Cost-Effectiveness of Screening Strategies for Gonorrhea Among Females in Private Sector Care

Kyle T. Bernstein, PhD, ScM, Supriya D. Mehta, PhD, MHS, Anne M. Rompalo, MD, ScM, and Emily J. Erbelding, MD, MPH

OBJECTIVE: To identify the optimal screening algorithm for gonorrhea infection among females in private sector care, using cost-effectiveness analysis.

METHODS: We compared 6 strategies using decision analysis for urine nucleic acid amplification testing for gonorrhea testing in a theoretical cohort of 10,000 females aged 15–35 years: 1) screen women aged younger than 25 years; 2) screen women aged younger than 30 years; 3) screen women aged younger than 25 years who report any risk (pregnant, drug use, new sexual partner < 30 days); 4) screen women aged younger than 30 years who report any risk; 5) screen women aged younger than 25 years *or* those who report any risk; and 6) screen women aged younger than 30 years *or* those who report any risk. Infection prevalence and sensitivity and specificity were by direct observation from a retrospective cohort of females attending the Baltimore City Sexually Transmitted Disease Clinics between 1999 and 2002. The main outcome measures were untreated gonorrhea cases and their sequelae in women, transmission to a male partner, congenital outcomes, and cost to prevent a case.

RESULTS: Prevalence of gonorrhea was 3.0%. Not screening would result in 300 untreated cases. Not screening was cost-saving over all screening strategies. Strategy 6 resulted in the fewest cases of untreated infection (82), although Strategy 3 was the most cost-effective of the screening strategies. Univariate sensitivity analysis identified a threshold of 4.75% gonorrhea prevalence, more than which Strategy 3 became cost-saving over not screening.

CONCLUSION: Screening is recommended for females aged younger than 25 years with specific risks in populations with a gonorrhea prevalence of 4.75% or greater. *(Obstet Gynecol 2006;107:813–21)*

LEVEL OF EVIDENCE: II-2

In 2003, 335,104 cases of gonorrhea were reported to the Centers for Disease Control and Prevention (CDC), making it the second most frequent reportable disease after *Chlamydia trachomatis*.[1] The estimated direct global costs for gonorrhea infections in the United States are in excess of $1 billion (in 1994 dollars).[2] Several studies demonstrate that 30–80% of gonorrhea infections in women are asymptomatic,[3–6] and thus go unreported.[6–8] For example, in Baltimore, Maryland, where gonorrhea is hyperendemic, Turner et al[8] reported that the estimated number of people with an asymptomatic, untreated gonorrhea infection exceeds the total number of diagnosed gonorrhea cases reported to the health department. Asymptomatic infections often lead to delays in treatment and in turn increase the risk of adverse reproductive sequelae such as pelvic inflammatory disease (PID) and ectopic pregnancy.[9] Early identification and treatment of disease is a critical component of the promotion of reproductive health, particularly among women.

The CDC developed its first screening guidelines for *Chlamydia trachomatis* in 1985 and have since produced several revisions.[10,11] The 2002 Sexually Transmitted Disease (STD) Treatment Guidelines recommend testing all sexually active women aged younger than 25 years, as well as older sexually active women with risk factors.[12] Although gonorrhea screening often accompanies a *Chlamydia trachomatis* test, the CDC provides no guidance with respect to

From the Department of Emergency Medicine, New York University School of Medicine, New York, New York; Sexually Transmitted Disease Program, Division of Health Promotion and Disease Prevention, Baltimore City Health Department, Baltimore, Maryland; Department of Emergency Medicine, Boston University, School of Medicine, Boston, Massachusetts; and Division of Infectious Diseases, Johns Hopkins School of Medicine, Baltimore, Maryland.

Corresponding author: Kyle Bernstein, ScM, PhD, Department of Emergency Medicine, NYU School of Medicine, 462 First Ave, 3rd Floor, Room A345, New York, NY 10016; e-mail: kyle.bernstein@med.nyu.edu.

ISSN: 0029-7844/06

general or targeted screening for gonorrhea infection. In 2001, the CDC convened a panel of experts to address gaps in the prevention and control of gonorrhea in the United States. A major recommendation of this panel included "CDC should develop national screening guidelines to be used as a framework for the development of locally-appropriate screening criteria, and as guidance for areas or settings without local screening criteria.".[13]

Although no structured guidelines are in place, gonorrhea screening has been implemented in several areas among diverse populations, usually in conjunction with *Chlamydia trachomatis* testing. Among adolescent women tested in family planning clinics, the prevalence of gonorrhea is estimated to be between 0.1% and 2.8%; 0–5.7% among adolescents tested at prenatal clinics; 1.6–8.5% at school-based clinics; and 0.6–12.4% in juvenile detention facilities.[11] Several studies have examined the cost-effectiveness of implementing screening protocols for *Chlamydia trachomatis* and gonorrhea.[14–16,17] In an emergency department setting, screening women for *Chlamydia trachomatis* and gonorrhea aged 18 to 31 years was cost-saving over not screening.[18] Universal screening of women for *Chlamydia trachomatis* and gonorrhea was found to be cost-saving in a detention setting as well.[19] The findings of these 2 studies that screening costs less than not screening (ie, screening is cost-saving) is uncommon; generally a proposed health intervention has a net positive cost. The cost-effectiveness of a proposed intervention is judged in relation to the cost-effectiveness of other interventions, or in relation to an established cost-effectiveness criterion for the expected health benefits.[20]

