Prevalence of Chlamydial and Gonococcal Infections Among Young Adults in the United States

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Context Chlamydial and gonococcal infections are important causes of pelvic inflammatory disease, ectopic pregnancy, and infertility. Although screening for *Chlamydia trachomatis* is widely recommended among young adult women, little information is available regarding the prevalence of chlamydial and gonococcal infections in the general young adult population.

Objective To determine the prevalence of chlamydial and gonoccoccal infections in a nationally representative sample of young adults living in the United States.

Design, Setting, and Participants Cross-sectional analyses of a prospective cohort study of a nationally representative sample of 14322 young adults aged 18 to 26 years. In-home interviews were conducted across the United States for Wave III of The National Longitudinal Study of Adolescent Health (Add Health) from April 2, 2001, to May 9, 2002. This study sample represented 66.3% of the original 18924 participants in Wave I of Add Health. First-void urine specimens using ligase chain reaction assay were available for 12548 (87.6%) of the Wave III participants.

Main Outcome Measures Prevalences of chlamydial and gonococcal infections in the general young adult population, and by age, self-reported race/ethnicity, and geographic region of current residence.

Results Overall prevalence of chlamydial infection was 4.19% (95% confidence interval [CI], 3.48%-4.90%). Women (4.74%; 95% CI, 3.93%-5.71%) were more likely to be infected than men (3.67%; 95% CI, 2.93%-4.58%; prevalence ratio, 1.29; 95% CI, 1.03-1.63). The prevalence of chlamydial infection was highest among black women (13.95%; 95% CI, 11.25%-17.18%) and black men (11.12%; 95% CI, 8.51%-14.42%); lowest prevalences were among Asian men (1.14%; 95% CI, 0.40%-3.21%), white men (1.38%; 95% CI, 0.93%-2.03%), and white women (2.52%; 95% CI, 1.90%-3.34%). Prevalence of chlamydial infection was highest in the south (5.39%; 95% CI, 4.24%-6.83%) and lowest in the northeast (2.39%; 95% CI, 1.56%-3.65%). Overall prevalence of gonorrhea was 0.43% (95% CI, 0.29%-0.63%). Among black men and women, the prevalence was 2.13% (95% CI, 1.46%-3.10%) and among white young adults, 0.10% (95% CI, 0.03%-0.27%). Prevalence of coinfection with both chlamydial and gonococcal infections was 0.030% (95% CI, 0.18%-0.49%).

Conclusions The prevalence of chlamydial infection is high among young adults in the United States. Substantial racial/ethnic disparities are present in the prevalence of both chlamydial and gonococcal infections.

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CHLAMYDIA TRACHOMATIS AND *Neisseria gonorrhoeae* infections cause substantial morbidity in the United States.[1] In women, chlamydial and gonococcal infections may cause pelvic inflammatory disease, tubal infertility, chronic pelvic pain, and ectopic pregnancy.[2,3] Chlamydial infection may also be linked to cervical cancer.[4] Chlamydial and gonococcal infections may increase susceptibility to and transmission of human immunodeficiency virus in both men and women.[5] Because these infections are easy to diagnose and curable with a single dose of oral antibiotics, early detection and treatment are an important component of efforts to reduce the disease burden.

Early detection of these infections is challenging because most women and men with chlamydial infection and many women with gonorrhea are asymptomatic.[2,6] However, infected persons who are asymptomatic can still transmit the infection to sexual partners and are at risk for complica-

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tions.[2,6] Consequently, many major medical organizations recommend screening of adolescent and young adult women who are asymptomatic for chlamydial infection.[7-13] The identification of annual chlamydia screening among sexually experienced young women as a Health Plan Employer Data and Information Set measure[14] for quality of care provided by managed care organizations highlights the recognized importance of screening. In contrast, chlamydia screening for men has been endorsed less consistently.[9] Screening for gonorrhea is recommended for high-risk women.[8]

Current screening recommendations are based primarily on reported cases and clinic-based prevalence estimates. These estimates are suboptimal for informing policies because cases are underreported and clinic populations have limited generalizability. Population-based studies provide more accurate and representative prevalence estimates. However, to our knowledge, the only previous national prevalence estimate of chlamydial infection in the United States was limited to young men and had a relatively small sample size.[15] Other prevalence estimates have been limited to single urban areas.[16,17] Wave III of The National Longitudinal Survey of Adolescent Health (Add Health) provides the first opportunity to determine the national prevalence of chlamydial and gonococcal infection in young adult women and men in the United States. Using Wave III Add Health data, we assessed the general population estimates of the prevalence of chlamydial and gonococcal infection among young adults from different racial and ethnic groups. Additionally, we provided estimates of overlap of gonorrhea and chlamydial infections.

