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Submission Category: Original Research

Title: Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections among US adults in early and mid-adulthood

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Running Head: Parental Imprisonment and STI Risk in Adulthood

Abstract

Objectives: One-in-six young adults in the U.S. report experiencing the child trauma of parental imprisonment. Prior studies have associated parental imprisonment with risk of sexually transmitted infection (STI); however, potential data and methodological issues may have limited the reliability and accuracy of prior findings. Examining cumulative and longitudinal risk, we address several methodological limitations of prior studies, and also examine comparative risk by gender and ethnicity of the respondents.

Design: A national cohort study from the National Longitudinal Study of Adolescent to Adult Health using (1) a cross-sectional sample of adults at ages 24-32 and (2) a longitudinal sample between ages 18-32. Both analyses estimate odds ratios for STI infection associated with parental imprisonment and examine variation by parent/child gender and respondent ethnicity.

Setting: In-home interviews in the United States at Wave 1 (1994-1995), Wave 3 (2001-2003) and Wave IV (2007-2009).

Participants: 15,684 respondents completing interviews at Wave 1 (ages 12-18) and Wave 4 (ages 26-32), including 8557, including 8556 female, 3437 black, and 2397 respondents reporting parental imprisonment in childhood.

Results: Father only imprisonment is associated with increased odds of 1.26 (95% confidence interval (CI): 1.11, 1.43) of lifetime STI infection and a 1.19 increased odds (95% CI: 1.01, 1.37) of STI infection in the past 12 months between ages 18-32, adjusting for familial, neighborhood, individual, and sexual risk factors. Maternal imprisonment is associated with higher risk of lifetime STI, but the 95% CIs overlapped with 1 adjusted for confounders (95% CI: 0.84, 1.35). Examining predicted probabilities of STI infection, our findings show additive risks for women, blacks, and parental imprisonment.

Conclusion: Adjusting for confounders, only paternal imprisonment is associated with slightly elevated risk of annual and lifetime risk of STI infection. Additive effects show that parental imprisonment modestly increases ethnic and gender risk for STI infection.

Keywords:

Sexually transmitted infections; parental imprisonment; mass incarceration; health status disparities; minority health

Strengths & Limitations

- This study addresses data and methodological issues of prior work to improve accuracy and reliability for estimating the association between parental imprisonment and risk of STI infection
- The study leverages cross-sectional and longitudinal measures to compare lifetime and longitudinal risk
- Comparative analysis is performed to determine potential variations in STI risk by maternal and paternal imprisonment, respondent gender and respondent ethnicity.
- The study lacks measures to determine underlying potential causal factors, such as residential instability and parental criminality that may explain the association.
- While STI self-reports are prospectively collected, data on parental imprisonment is retrospectively collected.

Introduction

Currently, 2.6 million U.S. children have a parent in prison, with 4% of white, 24% of black, and 11% of Hispanic children ever experiencing parental imprisonment.[1] Parental imprisonment is linked to a range of adversities from birth to death, including prenatal exposure to alcohol and drugs, poor academic and educational outcomes, criminal behavior and subsequent imprisonment.[2-4] Parental imprisonment is also associated with health adversities that include sexually transmitted infections (STIs), depression, cardiovascular and metabolic diseases, respiratory conditions, and mortality.[5-8]

Rates of STI infection have generally increased in the U.S. Between 2000 and 2017, chlamydial infection rates doubled from 251.4 to 528.8 per 100,000, while gonorrhea infection rates increased by 75% from 99.1 to 171.9 cases per 100,000 between 2009 and 2017.[9] An STI that is undetected and left untreated may result in a range of chronic health issues such as infertility or adverse birth outcomes (chlamydia, gonorrhea), cervical and testicular cancers (HPV), and mortality (syphilis, HIV/AIDS).[9-11] Increased risk for STIs associated with experiencing parental imprisonment may thus contribute to a range of adverse outcomes later in the lifecourse.

In cross-sectional analyses of the National Longitudinal Study of Adolescent to Adult Health (Add Health), parental imprisonment has been associated with STI infection in adolescence and adulthood.[2,12-14] Further studies have linked STI infection with substance abuse, childhood trauma, early sexual activity, and risky sexual behavior.[2,12-17] These analyses also suggest that women[12] and minorities[14,16] who experience parental imprisonment may be at greater risk for STI infections. Parental imprisonment has also been associated with altered age trajectories for engaging in delinquent behavior and drug use.[18,19] Some research examining cross-sectional risk of STI infection at multiple time points suggests that STI

infection risk associated with parental imprisonment may vary by life stage and be mediated by factors such as child abuse, substance use, or sexual risk taking.[12,14]

While this research suggests parental imprisonment is associated with STI infection, important research gaps remain. First, longitudinal analysis may extend this research to a) determine how the association between parental imprisonment and STI risk may comparatively hold over adulthood, and b) understand the potential confounding or mediating roles of other related factors that can help to mediate STI risk.[20] Second, research is also needed to examine potential STI risk disparities for parental imprisonment by parent/child gender and ethnicity,[5] particularly in light of findings that women and African Americans are more likely to contract an STI.[21-23] Third, most studies have focused on associations with 1-3 STIs,[2,12,13] while broader general risk for being diagnosed with an STI provides insights into general STI infection risks linked with parental imprisonment. Finally, existing studies have had methodological limitations, such as not accounting for missing data and analyzing small cell sizes, which create uncertainty about the generalizability of findings.

Our study extends previous research on the relationship between parental imprisonment and STI infection by using a longitudinal framework to analyze individual risk for being infected with a broad subset of STIs linked with parental incarceration in prior Add Health studies. We estimate 1) the cumulative risk of STI diagnosis at ages 24-32 addressing issues of survey weighting and missing data which may increase uncertainty and reliability, and 2) longitudinal analysis of 12-month risk of STI diagnosis between the ages of 18-32. We examine if gender of parent and child differentiates risk, along with mediating patterns for 1) sociodemographic, 2) familial and neighborhood characteristics, 3) individual risk and resiliency, and 4) sexual risk factors. Taken together, these analyses provide us with a comprehensive and detailed understanding of how parental imprisonment may be associated with individual patterns of STI infection in early to mid-adulthood. Furthermore, we examine

the extent to which moderating patterns of STI infection risk may vary by race, gender, and (in longitudinal models) age of respondent.

METHODS

Data

We use data from the U.S. National Longitudinal Study of Adolescent to Adult Health (Add Health). The Add Health study initially surveyed approximately 90,000 students enrolled in grades 7-12 (ages 12-18) in 1994-1995 in in-school interviews. Our study follows a subpopulation of ~20,750 respondents who were randomly selected from the in-school sample for in-home interviews. These respondents were followed up at three later waves: ~14,700 respondents at Wave 2 in 1996, 15,200 respondents at Wave 3 in 2001-2002, and ~15,700 respondents at Wave 4 in 2007-2008. Of the original sample, the proportion of Wave 1 respondents completing surveys at each round were: 71% at Wave 2, 73% at Wave 3, and 75% at Wave 4.[24] Our analysis includes only individuals completing both Wave 1 and Wave 4 interviews.

Due to space constraints and the complexity of the survey design and reasons for non-response at each wave, we refer readers to the Add Health descriptions of survey design and completion available on the Add Health study website https://www.cpc.unc.edu/projects/addhealth.

Our analytic sample consists of 15,684 individuals who completed questionnaires at both Waves 1 & 4 when questions about biological mother and father imprisonment were first asked; including 14,796 individuals with valid survey weights.

Measures

STI infections. Our outcome measure of STI infection is a dichotomous indicator for respondents reporting being told by a doctor, or other health professional of being infected with any of the following STIs: 1) chlamydia, 2) gonorrhea, 3) trichomoniasis, 4) syphilis, 5) hepatitis B, 6) human papilloma virus (HPV), 7) HIV/AIDs, and 8) other sexually transmitted diseases, not elsewhere reported by respondents such as genital herpes, genital warts, vaginitis, urethritis, pelvic inflammatory disease, or cervicitis.

From these reports, we construct an indicator for 1) ever being infected with an STI and 2) being infected with an STI in the 12 months prior to interview (available at Waves III and IV). For lifetime infection we supplement Wave IV reports with reports of being infected with any of the STIs listed above at earlier Waves, addressing cases where respondents are known to deny STI infections in self-reports at older ages.[25]

Parental imprisonment. At Wave IV, respondents were asked "Has your biological mother/father ever been in prison?" and "At what age was your biological mother/father first incarcerated?" Using these questions, we construct indicator variables for maternal and paternal imprisonment occurring prior to age 18. We code separate measures for (1) father imprisonment, (2) mother imprisonment, and (3) and mutually exclusive categories of mother and/or father imprisonment. While prior research suggests recollection of childhood traumas and reporting of parental imprisonment yields reliable estimates,[26,27] recollection of the specific age at first parent imprisonment may be less reliable, particularly in early childhood. Our coding addresses this potential issue in prior research.

Demographic controls. We include respondent age at each wave, biological sex, and if the respondent identified as black, white, Hispanic, Native American, Asian, or other racial classification at Wave I.

Familial/neighborhood controls. We control for mother's reported level of education and family structure at Wave I. We include Wave I neighborhood SES as the proportion of families in the respondent's census tract residing below the poverty level.

Individual risk measures. For individual controls, we incorporate measures of measured body mass index (BMI; kg/m^2) at Wave II, an indicator for physical child abuse (Wave IV self-report), difficult child temperament (Wave I parent interview), a Wave I school attachment scale, adolescent marijuana usage in the 30 days prior to the interview (Wave I), binge drinking in the prior 12 months to the interview (Waves I, III, & IV), and a 12-item Wave I delinquency score (for details of the school attachment and delinquency scales are available in Guo et al[28]).

STI risk factors. Measures include the number of sexual partners before age 18 and parental reports of the degree to which they discussed STI risk with respondents on a 5-point Likert scale.

Patient & Public Involvement

This study used anonymized secondary data from the National Longitudinal Study of Adolescent to Adult Health. As a result, this study was conducted without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop relevant outcomes or interpret the results. Study participants were not invited to contribute to the writing or editing of this document for readability or accuracy.

Analytical strategy

To analyze the risk of lifetime STI infection, we use logistic regression. Add Health uses multiplicative weights ranging between 20-18,342 (mean 1480.28, SD 1425.65) to create a representative national cohort at Wave 4.[29] This is a potential issue in prior studies

where missing data and small cell counts used in analysis may substantially increase uncertainty. Analysis of unweighted data and controls to address sample bias may, alternatively, more efficiently estimate STI risk.[30] We focus our presentation on the unweighted results, but also compare coefficients between the weighted and unweighted data to examine potential uncertainty.[31]

To analyze the probability of STI infection over time, we use a two-level random effects logistic regression model where self-reports of STI infection in the prior twelve months at each wave are nested within individuals.

We impute 75 datasets using multiple imputation (MI) by chained equations to address missing data issues; we note imputation may address bias due to (1) missing data removing cases of greater social disadvantage where the effects of parental imprisonment have been found to be less significant and (2) deleting 12% of cases of mothers (78/643) and 20% of cases of fathers (458/2283) who respondents reported had been imprisoned, but did not know the exact age of imprisonment.[5,32,33]

Predicted probabilities and 95% CIs are generated by estimating means and standard errors using reported model estimates. These estimates results use baseline demographic controls for age, race/ethnicity, and respondent gender to estimate variation among these groups, in the absence of mediators.

All analyses are conducted using STATA 15.1.

RESULTS

Table 1 contains descriptive statistics by respondent's history of parental imprisonment. Parental imprisonment is associated with increased risk of a range of adversities and disadvantages.

Lifetime STI infection

Table 2 presents results for lifetime risk of STI infection. The odds of STI infection were higher for imprisonment of the biological father (Odds ratio (OR): 1.49, 95% confidence interval (CI): 1.33, 1.68) and biological mother (OR: 1.48, 95% CI: 1.20, 1.89) in the baseline sociodemographic model (Model 1). Modest declines in these estimates were associated with familial and neighborhood factors (Model 2), individual risk factors (Model 3), and sexual behavior risk factors (Model 4), with 95% CIs for the OR of maternal imprisonment overlapping with the null value of 1 (OR: 1.24, 95% CI: 0.90, 1.55) in Model 3. Biological father remained a risk factor for STI infection (OR: 1.22, 95% CI: 1.08, 1.38) with the inclusion of all controls, while the 95% CIs for the odds ratio of maternal imprisonment included the null value of 1 (OR: 1.07, 95% CI: 0.84, 1.35).

Similar odds ratios for STI infection were observed for models for imprisonment of the biological father only (OR: 1.52, 95% CI: 1.34, 1.71), biological mother only (OR: 1.59, 95% CI: 1.20, 2.10), and biological mother and father (OR: 1.58, 95% CI: 1.16, 2.15). Similar mediation patterns were observed for biological father and biological mother imprisonment, with 95% CIs showing odds ratios >1 for biological father only (Models 1-5), biological mothers only (Models 1-4), and both father and mother imprisonment (Models 1-4).

Results using survey weights (Supplemental Table S1) show comparable ORs to those presented in Table 2, with wider confidence intervals.

We found no significant interactions for parental imprisonment with gender and race. To examine cumulative risk, we estimated joint probabilities for lifetime STI infection by child gender, black/non-black ethnicity, and mother or father imprisonment, presented in Table 3. These results show that being female, having an incarcerated parent, and being black

have additive effects for ever being infected with an STI. For example, a non-black male with no history of paternal imprisonment has a predicted probability of infection of 8.9% (95% CI: 8.2%, 9.6%), while those with a history of paternal imprisonment has a predicted probability of 12.5% (95% CI: 11.2%, 13.9%). In contrast, black women reporting no history of parental imprisonment had a 52.4% (95% CI: 50.2%, 54.6%) predicted probability of STI infection, compared to 61.7% (95% CI: 58.8%, 64.7%) with a history of paternal imprisonment. Similar predicted probabilities are associated with maternal imprisonment.

Longitudinal risk of STI infection

Table 4 examines longitudinal odds of STI infection in the 12-months prior to the interview. In these models, father imprisonment in the baseline model was associated with higher odds of STI infection (OR: 1.33, 95% CI: 1.13, 1.56). This association showed slight mediation when controls were introduced for familial and neighborhood (Model 2), individual (Model 3) and sexual behavior factors (Model 4); however, the 95% CIs for paternal imprisonment included the null value of 1 (95% CI: 0.98, 1.37) when all controls were included (Model 5). Maternal imprisonment showed no association with 12-month STI risk (Model 5 95% CI: 0.75, 1.40). In comparing imprisonment risk for categories of father and/or mother imprisonment, the 95% CIs of the association for father only imprisonment and STI risk remained >1 across all models, but mother only imprisonment, and father and mother imprisonment showed no associations with STI risk.

To test for differences in father imprisonment and 12-month STI risk, we examined if age, ethnicity and gender moderated results for paternal imprisonment, but found no statistically significant moderation patterns. In lieu of moderation, we examined if predicted probabilities of STI diagnosis by age, ethnicity and gender showed additive effects, as illustrated by Figures 1A (non-black respondents) and 1B (black respondents). In all models

there is a higher probability of diagnosis through the mid-20s, before the probability of STI diagnosis stabilizes. In Figure 1A, the predicted probability of diagnosis of an STI in the past 12 months is higher for women than men, with parental imprisonment associated with a modest increase in risk. These figures illustrate additive effects for paternal imprisonment, being black, and being a woman, with nearly one-fifth of black women who experience paternal imprisonment being diagnosed with an STI in the 12-months prior to interviews.

Sensitivity analysis

We conducted supplementary analyses to 1) compare MI results with complete case analysis for the main findings (Supplemental Tables 2 and 3); 2) compare the findings by Le et al.[13] for laboratory-confirmed infections of chlamydia and gonorrhea with our analysis for respondent self-reports of lifetime chlamydia and/or gonorrhea infection (Supplemental Table 4); and 3) test moderation results using complete case analysis by examining interactions for parental imprisonment by gender, race/ethnicity, and age (longitudinal results only). Comparisons 1) and 3) yielded substantively similar results. For 2), our results were consistent with prior research on variations between lab-confirmed and self-reported STI infection for: 1) father only, and 2) mother and father imprisonment were lower, but within 95% CIs, while odds for mother only imprisonment were lower than the results reported by Le et al.[13,34]

DISCUSSION

Using a national cohort sample, this study demonstrates that paternal imprisonment in childhood is consistently associated with higher lifetime odds of STI infection and in longitudinal annual risk for adults ages 18-32. While other studies have examined STI and sexual risk associated with parental imprisonment, our study is the first to systematically explore both cumulative and longitudinal associations between parental imprisonment and

risk of a broad spectrum of STI infections. These findings demonstrate that both maternal and paternal imprisonment are associated with increased cumulative risk of STI infection, while only paternal imprisonment is linked with increased annual risk of STI infection in longitudinal analysis.

In examining mediation patterns, familial/neighborhood, individual, and sexual risk factors only partially mediated the association between parental imprisonment and STI infection. While factors such as risky sexual behaviors and substance abuse have been found to potentially mediate the relationship between parental imprisonment and STI infection,[13,14] our analysis establishes that STI infection risk linked with parental imprisonment remains once accounting for single risk factors, while controlling for a range of confounders substantial reduces the associated odds of STI infection.

By examining predicted probabilities, we are able to provide a clearer understanding of how parental imprisonment, ethnicity, and respondent gender jointly lead to variations in STI infection at the population level. In both cross-sectional and longitudinal analysis, parental imprisonment is associated with modest, but consistent increases in risk of STI infection, with cumulative risk increasing for female and black respondents. Importantly, the magnitude of the association does not vary by gender or ethnicity.

Strengths and Weaknesses

Our study has a number of strengths. Our combination of cumulative and longitudinal analysis for STI infection allowed us to test if the general association between parental imprisonment and STI infection consistently holds over time for a broad range of STIs. By using strategies to systematically address limitations of prior research and the Add Health data, we have been able to strengthen our understanding of the validity of the association between parental imprisonment and STI risk; this has been done by use of multiple

imputation, including a broader range of self-reported STIs, comparing weighted and non-weighted data, ensuring sufficiently large cell sizes for parental imprisonment to reduce uncertainty, and using a single childhood cutoff (age>18) to reduce inaccuracies for potential recall bias for early age imprisonment. Using predicted probabilities, we were able to examine the magnitude of the effect of parental imprisonment risk and having an STI infection in a national cohort, when considering age, gender, and ethnicity of respondents. Lastly, by examining STI infection over time and supplementing Wave 4 STI reports of lifetime infection with reports of STI infection at earlier ages, we are able to 1) control for recall bias[25] and 2) allow for additional time for cases where asymptomatic STI infections may be underreported due to lack of testing,[35] known sources of biases for self-reported which may lead to underestimation at a single point in time.

Our study also has limitations. Prior research shows Add Health self-reports of STI infections were slightly lower overall for the general population, with greater under-reporting for minorities.[34] Increased prevalence of parental imprisonment among minorities and disadvantaged groups may lead to underestimation of our reported findings. As many STIs may be asymptomatic and revealed only with testing, our longitudinal analysis represents prevalence of 'diagnosis,' not infection rates.[25,36] Due to variation in questions across waves, we were unable to examine longitudinal models in adolescence, or analyze changes in STI risk between adolescence and adulthood. Parental imprisonment is also based on recollection, and administrative data may provide more reliable data within a jurisdiction.[37] Data restrictions, such as the lack of prospective data on parental imprisonment in childhood and related factors such as exposure to family instability and parental criminality, also prevented us from exploring underlying causation.

Conclusion

This study provides evidence that paternal imprisonment in childhood is associated with elevated lifetime and longitudinal annual risks of having an STI infection in early and mid-adulthood. We find that annual and lifetime risk of STI infection associated with parental imprisonment is compounded by gender and ethnicity. For adults who have experienced parental imprisonment in childhood, increased testing and treatment for STIs may help to reduce increased risks.

Footnotes

Contributors: Conception and design of study: MR, BH. Data preparation and analysis: MR. Interpreting results: MR, BH. Drafting of the initial manuscript: MR. Revising the manuscript critically: MR, BH. All authors approved the final manuscript.

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Competing interests: None declared.

Patient consent for publication: Not required.

Ethics approval: This project was reviewed and approved by The Australian National University Human Ethnics Research Committee (approval #: 2018/283).

Data and code: Access to the data is restricted to maintain participant confidentiality, but may be obtained from the Carolina Population Center (https://www.cpc.unc.edu/projects/addhealth/documentation/restricteduse). The code used in the analysis is available upon request from the corresponding author.

