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Prevention of mother-to-child transmission of infections during pregnancy: implementation of recommended interventions, United States, 2003–2004

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Abstract

OBJECTIVE—The objective of the study was to describe prenatal screening, positive test rates, and the administration of indicated interventions for hepatitis B, rubella, syphilis, group B streptococcus (GBS), chlamydia, and gonorrhea in the United States using 2 population-based surveys.

STUDY DESIGN—Both surveys abstracted demographic, prenatal, and delivery data from a representative sample of delivering women in 10 states. Analyses accounted for the complex sampling design.

RESULTS—Among the 7691 and 19,791 women in the 2 studies, screened proportions before delivery were more than 90% for hepatitis B and rubella, 80% for syphilis, 72–85% for GBS, and less than 80% for chlamydia and gonorrhea. Inadequate prenatal care was the strongest factor associated with no screening. Administration of interventions indicated by positive test results was variable but generally low.

CONCLUSION—Improved prenatal screening and administration of indicated treatments or interventions, particularly for syphilis, GBS, chlamydia, and gonorrhea, will further protect newborns from infection.

Keywords

chlamydia; gonorrhea; group B streptococcus; guidelines; hepatitis B; pregnancy; rubella; screening; syphilis; treatment

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During pregnancy, maternal infection with chlamydia, gonorrhea, syphilis, hepatitis B virus (HBV), rubella, and colonization with group B streptococcus (GBS) contributes to maternal,

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fetal, neonatal, and later morbidity and mortality. For example, approximately 25% of infants who become chronically infected with hepatitis B die prematurely from cirrhosis or liver cancer (2000–4000 deaths/year), 20–60% of infants born to women with untreated chlamydial infection develop conjunctivitis or pneumonia,[1,2] and untreated syphilis, depending on stage, affects 40% to virtually 100% of infants, 50% of which are preterm or stillborn.

Vertical transmission of all of these pathogens is preventable through appropriate prenatal screening and management of the mother and newborn. The Centers for Disease Control and Prevention (CDC), the American College of Obstetrics and Gynecology (ACOG), and the US Preventive Services Task Force (USPSTF) recommend routine, universal screening of all pregnant women for syphilis, chlamydia, HBV, and human immunodeficiency virus (HIV) as well as testing for rubella immunity.[3–6] The CDC and ACOG also recommend screening all women for GBS and high-risk women for gonorrhea.[3,7]

Recommended interventions include penicillin at least 30 days before delivery for syphilis, treatment during pregnancy for chlamydia and gonorrhea, administration of hepatitis B immunoglobulin, and vaccination for newborns born to HBV-positive women, postpartum maternal vaccination for rubella-susceptible women to protect future pregnancies, and intrapartum antibiotic prophylaxis for women colonized with GBS.

Many of these infections are known to disproportionately affect adults of certain racial and ethnic groups.[8–10] The identification of groups of pregnant women at the highest risk for infection as well as the recognition of factors associated with lack of prenatal screening and treatment are critical for improving the success of prenatal prevention programs.

We used 2 large, multistate, population-based surveys of labor and delivery records in the United States to describe, by state, the proportion of delivering women in 2003 and 2004 who received prenatal screening for preventable infectious diseases, tested positive for specific infections, and received adequate interventions. Some of the results of GBS screening and prophylaxis have previously been presented.[11] HIV screening results from these surveys will be presented in greater detail elsewhere. We also evaluated factors associated with lack of prenatal screening and maternal infection.

Materials and Methods

Survey design

Birthnet—Demographic, prenatal, and peripartum information was abstracted from 7691 US labor and delivery records from a random sample of 819,000 live births from 10 active surveillance sites (Table 1) in 2003–2004. The sample was stratified by surveillance area, birth year, and hospital; all hospitals with at least 10 births per year were included. Within strata a random sample of births was selected using a systematic probability-proportional-to-size selection. Data were weighted based on the probability of chart selection and adjusted to account for nonresponse. Adjustments were made within each surveillance area and year so that the number of term and preterm births represented that of the overall population.

Surveillance officers reviewed labor and delivery records for hepatitis B, rubella, syphilis, GBS, chlamydia, and gonorrhea testing data and on interventions for women testing positive. Because the neonatal chart was not abstracted, there is no information on administration of hepatitis B immune globulin and neonatal HBV vaccination.

Survey design

Division of HIV/AIDS Prevention (DHAP)/Research Triangle Institute (RTI)—

Births in 10 states with the highest rates of perinatal HIV transmission, high rates of pediatric AIDS, or state policies likely to have an impact on the rates of transmission were sampled using state vital records from calendar year 2003 (Table 1). In smaller states (Connecticut, District of Columbia, Maryland, New Jersey) all hospitals were eligible for selection; in larger states only certain locales were chosen.

In each state or locale, up to 11 delivery hospitals were selected using a systematic probability-proportional-to-size selection; 109 hospitals were selected. Of these, 97 participated in the survey (89.0%), and 220 delivery records were selected using a simple random sample. In some states, large hospitals were selected twice (for a total of 440 births) because of the hospital selection design. Hospital staff or nonhospital abstractors abstracted medical records for prenatal and peripartum testing data for hepatitis B, rubella, syphilis, GBS, and chlamydia. Interventions for women testing positive were also abstracted except for women with chlamydia. Receipt of infant HBV vaccine was abstracted from the infant's chart. The DHAP/RTI abstraction form was based on the Birthnet form for these infections.

Definitions

Race and ethnicity were abstracted from medical charts and may reflect self-identification as well as chart-abstractor or clinician interpretation. Because there were few American Indian/Alaska Native or Pacific Island women, they were combined in the "other" race category. Adequate testing for syphilis, gonorrhea, or chlamydia was defined as any test before the labor admission date because treatment should be provided before delivery (at least 30 days before delivery for syphilis) to reduce neonatal morbidity. A positive syphilis test was a positive rapid plasma reagin, so we were unable to assess who had active syphilis requiring treatment.

Adequate HBV and rubella testing was defined as a prenatal or antenatal test because intervention after delivery is still effective. Adequate testing for GBS was defined as a test at least 2 days before delivery because culture requires up to 48 hours, and effective intervention occurs during the intrapartum period.

