Incarceration and Number of Sexual Partners After Incarceration Among Vulnerable US Women, 2007–2017

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Objectives. To examine whether women's incarceration increases numbers of total and new sexual partners.

Methods. US women with or at risk for HIV in a multicenter cohort study answered incarceration and sexual partner questions semiannually between 2007 and 2017. We used marginal structural models to compare total and new partners at visits not following incarceration with all visits following incarceration and visits immediately following incarceration. Covariates included demographics, HIV status, sex exchange, drug or alcohol use, and housing instability.

Results. Of the 3180 participants, 155 were incarcerated. Women reported 2 partners, 3 or more partners, and new partners at 5.2%, 5.2%, and 9.3% of visits, respectively. Relative to visits not occurring after incarceration, odds ratios were 2.41 (95% confidence interval [CI] = 1.20, 4.85) for 2 partners, 2.03 (95% CI = 0.97, 4.26) for 3 or more partners, and 3.24 (95% CI = 1.69, 6.22) for new partners at visits immediately after incarceration. Odds ratios were similar for all visits following incarceration.

Conclusions. Women had more total partners and new partners immediately and at all visits following incarceration after confounders and loss to follow-up had been taken into account. (*Am J Public Health.* 2020;110:S100–S108. doi:10.2105/AJPH.2019.305410)

Approximately 219 000 women are currently incarcerated in the United States, and nearly 3 times that number are on parole or probation.[1,2] Women's incarceration has increased by 823% since the 1980s[1] and has continued to rise despite recent decreasing incarceration rates among men nationally.[2] The massive increase in women's incarceration has not been evenly distributed across the US population; women involved in the criminal justice system are more likely to be poor, to be non-White, and to have histories of physical and sexual trauma and substance use.[3,4]

Women with histories of incarceration bear a disproportionate burden of sexually transmitted infections (STIs), including HIV, and report higher numbers of sexual partners, more sex exchange, and increased frequencies of concurrent sexual partners relative to women who have never been incarcerated.[4–8]

Although others have described the multiple shared pathways involving jails or prisons and sexual risk behaviors, such as engagement in sex exchange and drug use, both the social ecological framework and network theory suggest mechanisms through which incarceration itself may function as a structural force altering a woman's risk for STIs.[4,9,10] The social ecological model demands an analysis of structural factors; network theory extends this, specifying that STIs in particular must be studied in the context of sexual networks, as a woman's risk is directly affected by her partner's (or partners') risk level as well as the structural and community factors that constrain her sexual network formation.[9,11]

Incarceration is a structural force with specific collateral consequences for women and potential implications for STI and HIV risk. Many women involved in the criminal justice system cycle experience extended periods of engagement with community supervision while on parole or probation, punctuated by repeated short periods of incarceration.[4,12] At reentry into the community, women often experience challenges with economic self-sufficiency after job or housing loss, and previously economically supportive relationships may have ended owing to incarceration.[13] This increased economic vulnerability and financial dependence may result in increased engagement in sex work or a reliance on informal

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transactional relationships, with associated heightened risks of sexual violence and condomless sex.[13–15]

Earlier work has shown associations between women's incarceration and risk for HIV and STI due to high-risk partners.[16] Women who have been incarcerated are more likely to report having multiple sexual partners than women who have never been incarcerated, although some of this effect is explained by drug use.[17,18] Arrest and incarceration in the past 6 months have been associated with having multiple partners and sexual partners who inject drugs or are known or suspected to be living with HIV.[15] The mechanisms underlying these associations are less clear and may mirror the relationship disruption and concentration of risk in networks due to imbalanced sex ratios and decreased availability of lower-risk partners that affect incarcerated men's sexual networks.[19,20]

The relationships between incarceration, high-risk sexual behavior, drug use, and sex exchange are complex, and studies attempting to build a causal connection between incarceration and sexual network structure have been limited by geographically specific samples, cross-sectional designs, and confounding.[15,17,18] Our aim was to examine the effects of women's incarceration on the numbers of total and new sexual partners, accounting for the important confounding factors of sex exchange, housing instability, and drug use. Guided by the social ecological framework and network theory, we hypothesized that incarceration would result in more total and new sexual partners, likely because of changes in social circumstances and sexual networks.