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Table 1: Means, standard deviations and test of group means for individual, family, neighborhood, and sexual risk variables, by exposure to parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Parental Imprisonment [n=2339]		No parental Imprisonment [n=12997]		Test of Group Means
	Mean/%	SD	Mean /%	SD	p-value (p<)
Parent Imprisonment					
Gender of Parent					
Father imprisoned	90.49%				
Mother Imprisoned	21.46%				
Joint Parental Imprisonment					
Father only Imprisoned	78.80%				
Mather only imprisoned	12.84%				
Mother & Father Both Imprisoned	12.84%				
Ever STI Diagnosis	31.53%		21.10%		0.0001
STI Diagnosis, Prior 12 Months					
Wave 3	7.77%		5.39%		0.0001
Wave 4	9.71%		7.06%		0.0001
Demographic Measures					
Age at Interview (years)					
Wave 1	15.41	(1.70)	15.63	(1.74)	0.0001
Wave 3	21.76	(1.74)	21.95	(1.77)	0.0001
Wave 4	28.32	(1.75)	28.52	(1.79)	0.0001
Respondent Gender					
Male	44.91%		47.08%		0.0500
Female	55.09%		52.92%		0.0500
Racial Phenotype (Wave 1)					
White	46.38%		54.00%		0.0001
Black	31.69%		20.74%		0.0001
Hispanic	16.53%		15.87%		0.4387
Asian	1.76%		6.91%		0.0001
Native American	2.83%		1.55%		0.0001
Other/Multiple Race	0.81%		0.92%		0.6020
Family & Neighborhood Measures					
Family Structure (Wave 1)					
Two Biological Parents	21.96%		57.82%		0.0001
Single Mother	36.09%		21.23%		0.0001
Single Father	4.62%		3.10%		0.0002
Two Parent, One Biological	25.09%		12.92%		0.0001
Other Family Structure	12.24%		4.92%		0.0001
Completed Parental Education					
Bachelor's Degree	15.34%		25.61%		0.0001
High School	60.52%		57.96%		0.0183
Less Than High School	24.14%		16.43%		0.0001

Percentage of families in respondent's census tract below poverty level	14.29%		11.47%		0.0001
Individual Measures					
School Attachment (Wave 1)	3.64	(0.92)	3.77	(0.96)	0.0001
Self-Reported BMI (Wave 1)	22.96	(4.70)	22.56	(4.49)	0.0001
Measured BMI (Wave 2)	23.47	(5.43)	23.07	(5.03)	0.0024
History of physical child abuse	15.99%		7.65%		0.0001
Parent's report, child temperament issues (Wave 1)	38.33%		29.47%		0.0001
Delinquent Activity Scale (Wave 1)	2.66	(4.34)	1.71	(3.29)	0.0001
Frequency of marijuana usage prior 30 days (wave 1)	0.38	(0.93)	0.23	(0.71)	0.0001
Reported Binge Drinking, Prior 12 months					
Wave 1	0.75	(1.37)	0.59	(1.18)	0.0001
Wave 3	1.02	(1.44)	1.12	(1.42)	0.0038
Wave 4	1.03	(1.41)	0.95	(1.29)	0.0096
Sexual Risk Measures					
Parental Discussion of STI risk with Respondent	3.26	(0.94)	3.12	(0.96)	0.0001
Number of Sex Partners Prior (age<18)	4.64	(9.92)	2.79	(6.45)	0.0001

Table 2: Odds ratios and 95% confidence intervals for lifetime STI diagnosis among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.49 [1.33, 1.68]	1.36 [1.21, 1.54]	1.33 [1.19, 1.49]	1.38 [1.23, 1.55]	1.22 [1.08, 1.38]
Biological Mother Imprisonment	1.48 [1.20, 1.82]	1.24 [1.00, 1.53]	1.24 [0.90, 1.55]	1.27 [1.08, 1.69]	1.07 [0.84, 1.35]
Biological Father only Imprisonment	1.52 [1.34, 1.71]	1.40 [1.23, 1.58]	1.37 [1.22, 1.55]	1.41 [1.25, 1.59]	1.26 [1.11, 1.43]
Biological Mother only Imprisonment	1.59 [1.20, 2.10]	1.34 [1.01, 1.78]	1.40 [1.05,1.87]	1.47 [1.11, 1.96]	1.21 [0.89,1.62]
Biological Mother & Father Imprisonment	1.58 [1.16, 2.15]	1.34 [0.98,1.84]	1.30 [0.95, 1.78]	1.45 [1.07,1.99]	1.12 [0.81,1.55]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Table 3: Predicted probabilities and 95% confidence intervals for ever being infected with an STI, by parent gender, child gender, and black/non-black racial classification (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

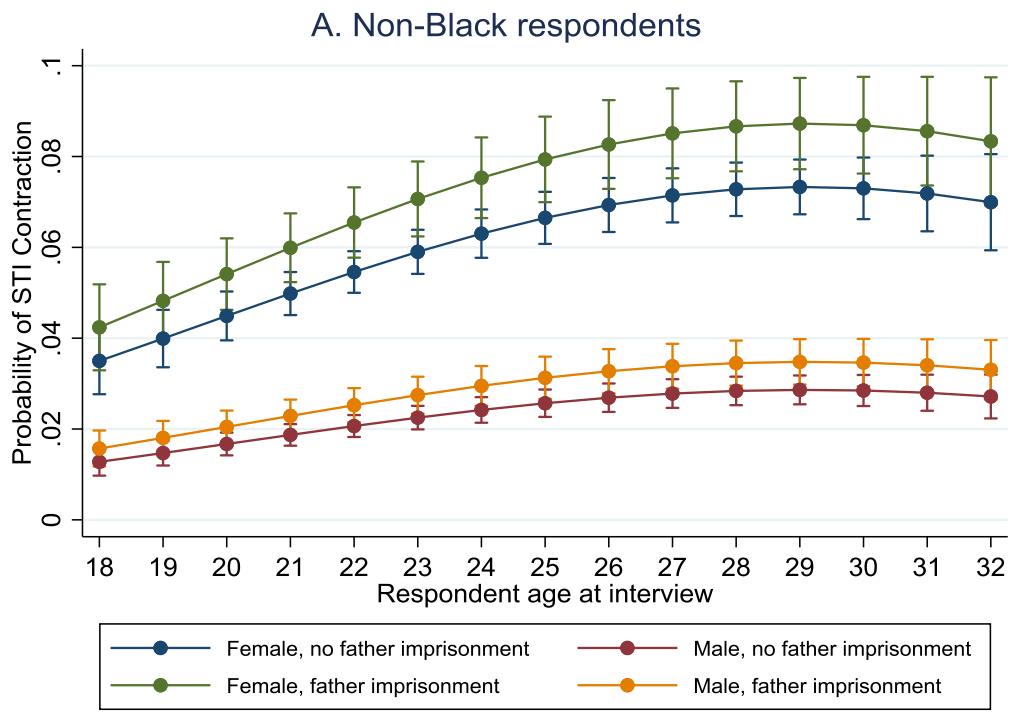
	Non-Black, Male	Non-Black, Female	Black, Male	Black, Female
Biological Father Imprisonment	12.5% [11.2%, 13.9%]	29.3% [27.0%, 31.7%]	35.8% [32.7%, 38.8%]	61.7% [58.8%, 64.7%]
No Biological Father Imprisonment	8.9% [8.2%, 9.6%]	22.1% [21.1%, 23.2%]	27.6% [25.6%, 29.5%]	52.4% [50.2%, 54.6%]
Biological Mother Imprisonment	13.5% [11.0%, 16.0%]	30.4% [25.6%, 35.1%]	37.7% [32.7%, 42.7%]	63.2% [58.4%, 68.0%]
No Biological Mother Imprisonment	9.6% [8.9%, 10.0%]	23.0% [22.0%, 24.1%]	29.1% [27.1%, 31.0%]	53.7% [51.7%, 55.8%]

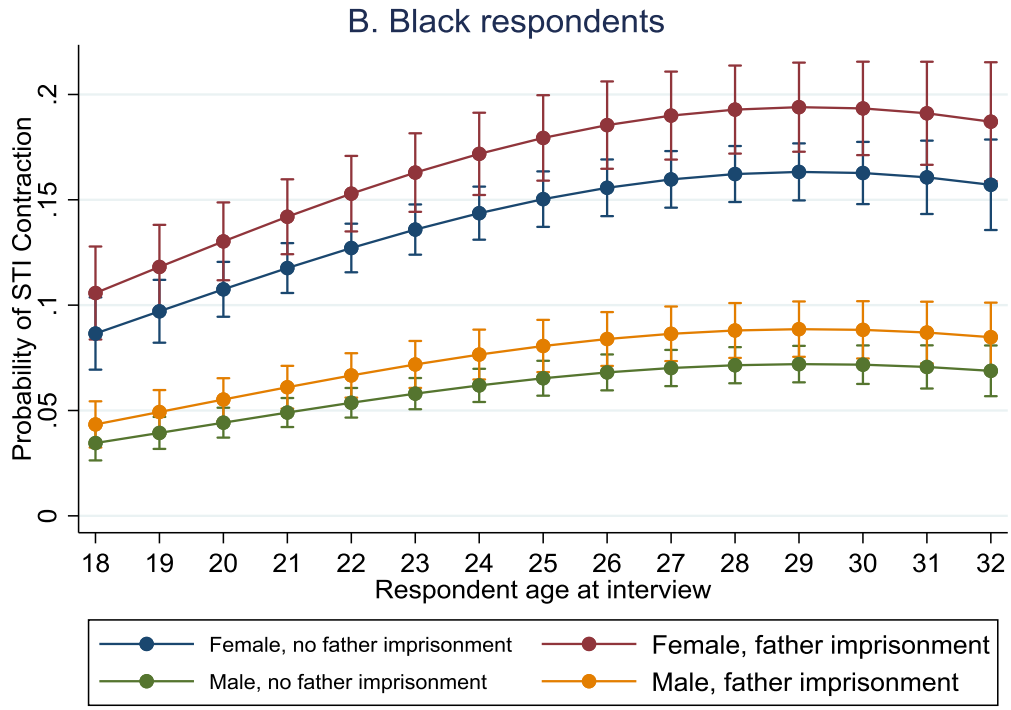
Notes: Predicted Probabilities generated based on Model 1 of Table 2 for respondents reporting if their (1) biological father or (2) biological mother was imprisoned at age<18.

Table 4: Odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.33 [1.13, 1.56]	1.26 [1.06, 1.50]	1.22 [1.03, 1.43]	1.26 [1.07, 1.49]	1.15 [0.98, 1.37]
Biological Mother Imprisonment	1.22 [0.89, 1.66]	1.10 [0.81, 1.51]	1.09 [0.80, 1.48]	1.17 [0.85, 1.58]	1.02 [0.75, 1.40]
Biological Father only Imprisonment	1.36 [1.15, 1.60]	1.30 [1.10, 1.54]	1.25 [1.06, 1.50]	1.30 [1.10, 1.55]	1.19 [1.01, 1.41]
Biological Mother only Imprisonment	1.43 [0.96, 2.14]	1.33 [0.88, 2.00]	1.31 [0.88, 1.95]	1.37 [0.92, 2.05]	1.24 [0.81,1.86]
Biological Mother & Father Imprisonment	1.12 [0.69, 1.82]	1.03 [0.63, 1.70]	0.95 [0.58, 1.56]	1.06 [0.65, 1.74]	0.89 [0.54, 1.46]

Notes: Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.





Supplemental Table 1. Weighted odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.47 [1.24, 1.74]	1.34 [1.13, 1.59]	1.34 [1.12, 1.60]	1.38 [1.16, 1.65]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.40 [1.04, 1.89]	1.17 [0.86, 1.59]	1.20 [0.89, 1.62]	1.28 [0.94, 1.74]	1.03 [0.76, 1.41]
Biological Father only Imprisonment	1.46 [1.22, 1.75]	1.35 [1.13, 1.61]	1.34 [1.11, 1.63]	1.39 [1.16, 1.66]	1.25 [1.04, 1.51]
Biological Mother only Imprisonment	1.40 [0.94, 2.10]	1.18 [0.78, 1.76]	1.17 [0.78, 1.77]	1.28 [0.83, 1.98]	1.01 [0.66, 1.54]
Biological Mother & Father Imprisonment	1.59 [1.13, 2.23]	1.36 [0.96, 1.93]	1.38 [0.98, 1.94]	1.43 [1.00, 2.05]	1.18 [0.83, 1.69]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table 2. Odds ratios and 95% confidence intervals for ever being infected with gonorrhea or chlamydia among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.58 [1.40, 1.77]	1.36 [1.21, 1.54]	1.45 [1.29, 1.63]	1.48 [1.32, 1.67]	1.28 [1.13, 1.44]
Biological Mother Imprisonment	1.58 [1.29, 1.91]	1.28 [1.04, 1.56]	1.41 [1.16, 1.73]	1.49 [1.23, 1.82]	1.20 [0.97, 1.48]
Biological Father only Imprisonment	1.58 [1.41, 1.78]	1.38 [1.22, 1.58]	1.48 [1.31, 1.68]	1.49 [1.32, 1.58]	1.29 [1.14, 1.48]
Biological Mother only Imprisonment	1.78 [1.30, 2.45]	1.45 [1.05, 2.00]	1.60 [1.16, 2.21]	1.67 [1.21, 2.30]	1.34 [0.97, 1.86]
Biological Mother & Father Imprisonment	1.73 [1.36, 2.20]	1.41 [1.10, 1.81]	1.55 [1.21, 1.98]	1.62 [1.27, 2.07]	1.29 [1.00, 1.67]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table 3. Complete case analysis for odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.48 [1.32, 1.65]	1.34 [1.19, 1.51]	1.36 [1.17, 1.57]	1.35 [1.19, 1.53]	1.24 [1.06, 1.44]
Biological Mother Imprisonment	1.48 [1.21, 1.82]	1.19 [0.96, 1.48]	1.14 [0.86, 1.51]	1.29 [1.03, 1.63]	0.93 [0.69, 1.25]
Biological Father only Imprisonment	1.49 [1.32, 1.67]	1.37 [1.21, 1.55]	1.40 [1.21, 1.63]	1.37 [1.20, 1.56]	1.29 [1.10, 1.51]
Biological Mother only Imprisonment	1.64 [1.27, 2.12]	1.33 [1.01, 1.74]	1.44 [1.02, 2.01]	1.48 [1.12, 1.95]	1.16 [0.81, 1.69]
Biological Mother & Father Imprisonment	1.55 [1.11, 2.15]	1.21 [0.86, 1.72]	0.95 [0.60, 1.50]	1.26 [0.86, 1.84]	0.76 [0.47, 1.25]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table 4. Complete case analysis for odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.30 [1.10, 1.53]	1.22 [1.03, 1.45]	1.16 [0.94, 1.42]	1.10 [1.00, 1.43]	1.07 [0.86, 1.33]
Biological Mother Imprisonment	1.21 [0.88, 1.65]	1.05 [0.75, 1.46]	1.20 [0.80, 1.81]	1.23 [0.88, 1.72]	1.08 [0.71, 1.65]
Biological Father only Imprisonment	1.33 [1.13, 1.58]	1.27 [1.06, 1.51]	1.22 [0.99, 1.51]	1.23 [1.02, 1.48]	1.14 [0.91, 1.42]
Biological Mother only Imprisonment	1.36 [0.93, 2.01]	1.22 [0.80, 1.85]	1.64 [1.00, 2.70]	1.46 [0.96, 2.22]	1.48 [0.88, 2.47]
Biological Mother & Father Imprisonment	1.15 [0.69, 1.92]	0.95 [0.56, 1.61]	0.79 [0.38, 1.63]	1.04 [0.58, 1.85]	0.67 [0.31, 1.44]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + Adolescent School Attachment + childhood physical abuse + difficult child temperament. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any pre-specified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	5-6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	6
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*6-7*
Bias	9	Describe any efforts to address potential sources of bias	6-9
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	8-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8-9
		(*b*) Describe any methods used to examine subgroups and interactions	8-9
		(*c*) Explain how missing data were addressed	8-9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	8-9

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	10, 12
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6-9
		(b) Indicate number of participants with missing data for each variable of interest	6-9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	6
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	6-9
		Cross-sectional study—Report numbers of outcome events or summary measures	6-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-12
		(*b*) Report category boundaries when continuous variables were categorized	6-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	9-12
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-15
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early and mid-adulthood

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Secondary Subject Heading:	Sexual health, Epidemiology, Sociology
Keywords:	EPIDEMIOLOGY, SOCIAL MEDICINE, PUBLIC HEALTH

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Submission Category: Original Research

Title Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early and mid-adulthood

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Running Head: Parental Imprisonment and STI Risk in Adulthood

Abstract

Objectives: One-in-six young adults in the U.S. experience parental imprisonment in childhood. Prior studies have associated parental imprisonment with risk of sexually transmitted infection (STI); however, potential data and methodological issues may have limited the reliability and accuracy of prior findings. Examining cumulative and longitudinal risk, we address several methodological limitations of prior studies and also examine comparative risk by respondent gender and ethnicity. We assess these associations using a range of controls.

Design: A national cohort study from the National Longitudinal Study of Adolescent to Adult Health using (1) a cross-sectional sample of adults at ages 24-32 and (2) a longitudinal sample between ages 18-32. Both analyses estimate odds ratios for STI infection associated with parental imprisonment and examine variation by parent/child gender and respondent ethnicity.

Setting: In-home interviews in the United States at Wave 1 (1994-1995), Wave 3 (2001-2003) and Wave IV (2007-2009).

Participants: 15,684 respondents completing interviews at Wave 1 (ages 12-18) and Wave 4 (ages 26-32), including 8556 female, 3437 black, and 2397 respondents reporting parental imprisonment.

Results: With controls, father-only imprisonment is associated with higher odds of 1.22 (95% confidence interval (CI): 1.09, 1.37) of lifetime STI infection and 1.19 higher odds (95% CI: 1.01, 1.41) of STI infection in the past 12 months between ages 18-32, adjusting for familial, neighborhood, individual, and sexual risk factors. Maternal imprisonment is associated with higher risk of lifetime STI, but the 95% CIs overlapped with 1 adjusted for confounders (95% CI: 0.90, 1.61). Examining predicted probabilities of STI infection, our findings show additive risks for women, blacks, and parental imprisonment.

Conclusion: Adjusting for confounders, only paternal imprisonment is associated with slightly elevated risk of annual and lifetime risk of STI infection. Additive effects show that parental imprisonment modestly increases ethnic and gender risk for STI infection.

Keywords:

Sexually transmitted infections; parental imprisonment; mass incarceration; health status disparities; minority health

Strengths & Limitations

- This study addresses data and methodological issues of prior work to improve accuracy and reliability for estimating the association between parental imprisonment and risk of STI infection.
- The study leverages cross-sectional and longitudinal measures to compare lifetime and longitudinal risk.
- Comparative analysis is performed to determine potential variations in STI risk by maternal and paternal imprisonment, and respondent gender and ethnicity.
- The study lacks measures to determine underlying potential causal factors, such as residential instability and parental criminality that may explain the association.
- While STI self-reports are prospectively collected, data on parental imprisonment is retrospectively collected.

Introduction

According to recent research, 2.6 million U.S. children have a parent in jail or prison, with 4% of white, 24% of black, and 11% of Hispanic children ever experiencing a parent serving time in state or federal prison.[1,2] Parental imprisonment is an adverse childhood experience linked to a range of adversities from birth to death, including prenatal exposure to alcohol and drugs, poor academic and educational outcomes, criminal behavior and subsequent imprisonment.[3-6] In the last decade, research has increasingly linked parental imprisonment to health issues that include sexually transmitted infections (STIs), depression, cardiovascular and metabolic diseases, respiratory conditions, and infant and adult mortality.[7-11] Since parental imprisonment is interrelated with other childhood traumas (e.g., family instability and child abuse) and linked with adverse outcomes (e.g., antisocial and risky behaviors), it is critical to document associations and potential mediating effects linking parental imprisonment to health outcomes later in the life course. Due to the interrelationship between parental imprisonment and other childhood traumas, such as family instability and child abuse, and linkage with outcomes, such as antisocial and risky behaviors, documenting associations and potential mediating effects are critical for linking parental imprisonment to health outcomes later in the life course.[12-15] The present study assesses whether parental imprisonment is a risk factor for STI infections, and potential mediating factors that may explain this association.

The potential association between parental imprisonment and STIs in the U.S. is important given the scale of parental imprisonment in the U.S., increasing rates of STI infections, and resulting health complications from STI infection. Rates of STI infection have generally increased in the U.S. Between 2000 and 2017, chlamydial infection rates doubled from 251.4 to 528.8 per 100,000, while gonorrhea infection rates increased by 75% from 99.1 to 171.9 cases per 100,000 between 2009 and 2017.[16] An STI that is undetected and left

untreated may result in a range of chronic health issues such as infertility or adverse birth outcomes (chlamydia, gonorrhea), cervical and testicular cancers (HPV), and mortality (syphilis, HIV/AIDS).[16-18] Increased risk for STIs associated with experiencing parental imprisonment may thus contribute to a range of adverse outcomes later in the life course.

In cross-sectional analyses of the National Longitudinal Study of Adolescent to Adult Health (Add Health), parental imprisonment has been associated with STI infection in adolescence and adulthood.[3,15,19,20] Further studies have linked STI infection with substance abuse, childhood trauma, early sexual activity, and risky sexual behavior.[3,15,19-23] These analyses also suggest that women[19] and minorities[20,22] who experience parental imprisonment may be at greater likelihood of having an STI infection, though these gender and racial differentials were not tested for statistical significance. Parental imprisonment has also been associated with altered age trajectories for engaging in delinquent behavior and drug use, and age trajectories may similarly vary for STI infection.[24,25] Some research examining cross-sectional risk of STI infection at multiple time points suggests that STI infection risk associated with parental imprisonment may vary by life stage and be mediated by factors such as child abuse, family instability, substance use, adolescent antisocial behavior (particularly, life course persistent or chronic offending), or sexual risk taking.[19,20,26]

While this research suggests parental imprisonment is associated with STI infection, important research gaps remain that we address in our analysis. First, extending prior research to incorporate longitudinal analysis is important for determining how the association between parental imprisonment and STI risk may hold or change as individuals age out of early adulthood, while addressing potential temporal ordering issues of co-occurring risks such as antisocial behavior and substance use[27,28] By comparing cross-sectional results for lifetime risk of STI infection at ages 24-32 with longitudinal risk of annual STI infection, we are able to establish how parental imprisonment impacts age-graded risk of STI infection.

Secondly, we examine how the association between parental imprisonment and STI infection may vary by the potential confounding or mediating roles of other related factors. Understanding these mediation patterns is critical to identify potential pathways between childhood adversity and later adverse outcomes associated with parental imprisonment that may impact STI risk. We examine if gender of parent and child differentiates risk, along with mediating patterns for four sets of factors: 1) demographic, 2) familial and neighborhood characteristics (including familial socioeconomic status and household composition), 3) individual risk and resiliency, and 4) sexual risk factors.

Thirdly, research is also needed to examine potential STI risk disparities for parental imprisonment by parent/child gender and ethnicity,[7] particularly in light of findings that women and African Americans are more likely to contract an STI.[29-31] Results by Khan et al[20] are suggestive that STI infection risk associated with parental imprisonment is higher for minority groups, but this study did not statistically test if this risk for parental imprisonment was statistically significant across ethnic groups. Furthermore, the compounded risks by gender and ethnicity may not be additive, leading to variation in STI risk associated with parental imprisonment (e.g., black male and female respondents may have similar STI risk, or black females may have a greater STI risk than black males). By testing these associations, we are able to determine if the risk of parental imprisonment for STI infection may vary based on a respondent's gender and ethnicity.

Fourthly, most studies have focused on associations with 1-3 STIs,[3,15,19] while broader general risk for being diagnosed with an STI provides insights into general STI infection risks linked with parental imprisonment. We estimate the general risk of STI infection associated with parental imprisonment in cross-sectional and longitudinal models.

Finally, we test the validity of the models we estimate, addressing issues concerning survey weighting, small cell sizes, and missing data which may increase uncertainty and reliability issues in prior research on this topic. This is critical for providing consistent and reliable estimates gauging the extent to which parental imprisonment may be a risk factor for STI infection.

METHODS

Data

We use data from the U.S. National Longitudinal Study of Adolescent to Adult Health (Add Health). The Add Health study initially surveyed approximately 90,000 students enrolled in grades 7-12 (ages 12-18) in 1994-1995 in in-school interviews. Our study follows a subpopulation of ~20,750 respondents who were randomly selected from the in-school sample for in-home interviews. These respondents were followed up at three later waves: ~14,700 respondents at Wave 2 in 1996, 15,200 respondents at Wave 3 in 2001-2002, and ~15,700 respondents at Wave 4 in 2007-2008. Of the original sample, the proportion of Wave 1 respondents completing surveys at each round were: 71% at Wave 2, 73% at Wave 3, and 75% at Wave 4.[32] Our analysis includes only individuals completing both Wave 1 and Wave 4 interviews, with 74.5% and 81.5% of these respondents completing interviews, respectively, at Waves 2 & 3.

Due to space constraints and the complexity of the survey design and reasons for non-response at each wave, we refer readers to the Add Health descriptions of survey design and completion available on the Add Health study website https://www.cpc.unc.edu/projects/addhealth.