Most cost-effectiveness analyses examine *Chlamydia trachomatis* and gonorrhea screening algorithms in specialized sites of clinical services (ie, emergency departments, jails and prisons, STD clinics). We examined 6 gonorrhea screening strategies for implementation among women visiting private-sector clinicians using a medical cost and outcome decision model based on data from women attending the Baltimore City STD clinics between 1999 and 2002. Screening criteria based on age only and age and risk factors were compared with not screening. The goal of this analysis was to provide information to health care practitioners and medical decision makers as to how to potentially modify or implement a gonorrhea screening program for women in their clinic settings.

MATERIALS AND METHODS

All females aged 15–35 years who visited 1 of the 2 Baltimore City Health Department STD clinics between 1999 and 2002 and had a diagnostic test for gonorrhea performed were included in this analysis. As part of the standard clinical examination, symptom history, reason for visit, and risk behaviors were collected on standardized data collection forms and electronically captured. Women presumed or confirmed to be infected with gonorrhea were treated according to treatment guidelines current at the time of the visit.[12,21] Women with culture-confirmed gonorrhea were compared with those who tested negative for gonorrhea infection to identify relevant risk factors. Characteristics examined included age, pregnancy, reason for visit, STD history, symptom history, drug use, number of sexual partners, exchanging sex for drugs or money, new sexual partners in past 30 days, and sexual partner with risk (known human immunodeficiency virus (HIV)–positive, bisexual, drug using).

Univariate statistics using χ^2 compared women with and without gonorrhea infection (Table 1). Characteristics identified as statistically significant ($P < .05$) at the univariate level were included in a multivariate logistic regression model. The final logistic regression model was selected based on likelihood ratio statistics. Risks for gonorrhea infection identified in the final multivariate model were age less than 25 years, new sexual partner in the past 30 days, pregnancy, and drug use (Bernstein KT, Rompalo A, Olthoff G, Erbelding EJ. Suggestions for screening guidelines for Neisseria Gonorrhoeae infection. Presented at the National STD Prevention Conference,

Table 1. Characteristics of Asymptomatic Women Receiving Gonorrhea Testing, Baltimore City Health Department Sexually Transmitted Diseases Clinic, 1999-2002

	Asymptomatic GC Positive	GC Negative
Total	596 (3.0)	19,573 (97.0)
Age category (y)*		
15–18	121 (20.3)	2,985 (15.3)
> 18–25	333 (56.0)	9,471 (48.5)
> 25–35	141 (23.7)	7,094 (36.3)
Race/ethnicity		
White	14 (2.4)	581 (3.0)
African American	576 (96.6)	1,8751 (95.8)
Other	9 (1.0)	238 (1.2)
Pregnant*	7 (1.2)	91 (0.4)
New sexual partner in past 30 days*	106 (17.8)	2,599 (13.3)
Drug use (6 mo)*†	32 (5.4)	2,012 (10.3)

GC, *Neisseria gonorrhoeae.*
Values are n (%).
* $P < .05$ χ^2 test.
† Direction of association reversed in multivariate logistic regression.

Philadelphia, Pennsylvania, March 8–11, 2004). Six screening criteria were created based on these factors. The sensitivity and specificity of the 6 screening criteria and their respective 95% confidence intervals were calculated. Analyses were conducted using SAS 8.2 (SAS Institute, Cary, NC). Use of these clinic data for this outcome was deemed exempt from review by both the institutional review board of the Johns Hopkins Medical Institutions.

The 6 decision branches of the tree represent the 6 screening strategies: Strategy 1 was to test all females aged younger than 25 years (standard CDC *Chlamydia trachomatis* recommendation); Strategy 2 tested all females aged younger than 30 years; Strategy 3 tested all females aged younger than 25 years who also reported any risk factor (defined as pregnant, new sexual partner in past 30 days, or self-reported drug use); Strategy 4 involved testing all females aged younger than 30 years who *also* reported any risk factor; Strategy 5 screened all females aged younger than 25 years *or* reported any risk factor; Strategy 6 included testing all who were aged younger than 30 years *or* reported any risk factor.

We used the number of cases of untreated gonorrhea infection and subsequent sequelae in women, episodes of transmission to sexual partners, congenital infections prevented per year, as well as prevention costs, as the outcomes considered in this cost-effectiveness analysis. Models were analyzed using TreeAge Pro 2005 (Treeage, Inc., Williamstown, MA), which calculated the probabilities associated with each Strategy on the basis of Bayes theorem. The analysis conducted here was limited to cases of gonorrhea that would occur in the female patient and her male sexual partner. The time horizon was a maximum of 10 years. A baseline discount rate of 3% was applied to sequelae costs that were expected to occur in the future.