METHODS

The Women's Interagency HIV Study (WIHS) is a geographically diverse, multicenter cohort study of women living with or at risk for HIV; recruitment, retention, and participant characteristics have been described elsewhere.[21] Since initiation of the cohort in 1993, women 25 to 60 years of age have been recruited in 4 waves and participate in biannual study visits. Eligibility criteria have been similar across waves. HIV-seronegative women were eligible for the study if they had

at least 1 high-HIV-risk exposure in the preceding 5 years (STI diagnosis; sex without a condom with 3 or more men; sex with a condom with 6 or more men; trading sex; sex with an HIV-seropositive man; injection drug use or use of crack cocaine, cocaine, heroin, or methamphetamine; or any partner with these risk characteristics). Incarceration questions were added to the WIHS in October 2007, and a question about new sexual partners was added in October 2013.

Eligibility

Women in the WIHS were eligible for this analysis if, between October 2007 and September 2017, they had 3 consecutive visits without an incarceration episode and at least 1 subsequent visit. One of the 3 visits could be a missed visit, and we assumed that women were not incarcerated at missed visits unless the study staff noted that the visit was missed because of incarceration based on information from the participant. Women who died or missed 2 consecutive visits (loss to follow-up) were treated as censored at the last attended visit. Administrative censoring was applied such that women could contribute a maximum of 10 visits to the analysis. Inclusion of more than 10 visits for each woman led to extreme weight distributions (indicating a possible lack of positivity), in part because women recruited into the WIHS in the latest wave could not contribute more than 10 visits.

Overall, 3180 women met the inclusion criteria and contributed 26 890 visits, of which 97.9% (n = 26 351) were nonmissed visits. Because the Los Angeles site was discontinued in 2013, analyses focusing on the new sexual partner outcome did not include participants from that site. Women consented to use of their data as part of their overall WIHS participation.

Measures

The exposure variables were based on reporting yes or no to being incarcerated in a prison or a jail in the preceding 6 months. Study staff indicated visits missed as a result of incarceration. In addition, participants were asked at baseline whether they had previously been incarcerated.

Women responded to a question about the total number of male partners with whom

they engaged in vaginal, oral, or anal sex in the preceding 6 months. Because the distribution of partners was substantially zero and 1 inflated, and because many women rounded their responses, we categorized the outcome into no partners, 1 partner, 2 partners, and 3 or more partners in the preceding 6 months. The distribution of new sexual partners was also zero inflated, and few women indicated having more than 1 new sexual partner in the preceding 6 months. Thus, we used a dichotomous variable indicating no new partners or 1 or more new partners in the preceding 6 months.

Sociodemographic data included age at each visit and race, coded as Black, White, or other. We classified women at their first visit as enrolled in Bronx, NY; Brooklyn, NY; Washington, DC; San Francisco, CA; Los Angeles, CA; Chicago, IL; Chapel Hill, NC; Atlanta, GA; Miami, FL; Birmingham, AL; or Jackson, MS. The 2 New York sites were grouped, as were the southern sites (North Carolina, Georgia, Florida, Alabama, and Mississippi). We dichotomized level of education as completion of less than high school or at least high school. Baseline HIV status was used; 4 women who seroconverted during the study period were considered HIV seronegative. Housing instability was updated at each visit. A woman was considered unstably housed if she reported living in a rooming, boarding, or halfway house; in a shelter or welfare hotel; or on the street.

Sex exchange was assessed at each visit with a question asking whether the respondent had had sex for drugs, money, or shelter in the preceding 6 months. We included 3 substance use variables: hard drug use (crack cocaine, cocaine, heroin, methamphetamines, other opioids, or any injection use), alcohol use (none, 1–7 drinks per week, or more than 7 drinks per week), and marijuana use.

Missing Data

We filled in missing data for alcohol, marijuana, and hard drug use; sex exchange; and unstable housing (3.9%–5.5% of visits) by carrying forward the most recent value (data were carried backward from the nearest subsequent value if there were no prior visit data). Missing data on incarceration status (4.8%–5.6% of visits), history of incarceration

(2.0%–2.7% of visits), and the categorical sexual partner variable (6.0%–6.9% of visits) were multiply imputed (the proportion of missing data by variable is shown in Table A, available as a supplement to the online version of this article at http://www.ajph.org).

We conducted multiple imputation via fully conditional specification for both continuous and categorical variables. The imputation model was as rich as the analytic models and included alcohol, marijuana, and hard drug use; sex exchange; and unstable housing as time-varying predictors and WIHS site, age, HIV status, education, and race as baseline predictors. The weight and analytic models described subsequently were conducted independently with each of 30 multiply imputed data sets, and results were combined via Rubin's method.[22] Although multiple imputation has limitations, including reliance on a missing at random assumption, the proportions of missing data are relatively small.

