

1 **Sexually transmitted infections in association with area-level prostitution and drug-**
2 **related arrests**

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25 **KEYWORDS:** sex work, drug-related arrests, ecological, sexually transmitted infections

26
27 **Short Summary**

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29 Our study demonstrates the overlapping but distinctive ways by which communities are
30 differentially represented in STI surveillance data: both prostitution arrests and drug-
31 related arrests are associated with area-level STI rates.

32
33 **Abstract**

34
35 **Objectives:** Examine the mediators and moderators of area-level prostitution arrests
36 and sexually transmitted infections (STI) using population level data.

37 **Methods:** Using justice and public health STI/HIV data in Marion County (Indianapolis),

38 Indiana, over an 18-year period, we assessed the overall association of area-level

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39 prostitution arrests and STI /HIV, and mediators and moderators of the relationship.
40 Point-level arrests were geocoded and aggregated by census block group.
41 Results: Results indicate a positive relationship between numbers of prostitution arrests
42 and area-level STI rates. There was a dose-response relationship between prostitution
43 arrests and STI rates when accounting for drug-related arrests. The highest quintile block
44 groups had significantly higher rates of reported chlamydia (IRR: 3.29, 95% CI: 2.82,
45 3.84), gonorrhea (IRR: 4.73, 95% CI: 3.90, 5.57), syphilis (IRR: 4.28, 95% CI: 3:47,
46 5.29), and HIV (IRR: 2.76, 95% CI: 2.24, 3.39) compared with the lowest quintile. When
47 including drug arrests, the third highest quintile block groups had lower IRR for reported
48 rates of chlamydia (IRR: 1.28, 95% CI: 1.10, 1.49) and gonorrhea (IRR: 1.28, 95%
49 CI:1.06,1.55), indicating that drug arrests mediated the prostitution arrest effect.
50 Conclusions: These findings can inform public health agencies and community-based
51 organizations that conduct outreach in these areas to expand their efforts to include harm
52 reduction and HIV/STI testing for both sex workers and individuals experiencing
53 substance use disorder. Another implication of these data is the importance of greater
54 collaboration in public health and policing efforts to address overlapping epidemics that
55 engage both health and legal intervention.

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64 The authors have no conflicts of interest to disclose.

65

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69

70 **Introduction**

71 Nearly 20 million new sexually transmitted infections (STIs) occur annually in the United

72 States, and they disproportionately affect the incarcerated population, female sex

73 workers, and people who use drugs (PWUD). Female sex workers are among the

74 populations most affected by STIs and HIV globally and domestically. Among female

75 sex workers, rates of STIs range from 9 to 60 times that of the general population,¹⁻³

76 similarly, as many as one in five female sex workers in the United States is HIV positive

77 (95% CI: 13.5%-21.9%).⁴ Female sex workers also commonly participate in injection and

78 non-injection drug use.⁵ Among PWUD via injection, exchanging sex for money or drugs

79 within the past year increased the likelihood of STI nearly fourfold.⁶ For instance,

80 injection drug use among female sex workers increased the likelihood of an active

81 syphilis infection by three times in two US-Mexico border cities.⁷ Injecting and using

82 drugs places female sex workers at elevated risk for acquiring and transmitting STIs

83 within their network, as engaging in high-risk activities such as condomless sex is more

84 likely when actively using drugs.^{6,8,9}

85 Neighborhood factors associated with higher rates of STIs include high incarceration

86 rates, economic disadvantage, and low education levels.¹⁰⁻¹⁴ Drug use and dealing are

87 associated with higher rates of STIs at the individual and neighborhood level.^{13,15}

88 Neighborhoods with known drug markets have highly interconnected network structures

89 which help maintain disease transmission and are also associated with selecting a high-

90 risk sexual partner and having a current infection with a bacterial STI.¹³ Research into the

91 spatial association of neighborhood drug markets and STIs demonstrated an 11% increase
92 in gonorrhea in the local neighborhood and a 27% increase of gonorrhea in adjacent
93 neighborhoods.¹⁴ These results suggest that drug markets and their sexual networks
94 extend beyond the boundaries of census block groups.¹⁴ These studies, however, largely
95 examined only gonorrhea and other STIs may have a different association with drug
96 markets and neighborhoods.