METHODS

Study Design and Sample

Add Health is a prospective cohort study that has followed almost 20 000 adolescents into adulthood.[18] We describe cross-sectional analyses based on Wave III of Add Health (April 2, 2001, to May 9, 2002), which targeted all original Wave I participants currently living in the continental United States, Hawaii, and Alaska. The University of North Carolina institutional review board approved all study procedures.

The sampling design for Add Health has been described in detail elsewhere.[18,19] The primary sampling frame for the original Add Health sample included all high schools in the United States with an 11th grade and at least 30 enrollees in the school. From this sampling frame, a systematic random sample of 80 high schools and 52 middle schools in the United States was chosen with unequal probability of selection. The sampling of schools was stratified to ensure that the schools were representative of US schools with respect to region, urbanicity, school type, percentage of white students, and school size. For each high school selected, the largest feeder school, usually a middle school, was also recruited.

The original study participants were identified from rosters of students in grades 7 through 12 enrolled in the selected schools, early in the 1994-1995 school year. The random sample of students was stratified by grade and sex. Black youth in families with relatively higher socioeconomic status and certain Latino groups were oversampled to increase the precision of estimates for these ethnic groups. For Wave III, poststratification sampling weights were calculated to account for persons who could not be located or refused to participate. With these sampling weights, accounting for the school as the primary sampling unit and using region of the country as a stratification variable, the Add Health cohort provided a representative sample of young adults aged 18 to 26 years in the United States.

Interviews and Specimen Collection

All original Wave I Add Health respondents who could be contacted were asked to identify a time and place for the Wave III interview. An interviewer traveled to their home or another suitable location identified by the potential participant. After obtaining written consent for the interviews, interviewers conducted the approximately 90-minute sessions in as private an area as possible. Interviewers entered questionnaire responses directly into a computer. Participants used computer-assisted self-interview to answer potentially sensitive questions (eg, questions about sexual behavior).

Consent for testing for chlamydial and gonoccocal infections was obtained after interview completion. Participants received $10 for providing a urine specimen. Participants who provided a urine specimen received information regarding chlamydial, gonococcal, and other sexually transmitted infections and were encouraged to call a toll-free telephone number for test results. Participants were also informed that they were not being tested for all sexually transmitted infections and should not view their participation in the Add Health study as a substitute for health care. Results of assays for chlamydial and gonococcal infections were not reported to local public health departments, based on the terms of a Certificate of Confidentiality obtained from the US Department of Health and Human Services. A more detailed description of Add Health sexually transmitted infection testing is available elsewhere.[20]

Urine specimens were collected in a 30-mL container with a mark at 15 mL. The target volume for testing was 15 to 20 mL of first-void urine. Interviewers instructed participants in the appropriate collection techniques. Urine samples were placed in coolers after collection. Specimens were maintained at approximately 4°C until they were packaged with fresh ice packs and shipped by overnight express to arrive at the laboratory by 10 AM the following morning. Samples were received in the laboratory within 4 days of collection. Upon arrival, urine specimens were inspected for adherence to appropriate shipping conditions, including the presence of the appropriate bar code label, date and time of collection, temperature on arrival, and volume of urine. All urine samples were pro-

cessed on the day of arrival by trained laboratory technologists.

C trachomatis and *N gonorrhoeae* were identified in urine specimens by using ligase chain reaction (LCR) assays (Abbott Laboratories, Abbott Park, Ill). Ligase chain reaction assays were performed according to the manufacturer's instructions, except that specimens exceeding the recommended volume of 20 mL were tested. The testing laboratory performed sample processing in a dedicated preamplification area that was monitored routinely for contamination by wipe testing. An open vial was maintained on the bench top and then carried through sample processing to monitor contamination. A laboratory-prepared positive control was also processed with each run as an external monitor of sample processing and detection. The postamplification area, including instrumentation, was monitored by wipe testing in a similar fashion to the preamplification area. Routine instrumentation monitoring and preventive maintenance was performed per the manufacturer's recommendations. The LCR results were reviewed for acceptability by the responsible technologist as well as a second individual. Ligase chain reaction results were expressed as a signal to cutoff ratio determined by relating the sample rate for each specimen to the cutoff value of assay calibrator duplicates. The Abbott analyzer automatically performed these calculations. All chlamydial and gonococcal samples with a signal to cutoff ratio of at least 0.80 were retested to minimize the potential for false-positive test results.[20] Retested samples with a signal to cutoff ratio of at least 1.00 were considered positive. All test results were entered into a database by an individual technologist who used a bar code scanner to ensure accurate result-sample identification. Two additional reviewers verified the computer entry.