Statistical Approach

Estimation of the effect of a time-varying exposure on bivariate or multivariate outcomes traditionally relies on generalized logistic regression to model the odds of the outcome at a given time as a function of past exposure history. This approach may be biased if there are time-dependent covariates that both are risk factors for the outcome and predict subsequent exposure and if past exposure history predicts the risk factors. Marginal structural models are estimated via inverse-probability-of-treatment weights (IPTWs) to appropriately adjust for time-dependent confounders affected by earlier exposures.[23] When correctly specified, IPTWs create a pseudo-population wherein any confounding based on covariates included in the weight model has been eliminated (Figure A, available as a supplement to the online version of this article at http://www.ajph.org). The final weighted model uses only the exposure and time to predict the outcome, as confounders are controlled for with the IPTWs, and provides unbiased estimates of the marginal effect of the exposure. Because incarceration (time-varying exposure) could affect the time-varying confounders (e.g., unstable housing), we chose to estimate a marginal structural model. We

selected covariates for the weight and analytic models based on the criminal justice and sexual behavior literature: baseline age,[24,25] race,[26,27] educational attainment,[25,28] HIV status,[6,29] WIHS site,[1,30] and prestudy incarceration.[7] We also used the following time-varying covariates: housing instability,[30,31] sex exchange,[7] drug and alcohol use,[32,33] and prior incarceration.

We defined 2 incarceration exposures. First, we specified that a woman stayed in incarcerated status once she had become incarcerated for the first time during the study period; this exposure (exposure 1) captures the effects of an incarceration at all visits afterward. Second, we specified that a woman could report incarceration in the preceding 6 months at one visit but could switch back to nonincarcerated status at her next visit; this exposure (exposure 2) captures the immediate effect of incarceration. We measured our outcomes at the visit following that in which we measured the exposure to separate them temporally with certainty.

To control for confounding, we created inverse-probability-of-treatment weights for exposures 1 and 2. For each exposure, 2 pooled logistic regression models were fit to obtain predicted probabilities for the numerators and denominators of the treatment weights. Time in all of the models was specified in visits via 3-knot restricted quadratic splines. For the numerator of the weights, pooled logistic regression models were fit predicting exposure based on time in visits. For the denominator of the weights, pooled logistic regression models were fit predicting exposure based on time in visits, baseline covariates, time-varying covariates from the 2 visits prior to the exposure, the outcome from the 2 prior visits, and, for exposure 2 only, the exposure from the 2 prior visits (to preserve temporality). The exposure 1 models incorporated visits up to and including each woman's first incarcerated visit during the study period, and the exposure 2 models included all eligible study visits.

We used stabilized inverse-probability-of-censoring weights to control for potential nonrandom loss to follow-up. We used pooled logistic regression for the numerators and denominators of the weights, both of which represented a woman's probability of not being censored at a given visit. We

included in the denominator model the same covariates as in the models for the treatment weights, except that the current exposure, covariates, and outcome were included in the censoring weights for both exposures.

We calculated the conditional treatment or censor weight for a single visit by taking the ratio of the predicted probabilities of the observed treatment (or censor status) at that visit. The final IPTWs and inverse-probability-of-censoring weights at visit i were created by multiplying each of the conditional treatment or censor weights from a women's first visit through visit i and then multiplying the IPTW and inverse-probability-of-censoring weights for visit i. We examined the distributions of the weights combined across all visits as well as at each visit to confirm that the means of the weights were close to 1 and that there were no extreme weights (Appendix A, available as a supplement to the online version of this article at http://www.ajph.org).

We estimated the effects of incarceration on the number of total and new male sexual partners using weights to address time-varying confounders (time, housing instability, sex exchange, drug and alcohol use, and, for exposure 2, prior incarceration), baseline confounders (age, race, educational attainment, HIV status, WIHS site, and prestudy incarceration), and informative censoring. In the case of 30 multiply imputed data sets for each model, we fit a weighted, generalized logit model for each exposure predicting the categorical number of total male sexual partners with a reference level of 1 partner and exposure and time in visits as predictors. We also fit weighted logistic regression models for each exposure predicting the number of new sexual partners with a reference level of no new partners and exposure and time in visits as predictors. For all models, we used weighted generalized estimating equations to obtain robust standard error estimates, accounting for within-subject correlations. For each model, results were pooled across the data sets. Analyses were conducted with SAS version 9.4 (SAS Institute Inc, Cary, NC).