97 The transmission of STIs among sexual networks is largely driven by core transmitters
98 and key social meeting locations (e.g., drug and sex markets).¹⁶ Core transmitters
99 maintain disease rates within populations as they repeatedly acquire and transmit the
100 disease among their network.¹⁷ Core groups have largely been defined by the number of
101 sex partners and network connections within core transmitters networks.^{18,19} In addition
102 to highly connected sexual networks, neighborhoods help explain variations in STI
103 transmission.^{19,20} Variations in STI rates and counts have been observed across and
104 within cities.²¹⁻²³ Recent research examined social meeting places characterized as drug
105 markets, sex markets or a combination of drug and sex markets. Sex markets have been
106 defined as spaces where sex is exchanged for money or drugs, venues included bars,
107 street corners, parks and schools.¹⁶ Results indicate drug markets, sex markets, and
108 drug/sex markets are more likely to be frequented by core transmitters most likely to
109 transmit STIs; and these risk environments may be key drivers in STI transmission within
110 the communities.¹⁶ Less is known about how prostitution and drug-related arrests
111 influence area-level STI rates.

112 Understanding how prostitution and drug-related arrests are associated with STI rates
113 may inform public health and community policing strategies. Therefore, the objectives of

114 this study were to assess the association of area-level sex work and STI infection and
115 examine mediators and moderators of this relationship. Using population-level justice
116 and public health STI data, this study expands prior research by including multiple STIs
117 and examining both prostitution and drug-related arrests over an 18-year time period.

118 **Methods**

119 *Study design and population*

120 We conducted a retrospective cohort study of area-level criminal arrest and STI
121 morbidity for chlamydia, gonorrhea, syphilis, and HIV in Marion County (Indianapolis),
122 Indiana from 2000-2018. Criminal arrest and STI morbidity data were obtained in
123 collaboration with the Indianapolis Metropolitan Police Department and Marion County
124 Public Health Department, respectively.

125 *Measures*

126 The primary predictor measures were area-level prostitution and drug-related arrests. We
127 obtained all arrest data from 2000 – 2018 from the Indianapolis Metropolitan Police
128 Department. The primary exposures of interest were prostitution and drug arrests
129 (n=117,770). Prostitution arrests were defined as any arrest for engaging in transactional
130 sex, and drug arrests were defined as any arrest for drug distribution, paraphernalia, and
131 drug possession. Dual arrests were categorized when an individual was arrested for both
132 prostitution and drug-related offense during the same incident. Point-level prostitution
133 and drug-related arrests were geocoded and aggregated by Census block group. Census
134 block groups were divided into quintiles by prostitution and drug-related arrests, using
135 the first quintile (lowest arrests) as the reference category.

136

137

138 The outcome measure for this study was STI incidence rate ratios, defined as the number
139 of new chlamydia, gonorrhea, syphilis, and HIV diagnoses within Census block groups.
140 We obtained all reported chlamydia, gonorrhea, syphilis, and HIV cases (n=266,868)
141 diagnosed in Marion County from 2000-2018. When two positive tests for the same STI
142 organism occurred for an individual within 30 days of each other,²⁴⁻²⁶ only the initial
143 positive test was included to avoid double counting. We defined co-infection rates as any
144 individual with a positive test for two different STIs within 14 days of each other.
145 Census data moderating factors were aggregated at Census block group level and
146 included race/ethnicity and socioeconomic status. Census block groups were defined by
147 >75% Black and >20% Latino (top decile) and >60% living below 200% of federal
148 poverty line (top quartile). A measure was created to indicate time period (2000-2003;
149 2004-2009; 2010-2013; 2014-2018) to adjust for potential temporal trends.

150 Geocoding

151 Addresses from both STI and arrest data sources were geocoded to street location using
152 ArcGIS v10.8 and Marion County base maps. Among the STI data, 83% of residential
153 addresses (n=222,118) were successfully geocoded, geotagged, and aggregated to their
154 associated Census block group. Cases that did not geocode contained missing address
155 information, were outside Marion County, or the individual was listed as homeless.
156 A total of 98% (n=115,443) were successfully geocoded and aggregated to their
157 associated Census block group. We also geocoded arrestee residential addresses listed in
158 the arrest report and successfully geocoded 75%. The cases that did not geocode

159 contained a non-street address (e.g., Mexico, 123 Main St.), recorded refusal to provide
160 address to the arresting officer, or were listed as homeless.

161 Analysis

162 We calculated population based STI rates per 100,000 for each census block group
163 overall and by year. We performed negative binomial and zero-inflated negative binomial
164 regression models to estimate incident rate ratios (IRR) of each STI. Incidence rate ratios
165 were stratified by 4-year time periods (2000-2003, 2004-2008, 2009-2013,2014-2018),
166 minority and ethnic composition, and poverty level of each Census block group.