Our analytic sample consists of 15,684 individuals who completed questionnaires at both Waves 1 & 4 when questions about biological mother and father imprisonment were

first asked; including 14,796 individuals with valid survey weights. The reduced number of cases arises from individuals missing information from the school or household-level needed to create nationally-representative weights for the cohort; as an example, sibling pairs in the in-home sample but not enrolled in the same school were not given sampling weights.[33]

Measures

All measures are constructed using measures from Waves I-IV of the Add Health. Codebooks and response patterns for the variables used to construct the measures below are available on the Add Health website at: https://addhealth.cpc.unc.edu/documentation/codebooks/

STI infections. Our outcome measure of STI infection is a dichotomous indicator for respondents reporting being told by a doctor, or other health professional of being infected with any of the following STIs: 1) chlamydia, 2) gonorrhea, 3) trichomoniasis, 4) syphilis, 5) hepatitis B, 6) human papilloma virus (HPV), 7) HIV/AIDs, and 8) other sexually transmitted diseases, not elsewhere reported by respondents such as genital herpes, genital warts, vaginitis, urethritis, pelvic inflammatory disease, or cervicitis.

From these reports, we construct an indicator for 1) ever being infected with an STI and 2) being infected with an STI in the 12 months prior to interview (available at Waves III and IV). For lifetime infection we supplement Wave IV reports with reports of being infected with any of the STIs listed above at earlier Waves, addressing cases where respondents are known to deny STI infections in self-reports at older ages.[34]

Parental imprisonment. At Wave IV, respondents were asked "(Has/did) your biological mother/father ever (spent/spend) time in jail or prison?" and "How old were you when your biological mother/father went to jail or prison (the first time)?" Using these questions, we construct indicator variables for maternal and paternal imprisonment occurring prior to age 18. We code separate measures for (1) father imprisonment, (2) mother imprisonment, and

(3) and mutually exclusive categories of mother and/or father imprisonment. While prior research suggests recollection of childhood traumas and reporting of parental imprisonment yields reliable estimates,[35,36] recollection of the specific age at first parent imprisonment may be less reliable, particularly in early childhood. Our coding addresses this potential issue in prior research.

Demographic controls. We include respondent age at each wave, biological sex, and if the respondent identified as black, white, Hispanic, Native American, Asian, or other racial classification at Wave I.

Familial/neighborhood controls. We control for parent's reported level of education and family structure at Wave I (in over 90% of cases, the parent reporting education is the biological mother or step-mother). We include Wave I neighborhood SES as the proportion of families in the respondent's census tract residing below the poverty level.

Individual risk measures. For individual controls, we incorporate measures of measured body mass index (BMI; kg/m^2) at Wave II, an indicator for physical child abuse (Wave IV self-report), difficult child temperament (Wave I parent interview), a Wave I school attachment scale, adolescent marijuana usage in the 30 days prior to the interview (Wave I), binge drinking in the prior 12 months to the interview (Waves I, III, & IV), and a 12-item Wave I delinquency score (for details of the school attachment and delinquency scales are available in Guo et al[37]).

STI risk factors. Measures include the total number of sexual partners before age 18 and parental reports of the degree to which they discussed STI risk with respondents on a 5-point Likert scale (with higher scores indicating greater discussion about STI risks).

Patient & Public Involvement

This study used anonymized secondary data from the National Longitudinal Study of Adolescent to Adult Health. As a result, this study was conducted without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop relevant outcomes or interpret the results. Study participants were not invited to contribute to the writing or editing of this document for readability or accuracy.

Analytical strategy

To analyze the risk of lifetime STI infection, we use logistic regression. Add Health uses multiplicative weights ranging between 20-18,342 (mean 1,480.28, SD 1,425.65) to create a representative national cohort at Wave 4.[38] This is a potential issue in prior studies where missing data and small cell counts used in analysis may substantially increase uncertainty. Analysis of unweighted data and controls to address sample bias may, alternatively, more efficiently estimate STI risk.[39] We focus our presentation on the unweighted results, but also compare coefficients between the weighted and unweighted data to examine potential uncertainty.[40]

To analyze the probability of STI infection over time, we use a two-level random effects logistic regression model where self-reports of STI infection in the prior twelve months at each wave are nested within individuals.

We impute 75 datasets using multiple imputation (MI) by chained equations to address missing data issues; we note imputation may address bias due to (1) missing data removing cases of greater social disadvantage where the effects of parental imprisonment have been found to be less significant and (2) deleting 12% of cases of mothers (78/643) and 20% of cases of fathers (458/2283) who respondents reported had been imprisoned, but did not know the exact age of imprisonment.[7,41,42]

Predicted probabilities and 95% CIs are generated by estimating means and standard errors using reported model estimates. These estimates results use baseline demographic controls for age, race/ethnicity, and respondent gender to estimate variation among these groups, in the absence of mediators.

We used STATA 15.1 for all analyses.

RESULTS

Table 1 contains descriptive statistics by respondent's history of parental imprisonment. Parental imprisonment is associated with increased risk of a range of adversities and disadvantages.

Lifetime STI infection

Table 2 presents results for lifetime risk of STI infection. The odds of STI infection were higher for imprisonment of the biological father (Odds ratio (OR): 1.49, 95% confidence interval (CI): 1.33, 1.68) and biological mother (OR: 1.48, 95% CI: 1.20, 1.82) in the baseline demographic model (Model 1). Modest declines in these estimates were associated with familial and neighborhood factors (Model 2), individual risk factors (Model 3), and sexual behavior risk factors (Model 4). Biological father remained a risk factor for STI infection (OR: 1.24, 95% CI: 1.04, 1.48) with the inclusion of all controls, while the 95% CIs for the odds ratio of maternal imprisonment included the null value of 1 (OR: 1.13, 95% CI: 0.94, 1.36).

Similar odds ratios for STI infection were observed for models for imprisonment of the biological father only (OR: 1.52, 95% CI: 1.34, 1.71), biological mother only (OR: 1.59, 95% CI: 1.20, 2.10), and biological mother and father (OR: 1.58, 95% CI: 1.16, 2.15). Similar mediation patterns were observed for biological father and biological mother imprisonment, with 95% CIs showing odds ratios >1 for biological father only (Models 1-5),

biological mothers only (Models 1-4), and both father and mother imprisonment (Models 1-4).

In all cases, no single set of risk factors led to non-significance. Supplemental Table S1 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 2.

Results using survey weights (Supplemental Table S2) show comparable ORs to those presented in Table 2, with wider confidence intervals.

We found no significant interactions for parental imprisonment with gender and race. To examine cumulative risk, we estimated joint probabilities for lifetime STI infection by child gender, black/non-black ethnicity, and mother or father imprisonment, presented in Table 3. These results show that being female, having an incarcerated parent, and being black have additive effects for ever being infected with an STI. For example, a non-black male with no history of paternal imprisonment has a predicted probability of infection of 8.9% (95% CI: 8.2%, 9.6%), while those with a history of paternal imprisonment has a predicted probability of 12.5% (95% CI: 11.2%, 13.9%). In contrast, black women reporting no history of parental imprisonment had a 52.4% (95% CI: 50.2%, 54.6%) predicted probability of STI infection, compared to 61.7% (95% CI: 58.8%, 64.7%) with a history of paternal imprisonment. Similar predicted probabilities are associated with maternal imprisonment.

Longitudinal risk of STI infection

Table 4 examines longitudinal odds of STI infection in the 12-months prior to the interview. In these models, father imprisonment in the baseline model was associated with higher odds of STI infection (OR: 1.33, 95% CI: 1.13, 1.56). This association showed slight mediation when controls were introduced for familial and neighborhood (Model 2), individual (Model 3) and sexual behavior factors (Model 4); however, the 95% CIs for

paternal imprisonment included the null value of 1 (95% CI: 0.98, 1.37) when all controls were included (Model 5). Maternal imprisonment showed no association with 12-month STI risk (Model 5 95% CI: 0.75, 1.40). In comparing imprisonment risk for categories of father and/or mother imprisonment, the 95% CIs of the association for father only imprisonment and STI risk remained >1 across all models, but mother only imprisonment, and father and mother imprisonment showed no associations with STI risk.

Supplemental Table S3 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 4.

To test for differences in father imprisonment and 12-month STI risk, we examined if age, ethnicity, and gender moderated results for paternal imprisonment, but found no statistically significant moderation patterns. In lieu of moderation, we examined if predicted probabilities of STI diagnosis by age, ethnicity and gender showed additive effects, as illustrated by Figure 1 (non-black respondents) and Figure 2 (black respondents). In all models there is a higher probability of diagnosis through the mid-20s, before the probability of STI diagnosis stabilizes. In Figure 1, the predicted probability of diagnosis of an STI in the past 12 months is higher for women than men, with parental imprisonment associated with a modest increase in risk. Figure 2 shows a similar pattern, with higher baseline rates among black respondents. Collectively, these figures illustrate additive effects for paternal imprisonment, being black, and being a woman, with nearly one-fifth of black women who experience paternal imprisonment being diagnosed with an STI in the 12-months prior to interviews.

Sensitivity analysis

We conducted supplementary analyses to 1) compare MI results with complete case analysis for the main findings (Supplemental Tables S4 and S5); 2) compare the findings by

Le et al.[15] for laboratory-confirmed infections of chlamydia and gonorrhea with our analysis for respondent self-reports of lifetime chlamydia and/or gonorrhea infection (Supplemental Table S6); and 3) test moderation results using complete case analysis by examining interactions for parental imprisonment by gender, race/ethnicity, and age in longitudinal models (Raw output for moderation testing available on request). Comparisons 1) and 3) yielded substantively similar results. For 2), our results were consistent with prior research on variations between lab-confirmed and self-reported STI infection for: 1) father only, and 2) mother and father imprisonment were lower, but within 95% CIs, while odds for mother only imprisonment were lower than the results reported by Le et al.[15,43]

DISCUSSION

Using a U.S.-based cohort study, we demonstrate that individuals experiencing paternal imprisonment, without co-occurring maternal imprisonment, in childhood is an independent risk factor for (1) higher lifetime odds of STI infection and (2) longitudinal annual STI infection risk in adults ages 18-32.

In basic demographic models controlling for age, race, and gender, we found maternal and/or paternal imprisonment are associated with increased cumulative risk of STI infection, with predicted probabilities for STI infection showing additive risk for parental imprisonment, gender, and race. However, after introducing controls, only paternal imprisonment (with or without co-occurring maternal imprisonment) remained significant. In longitudinal models, respondents experiencing paternal imprisonment only in childhood faced a statistically higher risk for annual STI infection after controls were added. Gender and ethnicity also independently raised risks of annual infection in longitudinal analysis. Furthermore, odds ratios for lifetime and annual STI infections associated with experiencing paternal imprisonment only were statistically significant and similar (OR ~1.2) once adjusted

for controls, suggesting consistency in cross-sectional and longitudinal results for paternal imprisonment only as a modest, but independent risk factor for STI infection.

In examining mediation patterns, the introduction of familial/neighborhood, individual risk and resilience factors, and sexual risk each showed some mediation effect between (1) maternal and/or paternal imprisonment and lifetime STI infection and (2) paternal imprisonment and annual STI infection. While factors such as risky sexual behaviors and substance abuse have been found to potentially mediate the relationship between parental imprisonment and STI infection,[15,20] our results show that the set of combined controls fully or substantially mitigated these associations. This finding is generally consistent with other studies where results for parental imprisonment are partially or fully mediated when controls are added for co-occurring risks such as parental criminality, poverty, and residential instability.[12,13,44,45] As noted in the introduction, parental imprisonment potentially acts as both an adverse childhood event and a risk factor for adversity in the later life course. Thus, our findings suggest that STI risk associated with parental imprisonment may be partly explained by childhood adversities and disadvantages that include physical abuse, low school attachment, and living in a neighborhood with high rates of poverty. At the same time, parental imprisonment may lead to antisocial behaviors, change in BMI, alcohol and drug use, and a higher number of sex partners that contribute to sexual risk taking and sexual health issues associated with parental imprisonment and STI infection. As suggested by Roettger & Dennision,[5] complex interrelationships exist between parental imprisonment, adversities encountered throughout stages of the life course, and interrelated adverse behavioral outcomes; interventions to reduce risk of STI infection will likely require addressing multiple traumatic experiences and behaviors. For health practitioners, asking individuals about parental imprisonment histories, due to the range of associated risks, may serve as way to better assess risk of STI infection.

One unexpected finding was that maternal imprisonment and joint mother and father imprisonment, after adjusting confounders and mediators, were not significant predictors of lifetime STI risk and were also non-significant in longitudinal analysis. While this may be due to smaller sample sizes compared to paternal imprisonment, it is also critical to note that these types of imprisonment may be associated with broader sets of disadvantages, such as poverty and family instability.[46,47]

Strengths and Weaknesses

Our study has a number of strengths. Our combination of cumulative and longitudinal analysis for STI infection allowed us to test if the general association between parental imprisonment and STI infection consistently holds over time for a broad range of STIs. Addressing a range of prior methodological issues and using supplemental analysis to investigate the reliability and accuracy of our results, we have been able to examine the validity of the association between parental imprisonment and STI risk. Examining variations by age, gender, and ethnicity of respondents using predicted probabilities, we have been able to test for potential variations in parental imprisonment and STI infection. By including a range of controls, we have been able to shed additional insight into potential adverse childhood experiences and co-occurring risk factors that may mediate the association between parental imprisonment and sexual behaviors that may lead to STI infection. Lastly, by examining STI infection over time and supplementing Wave 4 STI reports of lifetime infection with reports of STI infection at earlier ages, we were able to 1) control for recall bias[34] and 2) allow for additional time for cases where asymptomatic STI infections may be underreported due to lack of testing at one particular timepoint,[48] known sources of biases for self-reported measures.

Our study also has notable limitations. Prior research shows Add Health self-reports of STI infections were slightly lower overall for the general population, with greater under-reporting for minorities;[43] laboratory-based testing may thus yield, particularly longitudinally, variation from our reported findings of similar risks for parental imprisonment by ethnicity over time. As many STIs may be asymptomatic and revealed only with testing, our longitudinal analysis represents prevalence of 'diagnosis,' not infection rates.[34,49] Due to variation in questions across waves, we were unable to examine longitudinal models in adolescence, or analyze changes in STI risk between adolescence and adulthood. Our measure of parental imprisonment is also based on recollection and may include shorter jail and longer prison sentences that yield differing risks; the collection of administrative data may provide more reliable data for evaluating STI infection risk within a jurisdiction.[50] Data limitations, such as the lack of prospective data on parental imprisonment in childhood, the inability to temporally link parental imprisonment with subsequent sexual risk and STI infections, and unmeasured, related factors such as exposure to family instability and parental criminality, also prevented us from exploring underlying causation. Gene-environment interactions for risky behaviors, such as self-control or sensation seeking, that lead to increased STI risk are not observed in our study, but may also explain our association if transmitted from parent to child.[51-53]

Conclusion

This study provides evidence that paternal imprisonment only in childhood is associated with elevated lifetime and longitudinal annual risks of having an STI infection in early and mid-adulthood. We find that annual and lifetime risk of STI infection associated with parental imprisonment only is additive to increased risks for STI infections for women and black respondents. For adults who have experienced parental imprisonment in childhood, increased testing and treatment for STIs may help to reduce increased risks. Addressing co-

occurring childhood traumas and behavioral issues linked to parental imprisonment, such as child abuse, substance use, and poor sexual health, are important in creating policies and interventions to reduce the risk of STI infection in adolescence and early adulthood.

Footnotes

Contributors: Conception and design of study: MR, BH. Data preparation and analysis: MR. Interpreting results: MR, BH. Drafting of the initial and revised submissions: MR. Revising all manuscript submissions critically: MR, BH. All authors approved the final manuscript.

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Data and code: Access to the data is restricted to maintain participant confidentiality, but may be obtained from the Carolina Population Center (https://www.cpc.unc.edu/projects/addhealth/documentation/restricteduse). The code used in the analysis is available upon request from the corresponding author.

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Figure 1: Age-graded risk for self-reported STI infection in 12 months prior to interview for non-Black respondent infection probabilities are presented by respondent gender and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

Figure 2: Age-graded risk for self-reported STI infection in 12 months prior to interview for Black respondent infection probabilities are presented by respondent gender and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

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Table 1: Means, standard deviations and test of group means for individual, family, neighborhood, and sexual risk variables, by exposure to parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Parental Imprisonment [n=2339]		No parental Imprisonment [n=12997]		Test of Group Means
	Mean/%	SD	Mean /%	SD	p-value (p<)
Parent Imprisonment					
Gender of Parent					
Father imprisoned	87.16%				
Mother Imprisoned	21.23%				
Joint Parental Imprisonment					
Father only Imprisoned	78.77%				
Mather only imprisoned	12.84%				
Mother & Father Both Imprisoned	8.39%				
Ever STI Diagnosis	31.53%		21.10%		0.0001
STI Diagnosis, Prior 12 Months					
Wave 3	7.77%		5.39%		0.0001
Wave 4	9.71%		7.06%		0.0001
Demographic Measures					
Age at Interview (years)					
Wave 1	15.41	(1.70)	15.63	(1.74)	0.0001
Wave 3	21.76	(1.74)	21.95	(1.77)	0.0001
Wave 4	28.32	(1.75)	28.52	(1.79)	0.0001
Respondent Gender					
Male	44.91%		47.08%		0.0500
Female	55.09%		52.92%		0.0500
Racial Phenotype (Wave 1)					
White	46.38%		54.00%		0.0001
Black	31.69%		20.74%		0.0001
Hispanic	16.53%		15.87%		0.4387
Asian	1.76%		6.91%		0.0001
Native American	2.83%		1.55%		0.0001
Other/Multiple Race	0.81%		0.92%		0.6020
Family & Neighborhood Measures					
Family Structure (Wave 1)					
Two Biological Parents	21.96%		57.82%		0.0001
Single Mother	36.09%		21.23%		0.0001
Single Father	4.62%		3.10%		0.0002
Two Parent, One Biological	25.09%		12.92%		0.0001
Other Family Structure	12.24%		4.92%		0.0001
Completed Parental Education					
Bachelor's Degree	15.34%		25.61%		0.0001
High School	60.52%		57.96%		0.0183
Less Than High School	24.14%		16.43%		0.0001

Percentage of families in respondent's census tract below poverty level	14.29%		11.47%		0.0001
Individual Measures					
School Attachment (Wave 1)	3.64	(0.92)	3.77	(0.96)	0.0001
Self-Reported BMI (Wave 1)	22.96	(4.70)	22.56	(4.49)	0.0001
Measured BMI (Wave 2)	23.47	(5.43)	23.07	(5.03)	0.0024
History of physical child abuse	15.99%		7.65%		0.0001
Parent's report, child temperament issues (Wave 1)	38.33%		29.47%		0.0001
Delinquent Activity Scale (Wave 1)	2.66	(4.34)	1.71	(3.29)	0.0001
Frequency of marijuana usage prior 30 days (wave 1)	0.38	(0.93)	0.23	(0.71)	0.0001
Reported Binge Drinking, Prior 12 months					
Wave 1	0.75	(1.37)	0.59	(1.18)	0.0001
Wave 3	1.02	(1.44)	1.12	(1.42)	0.0038
Wave 4	1.03	(1.41)	0.95	(1.29)	0.0096
Sexual Risk Measures					
Parental Discussion of STI risk with Respondent	3.26	(0.94)	3.12	(0.96)	0.0001
Number of Sex Partners Prior (age<18)	4.64	(9.92)	2.79	(6.45)	0.0001

Table 2: Odds ratios and 95% confidence intervals for lifetime STI diagnosis among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.49 [1.33, 1.68]	1.36 [1.21, 1.54]	1.33 [1.19, 1.49]	1.38 [1.23, 1.55]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.48 [1.20, 1.82]	1.22 [1.02, 1.44]	1.30 [1.09, 1.55]	1.37 [1.16, 1.63]	1.13 [0.94, 1.36]
Biological Father only Imprisonment	1.52 [1.34, 1.71]	1.33 [1.19, 1.48]	1.34 [1.22, 1.55]	1.36 [1.22, 1.51]	1.22 [1.09, 1.37]
Biological Mother only Imprisonment	1.59 [1.20, 2.10]	1.32 [1.00, 1.75]	1.39 [1.05,1.87]	1.47 [1.11, 1.95]	1.20 [0.90,1.61]
Biological Mother & Father Imprisonment	1.58 [1.16, 2.15]	1.33 [1.07,1.66]	1.39 [1.11, 1.72]	1.45 [1.07,1.99]	1.21 [0.97,1.52]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1 (Demographic controls)= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2 (Family & Neighborhood controls)= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls)= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4 (Sexual risk controls) =Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls)=all variables used in prior models.

