya Campbell (sexually transmitted infection data), for generously sharing their data and expertise in using these data. We would like to recognize Shawn Hoch's expert management skills with these large and complex data sets. Aaron Burgess and Shawn Hoch assisted with data linkage, which would not have been possible without the expert help of Shaun Grannis, MD, MS, and James Egg.

## Human Participant Protection

This study was approved by the Indiana University institutional review board and review boards from each collaborating agency.

## References

1. Glaze L, Parks E. *Correctional Populations in the United States, 2011*. Washington, DC: US Department of Justice, Bureau of Justice Statistics; 2012.

2. Office of Juvenile Justice and Delinquency Prevention. *Census of Juveniles in Residential Placement 2010*. Washington, DC: US Department of Justice, Office of Justice Programs; 2011.

3. Heimberger TS, Chang HG, Birkhead GS, et al. High prevalence of syphilis detected through a jail screening program. A potential public health measure to address the syphilis epidemic. *Arch Intern Med*. 1993;153 (15):1799–1804.

4. Kahn RH, Mosure DJ, Blank S, et al. *Chlamydia trachomatis* and *Neisseria gonorrhoeae* prevalence and coinfection in adolescents entering selected US juvenile detention centers, 1997–2002. *Sex Transm Dis*. 2005;32(4):255–259.

5. Joesoef MR, Weinstock HS, Kent CK, et al. Sex and age correlates of chlamydia prevalence in adolescents and adults entering correctional facilities, 2005: implications for screening policy. *Sex Transm Dis*. 2009; 36(2 suppl):S67–S71.

6. Satterwhite CL, Joesoef MR, Datta SD, Weinstock H. Estimates of *Chlamydia trachomatis* infections among men: United States. *Sex Transm Dis*. 2008;35(11 suppl): S3–S7.

7. Willers DM, Peipert JF, Allsworth JE, Stein MD, Rose JS, Clarke JG. Prevalence and predictors of sexually transmitted infection among newly incarcerated females. *Sex Transm Dis*. 2008;35(1):68–72.

8. Javanbakht M, Murphy R, Harawa NT, et al. Sexually transmitted infections and HIV prevalence among incarcerated men who have sex with men, 2000–2005. *Sex Transm Dis*. 2009;36(2 suppl):S17–S21.

9. Joesoef MR, Kahn RH, Weinstock HS. Sexually transmitted diseases in incarcerated adolescents. *Curr Opin Infect Dis*. 2006;19(1):44–48.

10. Mertz KJ, Voigt RA, Hutchins K, Levine WC; Jail STD Prevalence Monitoring Group. Findings from STD screening of adolescents and adults entering corrections facilities: implications for STD control strategies. *Sex Transm Dis*. 2002;29(12):834–839.

11. Franklin WB, Katyal M, Mahajan R, Parvez FM. Chlamydia and gonorrhea screening using urine-based nucleic acid amplification testing among males entering New York City jails: a pilot study. *J Correct Health Care*. 2012;18(2):120–130.

12. Solomon L, Flynn C, Muck K, Vertefeuille J. Prevalence of HIV, syphilis, hepatitis B, and hepatitis C among entrants to Maryland correctional facilities. *J Urban Health*. 2004;81(1):25–37.

13. Flanigan TP, Zaller N, Beckwith CG, et al. Testing for HIV, sexually transmitted infections, and viral hepatitis in jails: still a missed opportunity for public health and HIV prevention. *J Acquir Immune Defic Syndr*. 2010; 55(suppl 2):S78–S83.

14. Belenko S, Dembo R, Weiland D, et al. Recently arrested adolescents are at high risk for sexually transmitted diseases. *Sex Transm Dis*. 2008;35(8):758–763.

15. Rogers SM, Khan MR, Tan S, Turner CF, Miller WC, Erbelding E. Incarceration, high-risk sexual partnerships and sexually transmitted infections in an urban population. *Sex Transm Infect*. 2012;88(1):63–68.

16. Robertson AA, Thomas CB, St Lawrence JS, Pack R. Predictors of infection with chlamydia or gonorrhea in incarcerated adolescents. *Sex Transm Dis*. 2005;32(2): 115–122.

17. Pack RP, Diclemente RJ, Hook EW III, Oh MK. High prevalence of asymptomatic STDs in incarcerated minority male youth: a case for screening. *Sex Transm Dis*. 2000;27(3):175–177.

18. Hammett TM, Drachman-Jones A. HIV/AIDS, sexually transmitted diseases, and incarceration among women: national and southern perspectives. *Sex Transm Dis*. 2006;33(7 suppl):S17–S22.

19. Altice FL, Marinovich A, Khoshnood K, Blankenship KM, Springer SA, Selwyn PA. Correlates of HIV infection among incarcerated women: implications for improving detection of HIV infection. *J Urban Health*. 2005;82(2): 312–326.