167 Density maps were created using a kernel density function (KDF) of point-level data,
168 categorizing along a color gradient (red=highest concentration; blue=lowest
169 concentration). The kernel density algorithm examines each incident point and calculated
170 intensity rates based on how many incidents are clustered near the given incident point.
171 Near incidents are defined as those falling within a predetermined search radius that
172 extends out from the incident point under examination. The KDF was color-coded into
173 quintiles for prostitution arrests, drug arrests, and chlamydia rates. Gonorrhoea, syphilis,
174 and HIV rates are presented based on chlamydia decile cutoffs.

175 **Results**

176 Yearly population rates of STIs indicate trends over the study period. Across all STIs,
177 rates were higher in the early 2000s, dropped between 2009–2012, and have since
178 increased to similar rates seen in the early 2000s (Table 1). Density maps show clusters
179 of prostitution and drug arrests and rates of chlamydia, gonorrhoea, syphilis and HIV in
180 Marion County (Figure 1). Comparing the arrests density maps to the STI density maps,

181 several patterns emerge that suggest associations between prostitution and drug-related
182 arrests and STI incidence rates.

183 The number of prostitution arrests within a census block group was positively correlated
184 with the IRR for all types of STI (Table 2). In an unadjusted model, the highest quintile
185 block groups (i.e., those with the highest density of prostitution arrests) had significantly
186 higher rates of reported chlamydia (IRR: 3.29, 95% CI: 2.82, 3.84), gonorrhea (IRR:
187 4.73, 95% CI: 3.90, 5.57), syphilis (IRR: 4.28, 95% CI: 3.47, 5.29), and HIV (IRR: 2.76,
188 95% CI: 2.24, 3.39) compared with the lowest quintile. When drug arrests were included
189 in the model, the third highest quintile block groups had lower IRR for reported rates of
190 chlamydia (IRR: 1.28, 95% CI: 1.10, 1.49) and gonorrhea (IRR: 1.28, 95% CI:1.06,1.55),
191 indicating that drug arrests mediated the prostitution arrest effect. The top three
192 prostitution quintiles were associated with increased rates of HIV (IRR: 1.43, 95%
193 CI:1.17,1.74; 1.55, 95% CI: 1.22,1.97; 1.48, 95% CI:1.15,1.92) but are also mediated by
194 drug arrests. Other prostitution quintiles were not associated with higher incidence rate
195 ratios for chlamydia, gonorrhea or syphilis when controlling for drug-related arrests.

196 There was evidence of moderation by area racial and ethnic composition, however,
197 differences were observed across STIs. The percentage of Black composition in a census
198 block group moderated the association between sex work and STI incidence rate ratios in
199 the third quintile census block groups for chlamydia (IRR: 1.21, 95% CI:1.05,1.41) and
200 gonorrhea (IRR: 1.23, 95% CI:1.02,1.49) when adjusting for area-level drug arrests,
201 however, the percent of Latino composition in a census block group showed no consistent
202 association.

203 The top two quintiles of dual (prostitution and drug) arrests were positively associated
204 with all STIs. IRR were stronger across all STIs for dual arrests than for prostitution and
205 drug-related arrests (IRR: chlamydia 1.80, 95% CI:1.59, 2.03, gonorrhea 2.11, 95%
206 CI:1.82, 2.45, syphilis 2.09, 95% CI:1.75, 2.49, HIV 1.85, 95% CI: 1.58, 2.16). This
207 relationship was also moderated by census block group composition for Black, Latino,
208 and poverty levels in the top quintile (IRR: chlamydia 1.60, 95% CI: 1.43, 1.78,
209 gonorrhea 1.92, 95% CI: 1.67, 2.21, syphilis 2.00, 95% CI: 1.66, 2.40, HIV 1.77, 95%
210 CI: 1.51, 2.09) (Table 3). We examined co-infection rates within census block groups
211 and differences across four time periods and results from each followed a similar pattern
212 to the results presented above (Appendix A).