Table 3: Predicted probabilities and 95% confidence intervals for ever being infected with an STI, by parent gender, child gender, and black/non-black racial classification (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

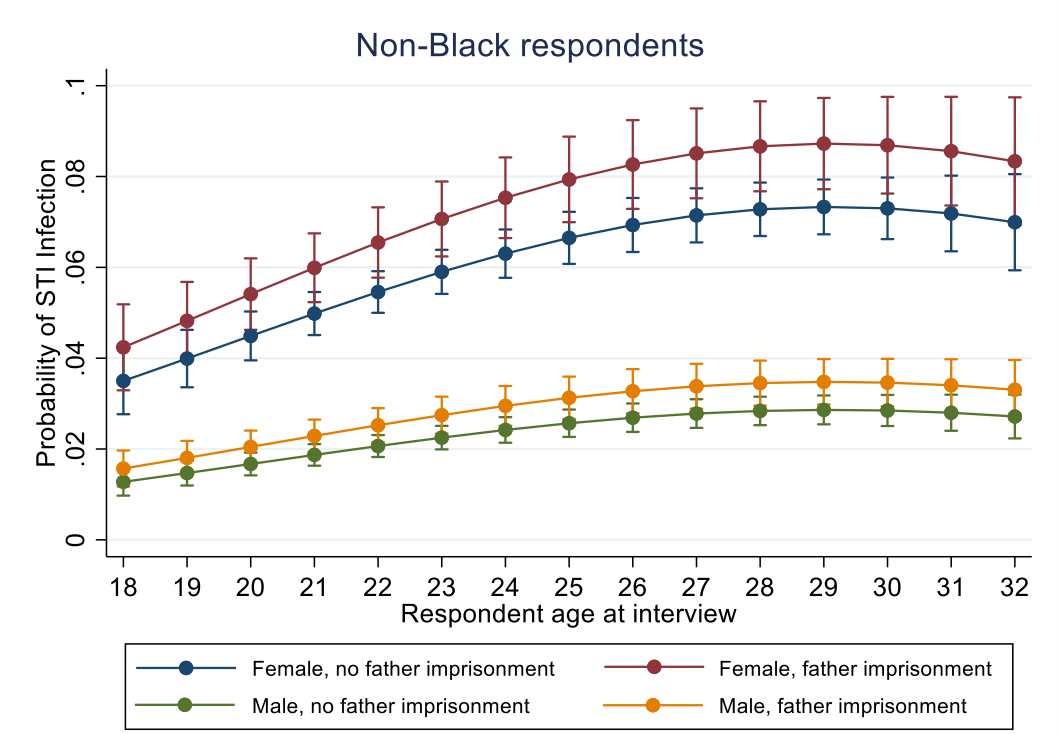
	Non-Black, Male	Non-Black, Female	Black, Male	Black, Female
Biological Father Imprisonment	12.5% [11.2%, 13.9%]	29.3% [27.0%, 31.7%]	35.8% [32.7%, 38.8%]	61.7% [58.8%, 64.7%]
No Biological Father Imprisonment	8.9% [8.2%, 9.6%]	22.1% [21.1%, 23.2%]	27.6% [25.6%, 29.5%]	52.4% [50.2%, 54.6%]
Biological Mother Imprisonment	13.5% [11.0%, 16.0%]	30.4% [25.6%, 35.1%]	37.7% [32.7%, 42.7%]	63.2% [58.4%, 68.0%]
No Biological Mother Imprisonment	9.6% [8.9%, 10.0%]	23.0% [22.0%, 24.1%]	29.1% [27.1%, 31.0%]	53.7% [51.7%, 55.8%]

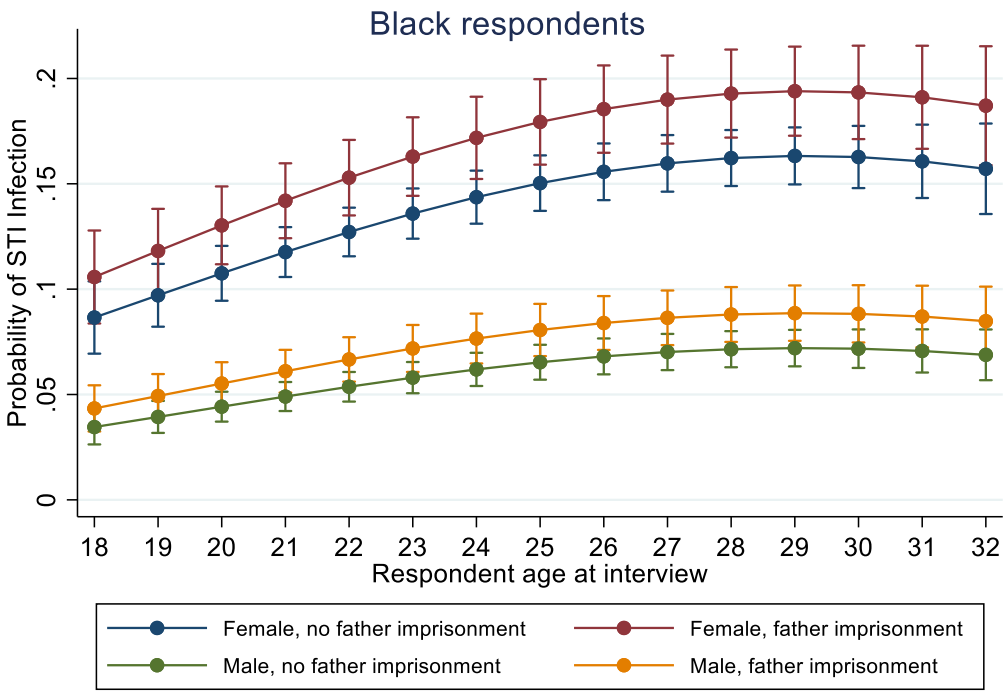
Notes: Predicted Probabilities generated based on Model 1 of Table 2 for respondents reporting if their (1) biological father or (2) biological mother was imprisoned at age<18. Model predictors of STI infection include parental imprisonment, respondent age, respondent gender, and respondent ethnicity.

Table 4: Odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.33 [1.13, 1.56]	1.26 [1.06, 1.50]	1.22 [1.03, 1.43]	1.26 [1.07, 1.49]	1.15 [0.98, 1.37]
Biological Mother Imprisonment	1.22 [0.89, 1.66]	1.10 [0.81, 1.51]	1.09 [0.80, 1.48]	1.17 [0.85, 1.58]	1.02 [0.75, 1.40]
Biological Father only Imprisonment	1.36 [1.15, 1.60]	1.30 [1.10, 1.54]	1.25 [1.06, 1.50]	1.30 [1.10, 1.55]	1.19 [1.01, 1.41]
Biological Mother only Imprisonment	1.43 [0.96, 2.14]	1.33 [0.88, 2.00]	1.31 [0.88, 1.95]	1.37 [0.92, 2.05]	1.24 [0.81,1.86]
Biological Mother & Father Imprisonment	1.12 [0.69, 1.82]	1.03 [0.63, 1.70]	0.95 [0.58, 1.56]	1.06 [0.65, 1.74]	0.89 [0.54, 1.46]

Notes: Model 1 (Demographic controls)= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2 (Family & Neighborhood controls)= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls)= Model 1 +respondent adolescent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + binge drinking prior 12 months + serious adolescent delinquency. Model 4 (Sexual risk) =Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls) =all variables used in prior models.





Supplemental Table S1: Lifetime Odds of Contracting an STI Associated with Parental Imprisonment With Full Controls

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.24 [1.04,1.48]		
Mother Imprisoned		1.13 [0.94, 1.36]	
Joint Parental Imprisonment			
Father only Imprisoned			1.22 [1.09, 1.37]
Mather only imprisoned			1.20 [0.90,1.61]
Mother & Father Both Imprisoned			1.21 [0.97,1.52]
Demographic Measures			
Age at interview	0.96 [0.91,1.00]	0.96 [0.94,0.98]	0.96 [0.94,0.99]
Female	3.48 [3.01, 4.02]	3.30 [3.00,3.61]	3.29 [3.00, 3.61]
Racial Phenotype (Wave 1)			
White [reference]			
Black	4.26 [3.67,4.95]	4.00 [3.59,4.46]	4.00 [3.58,4.45]
Hispanic	1.45 [1.12,1.86]	1.30 [1.14,1.49]	1.30 [1.14,1.48]
Asian	1.10 [0.81,1.47]	1.01 [0.83,1.24]	1.03 [0.84,1.25]
Native American	2.09 [1.41,3.12]	1.78 [1.33,2.39]	1.76 [1.31,2.36]
Other/Multiple Race	1.51 [0.93,2.44]	1.38 [0.92,2.08]	1.39 [0.93,2.07]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.00 [0.84,1.19]	1.09 [0.98,1.21]	1.04 [0.94,1.16]
Single Father	1.11 [0.81,1.48]	1.23 [0.97,1.56]	1.20 [0.95,1.52]
Two Parent, One Biological	1.20 [0.95,1.52]	1.26 [1.11,1.42]	1.19 [1.05,1.35]
Other Family Structure	1.44 [1.11,1.85]	1.46 [1.23,1.73]	1.40 [1.17,1.66]

Completed Parental Education			
Bachelor's Degree	1.03 [0.82,1.30]	0.96 [0.83,1.10]	0.97 [0.85,1.11]
High School	1.06 [0.87,1.30]	0.94 [0.84,1.06]	0.94 [0.84,1.06]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	0.98 [0.54.1.80]	1.11 [0.75.1.63]	1.10 [0.75.1.63]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.96 [0.90,1.02]	0.94 [0.90,0.99]	0.95 [0.90,0.99]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.30 [1.07,1.60]	1.39 [1.21,1.60]	1.36 [1.18,1.57]
Parent's report, child temperament issues (Wave 1)	1.16 [1.03,1.30]	1.13 [1.03,1.24]	1.13 [1.03,1.24]
Delinquent Activity Scale (Wave 1)	1.03 [1.01,1.04]	1.02 [1.00,1.04]	1.02 [1.01,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.17 [1.02,1.16]	1.14 [1.07,1.22]	1.14 [1.07,1.21]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.09 [1.02,1.16]	1.08 [1.04,1.13]	1.09 [1.04,1.13]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	1.02 [0.93,1.11]	1.06 [1.00,1.11]	1.05 [1.00,1.10]
Number of Sex Partners Prior (age<18)	1.03 [1.01,1.04]	1.03 [1.02,1.04]	1.03 [1.01,1.04]

Notes: Each model represents full results from Model 5 in Table 2, by measure of parental imprisonment.

Supplemental Table S2. Weighted odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.47 [1.24, 1.74]	1.34 [1.13, 1.59]	1.34 [1.12, 1.60]	1.38 [1.16, 1.65]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.40 [1.04, 1.89]	1.17 [0.86, 1.59]	1.20 [0.89, 1.62]	1.28 [0.94, 1.74]	1.03 [0.76, 1.41]
Biological Father only Imprisonment	1.46 [1.22, 1.75]	1.35 [1.13, 1.61]	1.34 [1.11, 1.63]	1.39 [1.16, 1.66]	1.25 [1.04, 1.51]
Biological Mother only Imprisonment	1.40 [0.94, 2.10]	1.18 [0.78, 1.76]	1.17 [0.78, 1.77]	1.28 [0.83, 1.98]	1.01 [0.66, 1.54]
Biological Mother & Father Imprisonment	1.59 [1.13, 2.23]	1.36 [0.96, 1.93]	1.38 [0.98, 1.94]	1.43 [1.00, 2.05]	1.18 [0.83, 1.69]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1+ respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S3: Longitudinal Odds of STI infection in the prior 12 months associated with Parental Imprisonment, full model results

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.12 [0.96,1.30]		
Mother Imprisoned		0.92 [0.71, 1.21]	
Joint Parental Imprisonment			
Father only Imprisoned			1.18 [1.01, 1.38]
Mather only imprisoned			1.17 [0.77,1.77]
Mother & Father Both Imprisoned			0.88 [0.62,1.24]
Demographic Measures			
Age	1.48 [1.18,1.86]	1.49 [1.18,1.87]	1.49 [1.18,1.87]
Age-Squared	0.99 [0.99,0.99]	0.99 [0.99,0.99]	0.99 [0.99,0.99]
Female	3.33 [2.91, 3.81]	3.34 [2.93, 3.82]	3.33 [2.91, 3.81]
Racial Phenotype (Wave 1)			
White [reference]			
Black	3.16 [2.71,3.68]	3.17 [2.71,3.68]	3.16 [2.71,3.68]
Hispanic	1.21 [1.00,1.47]	1.21 [1.00,1.47]	1.21 [1.00,1.47]
Asian	0.93 [0.70,1.24]	0.93 [0.70,1.24]	0.94 [0.71,1.25]
Native American	1.69 [1.12,2.55]	1.71 [1.14,2.58]	1.70 [1.13,2.55]
Other/Multiple Race	1.53 [0.88,2.69]	1.53 [0.88,2.69]	1.54 [0.88,2.71]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.05 [0.91,1.23]	1.09 [0.94,1.26]	1.05 [0.90,1.22]
Single Father	0.85 [0.60,1.21]	0.87 [0.61,1.24]	0.84 [0.59,1.20]
Two Parent, One Biological	1.10 [0.92,1.31]	1.15 [0.97,1.36]	1.10 [0.93,1.32]

Other Family Structure	1.19 [0.93,1.53]	1.25 [0.97,1.59]	1.20 [0.93,1.54]
Completed Parental Education			
Bachelor's Degree	1.05 [0.87,1.29]	1.05 [0.86,1.28]	1.06 [0.87,1.30]
High School	0.97 [0.82,1.15]	0.97 [0.82,1.14]	0.97 [0.82,1.15]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	2.02 [1.19,3.34]	2.03 [1.20,3.44]	2.01 [1.19,3.40]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.95 [0.89,1.01]	0.95 [0.89,1.01]	0.95 [0.89,1.01]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.15 [0.94,1.41]	1.17 [0.96,1.43]	1.15 [0.94,1.41]
Parent's report, child temperament issues (Wave 1)	1.18 [1.03,1.35]	1.18 [1.03,1.35]	1.17 [1.02,1.34]
Delinquent Activity Scale (Wave 1)	1.00 [0.99,1.03]	1.01 [0.99,1.03]	1.01 [0.99,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.14 [1.05,1.24]	1.14 [1.05,1.24]	1.14 [1.05,1.24]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.15 [1.10,1.20]	1.15 [1.10,1.20]	1.15 [1.10,1.20]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	0.98 [0.92,1.05]	0.98 [0.92,1.05]	0.98 [0.92,1.05]
Number of Sex Partners Prior (age<18)	1.02 [1.01,1.03]	1.02 [1.01,1.03]	1.02 [1.01,1.03]

Notes: Each model represents full results from Model 5 in Table 4, by measure of parental imprisonment.

Supplemental Table S4. Odds ratios and 95% confidence intervals for ever being infected with gonorrhea or chlamydia among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.58 [1.40, 1.77]	1.36 [1.21, 1.54]	1.45 [1.29, 1.63]	1.48 [1.32, 1.67]	1.28 [1.13, 1.44]
Biological Mother Imprisonment	1.58 [1.29, 1.91]	1.28 [1.04, 1.56]	1.41 [1.16, 1.73]	1.49 [1.23, 1.82]	1.20 [0.97, 1.48]
Biological Father only Imprisonment	1.58 [1.41, 1.78]	1.38 [1.22, 1.58]	1.48 [1.31, 1.68]	1.49 [1.32, 1.58]	1.29 [1.14, 1.48]
Biological Mother only Imprisonment	1.78 [1.30, 2.45]	1.45 [1.05, 2.00]	1.60 [1.16, 2.21]	1.67 [1.21, 2.30]	1.34 [0.97, 1.86]
Biological Mother & Father Imprisonment	1.73 [1.36, 2.20]	1.41 [1.10, 1.81]	1.55 [1.21, 1.98]	1.62 [1.27, 2.07]	1.29 [1.00, 1.67]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S5. Complete case analysis for odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.48 [1.32, 1.65]	1.34 [1.19, 1.51]	1.36 [1.17, 1.57]	1.35 [1.19, 1.53]	1.24 [1.06, 1.44]
Biological Mother Imprisonment	1.48 [1.21, 1.82]	1.19 [0.96, 1.48]	1.14 [0.86, 1.51]	1.29 [1.03, 1.63]	0.93 [0.69, 1.25]
Biological Father only Imprisonment	1.49 [1.32, 1.67]	1.37 [1.21, 1.55]	1.40 [1.21, 1.63]	1.37 [1.20, 1.56]	1.29 [1.10, 1.51]
Biological Mother only Imprisonment	1.64 [1.27, 2.12]	1.33 [1.01, 1.74]	1.44 [1.02, 2.01]	1.48 [1.12, 1.95]	1.16 [0.81, 1.69]
Biological Mother & Father Imprisonment	1.55 [1.11, 2.15]	1.21 [0.86, 1.72]	0.95 [0.60, 1.50]	1.26 [0.86, 1.84]	0.76 [0.47, 1.25]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S6. Complete case analysis for odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.30 [1.10, 1.53]	1.22 [1.03, 1.45]	1.16 [0.94, 1.42]	1.10 [1.00, 1.43]	1.07 [0.86, 1.33]
Biological Mother Imprisonment	1.21 [0.88, 1.65]	1.05 [0.75, 1.46]	1.20 [0.80, 1.81]	1.23 [0.88, 1.72]	1.08 [0.71, 1.65]
Biological Father only Imprisonment	1.33 [1.13, 1.58]	1.27 [1.06, 1.51]	1.22 [0.99, 1.51]	1.23 [1.02, 1.48]	1.14 [0.91, 1.42]
Biological Mother only Imprisonment	1.36 [0.93, 2.01]	1.22 [0.80, 1.85]	1.64 [1.00, 2.70]	1.46 [0.96, 2.22]	1.48 [0.88, 2.47]
Biological Mother & Father Imprisonment	1.15 [0.69, 1.92]	0.95 [0.56, 1.61]	0.79 [0.38, 1.63]	1.04 [0.58, 1.85]	0.67 [0.31, 1.44]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adult binge drinking (time-varying) + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*

Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-8
Objectives	3	State specific objectives, including any pre-specified hypotheses	4-8
Methods			
Study design	4	Present key elements of study design early in the paper	8-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8-9
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9-10*
Bias	9	Describe any efforts to address potential sources of bias	8-11
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-12
		(*b*) Describe any methods used to examine subgroups and interactions	10-12
		(*c*) Explain how missing data were addressed	10-12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	10-11

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	12, 14-15
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-12
		(b) Indicate number of participants with missing data for each variable of interest	8-9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8-12
		Cross-sectional study—Report numbers of outcome events or summary measures	8-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	8-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-14
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early adulthood

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Submission Category: Original Research

Title Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early adulthood

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Running Head: Parental Imprisonment and STI Risk in Adulthood

Abstract

Objectives: One-in-six young adults in the U.S. experience parental imprisonment in childhood. Prior studies have associated parental imprisonment with risk of sexually transmitted infection (STI); however, potential data and methodological issues may have limited the reliability and accuracy of prior findings. Examining cumulative and longitudinal risk, we address several methodological limitations of prior studies and also examine comparative risk by respondent gender and ethnicity. We assess these associations using a range of control variables.

Design: A national cohort study from the National Longitudinal Study of Adolescent to Adult Health using (1) a cross-sectional sample of adults at ages 24-32 and (2) a longitudinal sample between ages 18-32. Both analyses estimate odds ratios for STI infection associated with parental imprisonment and examine variation by parent/child gender and respondent ethnicity.

Setting: In-home interviews in the United States at Wave 1 (1994-1995), Wave 3 (2001-2003) and Wave IV (2007-2009).

Participants: 15,684 respondents completing interviews at Wave 1 (ages 12-18) and Wave 4 (ages 26-32), including 8,556 female, 3,437 black, and 2,397 respondents reporting parental imprisonment.

Results: Father-only imprisonment is associated with 1.22 higher odds (95% confidence interval (CI): 1.09, 1.37) of lifetime STI infection and 1.19 higher odds (95% CI: 1.01, 1.41) of STI infection in the past 12 months between ages 18-32, adjusting for familial, neighborhood, individual, and sexual risk factors. Maternal imprisonment is associated with higher risk of lifetime STI, but the 95% CIs overlapped with 1 adjusted for confounders (95% CI: 0.90, 1.61). Examining predicted probabilities of STI infection, our findings show additive risks for women, blacks, and parental imprisonment.

Conclusion: Adjusting for confounders, only paternal imprisonment is associated with slightly elevated risk of annual and lifetime risk of STI infection. Additive effects show that parental imprisonment modestly increases ethnic and gender risk for STI infection.

Keywords:

Sexually transmitted infections; parental imprisonment; mass incarceration; health status disparities; minority health

Strengths & Limitations

- This study addresses data and methodological issues of prior work to improve accuracy and reliability for estimating the association between parental imprisonment and risk of STI infection.
- The study leverages cross-sectional and longitudinal measures to compare lifetime and longitudinal risk.
- Comparative analysis is performed to determine potential variations in STI risk by maternal and paternal imprisonment, and respondent gender and ethnicity.
- The study lacks measures to determine underlying potential causal factors, such as residential instability and parental criminality that may explain the association.
- While STI self-reports are prospectively collected, data on parental imprisonment is retrospectively collected.

Introduction

According to recent research, 2.6 million U.S. children have a parent in jail or prison, with 4% of white, 24% of black, and 11% of Hispanic children ever experiencing a parent serving time in state or federal prison.[1,2] Parental imprisonment is an adverse childhood experience linked to a range of adversities from birth to death, including prenatal exposure to alcohol and drugs, poor academic and educational outcomes, criminal behavior and subsequent imprisonment.[3-6] In the last decade, research has increasingly linked parental imprisonment to health issues that include sexually transmitted infections (STIs), depression, cardiovascular and metabolic diseases, respiratory conditions, and infant and adult mortality.[7-11] Due to the interrelationship between parental imprisonment and other childhood traumas, such as family instability and child abuse, and linkage with outcomes, such as antisocial and risky behaviors, documenting associations and potential mediating effects is critical for linking parental imprisonment to health outcomes later in the life course.[12-15] The present study assesses whether parental imprisonment is a risk factor for STI infections and potential mediating factors that may explain this association.

The potential association between parental imprisonment and STIs in the U.S. is important given the scale of parental imprisonment in the U.S., increasing rates of STI infections, and resulting health complications from STI infection. Rates of STI infection have generally increased in the U.S. Between 2000 and 2017, chlamydial infection rates doubled from 251.4 to 528.8 per 100,000, while gonorrhea infection rates increased by 75% from 99.1 to 171.9 cases per 100,000 between 2009 and 2017.[16] An STI that is undetected and left untreated may result in a range of chronic health issues such as infertility or adverse birth outcomes (chlamydia, gonorrhea), cervical and testicular cancers (HPV), and mortality (syphilis, HIV/AIDS).[16-18] An increased risk for STIs associated with experiencing parental imprisonment may thus contribute to a range of adverse outcomes later in the life course.

In cross-sectional analyses of the National Longitudinal Study of Adolescent to Adult Health (Add Health), parental imprisonment has been associated with STI infection in adolescence and adulthood.[3,15,19,20] Further studies have linked STI infection with substance abuse, childhood trauma, early sexual activity, and risky sexual behavior.[3,15,19-23] These analyses also suggest that women[19] and minorities[20,22] who experience parental imprisonment may be at greater likelihood of having an STI infection, though these gender and racial differentials were not tested for statistical significance. Parental imprisonment has also been associated with altered age trajectories for engaging in delinquent behavior and drug use, and age trajectories may similarly vary for STI infection.[24,25] Some research examining cross-sectional risk of STI infection at multiple time points suggests that STI infection risk associated with parental imprisonment may vary by life stage and be mediated by factors such as child abuse, family instability, substance use, adolescent antisocial behavior (particularly, life course persistent or chronic offending), or sexual risk taking.[19,20,26]

While this research suggests parental imprisonment is associated with STI infection, important research gaps remain that we address in our analysis. Extending prior research to incorporate longitudinal analysis is important for determining how the association between parental imprisonment and STI risk may hold or change as individuals age out of early adulthood, while addressing potential temporal ordering issues of co-occurring risks such as antisocial behavior and substance use.[27,28] By comparing cross-sectional results for lifetime risk of STI infection at ages 24-32 with longitudinal risk of annual STI infection, we are able to establish how parental imprisonment impacts age-graded risk of STI infection.

We also examine how the association between parental imprisonment and STI infection may vary by the potential confounding or mediating roles of other related factors. Understanding these mediation patterns is critical for identifying potential pathways between childhood adversity and later adverse outcomes associated with parental imprisonment that

may impact STI risk. We examine if gender of parent and child differentiates risk, along with mediating patterns for four sets of factors: 1) demographic, 2) familial and neighborhood characteristics (including familial socioeconomic status and household composition), 3) individual risk and resiliency, and 4) sexual risk factors.

We examine potential STI risk disparities for parental imprisonment by parent/child gender and ethnicity,[7] particularly in light of findings that women and African Americans are more likely to contract an STI.[29-31] Results by Khan et al[20] are suggestive that STI infection risk associated with parental imprisonment is higher for minority groups, but this study did not statistically test if this risk for parental imprisonment was statistically significant across ethnic groups. Furthermore, the compounded risks by gender and ethnicity may not be additive, leading to variation in STI risk associated with parental imprisonment (e.g., black male and female respondents may have similar STI risk, or black females may have a greater STI risk than black males). By testing these associations, we are able to determine if the risk of parental imprisonment for STI infection may vary based on a respondent's gender and ethnicity.