The sequelae sequence and probabilities of outcomes from an untreated gonorrhea infection were derived from the literature (Table 2). Published reports show the probability of PID ranges from 10% to 40%.[22–24] We assumed a 30% probability of PID in our base case analysis, 60% subclinical infection, and 15% inpatient treatment. For long-term sequelae, we included the probabilities of ectopic pregnancy, chronic pelvic pain, and tubal infertility. Additionally, we included the cost of transmission of infection to a male sexual partner, with subsequent urethritis and epididymitis; as well as congenital outcomes.

Published literature was reviewed, and the direct cost estimates used in this analysis are shown in Table 3. Treatment costs of PID, chronic pelvic pain, tubal infertility, and ectopic pregnancy were outcomes considered for untreated infections among women. Treatment costs for men included acute urethritis and epididymitis. Ectopic pregnancy was expected to occur 5 years after an untreated gonorrhea infection, 2 years to 5 years for chronic pelvic pain, and 7 to 10 years for tubal infertility.[23,50] Sequelae that were expected to occur in the future were discounted at an annual rate of 3%.[20] Minimum and maximum cost estimates (Table 3) take into account variations in sequelae incidence (Table 2). Indirect costs, such as days of work or school missed or infertility-related costs, were not included in this analysis.

All costs were adjusted to 2003 dollars using the medical care component of the Consumer Price Index for all urban users (United States Bureau of Labor and Statistics). The total costs of infection were derived from incidence and cost estimates. The expected cost of sequelae of 1 untreated infection in a woman was $821 (range $101 to $2,403), $3.36 in neonates (range $3.00 to $7.84), and $23.42 in males (range $5.44 to $117), for a total base case cost of $848 (range $109 to $2,528). Outcome of infection and associated costs were applied to a theoretical cohort of 10,000 women aged 15 to 35 years.

Programmatic costs included nucleic acid amplification testing (nucleic acid amplification testing), treatment, and adverse effects. This analysis was based on the assumption that gonorrhea screening would take place in the context of an existing medical visit. Therefore, the only substantial programmatic costs are related to diagnostic testing. The cost of urine nucleic acid amplification testingS testing was based on reimbursable cost estimates in Maryland (Table 3).[54] The proportion of women returning for treatment was estimated at 80% based on local data. In addition to deriving estimated programmatic costs from the literature, we estimated programmatic costs from the Maryland Medical Assistance Program Physicians' Fee Schedule for outpatient care: adverse effects of antibiotics, cure of uncomplicated infection, outpatient PID and epididymitis treatment, and urethritis (Table 3).[54] The choice of Current Procedural Terminology codes used to estimate programmatic costs was based on interview with several clinicians and the Clinical Director of the Baltimore City Health Department STD Clinics.

RESULTS

Table 1 describes the population used in this analysis. The prevalence of gonorrhea infection was 3% (95% confidence interval 2.7–3.2%). Compared with no screening, each of the 6 strategies would result in

Table 2. Probabilities of Outcomes of Sequelae

Variable	Base	Minimum	Maximum	Reference
Prevalence of GC	.03	.027	.032	BCHD STD*
Probability of treatment	.80	.60	1.0	BCHD STD
Strategy 1				BCHD STD
Sensitivity	.763	.725	.795	
Specificity	.363	.353	.369	
Strategy 2				BCHD STD
Sensitivity	.908	.880	.928	
Specificity	.169	.164	.174	
Strategy 3				BCHD STD
Sensitivity	.398	.358	.438	
Specificity	.724	.718	.731	
Strategy 4				BCHD STD
Sensitivity	.466	.426	.507	
Specificity	.642	.635	.648	
Strategy 5				BCHD STD
Sensitivity	.891	.863	.915	
Specificity	.191	.186	.197	
Strategy 6				BCHD STD
Sensitivity	.969	.949	.979	
Specificity	.008	.076	.084	
Urine NAATS sensitivity for GC	.96	.89	1.0	25-28
Urine NAATS specificity for GC	.99	.99	1.0	25-28
Develop PID	.30	.10	.40	15, 29-31
Asymptomatic PID	.60	.50	.75	15, 29, 32, 33
Inpatient PID	.15	.09	.27	15, 33-37
Surgery	.30	.10	.45	15, 33, 35, 39
Chronic pelvic pain	.18	.15	.30	23, 39, 40
Ectopic pregnancy	.078	.078	.091	9, 23
Tubal infertility	.15	.09	.18	9, 23, 39, 40
Tubal infertility evaluation	.25	.22	.45	36, 41-43
Pregnancy	.025	.023	.060	BCHD STD
Neonatal pneumonia	.10	.07	.16	44, 45
Neonatal conjunctivitis	.15	.15	.18	44, 45
Female-to-male transmission	.55	.28	.81	46,47
Urethritis	.70	.58	.82	48, 49
Epididymitis	.03	.01	.05	50, 51
Inpatient epididymitis	.087	.05	.15	50, 51
Minor adverse effects of antibiotic treatment, requiring treatment	.05	.02	.40	BCHD STD†
Efficacy of antibiotic treatment	.98	.98	.99	52, 53
Discount rate	.03	.01	.07	20

GC, *Neisseria gonorrhoeae*; BCHD, Baltimore City Health Department; STD, sexually transmitted diseases; NAATS, nucleic acid amplification testing; PID, pelvic inflammatory disease.