After completion of data collection, Abbott Laboratories issued a recall for certain lots of *N gonorrhoeae* LCR assays. Results from these assays (n=859, 6.0%), whether positive or negative, were excluded from the gonorrhea prevalence estimates.

Outcome Measures

In addition to measuring the prevalence of chlamydial and gonococcal infections, our analyses included 3 demographic variables: age based on reported birth date, race/ethnicity (self-reported as white, black, Native American, Asian American, or Latino), and geographic region of current residence (northeast, south, midwest, or west). In some cases, participant self-identified more than 1 racial/ethnic group. In that circumstance, we used a follow-up question identifying the group with which a participant primarily identified. We also included 3 measures assessing symptoms of infection in the 24-hour period preceding the interview: painful urination (dysuria), urethral discharge (men), and vaginal discharge (women).

Statistical Analyses

To ensure the national representation of our prevalence estimates for chlamydial and gonococcal infections, we used Stata version 7.0 (Stata Corp, College Station, Tex) to account for the complex survey design of Add Health, incorporating the school as the primary sampling unit, region as a stratification variable, and appropriate post-stratification weights. We calculated 95% confidence intervals (CIs) using a logit transformation. Prevalence ratios with 95% CIs were calculated using Poisson regression for survey data.[21]

Assessment of Test Performance and Nonresponse Biases

Given the relatively high prevalence of chlamydial infection and the potential impact of our observations on chlamydia screening policies, we conducted a sensitivity analysis to assess the effects of 2 potential sources of bias, test performance and nonresponse, on the prevalence estimates for chlamydial infection. We used plausible estimates of sensitivity (0.80, 0.90) and specificity (0.98, 0.99, 0.995) of the LCR assay to assess the potential impact of test imperfection on the prevalence estimates.[20,22,23] We present the data from a very low estimate (sensitivity=0.80 and specificity=0.98) and a realistic estimate (sensitivity=0.90 and specificity=0.995). These analyses were performed in conjunction with the assessment of the effects of nonresponse.

In Wave III of Add Health, 6% of the original Wave I study population refused participation and an additional 19% could not be located or were unable to participate for other reasons. Nine percent of the original study population did not have a urine specimen available for chlamydial testing; 14% did not have a specimen or result for gonococcal testing. This nonresponse can potentially bias the prevalence estimates under 2 conditions: if the response rate varies by an observed attribute, such as race or sex, which is associated with prevalence; or if the nonrespondents have a different pattern of prevalence from respondents with similar observed attributes. In the latter case, an unobserved attribute may influence both survey participation and level of risk.

To address the first source of potential nonresponse bias, we used post-stratification weights developed by the Add Health research team to ensure that the observed sample has the proper race and sex distribution.

We addressed the second potential source of nonresponse bias through sensitivity analysis using the method described by Brookmeyer and Gail.[24] Given the proportion of missing assays π_{miss}, the prevalence in the observed assays π^{+}_{obs}, and the prevalence ratio of infection for the missing assays compared with the observed assays ρ, the population prevalence π^{+} can be estimated under different assumptions about the prevalence ratio from $\{[\pi_{miss} \times \pi^{+}_{obs} \times \rho] + [(1-\pi_{miss}) \times \pi^{+}_{obs}]\}$. We use the unknown ρ as a sensitivity parameter to project the number of cases we would estimate under different prevalence ratio scenarios, allowing ρ to vary by sex, race, and region but assuming the prevalence ratio within each subgroup is the same. We present results from 2 estimates of ρ, 0.5 and 2.0, reflecting the circumstances in which the persons with missing assays are one half

and twice as likely to have chlamydial infection.

RESULTS

Study Population

Of the 18924 Add Health participants in the nationally representative weighted Wave I sample, 1109 (5.9%) refused participation, 3493 (18.5%) could not be located or were unable to participate, and 14322 (75.7%) were located and agreed to participate in Wave III. Of these, 1130 (7.9%) refused to provide a urine specimen, 226 (1.6%) were unable to provide a specimen at the time of the interview, and 418 specimens (2.9%) could not be processed due to shipping or laboratory problems. In all, specimens from 12548 Wave III participants (87.6%), representing 66.3% of the original 18924 participants, were available for *C trachomatis* testing. For *N gonorrhoeae* testing, 11689 of the Wave III participants (81.6%) were included in the prevalence estimates.

Including participants who did and did not provide urine specimens, 52.8% of the study sample were women (TABLE 1). The majority (54.2%) of participants were white, with substantial representation of black (21.3%), Latino (16.3%), Asian American (7.2%), and Native American (1.0%) participants. The mean age of the participants was 22.0 years (SD, 1.8 years).