Adequate therapy was defined as newborn vaccination against hepatitis B before discharge for women who had Hep-BsAg, maternal rubella vaccination before discharge for women who were rubella nonimmune or equivocal; maternal parenteral penicillin at least 4 weeks prior to delivery for syphilis; maternal intrapartum antibiotic receipt for GBS; maternal erythromycin, amoxicillin, or azithromycin for chlamydia; and maternal ceftriaxone, cefixime, or spectinomycin for gonorrhea.

Prenatal care was categorized into adequate, inadequate, or intermediate based on the Kessner/Institute of Medicine index[12]; the models adequate and intermediate were combined and compared with inadequate or no care. Preterm was defined as delivery at less than 37 weeks' gestation.

Analysis

Sample weights were used in all analyses to account for the unequal probability of selection. SUDAAN (RTI International, Research Triangle Park, NC) was used to account for the stratified complex survey design; we present weighted proportions. Multivariable analyses were performed using all main effects that were found to be significant in bivariate analyses with $P < .15$. Final multivariable models included those effects that remained significant with a $P < .05$. A CDC institutional review board determined that these projects were program evaluations, and therefore, informed consent was not required. As appropriate, the local institutional review board at each participating site also reviewed the protocol and waived the requirement for informed consent.

Results

A total of 7691 labor and delivery records were abstracted for the Birthnet survey and 19,791 for the DHAP/RTI survey (Table 1). In both surveys, the mean maternal age was 28 years (Table 2). The preterm delivery rate among the women in the Birthnet project was 11.0% (95% confidence interval [CI], 10.0–12.1), whereas the rate was 16.2% (95% CI, 14.5–18.0%) in the DHAP/RTI survey. The populations were similar for many maternal and reproductive health characteristics (Table 2).

Prenatal screening

In both surveys, prenatal screening rates were highest for HBV and rubella (Birthnet: 96.9% and 97.5%, DHAP/RTI: 91.6% and 91.5 %, respectively). Variation across states was small (Tables 3 and 4). Including admission tests, syphilis screening was almost 95% (Birthnet: 93.6%; 95% CI, 92.9–94.2%); however, only 80% of women had screening prior to admission, with significant differences by site (Tables 3 and 4). Screening rates for GBS were also below 90% (Birthnet: 85.1%; 95% CI, 84.0–86.0; DHAP/RTI: 71.5%; 95% CI, 67.1–75.4%).

Prenatal screening rates for chlamydia and gonorrhea were the lowest of the infections evaluated (60–70%) and varied significantly by site. The 2 surveys differed significantly in the total proportion of women screened for HBV, rubella susceptibility, and GBS, with Birthnet documenting site-specific estimates that were generally higher than DHAP/RTI. However, in the states sampled in both studies, the estimates of the proportion of women screened did not significantly differ except for syphilis in Connecticut, chlamydia in Maryland, and GBS in Tennessee (Tables 3 and 4).

Inadequate prenatal care increased the risk for no maternal screening 1.5- to 6.3-fold for syphilis, hepatitis B, chlamydia, and rubella (Table 5). In Birthnet, women with inadequate care had a median of 3 visits (range, 0–16), and 10% had no visits; in DHAP/RTI they had a median of 4 visits (range, 0–17) and less than 1% had no visits, but 65% of women were

missing the number of visits. The mother's age less than 20 years was commonly associated with no screening. Medicaid insurance and black race sometimes increased and sometimes decreased the risk of no screening.

Prenatal screening test results

The proportion of women who tested positive for HBV, rubella susceptibility, syphilis, chlamydia, or GBS did not vary significantly by survey (Tables 3 and 4). Less than 1% of women were positive for hepatitis B surface antigen, syphilis, and gonorrhea. Chlamydia positivity was slightly higher (Birthnet: 3.3%; 95% CI, 2.7–4.0%), followed by rubella susceptibility (DHAP/RTI: 8.2%; 95% CI, 6.7– 10.0%) and GBS colonization (Birthnet: 24.2%; 95% CI, 23–25.5%). The proportion of Asian women with hepatitis B surface antigen was 2.8% (Birthnet: 95% CI, 1.7–4.4%, infected, n = 39) and 4.2% (DHAP/RTI: 95% CI, 2.5–6.5%, n = 104), whereas among other racial groups, the positivity was less than 1%.

There were no significant differences in rubella susceptibility by race (Figure, B) or Hispanic ethnicity (Birthnet: Hispanic, 9.6% [95% CI, 8.0–11.6%] vs non-Hispanic, 7.9% [95% CI, 7.1– 8.7%]; DHAP/RTI: Hispanic, 8.0% [95% CI, 6.0–10.6%] vs non-Hispanic, 9.9% [95% CI, 6.8–14.2%]). The proportion of women with a positive syphilis test did differ significantly by race (Birthnet: black, 1.0% [95% CI, 0.45– 2.1%], white, 0.1% [95% CI, 0.04–0.3%] [positive, n = 16]; DHAP/RTI: black, 1.3% [95% CI, 0.9–1.7%], white, 0.5% [95% CI, 0.3–0.7%] [positive, n = 112]) (Figure) but not ethnicity (data not shown).

The chlamydia positivity rate (Birthnet, n = 159, and DHAP/RTI, n = 506) was 3–5 times higher for black women compared with white women (Birthnet: 6.9% [95% CI, 5.2–9.2%] vs 1.9% [95% CI, 1.4–2.7%]; DHAP/RTI: 7.2% [95% CI, 6.2–8.6%] vs 1.4% [95% CI, 1.1–1.9%]); there were similar differences by race for gonorrhea (infected, n = 22) (Figure). Beyond race and ethnicity, maternal age less than 20 years, Medicaid payment for labor and delivery, and illicit drug use were sometimes associated with a positive test result for some of the infections, but we did not find consistent associations across studies or pathogens (Table 6).