RESULTS

Baseline characteristics are shown in Table 1. The median age at the start of the study was

TABLE 1—Respondent-Level Baseline Characteristics and Percentages of Respondents With New Male Sexual Partners During the Study Period, by Incarceration Status: United States, Women's Interagency HIV Study (WIHS), 2007–2017

Characteristic	Overall No.	Overall % or Median (IQR)	Incarcerated No.	Incarcerated % or Median (IQR)	Not Incarcerated No.	Not Incarcerated % or Median (IQR)
Total partner sample[a]						
No. of women	3 180		155		3 025	
No. of visits	26 890		1 418		25 472	
Age, y	3 180	44 (37–50)	155	41 (35–47)	3 025	44 (37–50)
Education: high school or more	2 065	64.9	80	51.6	1 985	65.6
Race						
White	594	18.7	20	12.9	574	19.0
Black	2 155	67.8	112	72.3	2 043	67.5
Other	431	13.6	23	14.8	408	13.5
Positive HIV status	2 276	71.6	81	52.3	2 195	72.6
Site						
Bronx, NY	425	13.4	15	9.7	410	13.6
Brooklyn, NY	445	14.0	14	9.0	431	14.3
Washington, DC	362	11.4	16	10.3	346	11.4
Los Angeles, CA	415	13.1	17	11.0	398	13.2
San Francisco, CA	380	12.0	33	21.3	347	11.5
Chicago, IL	366	11.5	32	20.7	334	11.0
Chapel Hill, NC	182	5.7	8	5.2	174	5.8
Atlanta, GA	256	8.1	14	9.0	242	8.0
Miami, FL	133	4.2	1	0.7	132	4.4
Birmingham, AL	106	3.3	3	1.9	103	3.4
Jackson, MS	110	3.5	2	1.3	108	3.6
Incarceration prior to study period[b]	1 235	39.9	116	76.3	1 119	38.0
Exchanged sex in past 6 mo[c]	78	2.5	10	6.5	68	2.3
Alcohol use in past 6 mo						
None	1 761	55.4	67	43.2	1 694	56.0
>0–7 drinks/week	983	30.9	46	29.7	937	31.0
>7 drinks/week	436	13.7	42	27.1	394	13.0
Marijuana use in past 6 mo	592	18.6	47	30.3	545	18.0
Hard drug use in past 6 mo[d]	340	10.7	52	33.6	288	9.5
Unstable housing in past 6 mo	112	3.5	13	8.4	99	3.3
New partner sample[e]						
No. of women	2 532		106		2 426	
No. of visits	20 620		935		19 685	
Age, y	2 532	46 (39–53)	106	42 (36–48)	2 426	47 (39–53)
Education: high school or more	1 701	67.2	49	46.2	1 652	68.1
Race						
White	375	14.8	11	10.4	364	15.0
Black	1 876	74.1	80	75.5	1 796	74.0
Other	281	11.1	15	14.2	266	11.0

TABLE 1—*Continued*

Characteristic	Overall		Incarcerated		Not Incarcerated	
	No.	% or Median (IQR)	No.	% or Median (IQR)	No.	% or Median (IQR)
Positive HIV status	1 786	70.5	56	52.8	1 730	71.3
Site						
Bronx, NY	382	15.1	9	8.5	373	15.4
Brooklyn, NY	380	15.0	11	10.4	369	15.2
Washington, DC	317	12.5	13	12.3	304	12.5
Los Angeles, CA	0	0.0	0	0.0	0	0.0
San Francisco, CA	338	13.4	20	18.9	318	13.1
Chicago, IL	323	12.8	25	23.6	298	12.3
Chapel Hill, NC	185	7.3	8	7.6	177	7.3
Atlanta, GA	257	10.2	14	13.2	243	10.0
Miami, FL	133	5.3	1	0.9	132	5.4
Birmingham, AL	106	4.2	3	2.8	103	4.3
Jackson, MS	111	4.4	2	1.9	109	4.5
Incarceration prior to study period[b]	1 023	41.2	80	75.5	943	39.7
Exchanged sex in past 6 mo[c]	76	3.0	13	12.3	63	2.6
Alcohol use in past 6 mo						
None	1 286	50.8	42	39.6	1 244	51.3
>0–7 drinks/week	883	34.9	35	33.0	848	35.0
>7 drinks/week	363	14.3	29	27.4	334	13.8
Marijuana use in past 6 mo	533	21.1	39	36.8	494	20.4
Hard drug use in past 6 mo[d]	278	11.0	36	34.0	242	10.0
Unstable housing in past 6 mo	88	3.5	7	6.6	81	3.3
One or more new male sexual partners during study period[b]	937	37.0	68	64.2	869	35.8

Note. IQR = interquartile range.