Prevalence of Chlamydial Infection

The overall prevalence of chlamydial infection in our sample of young adults was 4.19% (95% CI, 3.48%-4.90%). Prevalence varied little by age (TABLE 2), but was more common among women (4.74%) than men (3.67%; prevalence ratio, 1.29; 95% CI, 1.03-1.63). Prevalence was more than 2 times higher in the south (5.39%) than in the northeast (2.39%) region (prevalence ratio, 2.26; 95% CI, 1.39-3.66).

The prevalence of chlamydial infection varied significantly by race/ethnicity (Table 2). Prevalence was lowest in white young adults (1.94%) and more than 6 times higher in black young adults (12.54%; prevalence ratio, 6.46; 95% CI, 4.68-8.91). The prevalence was also high in Native American young adults (10.41%), although this estimate is imprecise. Intermediate prevalences were observed in Latino young adults (5.89%). The prevalence among Asian American young adults (2.10%) was comparable with that of white young adults. We observed similar patterns after stratifying by both race/ethnicity and sex (TABLE 3). The highest prevalence in any group was among black women (13.95%), followed by black men (11.12%). The lowest prevalences were among Asian American men (1.14%), white men (1.38%), and white women (2.52%).

Nearly all participants (>95%) with chlamydial infection did not report symptoms in the 24 hours preceding specimen collection. Among men with chlamydial infection, the prevalences of urethral discharge and dysuria were only 3.33% and 1.88%, respectively. The prevalences of urethral discharge and dysuria among men without chlamydial infection were 0.02% and 0.97%, respectively. Among women with chlamydial infection, the prevalences of vaginal discharge and dysuria were 0.26% and 4.21%, respectively. The prevalences of vaginal discharge and dysuria among women without chlamydial infection were similar at 1.4% and 3.28%, respectively.

Among young adults who reported symptoms, the prevalence of chlamydial infection was much higher for men than women. Among the small number of young men reporting urethral discharge (n=17), the prevalence of chlamydial infection was high (38.46%), whereas the prevalence of chlamydial infection was only 6.01% among the women reporting dysuria (n=232) and 0.93% among those reporting vaginal discharge (n=98).

Prevalence of Gonorrhea

The overall prevalence of gonorrhea among young US adults was low (0.43%; 95% CI, 0.29%-0.63%). The prevalence of gonorrhea varied little by sex and age but was lower in the west (Table 2). However, substantial differences were observed by race/ethnic-

Table 1. Characteristics of the Wave III of The National Longitudinal Study of Adolescent Health Study Population (N = 14 322)*

Characteristics	No. of Participants	Unweighted %†	Weighted %‡
Sex			
Male	6767	47.3	50.8
Female	7555	52.8	49.2
Race/ethnicity§			
White	7741	54.2	67.6
Latino	2340	16.3	11.9
Black	3042	21.3	16.0
Asian American	1026	7.2	3.7
Native American	136	1.0	0.8
Age, y			
18-19	1453	10.2	12.7
20-21	4123	28.8	32.3
22-23	5520	38.5	32.1
24-25	3101	21.7	21.7
≥26	125	0.9	1.2
Region§			
West	3685	25.8	17.8
Midwest	3328	23.3	28.7
South	5506	38.5	40.2
Northeast	1790	12.3	13.4

*Because of rounding, percentages may not all total 100.
†Reflects the percentage of the characteristic in the study sample.
‡Reflects the representative proportion in the target US population.
§Number of participants sums to 14 285 for race/ethnicity and 14 309 for region due to a limited amount of missing data.

ity. The prevalence of gonorrhea was approximately 2% for both black men and women, which was 36 times greater and 14 times greater than white men and women, respectively (Table 3).

In this general population sample of young adults, most persons with gonorrhea were asymptomatic. Among men with gonorrhea, 4.43% reported dysuria and none reported a penile discharge in the previous 24 hours. Among women, 12.36% reported dysuria and 0.88% reported vaginal discharge.

Chlamydial and Gonococcal Coinfection

The overall prevalence of coinfection with both chlamydial and gonococcal infections was 0.30% (95% CI, 0.18%-0.49%). Among persons with gonorrhea, the prevalence of chlamydial infection was extremely high (69.97%; 95% CI, 51.66%-83.56%). This prevalence was similar among men (69.81%; 95% CI, 43.52%-87.40%) and women (70.15%; 95% CI, 43.69%-87.68%).

The prevalence of gonorrhea was also relatively high among those participants with chlamydial infection (7.29%; 95% CI, 4.69%-11.16%). Among men with chlamydial infection, the prevalence of gonorrhea was 8.65% (95% CI, 4.77%-15.19%) and among women, it was 6.24% (95% CI, 3.05%-12.36%).