Treatment, immunization, or prophylaxis

In the DHAP/RTI sites, the proportion of infants with documented HBV immunization at birth was 56% (95% CI, 49.6–62.8%); it ranged from 29% to 86% (Table 4). It was 73.9% (95% CI, 62.8–82.6%) among women who were hepatitis B surface antigen positive, with a range of 29–100% by site. The proportion of rubella-susceptible or indeterminate women with documented rubella immunization before discharge ranged from 30% to 73% in the Birthnet states and from 19% to 63% in the DHAP/RTI sites. The proportion of infected women receiving adequate maternal treatment for syphilis and chlamydia varied widely (40–100%) by state (Tables 3 and 4).

Comment

Prenatal screening for infectious diseases provides a unique opportunity to identify and treat at-risk women and to prevent possible disease transmission to the neonate. Both of the large,

multistate, population-based surveys we analyzed documented strong implementation of rubella and HBV prenatal screening recommendations but showed room for improvement in prenatal screening for syphilis, chlamydia, gonorrhea, and GBS. Additionally, up to 80% of women or infants with indications for treatment, vaccination, or prophylaxis based on their prenatal test results failed to receive these interventions.

Prenatal screening was highest for hepatitis B surface antigen (96.5% in the 1998–1999 Birthnet survey[11] and 96.9% in the current Birthnet study). Without such screening and prophylaxis, the CDC estimates that 20,000 infants would be born at risk for chronic hepatitis B annually.[13,14] Asian women were most likely to test positive. The discrepancy between the high screening rate and the lower rate of infant receipt of a birth dose of hepatitis b vaccine was concerning. Sustained high levels of hepatitis B screening and immunizations for newborns are critical for the reduction of hepatitis B transmission.

High rates of rubella screening were also sustained, 97.3% in 1998–1999[15] and 97.5% in this Birthnet survey. Rubella infection during early pregnancy often leads to miscarriages, stillbirths, or severe birth defects. However, despite guidance for postpartum vaccination of rubella susceptible women after delivery and before discharge, only 15–49% of susceptible women had documentation of postpartum vaccination. In contrast to studies from the 1990s when outbreaks occurred among susceptible Hispanic women,[15] we found an association of rubella susceptibility with white race and illicit drug use. Rubella screening and vaccination are an effective intervention; the incidence of domestic rubella transmission and congenital rubella syndrome has been reduced to zero.[17] Continued high levels of vaccination among children and women in the United States are needed as international efforts to achieve rubella elimination continue.[18]

Congenital syphilis rates have increased since 2005, following the increasing rates among women.[6] Despite laws mandating prenatal syphilis testing in all states and the national plan to eliminate syphilis,[19] only 80% of women were appropriately screened before admission. The proportion screened ranged from 68% (District of Columbia) to 93% (Connecticut).

The first Birthnet study from 1998 to 1999 found that the proportion of women who had any screening test for syphilis (regardless of timing) was 98.3%[15]; using similar methods and definitions, in this study the proportion was 93.6% (95% CI, 92.9–94.2%), a significant decline of almost 5%. For the 16 women who had syphilis detected during pregnancy in Birthnet, 6 were treated at least 30 days prior to delivery. Treatment after 30 days prior to delivery does not provide protection for the fetus against congenital syphilis. These data support a need for continued vigilance, universal screening, and early treatment of maternal syphilis.

This is the first report using population-based data on prenatal screening rates for chlamydia. Complications of untreated chlamydia in pregnant women include pelvic inflammatory disease (PID) and recommended hospitalization[3,20]; PID during the third and fourth months of gestation has been associated with congenital heart defects.[21] Twenty to 60% of infants of untreated women develop ophthalmia or pneumonia[1,2]; neither is prevented through newborn ocular prophylaxis with silver nitrate or antibiotic ointments. In both studies,

screening was low, ranging from 38% (Birthnet, Minnesota) to 82% (DHAP/RTI, Maryland).

In addition to recommending screening for pregnant women, the CDC, USP-STF, and ACOG recommend that all women aged 25 years or younger be screened at least annually for chlamydia.[3,5] In Birthnet, the screening rate for women under age 26 years was 69% (95% CI, 67–71%). Increasing chlamydia screening can further reduce maternal and infant morbidity.

Screening for gonorrhea appeared to correlate with screening for chlamydia. This may result from combination tests being used by laboratories and may not reflect provider selection of testing for gonorrhea (97% of women with a chlamydia test had a gonorrhea test, and 99% of women with a gonorrhea test also had a chlamydia test).

High-risk women, defined by the USPSTF as age younger than 25 years, a previous gonorrhea infection, other sexually transmitted diseases, new or multiple sex partners, inconsistent condom use, commercial sex work, or drug use are recommended for gonorrhea screening at the first prenatal visit.[6] Women who live in areas in which gonorrhea prevalence is high should also be screened at the first prenatal visit[3] (CDC map[22]). Because information on risk is usually not available in medical charts, it was not abstracted, and we were unable to evaluate the extent to which providers screened high-risk women.

Improved screening for gonorrhea will detect additional infections, particularly among high-risk women and in areas in which gonorrhea rates are high.[22] The risk factors for positivity with syphilis, chlamydia, and gonorrhea in the women in these studies corresponded to national and local risk factors: older age and black race for syphilis and young age and black race for chlamydia and gonorrhea.[8]

The proportion screened for GBS 2 days prior to delivery in the Birthnet survey increased from 52% overall in 1998–1999 to 85.1% in 2004–2005. This increase likely reflects implementation of national guidelines for universal late antenatal screening first issued in 2002[23]; updates occurred in 2010.[7] Such screening has reduced the rate of early-onset GBS disease in infants, although missed opportunities for prevention remain, particularly among preterm deliveries in which the risk of neonatal infection is also elevated.[11]

Few women had no prenatal care. Inadequate prenatal care, which was defined as care initiated after 22 weeks with few visits, was associated with no screening. However, most women with inadequate care did have opportunities for screening; it is unclear why screening did not occur. These findings are consistent with a previous analysis.[16]

Most uninsured women are currently eligible for prenatal care and screening tests through Medicaid. It is unclear what proportion of women with no prenatal care would have been eligible for Medicaid or would have attended prenatal care had they enrolled in Medicaid. However, screenings for many of the infections discussed in this paper are recommended by the USPSTF with an A or B rating. An additional complicating factor for attendance in prenatal care is that in the United States, up to half of pregnancies are unintended.