* Derived from local analysis of sexually transmitted diseases clinic data.

† Based on an informal survey of Baltimore City Health Department sexually transmitted diseases clinic providers, the proportion of patients who report significant symptoms is very low.

lower sequelae costs (Column B, Table 4) through greater numbers of identified and treated gonorrhea cases (Column D, Table 4). However, none of the screening strategies were cost-saving compared with not screening. Among the 6 strategies, the most selective strategy, Strategy 3, was the most cost-effective, with a cost of $535 for each additional treated case over no screening, whereas Strategy 6 resulted in the most treated cases.

One-way sensitivity analyses examined the minimums and maximums of cost estimates (Table 2). Enhanced screening became cost-saving over not screening only under 1 condition (Table 5): when the sequelae costs exceed $1342.60, Strategy 3 is cost-saving. By all other minimums and maximums, enhanced screening remained more costly than no screening, and Strategy 3 remained the most cost-effective of the enhanced screening strategies.

We then conducted a threshold analysis to identify other parameter variations that might affect the cost-effectiveness results. Strategy 3 became cost-saving over no screening when the prevalence of

Table 3. Final Cost Assumptions in 2003 U.S. Dollars

Cost Assumptions	Base	Minimum	Maximum	Reference
Antibiotics	5.80	5.80	15.82	[54]
Adverse effects of antibiotics	22.03	22.03	38.46	Medicaid Level 1-2 office visit[54]
Cure of uncomplicated infection	131	47.98	256	Medicaid Level 3 office visit plus antibiotics[50, 51, 54]
Outpatient PID treatment	304	183	553	[50, 54, 35, 37, 51, 56]*
Inpatient PID	6,696	2,804	8945	[35, 37, 41, 50, 51, 56]
Chronic pelvic pain	5,113	536	7,680	[35, 37, 41, 50, 56]
Surgery	3,117	3,117	3,335	[33, 35]
Ectopic pregnancy	7,662	2,301	11,080	[35, 37, 41, 50, 51]
Tubal infertility evaluation and management	5,003	756	9,738	[35, 37, 41, 50, 51]
Urethritis	42.55	30.97	121.54	Medicaid Level 2 office visit plus antibiotics[35, 54, 56]
Outpatient epididymitis	282	187	341	[35, 50, 54]
Inpatient epididymitis	4,042	1,552	5,390	[35, 41, 50, 51]
Infant pneumonia	1,161	952	1,596	[35, 41, 56]
Infant conjunctivitis	121	75.97	306	[35, 41, 56]
Urine NAATS	42.90	42.90	85.80	[54]
Annual discount rate	0.03	0.00	0.07	[20]

PID, pelvic inflammatory disease; NAATS, nucleic acid amplification testing.

Values are in dollars except where otherwise specified. Minimum and maximums represent variation in price, natural history, and discounting (0-7%). Ectopic pregnancy, tubal infertility, and chronic pelvic pain were expected to occur in the future and discounted accordingly: 5 years for ectopic pregnancy, 2–5 years for chronic pelvic pain, and 7–10 years for tubal infertility.

* Cost of outpatient pelvic inflammatory disease and epididymitis were calculated as the sum of the Medicaid 2004 estimates for a Level 5 established patient outpatient visit, $119.48 (Current Procedural Terminology 99215) and a Level 4 established patient outpatient visit for follow-up (as recommended by 2002 Centers for Disease Control and Prevention Treatment Guidelines,[12] $82.14 (Current Procedural Terminology 99214),[57] plus the average wholesale price of doxycycline 100 mg oral tablets twice per day for 7 days, $17.34,[58] $17.02 for 250 mg ceftriaxone,[58] and an estimated $5 injection administration fee.[41] The total estimated cost of outpatient pelvic inflammatory disease was calculated to be $240.98.

Table 4. Incremental Cost-Effectiveness of Six Screening Strategies for Gonorrhea per 10,000 Private Practice Female Patients, Aged 15 and over

Screening Strategy	A. Program Costs* Variable	B. Sequelae Cost	C. Total Cost	D. Cases of GC & CT Not Treated	E. Incremental Cost	F. Incremental Cases Treated	G. Incremental Cost/Effectiveness Ratio
No Screen	0	254,304	254,304	300	–	–	–
3. Screen age < 25 y AND risk	124,363	178,120	302,490	210	48,186	90	535.40
4. Screen age < 30 y AND risk	160,236	165,112	325,348	195	22,858	15	1,523.87
1. Screen age < 25 y	283,696	108,266	391,962	128	66,614	67	994.24
5. Screen age < 25 y OR risk	358,628	83,768	442,396	99	50,434	29	1,739.10
2. Screen age < 30 y	368,226	80,514	448,740	95	6,344	4	1,586.00
6. Screen age < 30 y OR risk	406,823	69,412	476,235	82	27,495	13	2,115.00

GC, *Neisseria gonorrhoeae*; CT, *Chlamydia trachomatis*.