To date, most studies have focused on associations with 1-3 STIs,[3,15,19] while broader general risk for being diagnosed with an STI provides insights into general STI infection risks linked with parental imprisonment. We estimate the general risk of STI infection associated with parental imprisonment in cross-sectional and longitudinal models.

Our analysis examines the validity of the models we estimate, addressing issues concerning survey weighting, small cell sizes, and missing data which may increase uncertainty and reliability issues in prior research on this topic. This is critical for providing consistent and reliable estimates gauging the extent to which parental imprisonment may be a risk factor for STI infection.

METHODS

Data

We use data from the U.S. National Longitudinal Study of Adolescent to Adult Health (Add Health). The Add Health study initially surveyed approximately 90,000 students enrolled in grades 7-12 (ages 12-18) in 1994-1995 in in-school interviews. Our study follows a subpopulation of ~20,750 respondents who were randomly selected from the in-school sample for in-home interviews. These respondents were followed up at three later waves: ~14,700 respondents at Wave 2 in 1996, 15,200 respondents at Wave 3 in 2001-2002, and ~15,700 respondents at Wave 4 in 2007-2008. Of the original sample, the proportion of Wave 1 respondents completing surveys at each round are: 71% at Wave 2, 73% at Wave 3, and 75% at Wave 4.[32] Our analysis includes only individuals completing both Wave 1 and Wave 4 interviews, with 74.5% and 81.5% of these respondents completing interviews, respectively, at Waves 2 & 3.

Details of the survey design and reasons for non-response at each wave are available from the Add Health website https://www.cpc.unc.edu/projects/addhealth.

Our analytic sample consists of 15,684 individuals who completed questionnaires at both Waves 1 & 4 when questions about biological mother and father imprisonment were first asked; including 14,796 individuals with valid survey weights. The reduced number of cases arises from individuals missing information from the school or household-level needed to create nationally-representative weights for the cohort; as an example, sibling pairs in the in-home sample but not enrolled in the same school were not given sampling weights.[33]

Measures

All measures are constructed using items taken from Waves I-IV of the Add Health survey and can be downloaded from the Add Health website.[34]

STI infections. Our outcome measure of STI infection is a dichotomous indicator for respondents reporting being told by a doctor, or other health professional of being infected with any of the following STIs: 1) chlamydia, 2) gonorrhea, 3) trichomoniasis, 4) syphilis, 5) hepatitis B, 6) human papilloma virus (HPV), 7) HIV/AIDs, and 8) other sexually transmitted diseases, not elsewhere reported by respondents such as genital herpes, genital warts, vaginitis, urethritis, pelvic inflammatory disease, or cervicitis.

From these reports, we construct an indicator for 1) ever being infected with an STI and 2) being infected with an STI in the 12 months prior to interview (available at Waves III and IV). For lifetime infection we supplement Wave IV reports with reports of being infected with any of the STIs listed above at earlier Waves, addressing cases where respondents are known to deny STI infections in self-reports at older ages.[35]

Parental imprisonment. At Wave IV, respondents were asked "(Has/did) your biological mother/father ever (spent/spend) time in jail or prison?" and "How old were you when your biological mother/father went to jail or prison (the first time)?" Using these questions, we construct indicator variables for maternal and paternal imprisonment occurring prior to age 18. We code separate measures for (1) father imprisonment, (2) mother imprisonment, and (3) and mutually exclusive categories of mother and/or father imprisonment. While prior research suggests recollection of childhood traumas and reporting of parental imprisonment yields reliable estimates,[36,37] recollection of the specific age at first parent imprisonment may be less reliable, particularly in early childhood. Our coding addresses this potential issue in prior research.

Demographic controls. We include respondent age at each wave, biological sex, and if the respondent identified as black, white, Hispanic, Native American, Asian, or other racial classification at Wave I.

Familial/neighborhood controls. We control for parent's reported level of education and family structure at Wave I (in over 90% of cases, the parent reporting education is the biological mother or step-mother). We include Wave I neighborhood SES as the proportion of families in the respondent's census tract residing below the poverty level.

Individual risk measures. For individual controls, we incorporate measures of measured body mass index (BMI; kg/m^2) at Wave II, an indicator for physical child abuse (Wave IV self-report), difficult child temperament (Wave I parent interview), a Wave I school attachment scale, adolescent marijuana usage in the 30 days prior to the interview (Wave I), binge drinking in the prior 12 months to the interview (Waves I, III, & IV), and a 12-item Wave I delinquency score (for details of the school attachment and delinquency scales are available in Guo et al[38]).

STI risk factors. Measures include the total number of sexual partners before age 18 and parental reports of the degree to which they discuss STI risk with respondents on a 5-point Likert scale (with higher scores indicating greater discussion about STI risks).

Patient & Public Involvement

This study uses anonymized secondary data from the National Longitudinal Study of Adolescent to Adult Health. As a result, this study is conducted without patient involvement in designing the study, creating outcomes, or interpreting results. Study participants are also not included in contributing to the writing or editing of this document for readability or accuracy.

Analytical strategy

To analyze the risk of lifetime STI infection, we use logistic regression. Add Health uses multiplicative weights ranging between 20-18,342 (mean 1,480.28, SD 1,425.65) to

create a representative national cohort at Wave 4.[34] This is a potential issue in prior studies where missing data and small cell counts used in analysis may substantially increase uncertainty. Analysis of unweighted data and controls to address sample bias may, alternatively, more efficiently estimate STI risk.[39] We focus our presentation on the unweighted results, but also compare coefficients between the weighted and unweighted data to examine potential uncertainty.[40]

To analyze the probability of STI infection over time, we use a two-level random effects logistic regression model where self-reports of STI infection in the prior twelve months at each wave are nested within individuals.

We impute 75 datasets using multiple imputation (MI) by chained equations to address missing data issues; we note imputation may address bias arising in prior research due to (1) missing data removing cases of greater social disadvantage where the effects of parental imprisonment have been found to be less significant and (2) removing 12% of cases of mothers (78/643) and 20% of cases of fathers (458/2283) where respondents report their parent as having been imprisoned, but not reporting the exact age when their parent was first imprisoned.[7,41,42]

Predicted probabilities and 95% CIs are generated by estimating means and standard errors using reported model estimates. These estimates results use baseline demographic controls for age, race/ethnicity, and respondent gender to estimate variation among these groups, in the absence of mediators.

We use STATA 15.1 for all analyses.

RESULTS

Table 1 contains descriptive statistics by respondent's history of parental imprisonment. Parental imprisonment is associated with increased risk of a range of adversities and disadvantages.

Lifetime STI infection

Table 2 presents results for lifetime risk of STI infection. The odds of STI infection were higher for imprisonment of the biological father (Odds ratio (OR): 1.49, 95% confidence interval (CI): 1.33, 1.68) and biological mother (OR: 1.48, 95% CI: 1.20, 1.82) in the baseline demographic model (Model 1). Modest declines in these estimates are associated with familial and neighborhood factors (Model 2), individual risk factors (Model 3), and sexual behavior risk factors (Model 4). Biological father remains a risk factor for STI infection (OR: 1.24, 95% CI: 1.04, 1.48) with the inclusion of all controls, while the 95% CIs for the odds ratio of maternal imprisonment included the null value of 1 (OR: 1.13, 95% CI: 0.94, 1.36).

Similar odds ratios for STI infection are observed for models for imprisonment of the biological father only (OR: 1.52, 95% CI: 1.34, 1.71), biological mother only (OR: 1.59, 95% CI: 1.20, 2.10), and biological mother and father (OR: 1.58, 95% CI: 1.16, 2.15). Similar mediation patterns are observed for biological father and biological mother imprisonment, with 95% CIs showing odds ratios >1 for biological father only (Models 1-5), biological mothers only (Models 1-4), and both father and mother imprisonment (Models 1-4).

In all cases, no single set of risk factors result in non-significance. Supplemental Table S1 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 2. Results using survey weights (Supplemental Table S2) also show comparable ORs to those presented in Table 2, with wider confidence intervals.

We find no significant interactions for parental imprisonment with gender and race. To examine cumulative risk, we estimate joint probabilities for lifetime STI infection by child gender, black/non-black ethnicity, and mother or father imprisonment, presented in Table 3. These results show that being female, having an incarcerated parent, and being black have additive effects for ever being infected with an STI. For example, a non-black male with no history of paternal imprisonment has a predicted probability of infection of 8.9% (95% CI: 8.2%, 9.6%), while those with a history of paternal imprisonment has a predicted probability of 12.5% (95% CI: 11.2%, 13.9%). In contrast, black women reporting no history of parental imprisonment had a 52.4% (95% CI: 50.2%, 54.6%) predicted probability of STI infection, compared to 61.7% (95% CI: 58.8%, 64.7%) with a history of paternal imprisonment. Similar predicted probabilities are associated with maternal imprisonment.

Longitudinal risk of STI infection

Table 4 examines longitudinal odds of STI infection in the 12-months prior to the interview. In these models, father imprisonment in the baseline model is associated with higher odds of STI infection (OR: 1.33, 95% CI: 1.13, 1.56). This association shows slight mediation when controls were introduced for familial and neighborhood (Model 2), individual (Model 3) and sexual behavior factors (Model 4); however, the 95% CIs for paternal imprisonment include the null value of 1 (95% CI: 0.98, 1.37) when all controls were included (Model 5). Maternal imprisonment shows no association with 12-month STI risk (Model 5 95% CI: 0.75, 1.40). In comparing imprisonment risk for categories of father and/or mother imprisonment, the 95% CIs of the association for father only imprisonment and STI risk remains >1 across all models, but mother only imprisonment, and father and mother imprisonment show no associations with STI risk.

Supplemental Table S3 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 4. We note that respondent age and heavy-drinking measures are time-varying measures that are not directly comparable to results presented in Supplemental Table S1.

To test for differences in father imprisonment and 12-month STI risk, we examine if age, ethnicity, and gender moderated results for paternal imprisonment, with no statistically significant moderation patterns observed. In lieu of moderation, we examine if predicted probabilities of STI diagnosis by age, ethnicity and gender show additive effects, as illustrated by Figure 1 (non-black respondents) and Figure 2 (black respondents). In all models there is a higher probability of diagnosis through the mid-20s, before the probability of STI diagnosis stabilizes. In Figure 1, the predicted probability of diagnosis of an STI in the past 12 months is higher for women than men, with parental imprisonment being associated with a modest increase in risk. Figure 2 shows a similar pattern, with higher baseline rates among black respondents. Collectively, these figures illustrate additive effects for paternal imprisonment, being black, and being a woman, with nearly one-fifth of black women who experience paternal imprisonment being diagnosed with an STI in the 12-months prior to interviews.

Sensitivity analysis

We conduct supplementary analyses to 1) compare MI results with complete case analysis for the main findings (Supplemental Tables S4 and S5); 2) compare the findings by Le et al.[15] for laboratory-confirmed infections of chlamydia and gonorrhea with our analysis for respondent self-reports of lifetime chlamydia and/or gonorrhea infection (Supplemental Table S6); and 3) test moderation results using complete case analysis by examining interactions for parental imprisonment by gender, race/ethnicity, and age in longitudinal

models (Raw output for moderation testing available on request). Comparisons 1) and 3) yield substantively similar results. For 2), our results are consistent with prior research on variations between lab-confirmed and self-reported STI infection for: 1) father only, and 2) mother and father imprisonment are lower, but within 95% CIs, while odds for mother only imprisonment are lower than the results reported by Le et al.[15,43]

DISCUSSION

Using a U.S.-based cohort study, we demonstrate that individuals experiencing paternal imprisonment, without co-occurring maternal imprisonment, in childhood is an independent risk factor for (1) higher lifetime odds of STI infection and (2) longitudinal annual STI infection risk in adults ages 18-32. In basic demographic models controlling for age, race, and gender, we find maternal and/or paternal imprisonment are associated with increased cumulative risk of STI infection, with predicted probabilities for STI infection showing additive risk for parental imprisonment, gender, and race. However, after introducing controls, only paternal imprisonment (without co-occurring maternal imprisonment) remains significant. In longitudinal models, respondents experiencing paternal imprisonment only in childhood face a statistically higher risk for annual STI infection after controls are added. Gender and ethnicity also independently raise risks of annual infection in longitudinal analysis. Furthermore, odds ratios for lifetime and annual STI infections associated with experiencing paternal imprisonment only are statistically significant and similar (OR ~1.2) once adjusted for controls, suggesting consistency in cross-sectional and longitudinal results for paternal imprisonment only as a modest, but independent risk factor for STI infection.

In examining mediation patterns, the introduction of familial/neighborhood, individual risk and resilience factors, and sexual risk each show some mediation effect

between (1) maternal and/or paternal imprisonment and lifetime STI infection and (2) paternal imprisonment and annual STI infection. While factors such as risky sexual behaviors and substance abuse may potentially mediate the relationship between parental imprisonment and STI infection,[15,20] our results show that the set of combined controls fully or substantially mitigated these associations. This finding is generally consistent with other studies where results for parental imprisonment are partially or fully mediated when controls are added for co-occurring risks such as parental criminality, poverty, and residential instability.[12,13,44,45]

As noted by Roettger & Dennision,[5] complex interrelationships exist between parental imprisonment, adversities encountered throughout stages of the life course, and interrelated adverse behavioral outcomes. Our findings align with this hypothesis, for instance, that paternal imprisonment shows similarly increased odds for STI infection that are also associated with child abuse and adolescent/adult substance use. While it remains critical that public health measures encourage safe sex and frequent testing to prevent and treat STIs associated with parental imprisonment, the need for earlier, more comprehensive health interventions is also important to address broader mental and physical health disparities linked with parental imprisonment and mass incarceration.[46-48] For example, treatment for substance use disorders and mental health issues linked with childhood abuse may be important components for reducing risky sexual behaviors among individuals with co-occurring histories of parental imprisonment. Addressing these "packages of risk"[49] – parental imprisonment and interrelated risks arising from different periods in the life course – is critical for ensuring that policies address the underlying causes which lead to risky sexual behaviors that may result in STI infection and later health complications.

One unexpected finding was that maternal imprisonment and joint mother and father imprisonment, after adjusting confounders and mediators, are not significant predictors of lifetime STI risk and are also non-significant in longitudinal analysis. While this may be due

to smaller sample sizes compared to paternal imprisonment, it is also critical to note that these types of imprisonment may be associated with broader sets of disadvantages, such as poverty and family instability.[49,50]

Strengths and Weaknesses

Our study contains a number of strengths. By combining cumulative and longitudinal analysis for STI infection, we investigate if the general association between parental imprisonment and STI infection consistently holds over time for a broad range of STIs. Addressing a range of prior methodological issues and using supplemental analysis to investigate the reliability and accuracy of our results, we examine the validity of the association between parental imprisonment and STI risk. Examining variations by age, gender, and ethnicity of respondents using predicted probabilities, we test for potential variations in parental imprisonment and STI infection. By including a range of controls, we shed additional insight into potential adverse childhood experiences and co-occurring risk factors that may mediate the association between parental imprisonment and sexual behaviors that may lead to STI infection. Lastly, by examining STI infection over time and supplementing Wave 4 STI reports of lifetime infection with reports of STI infection at earlier ages, we 1) control for recall bias[35] and 2) allow for additional time for cases where asymptomatic STI infections may be underreported due to lack of testing at one particular timepoint,[51] known sources of biases for self-reported measures.

Our study also contains notable limitations. Prior research shows Add Health self-reports of STI infections are slightly lower overall for the general population, with greater under-reporting for minorities;[43] laboratory-based testing may thus yield, particularly longitudinally, variation from our reported findings of similar risks for parental imprisonment by ethnicity over time. As many STIs may be asymptomatic and revealed only with testing,

our longitudinal analysis represents prevalence of 'diagnosis,' not infection rates.[35,52] Due to variation in questions across waves, we are unable to examine longitudinal models in adolescence, or analyze changes in STI risk between adolescence and adulthood. Our measure of parental imprisonment is also based on recollection and may include shorter jail and longer prison sentences that yield differing risks; the collection of administrative data may provide more reliable data for evaluating STI infection risk within a jurisdiction.[53] Data limitations, such as the lack of prospective data on parental imprisonment in childhood, the inability to temporally link parental imprisonment with subsequent sexual risk and STI infections, and unmeasured, related factors such as exposure to family instability and parental criminality, also prevents us from exploring underlying causation. Gene-environment interactions for risky behaviors, such as self-control or sensation seeking, that lead to increased STI risk are not observed in our study but may also explain our association if transmitted from parent to child.[54-56]

Conclusion

This study provides evidence that paternal imprisonment only in childhood is associated with elevated lifetime and longitudinal annual risks of having an STI infection in early and mid-adulthood. We find that annual and lifetime risk of STI infection associated with paternal imprisonment only is additive to increased risks for STI infections for women and black respondents. For adults who have experienced parental imprisonment in childhood, increased testing and treatment for STIs may help to reduce increased risks. However, broader policies and interventions are needed to address co-occurring childhood traumas and behavioral issues that link parental imprisonment with sexual health disparities.

Footnotes

Contributors: Conception and design of study: MR, BH. Data preparation and analysis: MR. Interpreting results: MR, BH. Drafting of the initial and revised submissions: MR. Revising all manuscript submissions critically: MR, BH. All authors approved the final manuscript.

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Patient consent for publication: Not required.

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Data and code: Access to the data is restricted to maintain participant confidentiality, but may be obtained from the Carolina Population Center (https://www.cpc.unc.edu/projects/addhealth/documentation/restricteduse). The code used in the analysis is available upon request from the corresponding author.

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Figure 1: Age-graded risk for self-reported STI infection in 12 months prior to interview for non-Black respondent infection probabilities are presented by respondent gender and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

Figure 2: Age-graded risk for self-reported STI infection in 12 months prior to interview for Black respondent infection probabilities are presented by respondent gender and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

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Table 1: Means, standard deviations and test of group means for individual, family, neighborhood, and sexual risk variables, by exposure to parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Parental Imprisonment [n=2,339]		No parental Imprisonment [n=12,997]		Test of Group Means
	Mean/%	SD	Mean /%	SD	p-value (p<)
Parent Imprisonment					
Gender of Parent					
Father imprisoned	87.16%				
Mother Imprisoned	21.23%				
Joint Parental Imprisonment					
Father only Imprisoned	78.77%				
Mather only imprisoned	12.84%				
Mother & Father Both Imprisoned	8.39%				
Ever STI Diagnosis	31.53%		21.10%		0.0001
STI Diagnosis, Prior 12 Months					
Wave 3	7.77%		5.39%		0.0001
Wave 4	9.71%		7.06%		0.0001
Demographic Measures					
Age at Interview (years)					
Wave 1	15.41	(1.70)	15.63	(1.74)	0.0001
Wave 3	21.76	(1.74)	21.95	(1.77)	0.0001
Wave 4	28.32	(1.75)	28.52	(1.79)	0.0001
Respondent Gender					
Male	44.91%		47.08%		0.0500
Female	55.09%		52.92%		0.0500
Racial Phenotype (Wave 1)					
White	46.38%		54.00%		0.0001
Black	31.69%		20.74%		0.0001
Hispanic	16.53%		15.87%		0.4387
Asian	1.76%		6.91%		0.0001
Native American	2.83%		1.55%		0.0001
Other/Multiple Race	0.81%		0.92%		0.6020
Family & Neighborhood Measures					
Family Structure (Wave 1)					
Two Biological Parents	21.96%		57.82%		0.0001
Single Mother	36.09%		21.23%		0.0001
Single Father	4.62%		3.10%		0.0002
Two Parent, One Biological	25.09%		12.92%		0.0001
Other Family Structure	12.24%		4.92%		0.0001
Completed Parental Education					
Bachelor's Degree	15.34%		25.61%		0.0001
High School	60.52%		57.96%		0.0183
Less Than High School	24.14%		16.43%		0.0001

Percentage of families in respondent's census tract below poverty level	14.29%		11.47%		0.0001
Individual Measures					
School Attachment (Wave 1)	3.64	(0.92)	3.77	(0.96)	0.0001
Measured BMI (Wave 2)	23.47	(5.43)	23.07	(5.03)	0.0024
History of physical child abuse	15.99%		7.65%		0.0001
Parent's report, child temperament issues (Wave 1)	38.33%		29.47%		0.0001
Delinquent Activity Scale (Wave 1)	2.66	(4.34)	1.71	(3.29)	0.0001
Frequency of marijuana usage prior 30 days (wave 1)	0.38	(0.93)	0.23	(0.71)	0.0001
Reported Binge Drinking, Prior 12 months					
Wave 1	0.75	(1.37)	0.59	(1.18)	0.0001
Wave 3	1.02	(1.44)	1.12	(1.42)	0.0038
Wave 4	1.03	(1.41)	0.95	(1.29)	0.0096
Sexual Risk Measures					
Parental Discussion of STI risk with Respondent	3.26	(0.94)	3.12	(0.96)	0.0001
Number of Sex Partners Prior (age<18)	4.64	(9.92)	2.79	(6.45)	0.0001

Table 2: Odds ratios and 95% confidence intervals for lifetime STI diagnosis among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.49 [1.33, 1.68]	1.36 [1.21, 1.54]	1.33 [1.19, 1.49]	1.38 [1.23, 1.55]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.48 [1.20, 1.82]	1.22 [1.02, 1.44]	1.30 [1.09, 1.55]	1.37 [1.16, 1.63]	1.13 [0.94, 1.36]
Biological Father only Imprisonment	1.52 [1.34, 1.71]	1.33 [1.19, 1.48]	1.34 [1.22, 1.55]	1.36 [1.22, 1.51]	1.22 [1.09, 1.37]
Biological Mother only Imprisonment	1.59 [1.20, 2.10]	1.32 [1.00, 1.75]	1.39 [1.05,1.87]	1.47 [1.11, 1.95]	1.20 [0.90,1.61]
Biological Mother & Father Imprisonment	1.58 [1.16, 2.15]	1.33 [1.07,1.66]	1.39 [1.11, 1.72]	1.45 [1.07,1.99]	1.21 [0.97,1.52]

Notes: Results are presented for parental imprisonment (age < 18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1 (Demographic controls) = Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2 (Family & Neighborhood controls) = Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls) = Model 1 + respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4 (Sexual risk controls) = Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls) = all variables used in prior models.