Although the 2 surveys provide data on a substantial population of women, there were limitations and differences by study and by state. Because of different sampling designs, they could not be combined. Despite having a larger sample than the Birthnet study, the multistage sampling design in the DHAP/RTI study led to wider confidence intervals around estimates. A Birthnet survey was conducted previously,[16] and many of the personnel involved perform regular chart reviews, possibly leading to more accurate abstractions.

Although ethnicity for women in the Birthnet study was determined for 98.5% of women, 43% in the DHAP/RTI study had unknown ethnicity. Ethnicity was not associated with screening positive for any test (in both studies) or not being screened, except for rubella in the DHAP/RTI study. Whereas Hispanic women were more likely to have been screened for rubella, because 43% of women had missing ethnicity, we cannot determine whether this association would hold true for the entire sample. Because the states selected for participation in the DHAP/RTI sample had high perinatal HIV transmission, their inclusion may have reflected a higher-risk maternal population; the preterm birth rate was higher, at 16%, than the Birthnet sample, at 12%.

The high proportion (>95%) of women screened for hepatitis B and for susceptibility to rubella represents a prevention implementation success and demonstrates that strong adherence to screening guidance is attainable and sustainable. However, screening for syphilis, chlamydia, gonorrhea, and GBS is suboptimal. There is a need for improved implementation of relevant guidelines for these infections. Improvements in rates of appropriate treatment and prophylaxis against all of the evaluated infections could further improve maternal and newborn health.

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Clinical implications

There are several clinical implications in this study, including the following: (1) most women receive adequate prenatal screening for hepatitis B and rubella; (2) prenatal screening for syphilis, chlamydia, gonorrhea, and GBS needs improvement; and (3) although rates of positivity for hepatitis B, rubella nonimmunity, syphilis, chlamydia, and gonorrhea are low, providing recommended treatments for these infections can reduce maternal and infant morbidity and mortality.

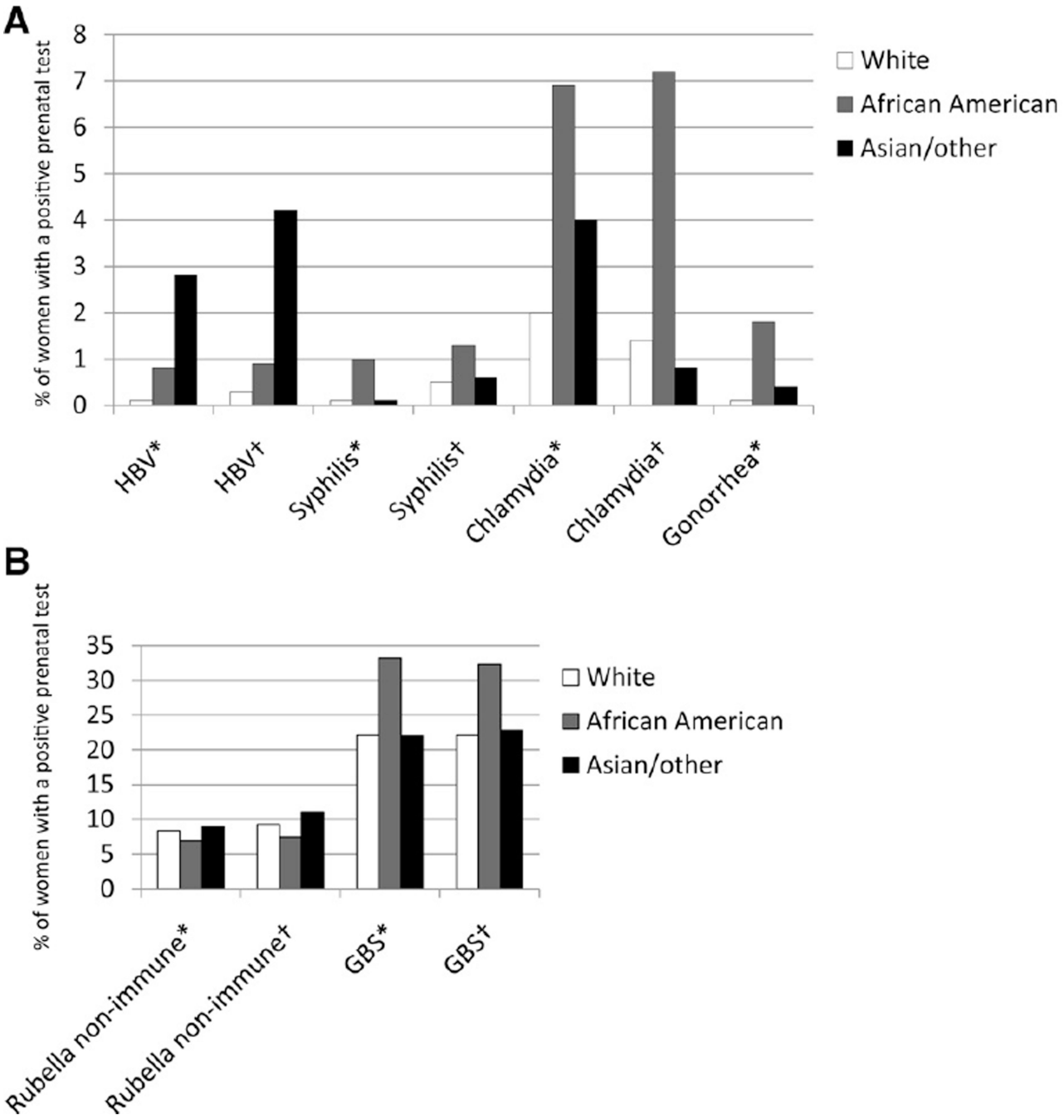

FIGURE. Prevalence of positive prenatal testing

Prevalence of positive prenatal testing for **A**, hepatitis B, syphilis, chlamydia, and gonorrhea and rubella and **B**, group B streptococcus in the Birthnet and DHAP/RTI surveys, by race.