Sensitivity Analyses

To ensure that the prevalence estimates for chlamydial infection were not too high, we conducted sensitivity analyses to assess the impact of nonresponse and diagnostic test performance on the prevalence estimates for chlamydial infection using several plausible estimates for nonresponse and test performance (TABLE 4).

To provide a direct estimate of the potential effect of nonresponse bias, we estimated the prevalence with different nonresponse conditions, without considering test performance. If persons without urine specimens were missing at random, the prevalence estimate is minimally affected (4.18%; 95% CI, 2.94%-5.53%). If the prevalence of chlamydial infection was twice as high among persons without a urine specimen vs those with a urine specimen ($\rho = 2.0$), the overall estimate for chlamydial infection would increase to 5.99% (95% CI, 4.18%-7.96%). If the prevalence of chlamydial infection was half as high among nonresponders ($\rho = 0.5$), the overall prevalence would decrease to 3.28% (95% CI, 2.31%-4.32%).

To provide an estimate of the maximum potential bias, we then considered the potential effects of poor test performance (sensitivity = 0.80 and specificity = 0.98) while simultaneously accounting for the effects of nonresponse. Estimates were lower than unadjusted estimates for most groups if nonrespondents were considered

Table 2. Prevalence of Chlamydial and Gonococcal Infections by Sex, Age, Race/Ethnicity, and Region

	Chlamydial Infection		Gonorrhea	
	Prevalence (95% CI)	Prevalence Ratio (95% CI)	Prevalence (95% CI)	Prevalence Ratio (95% CI)
Sex				
Male	3.67 (2.93-4.58)*	1.00	0.44 (0.26-0.77)	1.00
Female	4.74 (3.93-5.71)	1.29 (1.03-1.63)	0.42 (0.24-0.73)	0.95 (0.43-2.08)
Race/ethnicity				
White	1.94 (1.53-2.47)	1.00	0.10 (0.03-0.27)	1.00
Latino	5.89 (4.57-7.57)	3.03 (2.13-4.32)	0.20 (0.07-0.55)	2.06 (0.47-8.92)
Black	12.54 (10.23-15.29)	6.46 (4.68-8.91)	2.13 (1.46-3.10)	21.76 (7.16-66.13)
Asian American	2.10 (1.12-3.90)	1.08 (0.59-2.10)	NA	NA
Native American	10.41 (6.37-16.56)	5.36 (3.12-9.19)	NA	NA
Age, y				
18-19	4.05 (2.83-5.77)	1.14 (0.73-1.78)	0.12 (0.03-0.44)	0.49 (0.08-2.90)
20-21	4.70 (3.55-6.19)	1.32 (0.89-1.95)	0.64 (0.36-1.14)	2.67 (0.70-10.27)
22-23	4.10 (3.16-5.32)	1.15 (0.84-1.58)	0.47 (0.22-0.98)	1.95 (0.47-8.01)
24-25	3.56 (2.73-4.64)	1.00	0.24 (0.07-0.78)	1.00
≥26	5.67 (2.30-13.29)	1.59 (0.63-3.99)	0.34 (0.05-2.46)	1.42 (0.13-14.98)
Region				
West	3.17 (2.40-4.17)	1.33 (0.80-2.20)	0.04 (0.01-0.29)	0.10 (0.01-0.85)
Midwest	3.95 (2.72-5.70)	1.65 (0.94-2.92)	0.43 (0.19-1.00)	0.99 (0.26-3.68)
South	5.39 (4.24-6.83)	2.26 (1.39-3.66)	0.59 (0.37-0.94)	1.34 (0.44-4.10)
Northeast	2.39 (1.56-3.65)	1.00	0.44 (0.16-1.21)	1.00

Abbreviations: CI, confidence interval; NA, not available.
*Weighted percentage reflects the representative proportion in the target US population.

Table 3. Prevalence of Chlamydial and Gonococcal Infections by Sex and Race/Ethnicity