Table 3: Predicted probabilities and 95% confidence intervals for ever being infected with an STI, by parent gender, child gender, and black/non-black racial classification (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

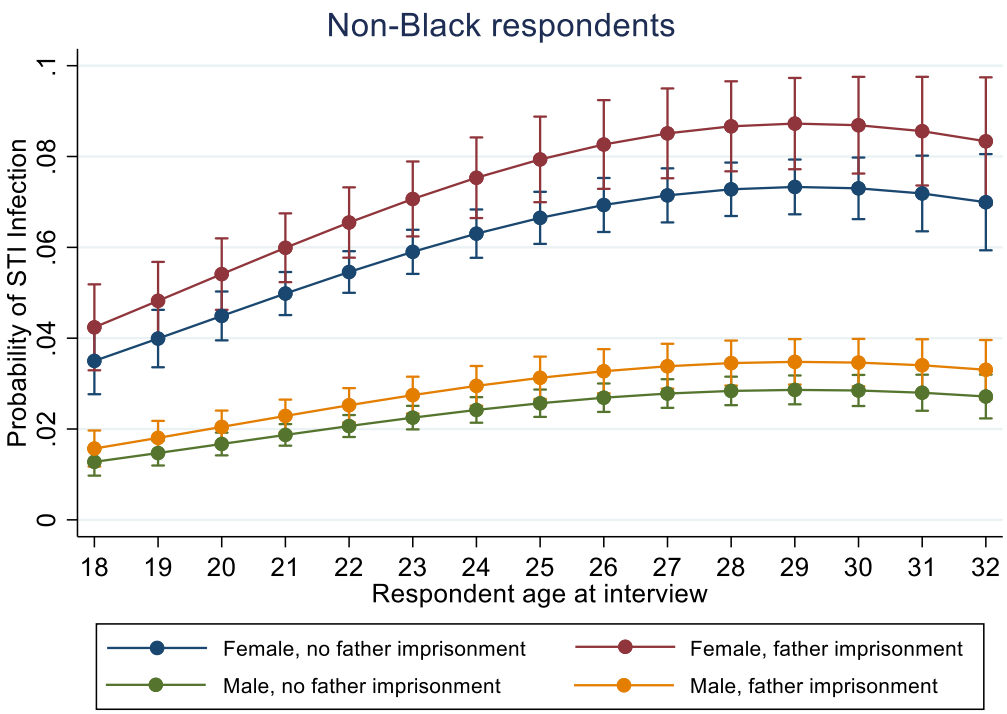
	Non-Black, Male	Non-Black, Female	Black, Male	Black, Female
Biological Father Imprisonment	12.5% [11.2%, 13.9%]	29.3% [27.0%, 31.7%]	35.8% [32.7%, 38.8%]	61.7% [58.8%, 64.7%]
No Biological Father Imprisonment	8.9% [8.2%, 9.6%]	22.1% [21.1%, 23.2%]	27.6% [25.6%, 29.5%]	52.4% [50.2%, 54.6%]
Biological Mother Imprisonment	13.5% [11.0%, 16.0%]	30.4% [25.6%, 35.1%]	37.7% [32.7%, 42.7%]	63.2% [58.4%, 68.0%]
No Biological Mother Imprisonment	9.6% [8.9%, 10.0%]	23.0% [22.0%, 24.1%]	29.1% [27.1%, 31.0%]	53.7% [51.7%, 55.8%]

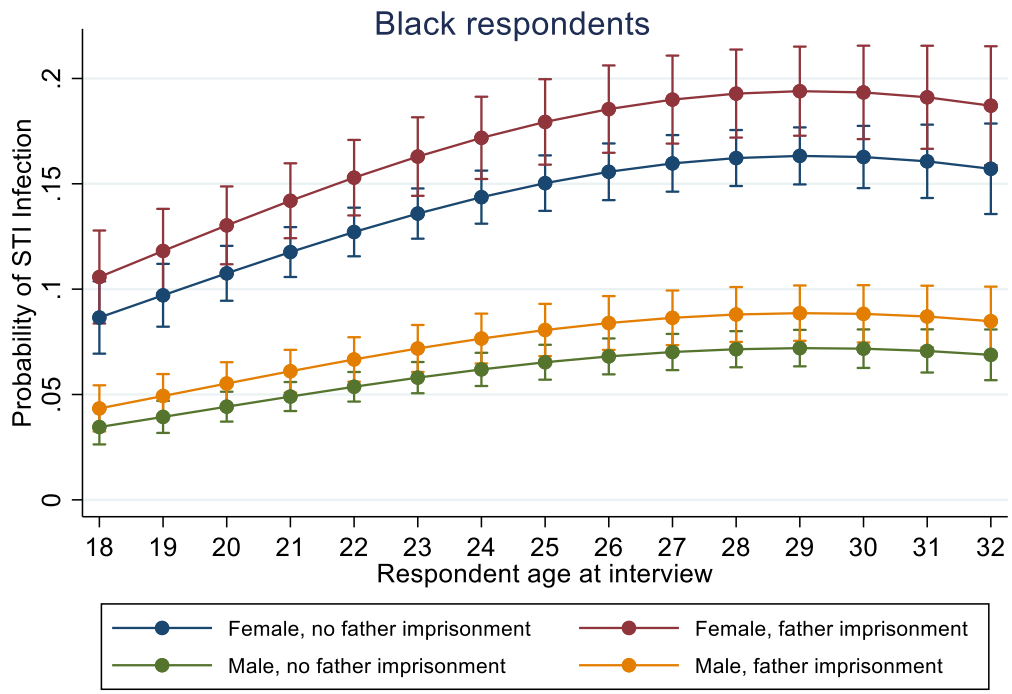
Notes: Predicted Probabilities generated based on Model 1 of Table 2 for respondents reporting if their (1) biological father or (2) biological mother was imprisoned at age < 18. Model predictors of STI infection include parental imprisonment, respondent age, respondent gender, and respondent ethnicity.

Table 4: Odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.33 [1.13, 1.56]	1.26 [1.06, 1.50]	1.22 [1.03, 1.43]	1.26 [1.07, 1.49]	1.15 [0.98, 1.37]
Biological Mother Imprisonment	1.22 [0.89, 1.66]	1.10 [0.81, 1.51]	1.09 [0.80, 1.48]	1.17 [0.85, 1.58]	1.02 [0.75, 1.40]
Biological Father only Imprisonment	1.36 [1.15, 1.60]	1.30 [1.10, 1.54]	1.25 [1.06, 1.50]	1.30 [1.10, 1.55]	1.19 [1.01, 1.41]
Biological Mother only Imprisonment	1.43 [0.96, 2.14]	1.33 [0.88, 2.00]	1.31 [0.88, 1.95]	1.37 [0.92, 2.05]	1.24 [0.81,1.86]
Biological Mother & Father Imprisonment	1.12 [0.69, 1.82]	1.03 [0.63, 1.70]	0.95 [0.58, 1.56]	1.06 [0.65, 1.74]	0.89 [0.54, 1.46]

Notes: Results are presented for parental imprisonment (age < 18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1 (Demographic controls) = Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2 (Family & Neighborhood controls) = Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls) = Model 1 + respondent adolescent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + binge drinking prior 12 months + serious adolescent delinquency. Model 4 (Sexual risk) = Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls) = all variables used in prior models.





Supplemental Table S1: Lifetime Odds of Contracting an STI Associated with Parental Imprisonment With Full Controls

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.24 [1.04,1.48]		
Mother Imprisoned		1.13 [0.94, 1.36]	
Joint Parental Imprisonment			
Father only Imprisoned			1.22 [1.09, 1.37]
Mather only imprisoned			1.20 [0.90,1.61]
Mother & Father Both Imprisoned			1.21 [0.97,1.52]
Demographic Measures			
Age at interview	0.96 [0.91,1.00]	0.96 [0.94,0.98]	0.96 [0.94,0.99]
Female	3.48 [3.01, 4.02]	3.30 [3.00,3.61]	3.29 [3.00, 3.61]
Racial Phenotype (Wave 1)			
White [reference]			
Black	4.26 [3.67,4.95]	4.00 [3.59,4.46]	4.00 [3.58,4.45]
Hispanic	1.45 [1.12,1.86]	1.30 [1.14,1.49]	1.30 [1.14,1.48]
Asian	1.10 [0.81,1.47]	1.01 [0.83,1.24]	1.03 [0.84,1.25]
Native American	2.09 [1.41,3.12]	1.78 [1.33,2.39]	1.76 [1.31,2.36]
Other/Multiple Race	1.51 [0.93,2.44]	1.38 [0.92,2.08]	1.39 [0.93,2.07]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.00 [0.84,1.19]	1.09 [0.98,1.21]	1.04 [0.94,1.16]
Single Father	1.11 [0.81,1.48]	1.23 [0.97,1.56]	1.20 [0.95,1.52]
Two Parent, One Biological	1.20 [0.95,1.52]	1.26 [1.11,1.42]	1.19 [1.05,1.35]
Other Family Structure	1.44 [1.11,1.85]	1.46 [1.23,1.73]	1.40 [1.17,1.66]

Completed Parental Education			
Bachelor's Degree	1.03 [0.82,1.30]	0.96 [0.83,1.10]	0.97 [0.85,1.11]
High School	1.06 [0.87,1.30]	0.94 [0.84,1.06]	0.94 [0.84,1.06]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	0.98 [0.54.1.80]	1.11 [0.75.1.63]	1.10 [0.75.1.63]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.96 [0.90,1.02]	0.94 [0.90,0.99]	0.95 [0.90,0.99]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.30 [1.07,1.60]	1.39 [1.21,1.60]	1.36 [1.18,1.57]
Parent's report, child temperament issues (Wave 1)	1.16 [1.03,1.30]	1.13 [1.03,1.24]	1.13 [1.03,1.24]
Delinquent Activity Scale (Wave 1)	1.03 [1.01,1.04]	1.02 [1.00,1.04]	1.02 [1.01,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.17 [1.02,1.16]	1.14 [1.07,1.22]	1.14 [1.07,1.21]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.09 [1.02,1.16]	1.08 [1.04,1.13]	1.09 [1.04,1.13]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	1.02 [0.93,1.11]	1.06 [1.00,1.11]	1.05 [1.00,1.10]
Number of Sex Partners Prior (age<18)	1.03 [1.01,1.04]	1.03 [1.02,1.04]	1.03 [1.01,1.04]

Notes: Each model represents full results from Model 5 in Table 2, by measure of parental imprisonment.

Supplemental Table S2. Weighted odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.47 [1.24, 1.74]	1.34 [1.13, 1.59]	1.34 [1.12, 1.60]	1.38 [1.16, 1.65]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.40 [1.04, 1.89]	1.17 [0.86, 1.59]	1.20 [0.89, 1.62]	1.28 [0.94, 1.74]	1.03 [0.76, 1.41]
Biological Father only Imprisonment	1.46 [1.22, 1.75]	1.35 [1.13, 1.61]	1.34 [1.11, 1.63]	1.39 [1.16, 1.66]	1.25 [1.04, 1.51]
Biological Mother only Imprisonment	1.40 [0.94, 2.10]	1.18 [0.78, 1.76]	1.17 [0.78, 1.77]	1.28 [0.83, 1.98]	1.01 [0.66, 1.54]
Biological Mother & Father Imprisonment	1.59 [1.13, 2.23]	1.36 [0.96, 1.93]	1.38 [0.98, 1.94]	1.43 [1.00, 2.05]	1.18 [0.83, 1.69]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1+ respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S3: Longitudinal Odds of STI infection in the prior 12 months associated with Parental Imprisonment, full model results

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.12 [0.96,1.30]		
Mother Imprisoned		0.92 [0.71, 1.21]	
Joint Parental Imprisonment			
Father only Imprisoned			1.18 [1.01, 1.38]
Mather only imprisoned			1.17 [0.77,1.77]
Mother & Father Both Imprisoned			0.88 [0.62,1.24]
Demographic Measures			
Age	1.48 [1.18,1.86]	1.49 [1.18,1.87]	1.49 [1.18,1.87]
Age-Squared	0.99 [0.99,0.99]	0.99 [0.99,0.99]	0.99 [0.99,0.99]
Female	3.33 [2.91, 3.81]	3.34 [2.93, 3.82]	3.33 [2.91, 3.81]
Racial Phenotype (Wave 1)			
White [reference]			
Black	3.16 [2.71,3.68]	3.17 [2.71,3.68]	3.16 [2.71,3.68]
Hispanic	1.21 [1.00,1.47]	1.21 [1.00,1.47]	1.21 [1.00,1.47]
Asian	0.93 [0.70,1.24]	0.93 [0.70,1.24]	0.94 [0.71,1.25]
Native American	1.69 [1.12,2.55]	1.71 [1.14,2.58]	1.70 [1.13,2.55]
Other/Multiple Race	1.53 [0.88,2.69]	1.53 [0.88,2.69]	1.54 [0.88,2.71]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.05 [0.91,1.23]	1.09 [0.94,1.26]	1.05 [0.90,1.22]
Single Father	0.85 [0.60,1.21]	0.87 [0.61,1.24]	0.84 [0.59,1.20]
Two Parent, One Biological	1.10 [0.92,1.31]	1.15 [0.97,1.36]	1.10 [0.93,1.32]

Other Family Structure	1.19 [0.93,1.53]	1.25 [0.97,1.59]	1.20 [0.93,1.54]
Completed Parental Education			
Bachelor's Degree	1.05 [0.87,1.29]	1.05 [0.86,1.28]	1.06 [0.87,1.30]
High School	0.97 [0.82,1.15]	0.97 [0.82,1.14]	0.97 [0.82,1.15]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	2.02 [1.19,3.34]	2.03 [1.20,3.44]	2.01 [1.19,3.40]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.95 [0.89,1.01]	0.95 [0.89,1.01]	0.95 [0.89,1.01]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.15 [0.94,1.41]	1.17 [0.96,1.43]	1.15 [0.94,1.41]
Parent's report, child temperament issues (Wave 1)	1.18 [1.03,1.35]	1.18 [1.03,1.35]	1.17 [1.02,1.34]
Delinquent Activity Scale (Wave 1)	1.00 [0.99,1.03]	1.01 [0.99,1.03]	1.01 [0.99,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.14 [1.05,1.24]	1.14 [1.05,1.24]	1.14 [1.05,1.24]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.15 [1.10,1.20]	1.15 [1.10,1.20]	1.15 [1.10,1.20]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	0.98 [0.92,1.05]	0.98 [0.92,1.05]	0.98 [0.92,1.05]
Number of Sex Partners Prior (age<18)	1.02 [1.01,1.03]	1.02 [1.01,1.03]	1.02 [1.01,1.03]

Notes: Each model represents full results from Model 5 in Table 4, by measure of parental imprisonment.

Supplemental Table S4. Odds ratios and 95% confidence intervals for ever being infected with gonorrhea or chlamydia among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.58 [1.40, 1.77]	1.36 [1.21, 1.54]	1.45 [1.29, 1.63]	1.48 [1.32, 1.67]	1.28 [1.13, 1.44]
Biological Mother Imprisonment	1.58 [1.29, 1.91]	1.28 [1.04, 1.56]	1.41 [1.16, 1.73]	1.49 [1.23, 1.82]	1.20 [0.97, 1.48]
Biological Father only Imprisonment	1.58 [1.41, 1.78]	1.38 [1.22, 1.58]	1.48 [1.31, 1.68]	1.49 [1.32, 1.58]	1.29 [1.14, 1.48]
Biological Mother only Imprisonment	1.78 [1.30, 2.45]	1.45 [1.05, 2.00]	1.60 [1.16, 2.21]	1.67 [1.21, 2.30]	1.34 [0.97, 1.86]
Biological Mother & Father Imprisonment	1.73 [1.36, 2.20]	1.41 [1.10, 1.81]	1.55 [1.21, 1.98]	1.62 [1.27, 2.07]	1.29 [1.00, 1.67]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S5. Complete case analysis for odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.48 [1.32, 1.65]	1.34 [1.19, 1.51]	1.36 [1.17, 1.57]	1.35 [1.19, 1.53]	1.24 [1.06, 1.44]
Biological Mother Imprisonment	1.48 [1.21, 1.82]	1.19 [0.96, 1.48]	1.14 [0.86, 1.51]	1.29 [1.03, 1.63]	0.93 [0.69, 1.25]
Biological Father only Imprisonment	1.49 [1.32, 1.67]	1.37 [1.21, 1.55]	1.40 [1.21, 1.63]	1.37 [1.20, 1.56]	1.29 [1.10, 1.51]
Biological Mother only Imprisonment	1.64 [1.27, 2.12]	1.33 [1.01, 1.74]	1.44 [1.02, 2.01]	1.48 [1.12, 1.95]	1.16 [0.81, 1.69]
Biological Mother & Father Imprisonment	1.55 [1.11, 2.15]	1.21 [0.86, 1.72]	0.95 [0.60, 1.50]	1.26 [0.86, 1.84]	0.76 [0.47, 1.25]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S6. Complete case analysis for odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.30 [1.10, 1.53]	1.22 [1.03, 1.45]	1.16 [0.94, 1.42]	1.10 [1.00, 1.43]	1.07 [0.86, 1.33]
Biological Mother Imprisonment	1.21 [0.88, 1.65]	1.05 [0.75, 1.46]	1.20 [0.80, 1.81]	1.23 [0.88, 1.72]	1.08 [0.71, 1.65]
Biological Father only Imprisonment	1.33 [1.13, 1.58]	1.27 [1.06, 1.51]	1.22 [0.99, 1.51]	1.23 [1.02, 1.48]	1.14 [0.91, 1.42]
Biological Mother only Imprisonment	1.36 [0.93, 2.01]	1.22 [0.80, 1.85]	1.64 [1.00, 2.70]	1.46 [0.96, 2.22]	1.48 [0.88, 2.47]
Biological Mother & Father Imprisonment	1.15 [0.69, 1.92]	0.95 [0.56, 1.61]	0.79 [0.38, 1.63]	1.04 [0.58, 1.85]	0.67 [0.31, 1.44]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adult binge drinking (time-varying) + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-8
Objectives	3	State specific objectives, including any pre-specified hypotheses	4-8
Methods			
Study design	4	Present key elements of study design early in the paper	8-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8-9
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9-10*
Bias	9	Describe any efforts to address potential sources of bias	8-11
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-12
		(*b*) Describe any methods used to examine subgroups and interactions	10-12
		(*c*) Explain how missing data were addressed	10-12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	10-11

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	12, 14-15
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-12
		(b) Indicate number of participants with missing data for each variable of interest	8-9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8-12
		Cross-sectional study—Report numbers of outcome events or summary measures	8-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	8-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-14
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early adulthood

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Submission Category: Original Research

Title Assessing the relationship between parental imprisonment in childhood and risk of sexually transmitted infections: A cohort study of US adults in early adulthood

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Running Head: Parental Imprisonment and STI Risk in Adulthood

Abstract

Objectives: One-in-six young adults in the U.S. experience parental imprisonment in childhood. Prior studies have associated parental imprisonment with risk of sexually transmitted infection (STI); however, potential data and methodological issues may have limited the reliability and accuracy of prior findings. Examining cumulative and longitudinal risk, we address several methodological limitations of prior studies and also examine comparative risk by respondent sex and ethnicity. We assess these associations using a range of control variables.

Design: A national cohort study from the National Longitudinal Study of Adolescent to Adult Health using (1) a cross-sectional sample of adults at ages 24-32 and (2) a longitudinal sample between ages 18-32. Both analyses estimate odds ratios for STI infection associated with parental imprisonment and examine variation by parent/child gender and respondent ethnicity.

Setting: In-home interviews in the United States at Wave 1 (1994-1995), Wave 3 (2001-2003) and Wave IV (2007-2009).

Participants: 15,684 respondents completing interviews at Wave 1 (ages 12-18) and Wave 4 (ages 26-32), including 8,556 female, 3,437 black, and 2,397 respondents reporting parental imprisonment.

Results: Father-only imprisonment is associated with 1.22 higher odds (95% confidence interval (CI): 1.09, 1.37) of lifetime STI infection and 1.19 higher odds (95% CI: 1.01, 1.41) of STI infection in the past 12 months between ages 18-32, adjusting for familial, neighborhood, individual, and sexual risk factors. Maternal imprisonment is not associated with higher risk of lifetime STI after adjusting for confounders (95% CI: 0.90, 1.61). Examining predicted probabilities of STI infection, our findings show additive risks for females, blacks, and parental imprisonment.

Conclusion: Adjusting for confounders, only paternal imprisonment is associated with slightly elevated risk of annual and lifetime risk of STI infection. Additive effects show that parental imprisonment modestly increases ethnic and female risk for STI infection.

Keywords:

Sexually transmitted infections; parental imprisonment; mass incarceration; health status disparities; minority health

Strengths & Limitations

- This study addresses data and methodological issues of prior work to improve accuracy and reliability for estimating the association between parental imprisonment and risk of STI infection.
- The study leverages cross-sectional and longitudinal measures to compare lifetime and longitudinal risk.
- Comparative analysis is performed to determine potential variations in STI risk by maternal and paternal imprisonment, and respondent sex and ethnicity.
- The study lacks measures to determine underlying potential causal factors, such as residential instability and parental criminality that may explain the association.
- While STI self-reports are prospectively collected, data on parental imprisonment is retrospectively collected.

Introduction

According to recent research, 2.6 million U.S. children have a parent in jail or prison, with 4% of white, 24% of black, and 11% of Hispanic children ever experiencing a parent serving time in state or federal prison.[1,2] Parental imprisonment is an adverse childhood experience linked to a range of adversities from birth to death, including prenatal exposure to alcohol and drugs, poor academic and educational outcomes, criminal behavior and subsequent imprisonment.[3-6] In the last decade, research has increasingly linked parental imprisonment to health issues that include sexually transmitted infections (STIs), depression, cardiovascular and metabolic diseases, respiratory conditions, and infant and adult mortality.[7-11] Due to the interrelationship between parental imprisonment and other childhood traumas, such as family instability and child abuse, and linkage with outcomes, such as antisocial and risky behaviors, documenting associations and potential mediating effects is critical for linking parental imprisonment to health outcomes later in the life course.[12-15] The present study assesses whether parental imprisonment is a risk factor for STI infections and potential mediating factors that may explain this association.

The potential association between parental imprisonment and STIs in the U.S. is important given the scale of parental imprisonment in the U.S., increasing rates of STI infections, and resulting health complications from STI infection. Rates of STI infection have generally increased in the U.S. Between 2000 and 2017, chlamydial infection rates doubled from 251.4 to 528.8 per 100,000, while gonorrhea infection rates increased by 75% from 99.1 to 171.9 cases per 100,000 between 2009 and 2017.[16] An STI that is undetected and left untreated may result in a range of chronic health issues such as infertility or adverse birth outcomes (chlamydia, gonorrhea), cervical and testicular cancers (HPV), and mortality (syphilis, HIV/AIDS).[16-18] An increased risk for STIs associated with experiencing parental imprisonment may thus contribute to a range of adverse outcomes later in the life course.