Asterisk indicates Birthnet. *Dagger* indicates DHAP/RTI.

DHAP/RTI, Division of HIV/AIDS Prevention/Research Triangle Institute.

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TABLE 1

States, locales, number of delivery charts reviewed, and birth cohort in Birthnet and DHAP/RTI studies

State	Birthnet locales[a]	n	Birth cohort[b]	DHAP/RTI locales	n	Birth cohort[b]
California	3 counties, Bay area	679	81,741	N/A		
Colorado	5 counties Denver	630	81,741	N/A		
Connecticut	Entire	861	82,505	Entire	2349	43,337
District of Columbia	N/A			Entire	1288	14,611
Florida	N/A			Selected	2083	104,518
Georgia	20 counties, Atlanta	977	145,731	Selected	2397	64,885
Maryland	Entire	906	130,644	Entire	1643	70,067
Michigan	N/A			Selected	1971	67,327
Minnesota	7 counties	727	78,298	N/A		
New Jersey	N/A			Entire	1399	113,375
New Mexico	6 counties	608	27,071	N/A		
New York	7 counties, Rochester and 3 counties, Albany	804	44,882	N/A		
Oregon	3 counties	622	40,356			
Pennsylvania	N/A			Selected	1875	22,287
South Carolina	N/A			Selected	2405	41,017
Tennessee	11 urban counties	877	110,089	Selected	2381	48,262
Total	10 states	7,691	819,528	10 states	19,791	589,686

Entire indicates that the sample was chosen from the entire state; Selected indicates that the sample was chosen from selected areas in the state.

DHAP/RTI, Division of HIV/AIDS Prevention/Research Triangle Institute; *N/A*, not applicable.

[a] Birthnet areas accessed from http://www.cdc.gov/abcs/methodology/surv-pop.html (accessed Nov. 10, 2010);

[b] Births in that locale during the study time period.

TABLE 2

Weighted proportion and 95% CI of delivering women with selected demographic, reproductive health, and behavioral characteristics in the Birthnet (n = 7691) and DHAP/RTI (n = 19,791) surveys

	Birthnet (n = 7691)		DHAP/RTI (n = 19,791)	
Maternal characteristics	**Sample size**	**% (95% CI)**	**Sample size**	**% (95% CI)**
Age, y				
<20	752	8.7 (8.0–9.5)	2242	9.8 (8.7–11.0)
≥20	6873	91.3 (90.5–92.0)	18,637	90.2 (89.0–91.3)
Race[a]				
White	4441	56.0 (54.7–57.3)	10,172	53.2 (46.7–59.6)
Black	1302	19.6 (18.6–20.7)	5510	24.3 (20.2–28.7)
Asian	351	5.2 (4.7–5.9)	540	2.9 (2.3–3.5)
Other/unknown	1597	19.1 (18.2–20.1)	3569	19.7 (15.0–25.4)
Ethnicity[a]				
Hispanic	1478	18.0 (17.1–19.0)	2851	18.3 (14.0–23.6)
Non-Hispanic	6014	80.5 (79.5–81.5)	8919	38.6 (32.1–45.5)
Unknown	199	1.5 (1.2–1.9)	8951	43.1 (36.1–50.4)
Prior preterm birth[b]				
Yes	475	6.9 (6.2–7.7)	1229	6.2 (5.4–7.0)
Illicit drug use[c]				
Yes	260	3.2 (2.8–3.7)	N/A	
Labor and delivery payment[d]				
Medicaid	2104	25.3 (24.2–26.4)	6169	27.0 (23.5–30.8)
Other insurance	4702	64.5 (63.3–65.7)	11,516	63.2 (58.6–67.6)
Other, self-pay	805	10.2 (9.5–11.0)	2164	9.9 (7.2–13.4)
Kessner index of prenatal care[e]				
Adequate (first Δ)	4057	58.5 (57.1–59.9)	9335	48.1 (45.0–51.3)
Intermediate (second Δ)	2193	31.6 (31.3–32.9)	5331	28.5 (26.5–30.5)
None or inadequate[f]	661	9.9 (9.1–10.8)	4496	23.1 (19.9–27.3)

	Birthnet (n = 7691)		DHAP/RTI (n = 19,791)	
Maternal characteristics	**Sample size**	**% (95% CI)**	**Sample size**	**% (95% CI)**
Missing	780		629	
Prenatal visits				
Mean number	7691	9.9 (9.8–10.0)	16,608	9.8 (9.6–10.0)
Method of delivery				
Cesarean	2037	25.5 (24.3–26.8)	5918	32.0 (30.6–33.5)
Vaginal	5654		13,513	

Δ, trimester.

CI, confidence interval; *DHAP/RTI*, Division of HIV/AIDS Prevention/Research Triangle Institute; *N/A*, not applicable.

[a] From chart or chart reviewer interpretation;

[b] Previous pregnancy ending in birth at <37 weeks' gestation;

[c] By chart review only;

[d] Labor and delivery;

[e] Category based on timing of initiation of prenatal care, gestational age at delivery, and number of visits;[9]

[f] None or third-trimester onset.

TABLE 3

Birthnet: weighted proportion of women receiving 1 or more prenatal screening tests, positive tests, and appropriate treatment, by infection and state, with 95% CIs