20. Spaulding AC, Miller J, Trigg BG, et al. Screening for sexually transmitted diseases in short-term correctional

institutions: summary of evidence reviewed for the 2010 Centers for Disease Control and Prevention sexually transmitted diseases treatment guidelines. *Sex Transm Dis.* 2013;40(9):679–684.

21. Rosen DL, Schoenbach VJ, Wohl DA, White BL, Stewart PW, Golin CE. Characteristics and behaviors associated with HIV infection among inmates in the North Carolina prison system. *Am J Public Health.* 2009;99(6):1123–1130.

22. Maruschak L, Beavers R. *HIV in Prisons, 2007–08.* Washington, DC: Bureau of Justice Statistics, US Department of Justice; 2009.

23. Sosman J, Macgowan R, Margolis A, et al. Sexually transmitted infections and hepatitis in men with a history of incarceration. *Sex Transm Dis.* 2011;38(7):634–639.

24. Stein MD, Caviness CM, Anderson BJ. Incidence of sexually transmitted infections among hazardously drinking women after incarceration. *Womens Health Issues.* 2012;22(1):e1–e7.

25. Khan MR, Doherty IA, Schoenbach VJ, Taylor EM, Epperson MW, Adimora AA. Incarceration and high-risk sex partnerships among men in the United States. *J Urban Health.* 2009;86(4):584–601.

26. Khan MR, Wohl DA, Weir SS, et al. Incarceration and risky sexual partnerships in a southern US city. *J Urban Health.* 2008;85(1):100–113.

27. Clark CB, McCullumsmith CB, Waesche MC, Islam MA, Francis R, Cropsey KL. HIV-risk characteristics in community corrections. *J Addict Med.* 2013;7(1):45–51.

28. Adams J, Nowels C, Corsi K, Long J, Steiner JF, Binswanger IA. HIV risk after release from prison: a qualitative study of former inmates. *J Acquir Immune Defic Syndr.* 2011;57(5):429–434.

29. Morrow KM, Project SSG. HIV, STD, and hepatitis risk behaviors of young men before and after incarceration. *AIDS Care.* 2009;21(2):235–243.

30. Grinstead OA, Faigeles B, Comfort M, et al. HIV, STD, and hepatitis risk to primary female partners of men being released from prison. *Women Health.* 2005;41(2):63–80.

31. Overhage JM, Suico J, McDonald CJ. Electronic laboratory reporting: barriers, solutions and findings. *J Public Health Manag Pract.* 2001;7(6):60–66.

32. Grannis SJ, Overhage JM, McDonald CJ. Analysis of identifier performance using a deterministic linkage algorithm. In: *Proc AMIA Symp.* 2002:305–309.

33. Grannis SJ, Overhage JM, Hui S, McDonald CJ. Analysis of a probabilistic record linkage technique without human review. In: *AMIA Annu Symp Proc.* 2003:259–263.

34. National Center for Health Statistics, Office of Analysis and Epidemiology. NCHS 2011 Linked Mortality Files matching methodology. 2013. Available at: http://www.cdc.gov/nchs/data/datalinkage/2011_linked_mortality_file_matching_methodology.pdf. Accessed August 18, 2015.

35. Johnson RE, Green TA, Schachter J, et al. Evaluation of nucleic acid amplification tests as reference tests for *Chlamydia trachomatis* infections in asymptomatic men. *J Clin Microbiol.* 2000;38(12):4382–4386.

36. Van Dyck E, Ieven M, Pattyn S, Van Damme L, Laga M. Detection of *Chlamydia trachomatis* and *Neisseria gonorrhoeae* by enzyme immunoassay, culture, and three nucleic acid amplification tests. *J Clin Microbiol.* 2001;39(5):1751–1756.

37. Ganesan A, Fieberg A, Agan BK, et al. Results of a 25-year longitudinal analysis of the serologic incidence of syphilis in a cohort of HIV-infected patients with unrestricted access to care. *Sex Transm Dis.* 2012;39(6):440–448.

38. Gottlieb SL, Pope V, Sternberg MR, et al. Prevalence of syphilis seroreactivity in the United States: data from the National Health and Nutrition Examination Surveys (NHANES) 2001–2004. *Sex Transm Dis.* 2008;35(5):507–511.

39. US Census Bureau. American Community Survey, 2012, detailed tables; using American FactFinder. Available at: http://factfinder.census.gov. Accessed December 31, 2013.

40. Sexually transmitted diseases surveillance 2011. Atlanta, GA: Centers for Disease Control and Prevention, National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention; 2012.

41. Oh MK, Cloud GA, Wallace LS, Reynolds J, Sturdevant M, Feinstein RA. Sexual behavior and sexually transmitted diseases among male adolescents in detention. *Sex Transm Dis.* 1994;21(3):127–132.