[a]The total partner sample included all WIHS participants who had 3 consecutive visits without incarceration and at least 1 visit following those 3 during the study period (October 2007–September 2017). One of the 3 visits without incarceration could be a missed visit. The study period was determined by the date when incarceration questions were added to the WIHS.

[b]Missing values are excluded.

[c]Exchanged sex for drugs, money, or shelter.

[d]Hard drug use includes use of crack, cocaine, heroin, methamphetamine, injection drugs, or nonprescription narcotics.

[e]The new partner sample included all WIHS participants who had 3 consecutive visits without incarceration and at least 1 visit following those 3 during the study period (October 2013–September 2017). One of the 3 visits without incarceration could be a missed visit. The study period for this analysis was determined by the date when questions about number of new sexual partners were added to the WIHS.

44 years (interquartile range: 37–50 years). The majority of the participants were Black (n = 2155; 67.8%) and had completed high school or more (n = 2065; 64.9%). Women from southern sites represented 24.8% (n = 787) of the sample, and 71.6% of the women were living with HIV (n = 2276). Only a small proportion reported unstable housing at baseline (n = 112; 3.5%). At baseline, 436 women (13.7%), 592 women (18.6%), and 340 women (10.7%) reported drinking more than 7 drinks per week, using marijuana, and using hard drugs, respectively. A total of 2.5% (n = 78) of women reported exchanging sex at baseline, and

fewer than half reported always using condoms. Because the question about new partners was added at a later visit, the study sample for analyses involving that variable was smaller (n = 2532) but was similar to the overall sample (Table 1).

Prior to the study period, 39.9% of the sample had been incarcerated (n = 1235). A total of 155 (4.8%) women were incarcerated during the study period. At the majority of study visits, women had 1 sexual partner (n = 13 419; 53.6%); at only 5.2% (n = 1310) and 3.1% (n = 767) of visits did women report having 2 and 3 or more sexual partners, respectively (Table 2). Women

reported having new sexual partners at 9.3% of visits (n = 1806).

The final weighted outcome model included only incarceration exposure and time as predictors. At all visits following an episode of incarceration during the study period (exposure 1), the odds ratios (ORs) for reporting no partners, 2 partners, and 3 or more partners (relative to 1 partner) were 1.38 (95% confidence interval [CI] = 0.72, 2.66), 1.76 (95% CI = 0.99, 3.13), and 2.16 (95% CI = 1.00, 4.65), respectively (Figure 1). At visits immediately after an incarceration (exposure 2), the odds of reporting no partners, 2 partners, and 3 or

Characteristics by Visit	Total Partner Sample[a]			New Partner Sample[b]		
	Overall, No. (%)	Incarcerated, No. (%)	Not Incarcerated, No. (%)	Overall, No. (%)	Incarcerated, No. (%)	Not Incarcerated, No. (%)
No. of women	3 180	155	3 025	2 532	106	2 426
No. of visits	26 890	1 418	25 472	20 620	935	19 685
Total number of male sexual partners in past 6 mo[c]						
0	9 535 (38.1)	385 (29.3)	9 150 (38.6)	. . .	. . .	. . .
1	13 419 (53.6)	636 (48.5)	12 783 (53.9)	. . .	. . .	. . .
2	1 310 (5.2)	174 (13.3)	1 136 (4.8)	. . .	. . .	. . .
≥ 3	767 (3.1)	117 (8.9)	650 (2.7)	. . .	. . .	. . .
≥ 1 new male sexual partners in past 6 mo[c]	. . .	. . .	. . .	1 806 (9.3)	171 (19.7)	1 635 (8.8)
Frequency of condom use during vaginal sex in past 6 mo[c]						
Always	7 930 (29.5)	322 (22.7)	7 608 (29.9)	5 657 (27.4)	238 (25.5)	5 419 (27.5)
Sometimes	3 691 (13.7)	340 (24.0)	3 351 (13.2)	2 638 (12.8)	221 (23.6)	2 417 (12.3)
Never	5 049 (18.8)	335 (23.6)	4 714 (18.5)	4 003 (19.4)	233 (24.9)	3 770 (19.2)
No vaginal sex in past 6 mo	10 220 (38.0)	421 (29.7)	9 799 (38.5)	8 322 (40.4)	243 (26.0)	8 079 (41.0)
Frequency of condom use during oral sex in past 6 mo[c]						
Always	964 (3.6)	79 (5.6)	885 (3.5)	712 (3.5)	66 (7.1)	646 (3.3)
Sometimes	748 (2.8)	107 (7.6)	641 (2.5)	553 (2.7)	68 (7.3)	485 (2.5)
Never	5 367 (20.0)	367 (25.9)	5 000 (19.6)	3 986 (19.3)	241 (25.8)	3 745 (19.0)
No oral sex in past 6 mo	19 811 (73.7)	865 (61.0)	18 946 (74.4)	15 369 (74.5)	560 (59.9)	14 809 (75.2)
Frequency of condom use during anal sex in past 6 mo[c]						
Always	423 (1.6)	30 (2.1)	393 (1.5)	289 (1.4)	13 (1.4)	276 (1.4)
Sometimes	122 (0.5)	22 (1.6)	100 (0.4)	89 (0.4)	12 (1.3)	77 (0.4)
Never	640 (2.4)	61 (4.3)	579 (2.3)	417 (2.0)	44 (4.7)	373 (1.9)
No anal sex in past 6 mo	25 705 (95.6)	1 305 (92.0)	24 400 (95.8)	19 825 (96.1)	866 (92.6)	18 959 (96.3)