		Birthnet site, % (95% CI)				
		California	Colorado	Connecticut	Georgia	Maryland
Infection	Total	3 counties	5 counties	All counties	20 counties	All counties
HBV test[a]	96.9 (96.4–97.4)	98.0 (96.7–98.8)	97.5 (95.7–98.6)	94.8 (92.9–96.2)	96.4 (94.7–97.6)	95.3 (93.5–96.6)
Positive	0.6 (0.4–0.8)	0.7 (0.2–2.1)	0.2 (0–1.3)	0.5 (0.2–1.6)	0.3 (0.1–1.2)	0.6 (0.2–1.70)
Rubella test[a]	97.5 (97.1–97.9)	98.3 (96.9–99.0)	97.3 (95.5–98.4)	96.7 (95.0–97.8)	97.8 (96.0–98.5)	96.4 (94.8–97.5)
Positive[b]	8.2 (7.4–8.9)	8.4 (6.0–11.6)	7.2 (5.3–9.7)	11.6 (9.2–14.4)	5.0 (3.6–7.0)	9.2 (7.2–11.6)
Maternal immunization	49.1 (45.0–53.2)	52.1 (37.3–66.5)	50.7 (37.8–63.5)	30.3 (21.9–40.2)	55.0 (40.8–68.4)	46.2 (36.0–56.6)
Syphilis test[c]	79.0 (77.9–80.0)	79.0 (77.9–80)	81.2 (77.8–84.2)	78.1 (75.1–80.9)	83.5 (80.2–86.2)	71 (67.6–74.1)
Positive	0.3 (0.2–0.5)	0	0	0.3 (0.1–1.3)	0.7 (0.3–1.9)	0.2 (0.1–1.3)
Treated	48.3 (21.1–76.6)			58.2 (9.9–94.7)	40.9 (7.8–85.0)	0
GBS test[d]	85.1 (84.0–86.0)	85.5 (82.2–88.3)	78.1 (74.3–81.5)	86.7 (83.7–89.2)	82.8 (79.5–85.7)	87 (84.3–89.3)
Positive	24.2 (23.0–25.5)	24.0 (20.3–28.2)	21.1 (17.4–25.2)	25.9 (22.5–29.7)	26.3 (22.7–30.2)	23.0 (19.8–26.7)
Maternal prophylaxis	86.8 (84.7–88.7)	87.8 (80.4–92.7)	91.5 (83.9–95.7)	76.9 (69.3–83.0)	87 (80.4–91.6)	87.3 (80.6–92.0)
Chlamydia test[c]	61.0 (59.7–62.2)	58.8 (54.8–62.7)	64.6 (61.0–68.1)	45.6 (42.1–49.2)	68.8 (65.2–72.2)	66.8 (63.3–70.1)
Positive	3.3 (2.7–4.0)	0.3 (0.1–2.1)	3.7 (2.2–6.1)	2.2 (1.1–4.7)	4.7 (3.0–7.3)	2.9 (1.7–5.0)
Treated	83.7 (74.5–90.0)	100	84.2 (54.4–96.0)	100	87.5 (67.0–96.0)	70.9 (39.6–90.1)
Gonorrhea test[c]	60.0 (58.8–61.2)	58.8 (54.8–62.9)	61.8 (58.0–65.4)	41.9 (38.5–45.4)	68.5 (64.9–71.9)	66.2 (62.6–69.6)
Positive	0.5 (0.3–0.9)	0	0.4 (0.1–1.9)	0.4 (0.1–2.8)	0.8 (0.3–2.1)	0.7 (0.2–2.2)

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		Birthnet site, % (95% CI)				
		California	Colorado	Connecticut	Georgia	Maryland
Infection	Total	3 counties	5 counties	All counties	20 counties	All counties
Treated	100		100	100	100	100

	Minnesota	New Mexico	New York	Oregon	Tennessee
Infection	7 counties	6 counties	7 counties	3 counties	11 counties
HBV test[a]	98.2 (96.8–99.0)	97.7 (96.2–98.7)	98.8 (97.6–99.4)	98.6 (97.2–99.3)	97.4 (95.9–98.4)
Positive	1.1 (0.5–2.4)	0	0.4 (0.1–1.2)	1.0 (0.4–2.2)	0.7 (0.2–1.9)
Rubella test[a]	97.3 (95.7–98.3)	98.6 (97.2–99.3)	98.7 (97.6–99.3)	99.8 (98.9–100)	97.6 (96.1–98.5)
Positive[b]	7.1 (5.3–9.5)	14.8 (12.1–18.0)	7.2 (5.5–9.3)	9.8 (7.7–12.4)	8.0 (6.1–10.5)
Maternal immunization	51.8 (39.4–64.0)	66.1 (56.0–75.0)	52.5 (40.4–64.3)	73.4 (61.0–83.0)	46.3 (34.3–58.8)
Syphilis test[c]	79.9 (76.6–82.7)	78.6 (75.2–81.6)	89.1 (86.6–91.1)	82.9 (79.8–85.6)	76.3 (73.3–79.0)
Positive	0.2 (0.1–1.4)	0	0.4 (0.1–1.4)	0.2 (0.1–1.4)	0.2 (0.1–1.5)
Treated	100		44.2 (4.7–92.7)	0	99.5 (92.1–100)
GBS test	87.3 (84.3–89.7)	88.1 (85.1–90.5)	88.8 (86.1–91)	85.8 (82.8–88.4)	84.9 (81.9–87.5)
Positive	26.2 (22.6–30.1)	16.2 (13.3–19.7)	22.6 (19.5–26.1)	20.4 (17.1–24.2)	26.6 (23–30.5)
Maternal prophylaxis	88.9 (82.5–93.2)	84.8 (75.6–90.9)	84.4 (77.7–89.3)	83.7 (75.0–89.8)	90.9 (85.0–94.7)
Chlamydia test[c]	37.7 (34.1–41.4)	71.0 (67.4–74.4)	67.4 (64.3–70.4)	64.8 (61.1–68.3)	64.0 (60.6–67.3)
Positive	3.9 (2.1–7.3)	3.5 (2.1–5.7)	4.2 (2.7–6.4)	2.3 (1.2–4.4)	3.6 (2.1–5.9)
Treated	80.7 (45.3–95.5)	84.1 (58.3–95.3)	89.2 (65.8–97.3)	79.3 (43.7–95.0)	83.2 (51.4–95.8)
Gonorrhea test[c]	36.9 (33.4–40.5)	69.9 (66.2–73.3)	68.5 (65.4–71.4)	64.1 (60.3–67.7)	63.8 (60.3–67.2)
Positive	0	0	0.5 (0.2–1.5)	0.3 (0.1–2.0)	0.9 (0.3–2.2)
Treated			100	100	100

CI, confidence interval; *GBS*, group B streptococcus; *HBV*, hepatitis B virus.