Assessed for base case: Prevalence of gonorrhea was 3.0%; follow-up was 80%. All costs are in 2003 dollars except where otherwise specified. "Risk" was defined as at least 1 of the following: new sex partner in the past 30 days, pregnant, or drug use. The incremental cost-effectiveness ratio in Column G is a comparison of the specified screening strategy to the reference, No Screening.

* Variable costs include costs of urine nucleic acid amplification testing, follow-up treatment, adverse effects, antibiotics. These varied by number of people tested.

gonorrhea in the population exceeded 4.75% or when the cost of nucleic acid amplification testing testing was less than $26.50. When the probability of follow-up was 100% and the cost of treatment was reduced to zero, no screening remained less costly, and Strategy 3 remained the most cost-effective of the enhanced screening strategies. Even when the sensitivities of Strategies 1–4 were 100%, no screening was still the least costly option.

For multiway parameter analysis we estimated worst case and best case scenarios. For the worst-case scenario, model inputs (prevalence of infection, sen-

Table 5. Results of 1-Way Sensitivity and Threshold Analyses

Input	Threshold	Strategy
Sequelae costs	> $1,342.60	Strategy 3
GC prevalence	> 4.75	Strategy 3
Probability of follow-up	100	No Screening
Cost of urine NAATS	< $26.50	Strategy 3
Cost of treatment	$0	No Screening
Strategy 1		
Sensitivity	100	No Screening
Specificity	> 68.4	Strategy 1
Strategy 2		
Sensitivity	100	No Screening
Specificity	> 62.0	Strategy 2
Strategy 3		
Sensitivity	> 65.9	Strategy 3
Specificity	> 83.3	Strategy 3
Strategy 4		
Sensitivity	> 85.5	Strategy 4
Specificity	> 80.5	Strategy 4
Strategy 5		
Sensitivity	100	No Screening
Specificity	> 62.7	Strategy 5
Strategy 6		
Sensitivity	100	No Screening
Specificity	> 65.6	Strategy 6

GC, *Neisseria gonorrhoeae*; NAATS, nucleic acid amplification testing. Values are % except where otherwise specified.

sitivities and specificities of screening strategies, and costs) were maximized or minimized to favor not screening over screening; for best-case scenario results, inputs were varied to favor enhanced screening. Multiway parameter variation showed that routine gonorrhea screening could be as costly as $2,391 per additional case of gonorrhea treated (worst case scenario, Strategy 3), or save as much as $1,195 per additional case treated (best case scenario).

DISCUSSION

We compared 6 gonorrhea screening strategies and found none to be cost-saving over not screening at all. Among the 6 strategies examined, the most cost-effective was to screen all females aged younger than 25 years who report a new sexual partner in the past 30 days, drug use, or pregnancy (Strategy 3). No screening remained the lowest cost strategy when all parameters were varied to examine the upper and lower probability and cost estimates, except when sequelae costs exceeded $1,343. When the prevalence of gonorrhea was greater than 4.75%, Strategy 3 became cost-saving over not screening.

In this analysis we evaluated several gonorrhea screening strategies for women aged 15–35 years in a simulated private sector setting and found that none were cost-saving compared with no screening program. These findings are contrary to others,[14–18] where in certain settings selective screening was shown to be cost-saving over not screening. Prior cost-effectiveness analyses have examined *Chlamydia trachomatis* and gonorrhea together and not gonorrhea alone.[18,19,41,55] Given that the prevalence of *Chlamydia trachomatis* is significantly higher than that of gonorrhea,[1] when these 2 outcomes are combined the prevalence of infection is higher. Corresponding averted sequelae costs are increased, becoming greater than programmatic costs (cost of assay, treatment, and clinician time). Further, cost-effectiveness analysis of gonorrhea screening in settings such as correctional facilities and emergency departments have a higher gonorrhea prevalence than in a private practice, which is what we estimate. We have found that selective gonorrhea screening became cost-saving when the prevalence of gonorrhea in the clinic population exceeds 4.75%. Although selective screening seems to be cost-saving in high prevalence populations, such as emergency department patients,[59] the analysis presented here suggests that general population-based screening for gonorrhea may not be cost-saving.

Additionally, the choice of diagnostic test will impact final cost-effectiveness. A recent cost-effectiveness analysis examining gonorrhea screening in emergency departments found that point-of-care testing was significantly more cost-effective than urine based diagnostics, primarily by improving the proportion of infected women treated.[59] However, in the analysis presented here, even when 100% of those gonorrhea positive were treated, no screening was still the least costly strategy, primarily because of the lower prevalence (3%) of gonorrhea modeled.