[a]The total partner sample included all WIHS participants who had 3 consecutive visits without incarceration and at least 1 visit following those 3 during the study period (October 2007–September 2017). One of the 3 visits without incarceration could be a missed visit. The study period was determined by the date when incarceration questions were added to the WIHS.

[b]The new partner sample included all WIHS participants who had 3 consecutive visits without incarceration and at least 1 visit following those 3 during the study period (October 2013–September 2017). One of the 3 visits without incarceration could be a missed visit. The study period for this analysis was determined by the date when questions about the number of new sexual partners were added to the WIHS.

[c]Missing values are excluded.

more partners respectively increased by 1.20 (95% CI = 0.66, 2.17), 2.41 (95% CI = 1.20, 4.85), and 2.03 (95% CI = 0.97, 4.26) relative to 1 partner.

The odds ratio for reporting 1 or more new partners versus no new partners at all visits after an episode of incarceration (exposure 1) was 2.15 (95% CI = 1.24, 3.75). For visits immediately following incarceration (exposure 2), the odds ratio was 3.24 (95% CI = 1.69, 6.22; Figure 2). The full output of all of the models is shown in Appendix A. The results were very robust to extreme weights (a sensitivity analysis

with truncated weights is shown in Appendix A).

DISCUSSION

Taken together, our findings suggest that incarceration, both remote and recent, significantly increases the odds of having new sexual partners and, to a lesser extent, may increase the odds of having multiple partners. These results reinforce incarceration as a structural force in women's lives, likely destabilizing their sexual networks and increasing

their exposure to new partners. Our use of weighting to account for loss to follow-up and time-varying confounders such as sex exchange, housing instability, and drug use yields more robust and less biased results than prior estimates. Our results are consistent with prior evidence that women with histories of incarceration are more likely to report multiple partnerships and new partnerships and strengthens causal arguments suggesting that incarceration serves as a structural force shaping women's sexual networks.[15,18]