[a] Sample includes only persons with documented testing on or prior to delivery date;

[b] Rubella susceptible or equivocal test;

[c] Sample includes only women with documented testing before admission date;

[d] Sample includes only persons with documented testing 2 or more days prior to delivery.

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TABLE 4

DHAP/RTI: weighted proportion of women receiving 1 or more prenatal screening tests, positive tests, and appropriate treatment, by infection and state, with 95% CIs

		DHAP/RTI site, % (95% CI)				
Infection	**Total**	**Connecticut**	**District of Columbia**	**Florida**	**Georgia**	**Maryland**
HBV test[a]	93.2 (90.4–95.2)	97.0 (95.4–98.0)	88.1 (85.9–90.0)	94.0 (90.2–96.4)	97.3 (95.3–98.5)	94.7 (87.7–97.9)
Positive	0.6 (0.4–0.8)	0.5 (0.3–1.0)	0.3 (0.1–0.7)	0.4 (0.2–0.8)	0.5 (0.3–0.9)	0.9 (0.4–1.9)
Infant immunization	56.3 (49.6–62.8)	72.0 (56.6–83.5)	60.5 (58.1–62.9)	14.8 (5.4–34.6)	68.2 (43.4–85.7)	76.3 (61.5–86.7)
Rubella test[a]	91.5 (88.9–93.5)	90.8 (72.7–97.3)	85.8 (83.5–87.9)	89.2 (79.7–94.6)	95.8 (92.1–97.8)	94.4 (90.5–96.7)
Positive[b]	8.2 (6.7–10.0)	6.5 (3.7–11.1)	7.6 (6.0–9.6)	11.4 (8.1–15.7)	5.7 (3.3–9.9)	8.4 (4.6–14.6)
Maternal immunization	36.8 (26.6–48.3)	39.2 (24.8–55.7)	19.2 (12.0–29.3)	28.9 (14.2–50.1)	47.2 (33.0–61.8)	28.6 (10.4–58.0)
Syphilis test[c]	80.8 (76.0–84.7)	92.9 (87.0–96.3)	67.9 (65.2–70.5)	83.1 (73.0–90.0)	91.4 (82.9–95.9)	80.2 (64.7–90.0)
Positive	0.7 (0.5–0.8)	0.5 (0.3–0.8)	0.5 (0.2–1.3)	1.0 (0.7–1.4)	0.9 (0.4–2.0)	0.5 (0.2–1.1)
GBS test[d]	71.5 (67.1–75.4)	78.1 (67.9–85.7)	73.9 (71.1–76.5)	67.9 (54.9–78.7)	72.9 (63.5–80.5)	75.7 (63.3–84.8)
Positive	25.2 (23.9–26.5)	25.6 (23.1–28.4)	26 (23.0–29.3)	23.1 (21.0–25.3)	25.3 (22.5–28.3)	27.4 (24.6–30.3)
Maternal prophylaxis	71.3 (68.0–74.4)	77.9 (68.8–84.9)	62.1 (54.9–68.8)	71.6 (65.5–76.9)	68.3 (37.2–88.7)	71.6 (60.7–80.5)
Chlamydia test[c]	67.2 (62.6–71.6)	54 (36.7–70.3)	72.3 (69.5–74.9)	72.0 (63.9–78.9)	68.5 (51.9–81.4)	82.2 (72.9–88.8)
Positive	3.3 (2.8–3.9)	2.8 (2.0–3.9)	2.0 (1.2–3.2)	2.6 (1.6–4.3)	3.8 (2.6–5.5)	1.7 (1.0–3.0)

Infection	**Michigan**	**New Jersey**	**Pennsylvania**	**South Carolina**	**Tennessee**
HBV test[a]	92.1 (80.1–96.9)	91.3 (82.7–95.8)	95.1 (93.8–96.1)	97.2 (95.8–98.1)	93.6 (87.3–96.9)
Positive	0.8 (0.3–2.1)	0.5 (0.2–1.0)	1.3 (0.8–2.0)	0.3 (0.2–0.7)	0.4 (0.2–0.8)
Infant immunization	75.2 (62.4–84.7)	57.6 (33.4–78.6)	86.2 (84.3–88.0)	71.7 (50.0–86.5)	38.3 (23.6–55.4)

Infection	Michigan	New Jersey	Pennsylvania	South Carolina	Tennessee
Rubella test[a]	91.7 (80.3–96.7)	87.8 (79.1–93.2)	93.9 (92.5–95.1)	94.5 (87.6–97.7)	94.2 (89.3–97.0)
Positive[b]	5.8 (4.2–7.8)	10.4 (4.7–21.7)	6.7 (5.5–8.1)	9.5 (6.9–12.9)	6.9 (5.5–8.6)
Maternal immunization	62.8 (53.5–71.3)	29.7 (8.3–66.3)	33.7 (25.7–42.8)	48.1 (26.5–70.4)	53.1 (38.4–67.3)
Syphilis test[c]	82.6 (65.9–92.1)	77.0 (62.7–86.9)	72.0 (69.6–74.2)	88.3 (76.5–94.6)	70.2 (46.9–86.3)
Positive	0.5 (0.2–1.2)	0.5 (0.3–1.0)	0.9 (0.4–1.7)	0.7 (0.5–1.2)	0.5 (0.2–1.1)
GBS test[d]	73.7 (61.2–83.2)	67.7 (54.4–78.7)	71.0 (68.7–73.2)	77.2 (71.2–82.3)	73.9 (67.6–79.3)
Positive	24.6 (22.2–27.2)	22.6 (17.5–28.6)	34.0 (31.1–37.1)	26.3 (24.8–27.8)	26.9 (23.6–30.4)
Maternal prophylaxis	77.0 (62.8–87.0)	69.6 (62.1–76.2)	46.8 (41.5–52.2)	76.9 (72.0–81.1)	75.9 (62.6–85.5)
Chlamydia test[c]	66.7 (47.9–81.4)	57.0 (41.5–71.2)	66.3 (63.9–68.7)	77.3 (65.9–85.8)	67.3 (60.4–73.6)
Positive	3.5 (1.5–8.0)	3.1 (2.2–4.4)	5.9 (4.5–7.6)	5.9 (4.2–8.3)	3.8 (2.0–7.4)

CI, confidence interval; *DHAP/RTI*, Division of HIV/AIDS Prevention/Research Triangle Institute; *GBS*, group B streptococcus; *HBV*, hepatitis B virus.