Although the screening strategies modeled here did not cost less than not screening (ie, they were not cost-saving), Strategy 3 led to a 30% reduction in untreated infections. The cost per additional infection treated was $535. Because there are limited data available on the effect of gonorrhea infection and sequelae on individuals' quality of life, the cost per quality-adjusted life year can not be calculated. The cost per quality-adjusted life year would allow direct comparison to the cost-effectiveness of other health interventions and also the conclusion as to whether the proposed strategy is "cost-effective" or "not cost-effective."[20]

Screening coverage for *Chlamydia trachomatis* has improved dramatically over the past decade.[1] The most recent 2002 STD Treatment Guidelines recommend all sexually active women aged younger than 25 years, as well as older sexually active women with

risk factors, get tested for *Chlamydia trachomatis*.[12] Although this analysis suggests that screening for gonorrhea among the general population of private care seekers is not cost-saving over not screening, the most cost-effective strategy was to screen women aged younger than 25 years who report a new sexual partner, pregnancy, or drug use. This strategy aligns well with the current CDC guidelines for *Chlamydia trachomatis* screening, which suggest screening all women aged 25 years and younger and older women with either new or multiple sex partners.[12] Given the large increase in availability of molecular diagnostics for *Chlamydia trachomatis* screening[12] and the ease in testing for both *Chlamydia trachomatis* and gonorrhea using the same nucleic acid amplification testing technology, often patients are tested for the presence of both infections. When a *Chlamydia trachomatis* diagnostic test is indicated, our findings suggest that gonorrhea testing may be more cost-effective if diagnostic testing is performed on a smaller subset of clients and not all females who meet the 2002 CDC Treatment guidelines for *Chlamydia trachomatis* screening. Prospective validation of risks for infection and the application of combining selective gonorrhea screening with *Chlamydia trachomatis* screening with subsequent cost-effectiveness analysis is necessary to confirm the cost-effectiveness. Although we modeled urine-based nucleic acid amplification testing screening, we have no reason to believe that nucleic acid amplification testing from cervical swabs would change the results presented here. When combined with a *Chlamydia* screening program, selective gonorrhea screening is likely to become more cost-effective, and the prevalence at which gonorrhea screening becomes cost-saving may be lowered.

Several limitations in this analysis merit discussion. First, data from the Baltimore City STD clinics were used to derive the gonorrhea prevalence estimates, as well as the 6 screening criteria examined. These data may not be representative of a general clinic population, which likely has a lower prevalence of gonorrhea infection and may have different risks for infection, or the risks identified in this analysis may have different sensitivities and specificities. However, few data regarding risk factors for infection are collected among the general population, making the examination of selective screening strategies for broader populations more difficult. As a result, our cost-effectiveness analysis is applied to a population of higher risk than would likely be seen in a general practice, which may have led to an overestimation of the cost-effectiveness of enhanced screening compared with no screening. Second, some costs and incidence of sequelae for *Chlamydia trachomatis* were used in this analysis. Considerably more information has been published examining the natural history of *Chlamydia trachomatis*. In cases where we were unable to identify published estimates of the probability or cost of an outcome for gonorrhea, the corresponding value for *Chlamydia trachomatis* was used. The effect of this on our results is unknown. Third, we evaluate these gonorrhea screening strategies with a static rather than dynamic model. We assume only 1 outcome per person, rather than the possibility of varying health states and reinfection. Additionally, we assume inpatient treatment for PID to be curative. Last, we did not include indirect costs in our analysis, such as days lost from work or school, which would have significantly increased the costs associated with an untreated case of gonorrhea. Therefore, had we used a dynamic model (which would incorporate the effects of reduced gonorrhea prevalence in subsequent transmission) and included indirect costs in this analysis, our results would have been more favorable to enhanced gonorrhea screening.[60] Conversely, we did not model a programmatic cost of provider time to assess risk or collect a gonorrhea test specimen.

This analysis has limitations inherent in cost-effectiveness analyses, in that the conditional sequelae probabilities and costs are estimated from several sources, and uncertainty may not be fully addressed by the use of minimums and maximums. Results of our sensitivity analysis showed little deviation from the results of the base-case analysis in terms of relative effectiveness of strategies. This was due to the precise 95% confidence intervals on the sensitivity and specificity of the algorithms. These estimates are directly derived from our data, and the precision is a result of the large sample of women tested. Further, the sensitivities and specificities identified by our threshold analysis that would make the enhanced screening strategies dominant are likely unattainable.

Although several studies have examined the cost-effectiveness of screening for gonorrhea or *Chlamydia trachomatis* among higher risk populations, we have explored the usefulness of several screening strategies for gonorrhea among a population of lower-risk women seeking care. Our findings imply that screening for gonorrhea in a low-prevalence population may be cost-effective when applied selectively. Further, when the prevalence exceeds 4.75%, selective screening may be cost-saving. Additionally, the selective screening criteria found most cost-effective (screen women aged younger than 25 years who report drug use, pregnancy, or a new sexual partner) advocates testing a large subset of women who would be tested

for *Chlamydia trachomatis* under the current CDC treatment guideline recommendations. Although more research is necessary to examine further the value of more generalized screening for gonorrhea, this study's results provide insight into the resource allocation of services and care among populations of women considered to be at a lower risk for gonorrhea infection.