	Chlamydial Infection		Gonorrhea	
Race/Ethnicity	Prevalence (95% CI)	Prevalence Ratio (95% CI)	Prevalence (95% CI)	Prevalence Ratio (95% CI)
		Men		
White	1.38 (0.93-2.03)*	1.00	0.07 (0.01-0.48)	1.00
Latino	7.24 (4.92-10.54)	5.26 (3.02-9.17)	0.27 (0.08-0.87)	4.08 (0.40-41.55)
Black	11.12 (8.51-14.42)	8.08 (5.09-12.83)	2.36 (1.40-3.95)	36.20 (4.63-282.57)
Asian American	1.14 (0.40-3.21)	0.83 (0.29-2.38)	NA	NA
Native American	7.99 (3.65-16.60)	5.80 (2.47-13.63)	NA	NA
		Women		
White	2.52 (1.90-3.34)	1.00	0.13 (0.04-0.43)	1.00
Latino	4.42 (3.06-6.36)	1.75 (1.10-2.79)	0.13 (0.02-0.90)	1.00 (0.10-9.67)
Black	13.95 (11.25-17.18)	5.53 (3.84-7.96)	1.91 (1.00-3.61)	14.64 (3.79-56.56)
Asian American	3.31 (1.63-6.63)	1.31 (0.61-2.81)	NA	NA
Native American	13.34 (5.68-28.26)	5.29 (2.24-12.48)	NA	NA

Abbreviations: CI, confidence interval; NA, not available.
*Weighted percentage reflects the representative proportion in the target US population.

Table 4. Sensitivity Analyses Demonstrating Estimated Prevalence of Chlamydial Infection Accounting for Nonresponse to the Survey and Diagnostic Test Performance

	Prevalence (95% Confidence Interval)*		
	Missing at Random	Prevalence Ratio = 0.5†	Prevalence Ratio = 2.0†
Sensitivity and Specificity = 1.0 (Nonresponse Only)			
Overall	4.18 (2.94-5.53)	3.28 (2.31-4.32)	5.99 (4.18-7.96)
Men	3.68 (3.02-4.38)	2.82 (2.34-3.36)	5.38 (4.39-6.44)
Race/ethnicity			
White	1.37 (0.89-1.91)	1.09 (0.71-1.52)	1.93 (1.23-2.71)
Latino	7.32 (4.77-10.19)	5.62 (3.66-7.79)	10.73 (6.96-15.00)
Black	11.09 (8.29-14.06)	8.40 (6.31-10.64)	16.49 (12.29-21.07)
Asian American	1.12 (0.12-2.54)	0.95 (0.10-2.18)	1.47 (0.16-3.30)
Native American	8.30 (0.10-18.74)	5.94 (0.08-13.53)	13.04 (0.13-29.70)
Women	4.70 (4.06-5.40)	3.75 (3.24-4.30)	6.60 (5.69-7.59)
Race/ethnicity			
White	2.50 (1.84-3.18)	2.06 (1.51-2.60)	3.39 (2.48-4.31)
Latino	4.40 (2.60-6.32)	3.36 (2.01-4.81)	6.49 (3.83-9.31)
Black	14.00 (11.26-16.78)	11.09 (8.93-13.36)	19.81 (15.89-23.73)
Asian American	3.43 (1.27-6.06)	2.72 (1.02-4.81)	4.87 (1.76-8.69)
Native American	13.08 (2.47-25.30)	9.97 (1.89-19.30)	19.30 (3.09-39.62)
Sensitivity = 0.80 and Specificity = 0.98			
Overall	2.86 (1.86-4.39)	2.03 (1.29-2.96)	4.97 (3.00-7.29)
Men	2.15 (1.31-3.05)	1.05 (0.43-1.74)	4.34 (3.07-5.69)
Race/ethnicity			
White	0	0	0 (0-0.91)
Latino	6.83 (3.55-10.50)	4.64 (2.13-7.42)	11.20 (6.36-16.67)
Black	11.66 (8.07-15.47)	8.20 (5.52-11.08)	18.58 (13.20-24.45)
Asian American	0 (0-0.69)	0 (0-0.23)	0 (0-1.67)
Native American	8.08 (0-21.46)	5.05 (0-14.78)	14.15 (0-35.52)
Women	3.46 (2.64-4.36)	2.25 (1.59-2.95)	5.90 (4.73-7.17)
Race/ethnicity			
White	0.64 (0-1.52)	0.07 (0-0.78)	1.78 (0.62-2.97)
Latino	3.08 (0.77-5.54)	1.75 (0.01-3.60)	5.76 (2.35-9.37)
Black	15.38 (11.87-18.94)	11.65 (8.88-14.56)	22.83 (17.80-27.86)
Asian Amercian	1.84 (0-5.21)	0.92 (0-3.60)	3.68 (0-8.58)
Native American	14.21 (0.60-29.87)	10.22 (0-22.18)	22.18 (1.39-48.23)
Sensitivity = 0.90 and Specificity = 0.995			
Overall	4.11 (2.74-5.60)	3.11 (2.04-4.27)	6.12 (4.12-8.30)
Men	3.55 (2.82-4.34)	2.59 (2.05-3.19)	5.45 (4.35-6.64)
Race/ethnicity			
White	0.97 (0.43-1.58)	0.66 (0.24-1.14)	1.60 (0.82-2.47)
Latino	7.62 (4.77-10.82)	5.72 (3.53-8.14)	11.43 (7.21-16.21)
Black	11.84 (8.71-15.15)	8.82 (6.49-11.33)	17.87 (13.18-22.98)
Asian American	0.69 (0-2.28)	0.50 (0-1.87)	1.08 (0-3.13)
Native American	8.72 (0-20.38)	6.08 (0-14.55)	14.01 (0-32.63)
Women	4.69 (3.98-5.47)	3.63 (3.06-4.25)	6.81 (5.80-7.93)
Race/ethnicity			
White	2.24 (1.50-3.00)	1.74 (1.13-2.35)	3.23 (2.22-4.26)
Latino	4.36 (2.35-6.50)	3.20 (1.68-4.81)	6.69 (3.72-9.84)
Black	15.08 (12.02-18.18)	11.83 (9.42-14.37)	21.57 (17.19-25.96)
Asian American	3.28 (0.86-6.22)	2.48 (0.58-4.82)	4.88 (1.41-9.16)
Native American	14.06 (2.20-27.71)	10.58 (1.55-21.01)	21.00 (2.89-43.71)