42. Bauer HM, Chartier M, Kessell E, et al. Chlamydia screening of youth and young adults in non-clinical settings throughout California. *Sex Transm Dis.* 2004;31(7):409–414.

43. Kelly PJ, Bair RM, Baillargeon J, German V. Risk behaviors and the prevalence of chlamydia in a juvenile detention facility. *Clin Pediatr (Phila).* 2000;39(9):521–527.

44. Weinick RM, Zuvekas SH, Cohen JW. Racial and ethnic differences in access to and use of health care services, 1977 to 1996. *Med Care Res Rev.* 2000;57(suppl 1):36–54.

45. Sampson RJ, Lauritsen JL. Racial and ethnic disparities in crime and criminal justice in the United States. *Crime Justice.* 1997;21:311–374.

46. Epperson MW, Khan MR, El-Bassel N, Wu E, Gilbert L. A longitudinal study of incarceration and HIV risk among methadone maintained men and their primary female partners. *AIDS Behav.* 2011;15(2):347–355.

47. Khan MR, Behrend L, Adimora AA, Weir SS, Tisdale C, Wohl DA. Dissolution of primary intimate relationships during incarceration and associations with post-release STI/HIV risk behavior in a Southeastern city. *Sex Transm Dis.* 2011;38(1):43–47.

48. Khan MR, Epperson MW, Mateu-Gelabert P, Bolyard M, Sandoval M, Friedman SR. Incarceration, sex with an STI- or HIV-infected partner, and infection with an STI or HIV in Bushwick, Brooklyn, NY: a social network perspective. *Am J Public Health.* 2011;101(6):1110–1117.

49. Parece MS, Herrera GA, Voigt RF, Middlekauff SL, Irwin KL. STD testing policies and practices in U.S. city and county jails. *Sex Transm Dis.* 1999;26(8):431–437.

50. Freudenberg N. *Coming Home From Jail: A Review of Health and Social Problems Facing US Jail Populations and of Opportunities for Reentry Interventions.* Washington, DC: Urban Institute; 2006.

51. Centers for Disease Control and Prevention. *HIV Testing Implementation Guidance for Correctional Settings.* 2009:1–38. Available at: http://www.cdc.gov/hiv/pdf/risk_correctional_settings_guidelines.pdf. Accessed August 18, 2015.

52. Horsburgh CR II, Jarvis JQ, McArther T, Ignacio T, Stock P. Seroconversion to human immunodeficiency virus in prison inmates. *Am J Public Health.* 1990;80(2):209–210.

53. Macalino GE, Vlahov D, Sanford-Colby S, et al. Prevalence and incidence of HIV, hepatitis B virus, and hepatitis C virus infections among males in Rhode Island prisons. *Am J Public Health.* 2004;94(7):1218–1223.

54. Belenko S, Dembo R, Rollie M, Childs K, Salvatore C. Detecting, preventing, and treating sexually transmitted diseases among adolescent arrestees: an unmet public health need. *Am J Public Health.* 2009;99(6):1032–1041.

55. Hawkins AS, O'Keefe AM, James X. Health care access and utilization among ex-offenders in Baltimore: implications for policy. *J Health Care Poor Underserved.* 2010;21(2):649–665.

56. Binswanger IA, Nowels C, Corsi KF, et al. "From the prison door right to the sidewalk, everything went downhill," a qualitative study of the health experiences of recently released inmates. *Int J Law Psychiatry.* 2011;34(4):249–255.

57. Leukefeld CG, Hiller ML, Webster JM, et al. A prospective examination of high-cost health services utilization among drug using prisoners reentering the community. *J Behav Health Serv Res.* 2006;33(1):73–85.

58. Meyer JP, Qiu J, Chen NE, Larkin GL, Altice FL. Frequent emergency department use among released prisoners with human immunodeficiency virus: characterization including a novel multimorbidity index. *Acad Emerg Med.* 2013;20(1):79–88.

59. McCorkel JA, Butzin CA, Martin SS, Inciardi JA. Use of health care services in a sample of drug involved offenders: a comparison with national norms. *Am Behav Sci.* 1998;41(8):1079–1089.

60. Wang EA, Pletcher M, Lin F, et al. Incarceration, incident hypertension, and access to health care: findings from the coronary artery risk development in young adults (CARDIA) study. *Arch Intern Med.* 2009;169(7):687–693.

61. Sered S, Norton-Hawk M. Criminalized women and the health care system: the case for continuity of services. *J Correct Health Care.* 2013;19(3):164–177.

62. Lipton L. Medicaid eligibility termination plagues former inmates. *Psychiatr News.* 2001;36(17):8.

63. Centers for Disease Control and Prevention. Chlamydia screening among sexually active young female enrollees of health plans—United States, 2000–2007. *MMWR Morb Mortal Wkly Rep.* 2009;58(14):362–365.