Our results might be explained by changes in women's sexual networks after an
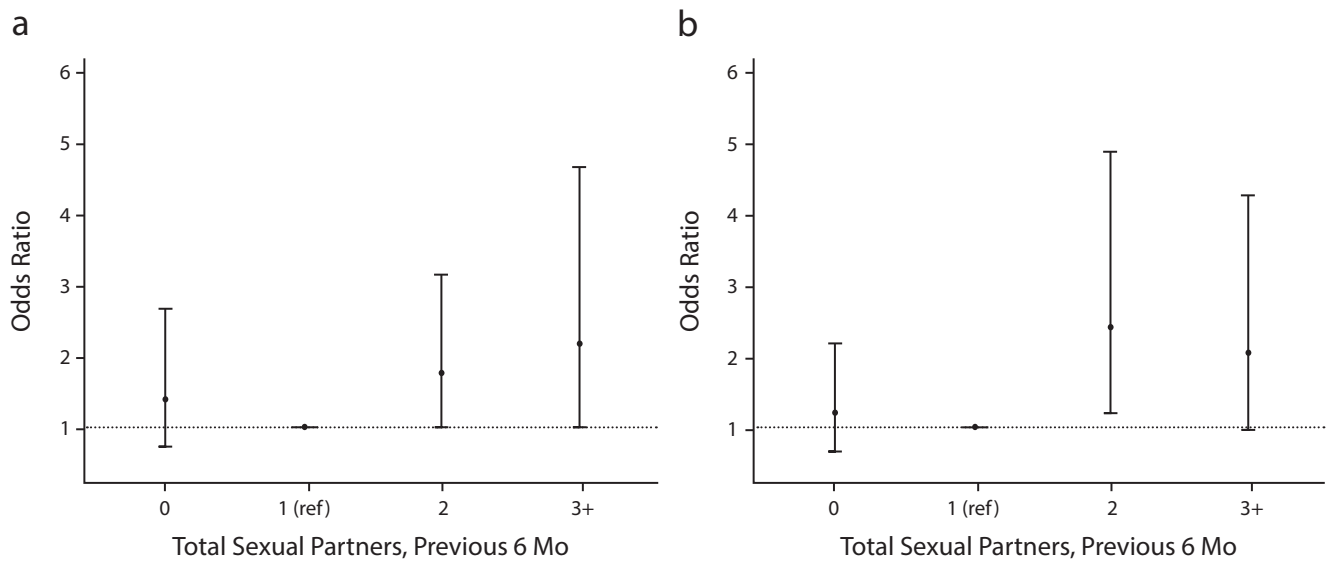
Note. Odds ratios were estimated via marginal structural models, adjusted for time, and weighted to account for age, race, educational attainment, HIV status, WIHS site, sex exchange, housing instability, drug and alcohol use, prestudy incarceration and prior incarceration during the study period, and loss to follow-up. Confidence intervals are shown as black bars. The model in part a compares all visits following an episode of incarceration with visits that do not follow incarceration. The model in part b compares visits immediately following an episode of incarceration with visits that do not immediately follow incarceration.

FIGURE 1—Weighted Adjusted Odds Ratios and 95% Confidence Intervals for No, 2, or 3 or More Total Sexual Partners in the Preceding 6 Months (Relative to 1 Sexual Partner) at (a) All Visits Following an Incarceration and (b) Visits Immediately Following an Incarceration: United States, Women's Interagency HIV Study (WIHS), 2007–2017

incarceration. We included sex exchange as a time-varying confounder in our estimation of the effects of incarceration on new partner acquisition, suggesting an effect of incarceration beyond the mediating role of sex exchange in women's risk of HIV and other STIs postincarceration.[4,13] It is likely that women's existing partnerships were disrupted by incarceration, leading them to form new relationships afterward. This would be consistent with previous work on the effects of men's incarceration on their committed partnerships.[34]

This application of marginal structural models offers important strengths, most significantly adjusting for time-dependent confounders affected by prior exposure and loss to follow-up that have not been included in prior analytic efforts focused on incarceration and patterns of sexual partnership.[15,17,18,23] Using an IPTW framework, however, means that coefficients for confounders are not estimated. Although the marginal structural model approach can contribute to causal arguments, moving beyond observed associations, it did not allow us to examine the strength and significance of associations between confounders and the outcome.

Limitations and Strengths

Although the WIHS is a multisite cohort study with geographically diverse sites, its sample is not nationally representative, which limits the generalizability of our findings. The potential accrual of benefits from behavioral changes or other factors related to years of WIHS participation may attenuate our estimates by buffering the effects of incarceration.[35] In addition, the inclusion of both women living with HIV and women at risk for HIV resulted in a heterogeneous cohort; HIV-seropositive women may have decreased their risk behaviors after their diagnosis, whereas HIV-seronegative women were recruited on the basis of their risk behaviors. Subgroup or stratified analyses by HIV status would be underpowered, and the pooling of data from these groups was a limitation of our study.

Assessments of incarceration in the WIHS are limited, as incarceration questions were not introduced until the median age of participants was 44 years, and fewer than 25% of participants were younger than 35 years. Of imprisoned US women, nearly half (46.3%) are younger than 35 years, and rates of incarceration are higher among younger adults.[26] Almost half of the women in our sample were incarcerated earlier in their lives. In addition, older women report fewer sexual partners than younger women, and future research should focus on how the effects of incarceration might differ in a younger cohort.