*Confidence interval is derived from bootstrap analyses.
†Prevalence ratio of infection for the missing assays compared with the observed assays. This reflects the circumstances in which the persons with missing assays are one half and twice as likely to have chlamydial infection.

missing at random or one half as likely to be infected ($\rho = 0.5$). Estimates remained slightly higher than unadjusted estimates if nonrespondents were considered twice as likely to be infected ($\rho = 2.0$). Estimates remained high for black adults regardless of test performance. The prevalence estimates were 0 for the white and Asian American men, suggesting test performance was unlikely to be this poor.

We then examined estimates with conditions that approximated expected test performance (sensitivity = 0.90 and specificity = 0.995). In this circumstance, estimates were generally comparable with those obtained with adjustment for nonresponse alone. Typically, estimates for low prevalence populations were reduced slightly and those for high prevalence populations were increased.

COMMENT

Add Health provides the most comprehensive assessment to date of the prevalence of chlamydial and gonococcal infections in young US adults. More than 4% of all young adults were infected with *C trachomatis*. The prevalence of chlamydial infection was higher among young women than men but this difference was not substantial. In this nationally representative sample, the prevalence of chlamydial infection was more than 6 times greater in black vs white young adults, and also high in Native American and Latino young adults. Although the overall prevalence of gonorrhea was low, the prevalence of gonorrhea was markedly higher among black young adults than other groups.

The marked differences in these sexually transmitted infections across racial and ethnic groups are disturbing. Although reporting bias and minority groups' disproportionate use of publicly funded clinics may affect previous prevalence estimates derived from clinics, these sources of bias cannot explain the racial/ethnic disparities observed in our general population sample. The Add Health study design ensured that prevalence estimates would be independent of reporting by clinicians and health care

seeking behavior. Furthermore, because black young adults with relatively higher socioeconomic status and certain Latino groups were oversampled, the precision of the prevalence estimates for black and Latino young adults was enhanced. Our results provide compelling evidence that nationwide disparities in chlamydial and gonococcal infections across racial/ethnic groups are real rather than the result of biased estimates.

The observed disparities in chlamydial and gonococcal infections by racial and ethnic groups may be responsible, in part, for considerable differences in reproductive health. Black women have 33% excess incidence in ectopic pregnancy compared with white women.[25] A substantial proportion of the excess mortality related to childbirth among black women in New York City is attributable to ectopic pregnancy.[26] Given the well-recognized association of chlamydial and gonococcal infections with tubal scarring, infertility, and ectopic pregnancy,[2,3] efforts to reduce chlamydial infection and gonorrhea in these populations may have important effects on morbidity and possibly mortality.

The low prevalence of gonorrhea is not unexpected. Unlike chlamydial infection, gonorrhea is frequently symptomatic, especially in men, and commonly necessitates medical care.[6] Furthermore, the duration of gonococcal infections is believed to be shorter,[27] which will result in a relative reduction in prevalence, compared with chlamydial infection. However, the very low prevalence of gonorrhea in these national estimates contrasts with a substantially higher prevalence observed in a population-based study in Baltimore, Md, in which the estimated prevalence was 5.3% among adults aged 18 to 35 years.[16] Baltimore has consistently had high reported incidence of gonorrhea,[28] and undoubtedly, the observed differences in prevalence relates to the highly clustered, geographically varied distribution of gonorrhea.[1,28]