213 Incidence rate ratios stratified by census block group minority concentration and poverty
214 showed that the top drug-related arrest quintile had consistently higher rates for all STIs
215 compared to the top prostitution arrest quintile (Appendix B). Associations between area-
216 level minority concentration and poverty and incident rate ratios of STI were strongest in
217 low minority and low poverty block groups overall. In low minority and low poverty
218 block groups, the top quintile of prostitution arrest was significantly associated with
219 higher incidence rate ratios for all STIs (IRR: chlamydia 1.42, 95% CI: 1.18, 1.72,
220 gonorrhea 1.65, 95% CI: 1.32, 2.07, syphilis 1.99, 95% CI: 1.50, 2.63, HIV 1.36, 95%
221 CI: 1.06, 1.76) compared to other population strata. In low minority and low poverty
222 census block groups, dual arrests were significantly associated with higher incidence rate
223 ratios for all STIs (IRR: chlamydia 1.84, 95% CI: 1.59, 2.13, gonorrhea 2.28, 95% CI:
224 1.89, 2.74, syphilis 2.49, 95% CI: 1.94, 3.19, HIV 2.14, 95% CI: 1.70, 2.69), compared to
225 single prostitution or drug-related arrest strata.

226 **Discussion**

227 Using population-level arrest and public health STI data, we examined prostitution and
228 drug-related arrests as they related to risk of area-level STI rates over an 18-year period.
229 STI rates were considerably higher than national rates reported by the CDC. For instance,
230 in 2018 the national rate for chlamydia was 539.9 per 100,000; whereas the Marion
231 County rate was 1,072.7 per 100,000. Marion County had the second highest syphilis rate
232 in the United States in 2000 but dropped to the fiftieth percentile in 2018.²⁷ Our data
233 demonstrate the overlapping but distinctive ways by which communities are differentially
234 represented in STI surveillance data: both prostitution arrests and drug-related arrests are
235 associated with area-level STI rates. However, drug-related arrests substantially mediate
236 the relationship of prostitution arrests and STI area-level infection rates. These data
237 suggest that arrests associated with drug markets and drug use are key determinants in
238 STI transmission.^{6,7,13,14} Since strategies for drug market policing are largely determined
239 at local levels, this indicates – at least from a public health perspective – that STI
240 prevention would benefit from approaches such as formal police-public health
241 partnerships.²⁸

242 Our data also showed the importance of poverty and race in moderating the relationships
243 of arrests and STI. When stratifying by the top half of dual arrests for both prostitution
244 and drug use, these, dual arrests were significantly associated with higher risk of all STIs
245 compared to single prostitution or drug arrest strata in low minority and low poverty
246 census block groups. These findings may indicate key social meeting locations are not
247 necessarily located in the most disadvantaged neighborhoods. As for other cities, core

248 STI transmitters frequented drug markets or sex markets (or both) and locations with
249 coexisting drug and sex markets had the highest transmission risk.¹⁶

250 Spatially, prostitution arrests were more geographically concentrated than drug-related
251 arrests. Prostitution and drug-related arrests, however, are correlated along the same main
252 transportation and commercial corridors in Marion County. Density maps of different STI
253 rates are highly related to one another and are consistent with local and national trends in
254 STI prevalence; the highest densities are for rates of chlamydia, followed closely by
255 gonorrhea, then syphilis and HIV.

256 We also assessed co-infection rates, residential address of arrestee, and changes over time
257 to determine differences in the association between prostitution and drug-related arrests
258 with area-level STI transmission rates. We hypothesized that co-infections would have a
259 stronger relationship with STI infection rates in areas with a higher prevalence of
260 prostitution and drug-related arrests; however, findings were nearly identical to single
261 STI rates, indicating that co-infections may be more driven by individual characteristics
262 than on the area-level environment. This is important because co-infections have
263 implications for higher risk for transmission. Early diagnosis and treatment of STIs can
264 significantly reduce complications that can occur if the infections progress. In fact, STI-
265 infected individuals are two to five times more likely to acquire HIV through sexual
266 contact.²⁹ Likewise, those co-infected with an STI and HIV are more likely to transmit
267 HIV during sexual contact.²⁹

268 Given that individuals arrested for prostitution and drug-related offenses may not
269 necessarily live in the neighborhood in which they are arrested, we examined both the
270 arrest incident address and the residential address listed in the arrest report. Findings were

271 nearly identical, indicating that individuals reside in the area in which they are arrested or
272 that they live in neighborhoods with similar STI infection rates. Lastly, we stratified
273 models by time periods to examine differences across time and results were consistent
274 across different historical intervals within the 18-year study timeframe. All of these
275 stratified analyses which showed consistent relationships between area-level arrests and
276 STI risk point to the robustness of these findings.