Despite these limitations, this study has important strengths. The sample was drawn from sites in 9 US states. The WIHS intentionally recruited HIV-seronegative women who were socioeconomically and racially similar to its HIV-seropositive participants and the general US population of women living with HIV, increasing the generalizability of our findings to women living with and at risk for HIV in the United States.[21] The large sample size and longitudinal design allowed for observation of relatively rare exposures such as incarceration and for temporal sequencing of exposures and outcomes.
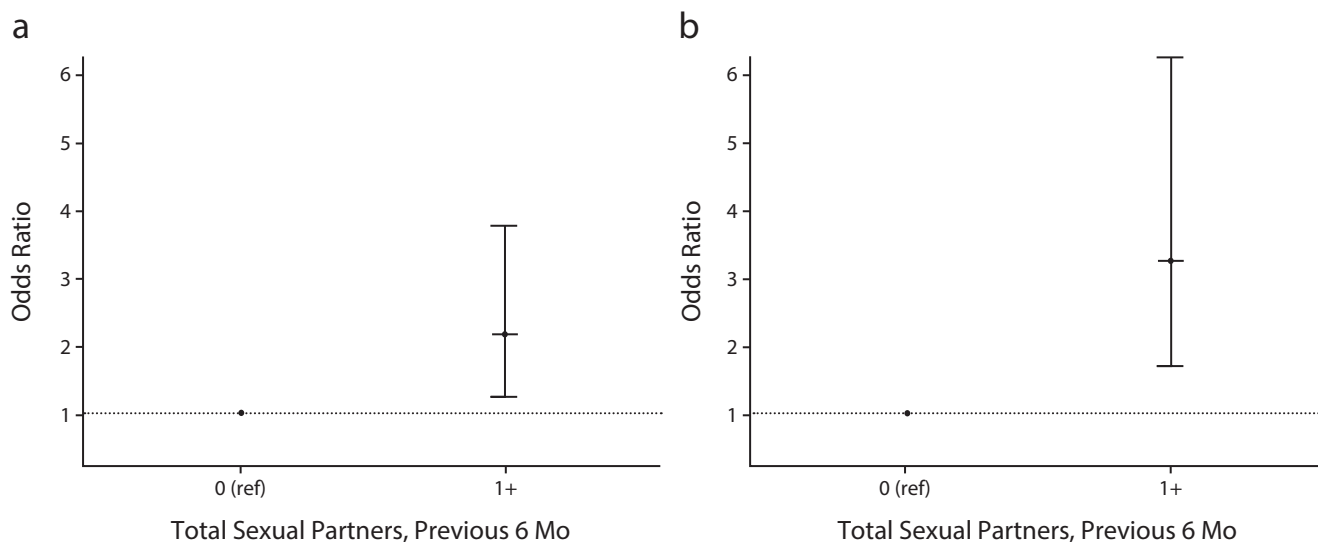
Note. Odds ratios were estimated via marginal structural models, adjusted for time, and weighted to account for age, race, educational attainment, HIV status, WIHS site, sex exchange, housing instability, drug and alcohol use, prestudy incarceration and prior incarceration during the study period, and loss to follow-up. Confidence intervals are shown as black bars. The model in part a compares all visits following an episode of incarceration with visits that do not follow incarceration. The model in part b compares visits immediately following an episode of incarceration with visits that do not immediately follow incarceration.

FIGURE 2—Weighted Adjusted Odds Ratios and 95% Confidence Intervals for 1 or More New Sexual Partners in the Preceding 6 Months (Relative to No New Sexual Partners) at (a) All Visits Following an Incarceration and (b) Visits Immediately Following an Incarceration: United States, Women's Interagency HIV Study (WIHS), 2010–2017

Public Health Implications

Our findings have important implications for HIV and STI risk among women who have experienced incarceration. First, the addition of new sexual partners to women's sexual networks may result in increased exposure to STIs and opportunities for transmitting infection. Only a minority of women in our study reported consistent condom use, reinforcing that new partners result in new exposures. Second, the population of incarcerated women is disproportionately drawn from groups that bear a heavy burden of HIV and other STIs, such as urban and rural Black women, women who are socioeconomically disadvantaged, and women who use drugs, and having new sexual partners who are also from this high-risk milieu may further increase HIV and STI risk.[16]

The results of our analyses extend prior work linking involvement in the criminal justice system to an elevated risk of STIs by contributing to a causal argument that women's incarceration shapes sexual networks through relationship disruption and the formation of new partnerships at the time of community reentry. Incarceration is a social force shaping sexual risk and sexual networks among women living with HIV and women at risk for HIV. To reduce women's risk for STIs and HIV, it will be necessary to use a combined approach of establishing prevention interventions for incarcerated women and decreasing women's exposure to the criminal justice system.

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