[a] Sample includes only persons with documented testing on or prior to delivery date;

[b] Rubella susceptible or equivocal test;

[c] Sample includes only women with documented testing before admission date;

[d] Sample includes only persons with documented testing 2 or more days prior to delivery.

TABLE 5

Characteristics associated with no prenatal testing for hepatitis B, rubella antibody, syphilis, chlamydia, and gonorrhea, by study, adjusted odds ratios and 95% CIs[a]

	Infection				
Characteristic	**Hepatitis B**	**Rubella**	**Syphilis**	**Chlamydia**	**Gonorrhea**
BIRTHNET					
Race					
Black	1.9 (1.3–1.7)	2.0 (1.2–3.5)		0.9 (0.7–1.0)	0.9 (0.7–1.0)
White/other	Referent	Referent		Referent	Referent
Illicit drug use					
Yes	2.2 (1.1–4.1)				
No	Referent				
Kessner index					
Inadequate		2.0 (1.1–3.7)	1.5 (1.2–2.0)		
Adequate		Referent	Referent		
Age, y					
<20				0.7 (0.6–0.9)	0.7 (0.6–0.9)
>20				Referent	Referent
L&D payment					
Medicaid				0.5 (0.5–0.6)	0.5 (0.5–0.6)
Other				Referent	Referent
DHAP/RTI					
Race					
White	0.8 (0.5–1.3)	1.0 (0.7–1.6)	0.7 (0.4–1.1)	1.4 (1.1–1.7)	
Black	1.2 (0.9–1.7)	2.3 (1.3–4.0)	1.1 (0.8–1.6)	1.1 (0.9–1.3)	
Asian	0.6 (0.4–0.9)	0.6 (0.3–1.1)	0.5 (0.4–0.8)	1.0 (0.6–1.5)	
Other	Referent	Referent	Referent	Referent	
Kessner index					
Inadequate	5.0 (3.4–7.4)	6.3 (3.7–10.9)	3.1 (2.2–4.3)	3.0 (2.4–3.8)	
Adequate	Referent	Referent	Referent	Referent	

Characteristic	Infection				
	Hepatitis B	**Rubella**	**Syphilis**	**Chlamydia**	**Gonorrhea**
Ethnicity					
Hispanic		1.6 (1.1–2.2)			
Non-Hispanic		Referent			
L&D payment					
Medicaid			0.6 (0.3–1.0)	0.8 (0.7–1.0)	
Private insurance			0.7 (0.4–1.0)	1.5 (1.2–1.9)	
Self/other			Referent	Referent	
Age, y					
<20				0.7 (0.6–0.8)	
>20					

CI, confidence interval; *DHAP/RTI*, Division of HIV/AIDS Prevention/Research Triangle Institute; *L&D*, labor and delivery.

[a]The following characteristics were evaluated in bivariate analyses: age (<20 years vs ≥20 years old), race (white, black, other), Hispanic ethnicity, adequacy of prenatal care (Institute of Medicine/Kessner index[9]: prenatal care starting in first or second trimester vs later onset of prenatal care), labor and delivery payment (Medicaid, private insurance, other), and (for Birthnet data) illicit drug use. If a characteristic did not reach a $P < .15$ in adjusted analysis, it is not presented.

TABLE 6

Characteristics associated with a positive screening test[a]

	Infection				
Characteristic	**Hepatitis B**	**Rubella**	**Syphilis**	**Chlamydia**	**Gonorrhea**
BIRTHNET					
Race					
Black		0.8 (0.6–1.0)	9.5 (2.6–34.4)	2.4 (1.5–3.9)	7.9 (2.2–29.1)
White/other		Referent	Referent	Referent	Referent
Illicit drug use					
Yes		2.1 (1.3–3.4)		2.5 (1.2–5.5)	2.9 (0.7–12.5)
No		Referent		Referent	Referent
L&D payment					
Medicaid			0.3 (0.1–1.2)	2.1 (1.4–3.4)	6.7 (1.4–31.6)
Other			Referent	Referent	Referent
Age, y					
<20				4.3 (2.6–7.1)	2.7 (1.0–7.8)
>20				Referent	Referent
DHAP/RTI					
Age, y					
<20	0.4 (0.1–1.1)	0.8 (0.7–1.1)	0.1 (0.04–0.4)	3.1 (2.5–4.0)	
>20	Referent	Referent	Referent	Referent	
Race					
White	0.5 (0.3–1.1)	1.3 (1.0–1.6)	0.8 (0.4–1.6)	0.5 (0.3–0.7)	
Black	1.9 (1.0–3.8)	1.0 (0.8–1.3)	2.5 (1.3–4.5)	1.9 (1.4–2.6)	
Asian	8.8 (3.7–20.9)	1.5 (1.0–2.3)	0.9 (0.2–5.0)	0.3 (0.1–1.0)	
Other	Referent	Referent	Referent	Referent	
L&D payment					
Medicaid				1.2 (0.9–1.6)	
Private insurance				0.6 (0.4–0.8)	

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Characteristic	Infection				
	Hepatitis B	Rubella	Syphilis	Chlamydia	Gonorrhea
Self/other				Referent	
Kessner index					
Inadequate				1.3 (1.0–1.8)	
Adequate				Referent	

CI, confidence interval; *L&D*, labor and delivery.

[a]The following characteristics were evaluated in bivariate analyses: age (<20 years vs ≥20 years old), race (white, black, other), Hispanic ethnicity, adequacy of prenatal care (Institute of Medicine/Kessner index[9]: prenatal care starting in first or second trimester vs later onset of prenatal care), labor and delivery payment (Medicaid, private insurance, other), and (for Birthnet data) illicit drug use. If a characteristic did not reach a $P < .15$ in adjusted analysis, it is not presented.