277 We did not examine access to health care, so it is unclear whether individuals and
278 communities in this study had equal access to STI testing and clinical care. Studies have
279 shown sex workers often lack health care due to fear of arrest, lack knowledge of testing
280 availability, and life distractions, such as the need to meet basic needs for food, shelter
281 and safety.³⁰ Furthermore, living in a disadvantaged neighborhood often limits access to
282 health care providers and decreases the likelihood of preventative care.³¹ A recent study
283 in Detroit highlighted the complexities of accessing healthcare services when intersecting
284 sex work, drug use, and poverty within individuals lives.³²

285 Our findings suggest that important relationships exist between STI infection and sex
286 work and, to a greater degree, drug-related arrests within specific communities, especially
287 for chlamydia, gonorrhea and HIV. This finding can inform public health agencies and
288 community-based organizations that conduct outreach in these areas to expand their
289 efforts to include harm reduction and HIV/STI testing for both sex workers and
290 individuals experiencing substance use disorder. Co-location of STI screening in
291 community courts,^{33,34} drug courts,³⁵ and syringe services programs³⁶ results in case
292 finding and treatment and are promising approaches for accessing hard to reach

293 populations who are vulnerable to STI. Such an effort could result in conserved resources
294 and better health outcomes.

295 Another implication of these findings is the importance of greater collaboration in public
296 health and policing efforts to address overlapping epidemics that engage both health and
297 legal intervention. Police agencies could provide data to local health departments on
298 areas of high sex work and drug arrests, helping these agencies to better target their
299 already stretched work force.²⁸ Police and public health co-response has proven
300 successful in crisis intervention teams, which comprise police officers and mental health
301 professionals to assist individuals suffering from mental illness.³⁷ Other police-public
302 health partnerships, such as the Cardiff model, have generated new policies and place-
303 based initiatives in violence prevention.^{28,38}

304 Understanding police practices and partnering with law enforcement has important
305 implications for sex workers, PWUD, and STI transmission, as certain policing practices
306 may force PWUD to avoid carrying clean syringes, inject quickly or with unsterile
307 needles which can increase the likelihood of STI transmission.³⁹ Neighborhoods with
308 higher STI rates are also oftentimes the same communities with higher violent crime
309 rates;^{40,41} which has implementations regarding police enforcement. Policing methods
310 such as ‘hot spot’ policing directs more police resources to communities with higher rates
311 of crime;^{42,43} however, individuals may not receive STI testing or other medical services
312 they need within the criminal justice system.⁴⁴

313 There have been advances in policing practices in recent years that seek to link
314 individuals to needed services and not into the justice system. For instance, arrest
315 diversion programs, such as Seattle’s Law Enforcement Assisted Diversion program

316 diverts individuals suspected of low-level drug and prostitution charges to social,
317 medical, and legal services compared to arrest. Results indicate a reduction in future
318 arrest for individuals involved in low-level drug and prostitution activity by nearly 60
319 percent.⁴⁵ Such diversion programs may be an opportunity to implement STI testing
320 among PWUD and sex workers. Syringe service programs have been implemented by
321 many states and aim to reduce infectious disease and improve outcomes for people who
322 inject drugs. Studies suggest police support such programs; however, officer education,
323 training, and understanding legal constraints are needed when implementing such
324 programs.⁴⁶

325 There are several limitations of this study. First, it is an ecological study design that
326 precludes knowing whether individual-level associations in fact exist (ecological fallacy);
327 however, our findings are important for STI surveillance and directing public health
328 resources to specific communities regardless of the causal mechanisms. Second, our data
329 only includes one metropolitan area and therefore may lack generalizability to smaller or
330 larger metropolitan areas. Marion County incorporates three smaller cities with their own
331 police departments. We used arrest data from Indianapolis Metropolitan Police
332 Department, which serves over 90% of Marion County. Census block groups from the
333 three smaller cities were removed from these analyses. Third, prostitution and drug-
334 related arrests do not necessarily reflect sex work and drug activity within an area.
335 Similarly, we do not know how testing was done within these communities during our
336 study timeframe. Although we had a population level of drug-related arrest, we did not
337 assess drug type, quantity, or quality, and differences may exist in regard to STI
338 transmission risk. Fourth, census block groups may not be the best indicator of area-level

339 effect and stronger effects may be observed at smaller levels of geography. Lastly, we
340 were not able to measure access to health care, possible bias in STI testing, or account for
341 community programs which may have been implemented during our study.

342 **Conclusion**

343 Prostitution arrests are associated with STI risk; however, this relationship is mediated by
344 drug arrests. The association between both prostitution and drug arrests and STI
345 incidence rates are strongest in low minority and low poverty communities, likely
346 indicating that high baseline STI prevalence is not moderated by levels of prostitution
347 and drug arrests. These data suggest that important relationships exist between STI risk
348 and sex work and, to a greater degree, drug arrests within communities that could better
349 inform intervention activities.

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