In cross-sectional analyses of the National Longitudinal Study of Adolescent to Adult Health (Add Health), parental imprisonment has been associated with STI infection in adolescence and adulthood.[3,15,19,20] Further studies have linked STI infection with substance abuse, childhood trauma, early sexual activity, and risky sexual behavior.[3,15,19-23] These analyses also suggest that women[19] and minorities[20,22] who experience parental imprisonment may be at greater likelihood of having an STI infection, though these sex and racial differentials were not tested for statistical significance. Parental imprisonment has also been associated with altered age trajectories for engaging in delinquent behavior and drug use, and age trajectories may similarly vary for STI infection.[24,25] Some research examining cross-sectional risk of STI infection at multiple time points suggests that STI infection risk associated with parental imprisonment may vary by life stage and be mediated by factors such as child abuse, family instability, substance use, adolescent antisocial behavior (particularly, life course persistent or chronic offending), or sexual risk taking.[19,20,26]

While this research suggests parental imprisonment is associated with STI infection, important research gaps remain that we address in our analysis. Extending prior research to incorporate longitudinal analysis is important for determining how the association between parental imprisonment and STI risk may hold or change as individuals age out of early adulthood, while addressing potential temporal ordering issues of co-occurring risks such as antisocial behavior and substance use.[27,28] By comparing cross-sectional results for lifetime risk of STI infection at ages 24-32 with longitudinal risk of annual STI infection, we are able to establish how parental imprisonment impacts age-graded risk of STI infection.

We also examine how the association between parental imprisonment and STI infection may vary by the potential confounding or mediating roles of other related factors. Understanding these mediation patterns is critical for identifying potential pathways between childhood adversity and later adverse outcomes associated with parental imprisonment that

may impact STI risk. We examine if sex of parent and child differentiates risk, along with mediating patterns for four sets of factors: 1) demographic, 2) familial and neighborhood characteristics (including familial socioeconomic status and household composition), 3) individual risk and resiliency, and 4) sexual risk factors.

We examine potential STI risk disparities for parental imprisonment by parent/child sex and ethnicity,[7] particularly in light of findings that women and African Americans are more likely to contract an STI.[29-31] Results by Khan et al[20] are suggestive that STI infection risk associated with parental imprisonment is higher for minority groups, but this study did not test if risk for parental imprisonment differed across ethnic groups. Furthermore, the compounded risks by sex and ethnicity may not be additive, leading to variation in STI risk associated with parental imprisonment (e.g., black male and female respondents may have similar STI risk, or black females may have a greater STI risk than black males). By testing these associations, we are able to determine if the risk of parental imprisonment for STI infection may vary based on a respondent's sex and ethnicity.

To date, studies have separately tested for associations between parental imprisonment and diagnosis of (1) HIV/AIDS, (2) gonorrhea and chlamydia, or (3) trichomoniasis, gonorrhea, and chlamydia.[3,15,19] In contrast, examining parental imprisonment and a broader, general risk for being diagnosed with an STI provides insights into general STI infection risks linked with parental imprisonment. We estimate the general risk of STI infection associated with parental imprisonment in cross-sectional and longitudinal models.

Our analysis examines the validity of the models we estimate, addressing issues concerning survey weighting, small cell sizes, and missing data which may increase uncertainty and reliability issues in prior research on this topic. This is critical for providing

consistent and reliable estimates gauging the extent to which parental imprisonment may be a risk factor for STI infection.

METHODS

Data

We use data from the U.S. National Longitudinal Study of Adolescent to Adult Health (Add Health). The Add Health study initially surveyed approximately 90,000 students enrolled in grades 7-12 (ages 12-18) in 1994-1995 in in-school interviews. Our study follows a subpopulation of ~20,750 respondents who were randomly selected from the in-school sample for in-home interviews. These respondents were followed up at three later waves: ~14,700 respondents at Wave 2 in 1996, 15,200 respondents at Wave 3 in 2001-2002, and ~15,700 respondents at Wave 4 in 2007-2008. Of the original sample, the proportion of Wave 1 respondents completing surveys at each round are: 71% at Wave 2, 73% at Wave 3, and 75% at Wave 4.[32] Our analysis includes only individuals completing both Wave 1 and Wave 4 interviews, with 74.5% and 81.5% of these respondents completing interviews, respectively, at Waves 2 & 3.

Details of the survey design and reasons for non-response at each wave are available from the Add Health website https://www.cpc.unc.edu/projects/addhealth.

Our analytic sample consists of 15,684 individuals who completed questionnaires at both Waves 1 & 4 when questions about biological mother and father imprisonment were first asked; including 14,796 individuals with valid survey weights. The reduced number of cases arises from individuals missing information from the school or household-level needed to create nationally-representative weights for the cohort; as an example, sibling pairs in the in-home sample but not enrolled in the same school were not given sampling weights.[33]

Measures

All measures are constructed using items taken from Waves I-IV of the Add Health survey and can be downloaded from the Add Health website.[34]

STI infections. Our outcome measure of STI infection is a dichotomous indicator for respondents reporting being told by a doctor, or other health professional of being infected with any of the following STIs: 1) chlamydia, 2) gonorrhea, 3) trichomoniasis, 4) syphilis, 5) hepatitis B, 6) human papilloma virus (HPV), 7) HIV/AIDs, and 8) other sexually transmitted diseases, not elsewhere reported by respondents such as genital herpes, genital warts, vaginitis, urethritis, pelvic inflammatory disease, or cervicitis.

From these reports, we construct an indicator for 1) ever being infected with an STI and 2) being infected with an STI in the 12 months prior to interview (available at Waves III and IV). For lifetime infection we supplement Wave IV reports with reports of being infected with any of the STIs listed above at earlier Waves, addressing cases where respondents are known to deny STI infections in self-reports at older ages.[35]

Parental imprisonment. At Wave IV, respondents were asked "(Has/did) your biological mother/father ever (spent/spend) time in jail or prison?" and "How old were you when your biological mother/father went to jail or prison (the first time)?" Using these questions, we construct indicator variables for maternal and paternal imprisonment occurring prior to age 18. We code separate measures for (1) father imprisonment, (2) mother imprisonment, and (3) and mutually exclusive categories of mother and/or father imprisonment. While prior research suggests recollection of childhood traumas and reporting of parental imprisonment yields reliable estimates,[36,37] recollection of the specific age at first parent imprisonment may be less reliable, particularly in early childhood. Our coding addresses this potential issue in prior research.

Demographic controls. We include respondent age at each wave, biological sex, and if the respondent identified as black, white, Hispanic, Native American, Asian, or other racial classification at Wave I.

Familial/neighborhood controls. We control for parent's reported level of education and family structure at Wave I (in over 90% of cases, the parent reporting education is the biological mother or step-mother). We include Wave I neighborhood SES as the proportion of families in the respondent's census tract residing below the poverty level.

Individual risk measures. For individual controls, we incorporate measures of measured body mass index (BMI; kg/m^2) at Wave II, an indicator for physical child abuse (Wave IV self-report), difficult child temperament (Wave I parent interview), a Wave I school attachment scale, adolescent marijuana usage in the 30 days prior to the interview (Wave I), binge drinking in the prior 12 months to the interview (Waves I, III, & IV), and a 12-item Wave I delinquency score (for details of the school attachment and delinquency scales are available in Guo et al[38]).

STI risk factors. Measures include the total number of sexual partners before age 18 and parental reports of the degree to which they discuss STI risk with respondents on a 5-point Likert scale (with higher scores indicating greater discussion about STI risks).

Patient & Public Involvement

This study uses anonymized secondary data from the National Longitudinal Study of Adolescent to Adult Health. As a result, this study is conducted without patient involvement in designing the study, creating outcomes, or interpreting results. Study participants are also not included in contributing to the writing or editing of this document for readability or accuracy.

Analytical strategy

To analyze the risk of lifetime STI infection, we use logistic regression. Add Health uses multiplicative weights ranging between 20-18,342 (mean 1,480.28, SD 1,425.65) to create a representative national cohort at Wave 4.[34] This is a potential issue in prior studies where missing data and small cell counts used in analysis may substantially increase uncertainty. Analysis of unweighted data and controls to address sample bias may, alternatively, more efficiently estimate STI risk.[39] We focus our presentation on the unweighted results, but also compare coefficients between the weighted and unweighted data to examine potential uncertainty.[40]

To analyze the probability of STI infection over time, we use a two-level random effects logistic regression model where self-reports of STI infection in the prior twelve months at each wave are nested within individuals.

We impute 75 datasets using multiple imputation (MI) by chained equations to address missing data issues; we note imputation may address bias arising in prior research due to (1) missing data removing cases of greater social disadvantage where the effects of parental imprisonment have been found to be less significant and (2) removing 12% of cases of mothers (78/643) and 20% of cases of fathers (458/2283) where respondents report their parent as having been imprisoned, but not reporting the exact age when their parent was first imprisoned.[7,41,42]

Predicted probabilities and 95% CIs are generated by estimating means and standard errors using reported model estimates. These estimates results use baseline demographic controls for age, race/ethnicity, and respondent sex to estimate variation among these groups, in the absence of mediators.

We use STATA 15.1 for all analyses.

RESULTS

Table 1 contains descriptive statistics by respondent's history of parental imprisonment. Parental imprisonment is associated with increased risk of a range of adversities and disadvantages.

Lifetime STI infection

Table 2 presents results for lifetime risk of STI infection. The odds of STI infection were higher for imprisonment of the biological father (Odds ratio (OR): 1.49, 95% confidence interval (CI): 1.33, 1.68) and biological mother (OR: 1.48, 95% CI: 1.20, 1.82) in the baseline demographic model (Model 1). Modest declines in these estimates are associated with familial and neighborhood factors (Model 2), individual risk factors (Model 3), and sexual behavior risk factors (Model 4). Biological father remains a risk factor for STI infection (OR: 1.24, 95% CI: 1.04, 1.48) with the inclusion of all controls, while the 95% CIs for the odds ratio of maternal imprisonment included the null value of 1 (OR: 1.13, 95% CI: 0.94, 1.36).

Similar odds ratios for STI infection are observed for models for imprisonment of the biological father only (OR: 1.52, 95% CI: 1.34, 1.71), biological mother only (OR: 1.59, 95% CI: 1.20, 2.10), and biological mother and father (OR: 1.58, 95% CI: 1.16, 2.15). Similar mediation patterns are observed for biological father and biological mother imprisonment, with 95% CIs showing odds ratios >1 for biological father only (Models 1-5), biological mothers only (Models 1-4), and both father and mother imprisonment (Models 1-4).

In all cases, no single set of risk factors result in non-significance. Supplemental Table S1 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 2. Results using survey weights (Supplemental Table S2) also show comparable ORs to those presented in Table 2, with wider confidence intervals.

We find no significant interactions for parental imprisonment with respondent's sex and race. To examine cumulative risk, we estimate joint probabilities for lifetime STI infection by child biological sex, black/non-black ethnicity, and mother or father imprisonment, presented in Table 3. These results show that being female, having an incarcerated parent, and being black have additive effects for ever being infected with an STI. For example, a non-black male with no history of paternal imprisonment has a predicted probability of infection of 8.9% (95% CI: 8.2%, 9.6%), while those with a history of paternal imprisonment has a predicted probability of 12.5% (95% CI: 11.2%, 13.9%). In contrast, black women reporting no history of parental imprisonment had a 52.4% (95% CI: 50.2%, 54.6%) predicted probability of STI infection, compared to 61.7% (95% CI: 58.8%, 64.7%) with a history of paternal imprisonment. Similar predicted probabilities are associated with maternal imprisonment.

Longitudinal risk of STI infection

Table 4 examines longitudinal odds of STI infection in the 12-months prior to the interview. In these models, father imprisonment in the baseline model is associated with higher odds of STI infection (OR: 1.33, 95% CI: 1.13, 1.56). This association shows slight mediation when controls were introduced for familial and neighborhood (Model 2), individual (Model 3) and sexual behavior factors (Model 4); however, the 95% CIs for paternal imprisonment include the null value of 1 (95% CI: 0.98, 1.37) when all controls were included (Model 5). Maternal imprisonment shows no association with 12-month STI risk (Model 5 95% CI: 0.75, 1.40). In comparing imprisonment risk for categories of father and/or mother imprisonment, the 95% CIs of the association for father only imprisonment and STI risk remains >1 across all models, but mother only imprisonment, and father and mother imprisonment show no associations with STI risk.

Supplemental Table S3 contains the odds ratios and 95% CIs for parental imprisonment and controls for results from Model 5 in Table 4. We note that respondent age and heavy-drinking measures are time-varying measures that are not directly comparable to results presented in Supplemental Table S1.

To test for differences in father imprisonment and 12-month STI risk, we examine if respondent age, ethnicity, and sex moderated results for paternal imprisonment, with no statistically significant moderation patterns observed. In lieu of moderation, we examine if predicted probabilities of STI diagnosis by age, ethnicity and respondent sex show additive effects, as illustrated by Figure 1 (non-black respondents) and Figure 2 (black respondents). In all models there is a higher probability of diagnosis through the mid-20s, before the probability of STI diagnosis stabilizes. In Figure 1, the predicted probability of diagnosis of an STI in the past 12 months is higher for women than men, with parental imprisonment being associated with a modest increase in risk. Figure 2 shows a similar pattern, with higher baseline rates among black respondents. Collectively, these figures illustrate additive effects for paternal imprisonment, being black, and being a woman, with nearly one-fifth of black women who experience paternal imprisonment being diagnosed with an STI in the 12-months prior to interviews.

Sensitivity analysis

We conduct supplementary analyses to 1) compare MI results with complete case analysis for the main findings (Supplemental Tables S4 and S5); 2) compare the findings by Le et al.[15] for laboratory-confirmed infections of chlamydia and gonorrhea with our analysis for respondent self-reports of lifetime chlamydia and/or gonorrhea infection (Supplemental Table S6); and 3) test moderation results using complete case analysis by examining interactions for parental imprisonment by biological sex, race/ethnicity, and age in

longitudinal models (Raw output for moderation testing available on request). Comparisons 1) and 3) yield substantively similar results. For 2), our results are consistent with prior research on variations between lab-confirmed and self-reported STI infection for: 1) father only, and 2) mother and father imprisonment are lower, but within 95% CIs, while odds for mother only imprisonment are lower than the results reported by Le et al.[15,43]

DISCUSSION

Using a U.S.-based cohort study, we demonstrate that individuals experiencing paternal imprisonment, without co-occurring maternal imprisonment, in childhood is an independent risk factor for (1) higher lifetime odds of STI infection and (2) longitudinal annual STI infection risk in adults ages 18-32. In basic demographic models controlling for age, race, and biological sex, we find maternal and/or paternal imprisonment are associated with increased cumulative risk of STI infection, with predicted probabilities for STI infection showing additive risk for parental imprisonment, respondent sex, and race. However, after introducing controls, only paternal imprisonment (without co-occurring maternal imprisonment) remains significant. In longitudinal models, respondents experiencing paternal imprisonment only in childhood face a statistically higher risk for annual STI infection after controls are added. Respondent sex and ethnicity also independently raise risks of annual infection in longitudinal analysis. Furthermore, odds ratios for lifetime and annual STI infections associated with experiencing paternal imprisonment only are statistically significant and similar (OR ~1.2) once adjusted for controls, suggesting consistency in cross-sectional and longitudinal results for paternal imprisonment only as a modest, but independent risk factor for STI infection.

In examining mediation patterns, the introduction of familial/neighborhood, individual risk and resilience factors, and sexual risk each show some mediation effect

between (1) maternal and/or paternal imprisonment and lifetime STI infection and (2) paternal imprisonment and annual STI infection. While factors such as risky sexual behaviors and substance abuse may potentially mediate the relationship between parental imprisonment and STI infection,[15,20] our results show that the set of combined controls fully or substantially mitigated these associations. This finding is generally consistent with other studies where results for parental imprisonment are partially or fully mediated when controls are added for co-occurring risks such as parental criminality, poverty, and residential instability.[12,13,44,45]

As noted by Roettger & Dennision,[5] complex interrelationships exist between parental imprisonment, adversities encountered throughout stages of the life course, and interrelated adverse behavioral outcomes. Our findings align with this hypothesis, for instance, that paternal imprisonment shows similarly increased odds for STI infection that are also associated with child abuse and adolescent/adult substance use. While it remains critical that public health measures encourage safe sex and frequent testing to prevent and treat STIs associated with parental imprisonment, the need for earlier, more comprehensive health interventions is also important to address broader mental and physical health disparities linked with parental imprisonment and mass incarceration.[46-48] For example, treatment for substance use disorders and mental health issues linked with childhood abuse may be important components for reducing risky sexual behaviors among individuals with co-occurring histories of parental imprisonment. Addressing these "packages of risk"[49] – parental imprisonment and interrelated risks arising from different periods in the life course – is critical for ensuring that policies address the underlying causes which lead to risky sexual behaviors that may result in STI infection and later health complications.

One unexpected finding was that maternal imprisonment and joint mother and father imprisonment, after adjusting confounders and mediators, are not significant predictors of lifetime STI risk and are also non-significant in longitudinal analysis. While this may be due

to smaller sample sizes compared to paternal imprisonment, it is also critical to note that these types of imprisonment may be associated with broader sets of disadvantages, such as poverty and family instability.[49,50]

Strengths and Weaknesses

Our study contains a number of strengths. By combining cumulative and longitudinal analysis for STI infection, we investigate if the general association between parental imprisonment and STI infection consistently holds over time for a broad range of STIs. Addressing a range of prior methodological issues and using supplemental analysis to investigate the reliability and accuracy of our results, we examine the validity of the association between parental imprisonment and STI risk. Examining variations by age, biological sex, and ethnicity of respondents using predicted probabilities, we test for potential variations in parental imprisonment and STI infection. By including a range of controls, we shed additional insight into potential adverse childhood experiences and co-occurring risk factors that may mediate the association between parental imprisonment and sexual behaviors that may lead to STI infection. Lastly, by examining STI infection over time and supplementing Wave 4 STI reports of lifetime infection with reports of STI infection at earlier ages, we 1) control for recall bias[35] and 2) allow for additional time for cases where asymptomatic STI infections may be underreported due to lack of testing at one particular timepoint,[51] known sources of biases for self-reported measures.

Our study also contains notable limitations. Prior research shows Add Health self-reports of STI infections are slightly lower overall for the general population, with greater under-reporting for minorities;[43] laboratory-based testing may thus yield, particularly longitudinally, variation from our reported findings of similar risks for parental imprisonment by ethnicity over time. As many STIs may be asymptomatic and revealed only with testing,

our longitudinal analysis represents prevalence of 'diagnosis,' not infection rates.[35,52] Due to variation in questions across waves, we are unable to examine longitudinal models in adolescence, or analyze changes in STI risk between adolescence and adulthood. Our measure of parental imprisonment is also based on recollection and may include shorter jail and longer prison sentences that yield differing risks; the collection of administrative data may provide more reliable data for evaluating STI infection risk within a jurisdiction.[53] Data limitations, such as the lack of prospective data on parental imprisonment in childhood, the inability to temporally link parental imprisonment with subsequent sexual risk and STI infections, and unmeasured, related factors such as exposure to family instability and parental criminality, also prevents us from exploring underlying causation. Gene-environment interactions for risky behaviors, such as self-control or sensation seeking, that lead to increased STI risk are not observed in our study but may also explain our association if transmitted from parent to child.[54-56]

Conclusion

This study provides evidence that childhood paternal imprisonment, without co-occurring maternal imprisonment, is associated with elevated lifetime and longitudinal annual risks of having an STI infection in early and mid-adulthood. We find that annual and lifetime risk of STI infection associated with paternal imprisonment only is additive to increased risks for STI infections for women and black respondents. For adults who have experienced parental imprisonment in childhood, increased testing and treatment for STIs may help to reduce increased risks. However, broader policies and interventions are needed to address co-occurring childhood traumas and behavioral issues that link parental imprisonment with sexual health disparities.

Footnotes

Contributors: Conception and design of study: MR, BH. Data preparation and analysis: MR. Interpreting results: MR, BH. Drafting of the initial and revised submissions: MR. Revising all manuscript submissions critically: MR, BH. All authors approved the final manuscript.

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Data Availability Statement: To maintain confidentiality of the data, data access is restricted by the study owners, the University of North Carolina at Chapel Hill. Access to the restricted data used in this paper may be obtained via contract by contacting the data owners via their website: https://www.cpc.unc.edu/projects/addhealth/contracts

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Figure 1: Age-graded risk for self-reported STI infection in 12 months prior to interview for non-Black respondent infection probabilities are presented by respondent sex and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

Figure 2: Age-graded risk for self-reported STI infection in 12 months prior to interview for Black respondent infection probabilities are presented by respondent sex and father's history of imprisonment (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

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Table 1: Means, standard deviations and test of group means for individual, family, neighborhood, and sexual risk variables, by exposure to parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Parental Imprisonment [n=2,339]		No parental Imprisonment [n=12,997]		Test of Group Means
	Mean/%	SD	Mean /%	SD	p-value (p<)
Parent Imprisonment					
Sex of Parent					
Father imprisoned	87.16%				
Mother Imprisoned	21.23%				
Joint Parental Imprisonment					
Father only Imprisoned	78.77%				
Mather only imprisoned	12.84%				
Mother & Father Both Imprisoned	8.39%				
Ever STI Diagnosis	31.53%		21.10%		0.0001
STI Diagnosis, Prior 12 Months					
Wave 3	7.77%		5.39%		0.0001
Wave 4	9.71%		7.06%		0.0001
Demographic Measures					
Age at Interview (years)					
Wave 1	15.41	(1.70)	15.63	(1.74)	0.0001
Wave 3	21.76	(1.74)	21.95	(1.77)	0.0001
Wave 4	28.32	(1.75)	28.52	(1.79)	0.0001
Respondent Sex					
Male	44.91%		47.08%		0.0500
Female	55.09%		52.92%		0.0500
Racial Phenotype (Wave 1)					
White	46.38%		54.00%		0.0001
Black	31.69%		20.74%		0.0001
Hispanic	16.53%		15.87%		0.4387
Asian	1.76%		6.91%		0.0001
Native American	2.83%		1.55%		0.0001
Other/Multiple Race	0.81%		0.92%		0.6020
Family & Neighborhood Measures					
Family Structure (Wave 1)					
Two Biological Parents	21.96%		57.82%		0.0001
Single Mother	36.09%		21.23%		0.0001
Single Father	4.62%		3.10%		0.0002
Two Parent, One Biological	25.09%		12.92%		0.0001
Other Family Structure	12.24%		4.92%		0.0001
Completed Parental Education					
Bachelor's Degree	15.34%		25.61%		0.0001
High School	60.52%		57.96%		0.0183
Less Than High School	24.14%		16.43%		0.0001

Percentage of families in respondent's census tract below poverty level	14.29%		11.47%		0.0001
Individual Measures					
School Attachment (Wave 1)	3.64	(0.92)	3.77	(0.96)	0.0001
Measured BMI (Wave 2)	23.47	(5.43)	23.07	(5.03)	0.0024
History of physical child abuse	15.99%		7.65%		0.0001
Parent's report, child temperament issues (Wave 1)	38.33%		29.47%		0.0001
Delinquent Activity Scale (Wave 1)	2.66	(4.34)	1.71	(3.29)	0.0001
Frequency of marijuana usage prior 30 days (wave 1)	0.38	(0.93)	0.23	(0.71)	0.0001
Reported Binge Drinking, Prior 12 months					
Wave 1	0.75	(1.37)	0.59	(1.18)	0.0001
Wave 3	1.02	(1.44)	1.12	(1.42)	0.0038
Wave 4	1.03	(1.41)	0.95	(1.29)	0.0096
Sexual Risk Measures					
Parental Discussion of STI risk with Respondent	3.26	(0.94)	3.12	(0.96)	0.0001
Number of Sex Partners Prior (age<18)	4.64	(9.92)	2.79	(6.45)	0.0001

Table 2: Odds ratios and 95% confidence intervals for lifetime STI diagnosis among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.49 [1.33, 1.68]	1.36 [1.21, 1.54]	1.33 [1.19, 1.49]	1.38 [1.23, 1.55]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.48 [1.20, 1.82]	1.22 [1.02, 1.44]	1.30 [1.09, 1.55]	1.37 [1.16, 1.63]	1.13 [0.94, 1.36]
Biological Father only Imprisonment	1.52 [1.34, 1.71]	1.33 [1.19, 1.48]	1.34 [1.22, 1.55]	1.36 [1.22, 1.51]	1.22 [1.09, 1.37]
Biological Mother only Imprisonment	1.59 [1.20, 2.10]	1.32 [1.00, 1.75]	1.39 [1.05,1.87]	1.47 [1.11, 1.95]	1.20 [0.90,1.61]
Biological Mother & Father Imprisonment	1.58 [1.16, 2.15]	1.33 [1.07,1.66]	1.39 [1.11, 1.72]	1.45 [1.07,1.99]	1.21 [0.97,1.52]

Notes: Results are presented for parental imprisonment (age < 18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1 (Demographic controls) = Parental Imprisonment + respondent age + respondent ethnicity + respondent sex. Model 2 (Family & Neighborhood controls) = Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls) = Model 1 + respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4 (Sexual risk controls) = Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls) = all variables used in prior models.