Previous population-based studies of the prevalence of chlamydial infection have been limited in scope.[15] Among young men, the prevalence of chlamydial infection was 3.1% among 18- to 19-year-olds and 4.5% among 20- to 26-year-olds, but the sample size was considerably smaller than the Add Health study sample, prevalence was not reported by race/ethnicity, and 95% CIs were not reported.[15] Other population-based studies in Baltimore and San Francisco, Calif, were limited geographically and by sample size.[16,17]

Consistent with these more limited population-based prevalence studies,[15-17] our results confirm that prevalence estimates obtained from clinic-based data sources do not accurately reflect the true prevalence of chlamydial infection among young adults. For example, in 2001, the Centers for Disease Control and Prevention (CDC) used clinic-based test reports to estimate incidence rates for chlamydial infection of 604.9 per 100 000 person-years for men and 2447.0 per 100 000 person-years for women aged 20 to 24 years.[1] Converting the incidence rates of the CDC to prevalence and assuming a mean duration of infection of 6 months to 1.5 years,[27] the expected general population prevalence of chlamydial infection would be between 0.3% and 0.9% in men and 1.2% and 3.6% in women. We found that the prevalence of chlamydial infection among young US men and women is much higher. The Add Health estimates also provide a realistic counterpoint to clinic-based studies that may overstate the prevalence of chlamydial infection, such as those conducted in clinics in which relatively high-risk persons present for sexually transmitted disease or family planning services.

The high national prevalence of chlamydial infection suggests that current screening strategies have failed to control this easily curable sexually transmitted infection in young adult men and women. One possible explanation is that current recommendations for screening may be inadequate. For example, young adult men who are asymptomatic account for a large reservoir of infection in the general population but screening recommendations have largely excluded men.[8] Although screening for adolescent boys was included as a recommendation in the 1998 CDC guidelines,[9] this recommendation was omitted in the more recent 2002 guidelines.[8]

Even if sexually experienced adolescents and young adults are observed in clinic settings and meet criteria for screening based on current recommendations, they may not be screened. The recommendations by the CDC regarding screening of adolescent girls are not widely observed.[29-32] Moreover, although most publicly funded clinics provide chlamydial screening for women, many cannot screen all women who meet CDC guidelines due to budgetary constraints.[33] Screening in private practice settings is even less common.[29,30] Our findings clearly support the importance of widespread implementation of current guidelines, including screening or treating persons with gonorrhea for chlamydial infection.

The lack of connection between young adults and health care systems may also contribute to the failure of the screening recommendations for chlamydial infection. Young adults are much less likely to have health insurance than any other age group and many do not have a regular physician or receive routine health care.[34,35] Young adults are often unaware of routine screening recommendations for chlamydial infection and do not know that infection may be asymptomatic.[36,37] All of these factors are likely to lead to fewer opportunities to screen young adults for chlamydial infection in clinic settings.

Our study, like all studies assessing the prevalence of sexually transmitted infections, is limited by the adequacy of the study sample and the characteristics of the diagnostic test used. The adequacy of our study sample depends on the representativeness of the original school-based sample, nonresponse to the follow-up survey for Wave III, and refusal or other problems that led to a missing specimen among participants in Wave III. Although the original sample included only students on school registers, assessment of the impact of exclusion of adolescent school dropouts

has suggested that this bias in Add Health is minimal.[38] Although 24% of the participants in Wave I could not be located for Wave III, this element of nonresponse has been accounted for in the poststratification adjustment of the sampling weights for Wave III. Finally, our sensitivity analyses suggested that our conclusions were robust to differences in characteristics of nonrespondents and test performance.

In conclusion, we found the prevalence of untreated asymptomatic chlamydial infection to be high in young adults in the United States. The high prevalence of chlamydial infection in both men and women suggests that current screening approaches that focus primarily on clinic-based testing of young women are inadequate. The reduction of disparities in the prevalence of both chlamydial and gonococcal infections across racial/ethnic groups must also be a priority.

Author Contributions: Dr Miller had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Miller, Ford, Cohen, Udry.
Acquisition of data: Miller, Schmitz, Hobbs, Cohen, Harris, Udry.
Analysis and interpretation of data: Miller, Ford, Morris, Handcock, Cohen, Udry.
Drafting of the manuscript: Miller, Ford, Cohen.
Critical revision of the manuscript for important intellectual content: Miller, Ford, Morris, Handcock, Schmitz, Hobbs, Cohen, Harris, Udry.
Statistical expertise: Miller, Morris, Handcock, Cohen.
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Study supervision: Cohen, Harris, Udry.
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Additional Information: Persons interested in obtaining data files from Add Health should contact Add Health, Carolina Population Center, 123 W Franklin St, Chapel Hill, NC 27516-2524.
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