REFERENCES

1. U.S. Dept. of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Center for Prevention Services, Division of STD/HIV Prevention, Surveillance and Information Systems Branch. Sexually Transmitted Disease Surveillance 2003. Atlanta (GA): Centers for Disease Control, National Center for Prevention Services; 2004.
2. Siegel JE. The economic burden of sexually transmitted diseases in the United States. In: Holmes, KK, Sparling PF, Mardh P-A, editors. Sexually transmitted diseases. 3rd ed. New York (NY): McGraw-Hill; 1999. p. 1367–79.
3. Hook EW III, Handsfield HH. Gonococcal infections in the adult. In: Holmes, KK, Sparling PF, Mardh P-A, editors. Sexually transmitted diseases. 3rd ed. New York (NY): McGraw-Hill; 1999. p. 451–66.
4. Judson FN. Gonorrhea. Med Clin North Am 1990;74: 1353–66.
5. Pedersen AH, Bonin P. Screening females for asymptomatic gonorrhea infection. Northwest Med 1971;70:255–61.
6. Institute of Medicine (U.S.). Committee on Prevention and Control of Sexually Transmitted Diseases. The hidden epidemic: confronting sexually transmitted disease. Washington (DC): National Academy Press; 1997.
7. Farley TA, Cohen DA, Elkins W. Asymptomatic sexually transmitted diseases: the case for screening. Prev Med 2003; 36:502–9.
8. Turner CF, Rogers SM, Miller HG, Miller WC, Gribble JN, Chromy JR, et al. Untreated gonococcal and chlamydial infection in a probability sample of adults. JAMA 2002;287: 726–33.
9. Westrom L, Joesoef R, Reynolds G, Hagdu A, Thompson SE. Pelvic inflammatory disease and fertility: a cohort study of 1,844 women with laparoscopically verified disease and 657 control women with normal laparoscopic results. Sex Transm Dis 1992;19:185–92.
10. Centers for Disease Control (CDC). Chlamydia trachomatis infections. Policy guidelines for prevention and control. MMWR Morb Mortal Wkly Rep 1985;34:53s–74s.
11. Chacko MR, Wiemann CM, Smith PB. Chlamydia and gonorrhea screening in asymptomatic young women. J Pediatr Adolesc Gynecol 2004;17:169–78.
12. Sexually transmitted diseases treatment guidelines 2002. Centers for Disease Control and Prevention. MMWR Recomm Rep 2002;51(RR-6):1–78.
13. Centers for Disease Control and Prevention (CDC). Control of Neisseria gonorrhoeae infection in the United States. Atlanta (GA): Centers for Disease Control and Prevention; 2003. Available at: http://www.cdc.gov/std/GCmtgreport.pdf. Retrieved January 23, 2006.
14. Howell MR, Quinn TC, Gaydos CA. Screening for Chlamydia trachomatis in asymptomatic women attending family planning clinics. A cost-effectiveness analysis of three strategies. Ann Intern Med 1998;128:277–84.
15. Paavonen J, Puolakkainen M, Paukku M, Sintonen H. Cost-benefit analysis of first-void urine Chlamydia trachomatis screening program. Obstet Gynecol 1998;92:292–8.
16. Randolph AG, Washington AE. Screening for Chlamydia trachomatis in adolescent males: a cost-based decision analysis. Am J Public Health 1990;80:545–50.
17. Gift T, Walsh C, Haddix A, Irwin KL. A cost-effectiveness evaluation of testing and treatment of Chlamydia trachomatis infection among asymptomatic women infected with Neisseria gonorrhoeae. Sex Transm Dis 2002;29:542–51.
18. Mehta SD, Bishai D, Howell MR, Rothman RE, Quinn TC, Zenilman JM. Cost-effectiveness of five strategies for gonorrhea and chlamydia control among female and male emergency department patients. Sex Transm Dis 2002 2002;29: 83–91.
19. Kraut-Becher JR, Gift TL, Haddix AC, Irwin KL, Greifinger RB. Cost-effectiveness of universal screening for chlamydia and gonorrhea in us jails. J Urban Health 2004;81:453–71.
20. Gold MR, Siegel JE, Russel L, Weinstein MC. Cost-effectiveness in health and medicine. New York (NY): Oxford University Press; 1996.
21. 1998 guidelines for treatment of sexually transmitted diseases. Centers for Disease Control and Prevention. MMWR Recomm Rep 1998;47(RR-1):1–111.
22. Hook EW 3rd, Richey CM, Leone P, Bolan G, Spalding C, Henry K, et al. Delayed presentation to clinics for sexually transmitted diseases by symptomatic patients: a potential contributor to continuing STD morbidity. Sex Transm Dis 1997; 24:443–8.
23. Westrom LV. Sexually transmitted diseases and infertility. Sex Transm Dis 1994;21:S32–7.
24. Westrom L. Pelvic inflammatory disease and other sexually transmitted diseases. Curr Opin Obstet Gynecol 1989;1:5–10.
25. Ching S, Lee H, Hook EW 3rd, Jacobs MR, Zenilman J. Ligase chain reaction for detection of Neisseria gonorrhoeae in urogenital swabs. J Clin Microbiol 1995;33:3111–4.
26. Gaydos CA, Rompalo AM. The use of urine and self-obtained vaginal swabs for the diagnosis of sexually transmitted diseases. Curr Infect Dis Rep 2002;4:148–57.
27. Martin DH, Cammarata C, Van Der Pol, B, Jones RB, Quinn TC, Gaydos CA, et al. Multicenter evaluation of AMPLICOR and automated COBAS AMPLICOR CT/NG tests for Neisseria gonorrhoeae. J Clin Microbiol 2000;38:3544–9.
28. Smith KR, Ching S, Lee H, Ohhashi Y, Hu HY, Fisher et al. Evaluation of ligase chain reaction for use with urine for identification of Neisseria gonorrhoeae in females attending a sexually transmitted disease clinic. J Clin Microbiol 1995;33: 455–7.
29. Wiesenfeld HC, Hillier SL, Krohn MA, Amortegui AJ, Heine RP, Landers DV, et al. Lower genital tract infection and endometritis: insight into subclinical pelvic inflammatory disease. Obstet Gynecol 2002;100:456–63.
30. Westrom L. Gynecological chlamydial infections. Infection 1982;10:S40–5.
31. Stamm WE, Guinan ME, Johnson C, Starcher T, Holmes KK, McCormack WM. Effect of treatment regimens for Neisseria gonorrhoeae on simultaneous infection with Chlamydia trachomatis. N Engl J Med 1984;310:545–9.
32. Macaluso M, Wang X, Brill I, Fleenor M, Robey L, Kelaghan J, et al. Participation and retention in a study of female condom use among women at high STD risk. Ann Epidemiol 2005;15: 105–11.