Table 3: Predicted probabilities and 95% confidence intervals for ever being infected with an STI, by parent sex, child sex, and black/non-black racial classification (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

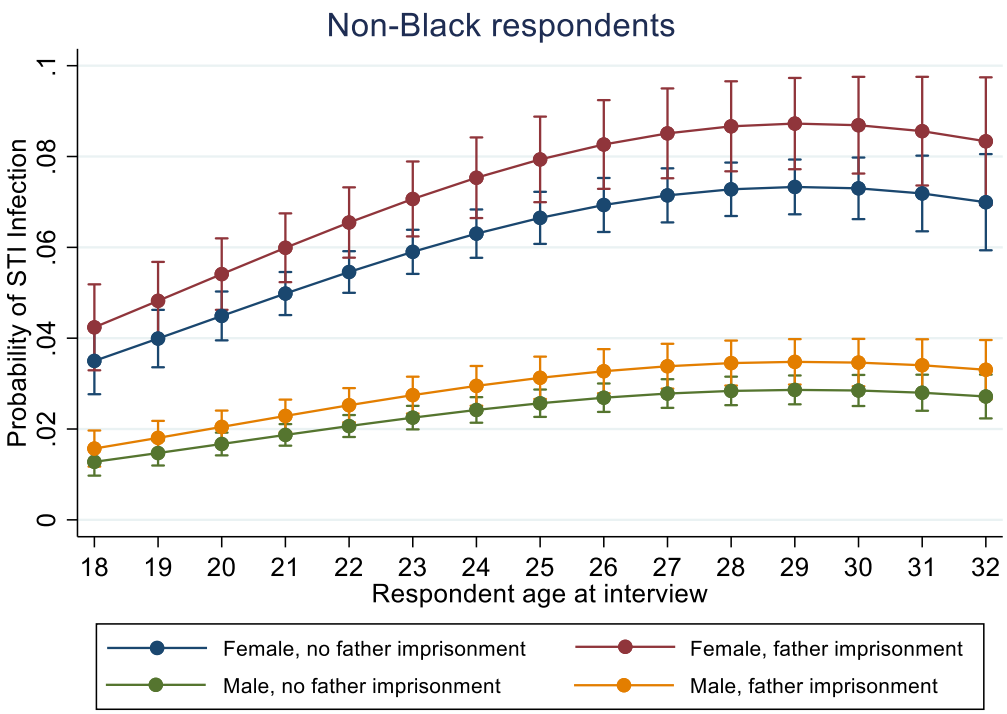
	Non-Black, Male	Non-Black, Female	Black, Male	Black, Female
Biological Father Imprisonment	12.5% [11.2%, 13.9%]	29.3% [27.0%, 31.7%]	35.8% [32.7%, 38.8%]	61.7% [58.8%, 64.7%]
No Biological Father Imprisonment	8.9% [8.2%, 9.6%]	22.1% [21.1%, 23.2%]	27.6% [25.6%, 29.5%]	52.4% [50.2%, 54.6%]
Biological Mother Imprisonment	13.5% [11.0%, 16.0%]	30.4% [25.6%, 35.1%]	37.7% [32.7%, 42.7%]	63.2% [58.4%, 68.0%]
No Biological Mother Imprisonment	9.6% [8.9%, 10.0%]	23.0% [22.0%, 24.1%]	29.1% [27.1%, 31.0%]	53.7% [51.7%, 55.8%]

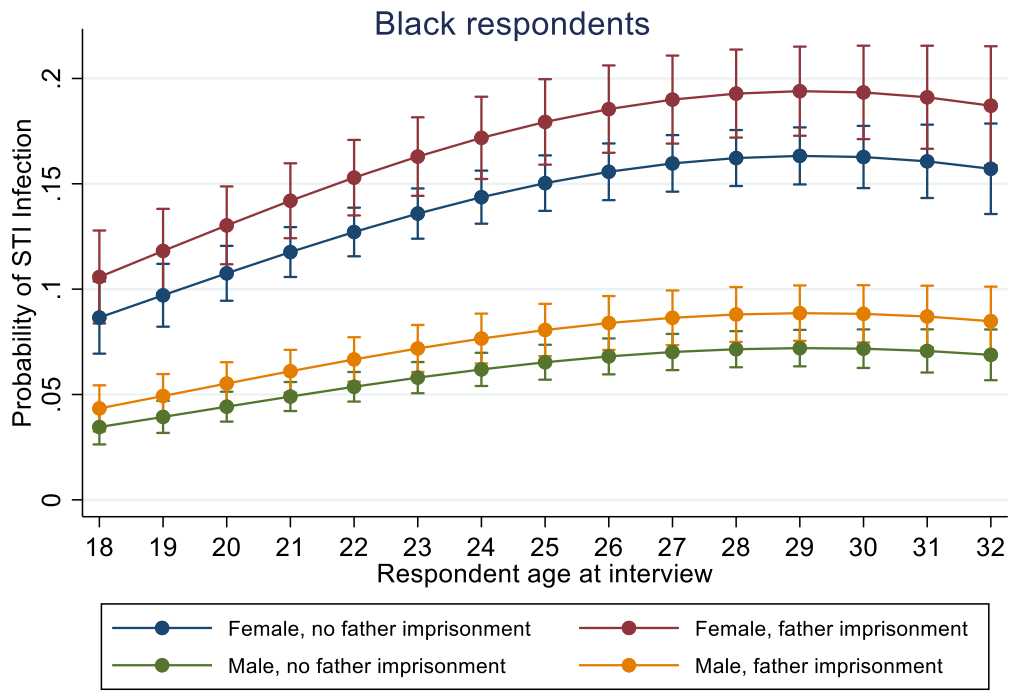
Notes: Predicted Probabilities generated based on Model 1 of Table 2 for respondents reporting if their (1) biological father or (2) biological mother was imprisoned at age < 18. Model predictors of STI infection include parental imprisonment, respondent age, respondent sex, and respondent ethnicity.

Table 4: Odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1: Demographic	Model 2: Family & Neighborhood	Model 3: Individual Risk	Model 4: Sexual Risk	Model 5: Full controls
Biological Father Imprisonment	1.33 [1.13, 1.56]	1.26 [1.06, 1.50]	1.22 [1.03, 1.43]	1.26 [1.07, 1.49]	1.15 [0.98, 1.37]
Biological Mother Imprisonment	1.22 [0.89, 1.66]	1.10 [0.81, 1.51]	1.09 [0.80, 1.48]	1.17 [0.85, 1.58]	1.02 [0.75, 1.40]
Biological Father only Imprisonment	1.36 [1.15, 1.60]	1.30 [1.10, 1.54]	1.25 [1.06, 1.50]	1.30 [1.10, 1.55]	1.19 [1.01, 1.41]
Biological Mother only Imprisonment	1.43 [0.96, 2.14]	1.33 [0.88, 2.00]	1.31 [0.88, 1.95]	1.37 [0.92, 2.05]	1.24 [0.81,1.86]
Biological Mother & Father Imprisonment	1.12 [0.69, 1.82]	1.03 [0.63, 1.70]	0.95 [0.58, 1.56]	1.06 [0.65, 1.74]	0.89 [0.54, 1.46]

Notes: Results are presented for parental imprisonment (age < 18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and (3) combined reports of biological father and mother imprisonment. Model 1 (Demographic controls) = Parental Imprisonment + respondent age + respondent ethnicity + respondent sex. Model 2 (Family & Neighborhood controls) = Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3 (Individual risk controls) = Model 1 + respondent adolescent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + binge drinking prior 12 months + serious adolescent delinquency. Model 4 (Sexual risk) = Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5 (Full controls) = all variables used in prior models.





Supplemental Table S1: Lifetime Odds of Contracting an STI Associated with Parental Imprisonment With Full Controls

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.24 [1.04,1.48]		
Mother Imprisoned		1.13 [0.94, 1.36]	
Joint Parental Imprisonment			
Father only Imprisoned			1.22 [1.09, 1.37]
Mather only imprisoned			1.20 [0.90,1.61]
Mother & Father Both Imprisoned			1.21 [0.97,1.52]
Demographic Measures			
Age at interview	0.96 [0.91,1.00]	0.96 [0.94,0.98]	0.96 [0.94,0.99]
Female	3.48 [3.01, 4.02]	3.30 [3.00,3.61]	3.29 [3.00, 3.61]
Racial Phenotype (Wave 1)			
White [reference]			
Black	4.26 [3.67,4.95]	4.00 [3.59,4.46]	4.00 [3.58,4.45]
Hispanic	1.45 [1.12,1.86]	1.30 [1.14,1.49]	1.30 [1.14,1.48]
Asian	1.10 [0.81,1.47]	1.01 [0.83,1.24]	1.03 [0.84,1.25]
Native American	2.09 [1.41,3.12]	1.78 [1.33,2.39]	1.76 [1.31,2.36]
Other/Multiple Race	1.51 [0.93,2.44]	1.38 [0.92,2.08]	1.39 [0.93,2.07]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.00 [0.84,1.19]	1.09 [0.98,1.21]	1.04 [0.94,1.16]
Single Father	1.11 [0.81,1.48]	1.23 [0.97,1.56]	1.20 [0.95,1.52]
Two Parent, One Biological	1.20 [0.95,1.52]	1.26 [1.11,1.42]	1.19 [1.05,1.35]
Other Family Structure	1.44 [1.11,1.85]	1.46 [1.23,1.73]	1.40 [1.17,1.66]

Completed Parental Education			
Bachelor's Degree	1.03 [0.82,1.30]	0.96 [0.83,1.10]	0.97 [0.85,1.11]
High School	1.06 [0.87,1.30]	0.94 [0.84,1.06]	0.94 [0.84,1.06]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	0.98 [0.54.1.80]	1.11 [0.75.1.63]	1.10 [0.75.1.63]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.96 [0.90,1.02]	0.94 [0.90,0.99]	0.95 [0.90,0.99]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.30 [1.07,1.60]	1.39 [1.21,1.60]	1.36 [1.18,1.57]
Parent's report, child temperament issues (Wave 1)	1.16 [1.03,1.30]	1.13 [1.03,1.24]	1.13 [1.03,1.24]
Delinquent Activity Scale (Wave 1)	1.03 [1.01,1.04]	1.02 [1.00,1.04]	1.02 [1.01,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.17 [1.02,1.16]	1.14 [1.07,1.22]	1.14 [1.07,1.21]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.09 [1.02,1.16]	1.08 [1.04,1.13]	1.09 [1.04,1.13]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	1.02 [0.93,1.11]	1.06 [1.00,1.11]	1.05 [1.00,1.10]
Number of Sex Partners Prior (age<18)	1.03 [1.01,1.04]	1.03 [1.02,1.04]	1.03 [1.01,1.04]

Notes: Each model represents full results from Model 5 in Table 2, by measure of parental imprisonment.

Supplemental Table S2. Weighted odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.47 [1.24, 1.74]	1.34 [1.13, 1.59]	1.34 [1.12, 1.60]	1.38 [1.16, 1.65]	1.24 [1.04, 1.48]
Biological Mother Imprisonment	1.40 [1.04, 1.89]	1.17 [0.86, 1.59]	1.20 [0.89, 1.62]	1.28 [0.94, 1.74]	1.03 [0.76, 1.41]
Biological Father only Imprisonment	1.46 [1.22, 1.75]	1.35 [1.13, 1.61]	1.34 [1.11, 1.63]	1.39 [1.16, 1.66]	1.25 [1.04, 1.51]
Biological Mother only Imprisonment	1.40 [0.94, 2.10]	1.18 [0.78, 1.76]	1.17 [0.78, 1.77]	1.28 [0.83, 1.98]	1.01 [0.66, 1.54]
Biological Mother & Father Imprisonment	1.59 [1.13, 2.23]	1.36 [0.96, 1.93]	1.38 [0.98, 1.94]	1.43 [1.00, 2.05]	1.18 [0.83, 1.69]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1+ respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S3: Longitudinal Odds of STI infection in the prior 12 months associated with Parental Imprisonment, full model results

	Father Imprisoned	Mother Imprisoned	Joint Mother/Father Imprisonment
Parent Imprisonment			
Single Parent Imprisonment			
Father imprisoned	1.12 [0.96,1.30]		
Mother Imprisoned		0.92 [0.71, 1.21]	
Joint Parental Imprisonment			
Father only Imprisoned			1.18 [1.01, 1.38]
Mather only imprisoned			1.17 [0.77,1.77]
Mother & Father Both Imprisoned			0.88 [0.62,1.24]
Demographic Measures			
Age	1.48 [1.18,1.86]	1.49 [1.18,1.87]	1.49 [1.18,1.87]
Age-Squared	0.99 [0.99,0.99]	0.99 [0.99,0.99]	0.99 [0.99,0.99]
Female	3.33 [2.91, 3.81]	3.34 [2.93, 3.82]	3.33 [2.91, 3.81]
Racial Phenotype (Wave 1)			
White [reference]			
Black	3.16 [2.71,3.68]	3.17 [2.71,3.68]	3.16 [2.71,3.68]
Hispanic	1.21 [1.00,1.47]	1.21 [1.00,1.47]	1.21 [1.00,1.47]
Asian	0.93 [0.70,1.24]	0.93 [0.70,1.24]	0.94 [0.71,1.25]
Native American	1.69 [1.12,2.55]	1.71 [1.14,2.58]	1.70 [1.13,2.55]
Other/Multiple Race	1.53 [0.88,2.69]	1.53 [0.88,2.69]	1.54 [0.88,2.71]
Family & Neighborhood Measures			
Family Structure (Wave 1)			
Two Biological Parents [reference]			
Single Mother	1.05 [0.91,1.23]	1.09 [0.94,1.26]	1.05 [0.90,1.22]
Single Father	0.85 [0.60,1.21]	0.87 [0.61,1.24]	0.84 [0.59,1.20]
Two Parent, One Biological	1.10 [0.92,1.31]	1.15 [0.97,1.36]	1.10 [0.93,1.32]

Other Family Structure	1.19 [0.93,1.53]	1.25 [0.97,1.59]	1.20 [0.93,1.54]
Completed Parental Education			
Bachelor's Degree	1.05 [0.87,1.29]	1.05 [0.86,1.28]	1.06 [0.87,1.30]
High School	0.97 [0.82,1.15]	0.97 [0.82,1.14]	0.97 [0.82,1.15]
Less Than High School [reference]			
Percentage of families in respondent's census tract below poverty level	2.02 [1.19,3.34]	2.03 [1.20,3.44]	2.01 [1.19,3.40]
Individual Resiliency & Vulnerability Measures			
School Attachment (Wave 1)	0.95 [0.89,1.01]	0.95 [0.89,1.01]	0.95 [0.89,1.01]
Measured BMI (Wave 2)	0.97 [0.96,0.98]	0.97 [0.96,0.98]	0.97 [0.96,0.98]
History of physical child abuse	1.15 [0.94,1.41]	1.17 [0.96,1.43]	1.15 [0.94,1.41]
Parent's report, child temperament issues (Wave 1)	1.18 [1.03,1.35]	1.18 [1.03,1.35]	1.17 [1.02,1.34]
Delinquent Activity Scale (Wave 1)	1.00 [0.99,1.03]	1.01 [0.99,1.03]	1.01 [0.99,1.03]
Frequency of marijuana usage prior 30 days (wave 1)	1.14 [1.05,1.24]	1.14 [1.05,1.24]	1.14 [1.05,1.24]
Reported Binge Drinking, Prior 12 months (Wave 1)	1.15 [1.10,1.20]	1.15 [1.10,1.20]	1.15 [1.10,1.20]
Sexual Risk Measures			
Parental Discussion of STI risk with Respondent	0.98 [0.92,1.05]	0.98 [0.92,1.05]	0.98 [0.92,1.05]
Number of Sex Partners Prior (age<18)	1.02 [1.01,1.03]	1.02 [1.01,1.03]	1.02 [1.01,1.03]

Notes: Each model represents full results from Model 5 in Table 4, by measure of parental imprisonment.

Supplemental Table S4. Odds ratios and 95% confidence intervals for ever being infected with gonorrhea or chlamydia among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.58 [1.40, 1.77]	1.36 [1.21, 1.54]	1.45 [1.29, 1.63]	1.48 [1.32, 1.67]	1.28 [1.13, 1.44]
Biological Mother Imprisonment	1.58 [1.29, 1.91]	1.28 [1.04, 1.56]	1.41 [1.16, 1.73]	1.49 [1.23, 1.82]	1.20 [0.97, 1.48]
Biological Father only Imprisonment	1.58 [1.41, 1.78]	1.38 [1.22, 1.58]	1.48 [1.31, 1.68]	1.49 [1.32, 1.58]	1.29 [1.14, 1.48]
Biological Mother only Imprisonment	1.78 [1.30, 2.45]	1.45 [1.05, 2.00]	1.60 [1.16, 2.21]	1.67 [1.21, 2.30]	1.34 [0.97, 1.86]
Biological Mother & Father Imprisonment	1.73 [1.36, 2.20]	1.41 [1.10, 1.81]	1.55 [1.21, 1.98]	1.62 [1.27, 2.07]	1.29 [1.00, 1.67]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S5. Complete case analysis for odds ratios and 95% confidence intervals for ever being infected with an STI infection among adults ages 26-32 reporting parental imprisonment in childhood (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.48 [1.32, 1.65]	1.34 [1.19, 1.51]	1.36 [1.17, 1.57]	1.35 [1.19, 1.53]	1.24 [1.06, 1.44]
Biological Mother Imprisonment	1.48 [1.21, 1.82]	1.19 [0.96, 1.48]	1.14 [0.86, 1.51]	1.29 [1.03, 1.63]	0.93 [0.69, 1.25]
Biological Father only Imprisonment	1.49 [1.32, 1.67]	1.37 [1.21, 1.55]	1.40 [1.21, 1.63]	1.37 [1.20, 1.56]	1.29 [1.10, 1.51]
Biological Mother only Imprisonment	1.64 [1.27, 2.12]	1.33 [1.01, 1.74]	1.44 [1.02, 2.01]	1.48 [1.12, 1.95]	1.16 [0.81, 1.69]
Biological Mother & Father Imprisonment	1.55 [1.11, 2.15]	1.21 [0.86, 1.72]	0.95 [0.60, 1.50]	1.26 [0.86, 1.84]	0.76 [0.47, 1.25]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adolescent binge drinking + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

Supplemental Table S6. Complete case analysis for odds ratios and 95% confidence intervals for longitudinal risk of STI infection in the 12 months prior to interview, ages 18-32 (National Longitudinal Study of Adolescent to Adult Health, 1994-2008).

	Model 1	Model 2	Model 3	Model 4	Model 5
Biological Father Imprisonment	1.30 [1.10, 1.53]	1.22 [1.03, 1.45]	1.16 [0.94, 1.42]	1.10 [1.00, 1.43]	1.07 [0.86, 1.33]
Biological Mother Imprisonment	1.21 [0.88, 1.65]	1.05 [0.75, 1.46]	1.20 [0.80, 1.81]	1.23 [0.88, 1.72]	1.08 [0.71, 1.65]
Biological Father only Imprisonment	1.33 [1.13, 1.58]	1.27 [1.06, 1.51]	1.22 [0.99, 1.51]	1.23 [1.02, 1.48]	1.14 [0.91, 1.42]
Biological Mother only Imprisonment	1.36 [0.93, 2.01]	1.22 [0.80, 1.85]	1.64 [1.00, 2.70]	1.46 [0.96, 2.22]	1.48 [0.88, 2.47]
Biological Mother & Father Imprisonment	1.15 [0.69, 1.92]	0.95 [0.56, 1.61]	0.79 [0.38, 1.63]	1.04 [0.58, 1.85]	0.67 [0.31, 1.44]

Notes: Results are presented for parental imprisonment (age<18) for (1) any reported biological father imprisonment, (2) any report of biological mother imprisonment and 3) combined reports of biological father and mother imprisonment. Model 1= Parental Imprisonment + respondent age + respondent ethnicity + respondent gender. Model 2= Model 1 + Wave 1 Family Structure + parent educational attainment + census tract family poverty rate. Model 3= Model 1 +respondent BMI + adolescent school attachment + childhood physical abuse + difficult child temperament + adolescent marijuana use + adult binge drinking (time-varying) + serious adolescent delinquency. Model 4=Model 1+ parental discussion of STI risk + number of sex partners prior to age 18. Model 5=all variables used in prior models.

STROBE 2007 (v4) checklist of items to be included in reports of observational studies in epidemiology*
Checklist for cohort, case-control, and cross-sectional studies (combined)

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-8
Objectives	3	State specific objectives, including any pre-specified hypotheses	4-8
Methods			
Study design	4	Present key elements of study design early in the paper	8-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	8-9
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	9-10
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*9-10*
Bias	9	Describe any efforts to address potential sources of bias	8-11
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	10-12
		(*b*) Describe any methods used to examine subgroups and interactions	10-12
		(*c*) Explain how missing data were addressed	10-12
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed	10-11

		Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	12, 14-15
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-9
		(b) Give reasons for non-participation at each stage	8-9
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8-12
		(b) Indicate number of participants with missing data for each variable of interest	8-9
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	6
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	8-9
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	8-12
		Cross-sectional study—Report numbers of outcome events or summary measures	8-12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	12-14
		(*b*) Report category boundaries when continuous variables were categorized	8-12
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	12-14
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	12-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	15-17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	15-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	20

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.
Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.