33. Marrazzo JM, Celum CL, Hillis SD, Fine D, DeLisle S, Handsfield HH. Performance and cost-effectiveness of selective screening criteria for Chlamydia trachomatis infection in women: implications for a national Chlamydia control strategy. Sex Transm Dis 1997;24:131–41.
34. Scholes D, Stergachis A, Heidrich FE, Andrilla H, Holmes KK, Stamm WE. Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. N Engl J Med 1996;334:1362–6.
35. Magid D, Douglas JM Jr, Schwartz JS. Doxycycline compared with azithromycin for treating women with genital Chlamydia trachomatis infections: an incremental cost-effectiveness analysis. Ann Intern Med 1996;124:389–99.
36. Washington AE, Katz P. Cost of and payment source for pelvic inflammatory disease: trends and projections, 1983 through 2000. JAMA 1991;266:2565–9.
37. Rein DB, Kassler WJ, Irwin KL, Rabiee L. Direct medical cost of pelvic inflammatory disease and its sequelae: decreasing, but still substantial. Obstet Gynecol 2000;95:397–402.
38. Yeh JM, Hook EW 3rd, Goldie SJ. A refined estimate of the average lifetime cost of pelvic inflammatory disease. Sex Transm Dis 2003;30:369–78.
39. Westrom L. Effect of acute pelvic inflammatory disease on fertility. Am J Obstet Gynecol 1975;121:707–13.
40. Ness RB, Soper DE, Holley RL, Peipert J, Randall H, Sweet RL, et al. Effectiveness of inpatient and outpatient treatment strategies for women with pelvic inflammatory disease: results from the Pelvic Inflammatory Disease Evaluation and Clinical Health (PEACH) Randomized Trial. Am J Obstet Gynecol 2002;186:929–37.
41. Blake DR, Gaydos CA, Quinn TC. Cost-effectiveness analysis of screening adolescent males for Chlamydia on admission to detention. Sex Transm Dis 2004;31:85–95.
42. Stephen EH, Chandra A. Use of infertility services in the United States: 1995. Fam Plann Perspect 2000;32:132–7.
43. Wilcox LS, Mosher WD. Use of infertility services in the United States. Obstet Gynecol 1993;82:122–7.
44. Schachter J, Grossman M, Sweet RL, Holt J, Jordan C, Bishop E. Prospective study of perinatal transmission of Chlamydia trachomatis. JAMA 1986;255:3374–7.
45. Rosenman MB, Mahon BE, Downs SM, Kleiman MB. Oral erythromycin prophylaxis vs watchful waiting in caring for newborns exposed to Chlamydia trachomatis. Arch Pediatr Adolesc Med 2003;157:565–71.
46. Lycke E, Lowhagen GB, Hallhagen G, Johannisson G, Ramstedt K. The risk of transmission of genital Chlamydia trachomatis infection is less than that of genital Neisseria gonorrhoeae infection. Sex Transm Dis 1980;7:6–10.
47. Blount JH. A new approach for gonorrhea epidemiology. Am J Public Health 1972;62:710–2.
48. Handsfield HH, Lipman TO, Harnisch JP, Tronca E, Holmes KK. Asymptomatic gonorrhea in men: diagnosis, natural course, prevalence and significance. N Engl J Med 1974;290:117–23.
49. Luciano AA, Grubin L. Gonorrhea screening: comparison of three techniques. JAMA 1980;243:680–1.
50. Petitta A, Hart SM, Bailey EM. Economic evaluation of three methods of treating urogenital chlamydial infections in the emergency department. Pharmacotherapy 1999;19:648–54.
51. Washington AE, Johnson RE, Sanders LL Jr. Chlamydia trachomatis infections in the United States: what are they costing us? JAMA 1987;257:2070–2.
52. Stoner BP, Douglas JM Jr, Martin DH, Hook EW 3rd, Leone P, McCormack WM, et al. Single-dose gatifloxacin compared with ofloxacin for the treatment of uncomplicated gonorrhea: a randomized, double-blind, multicenter trial. Sex Transm Dis 2001;28:136–42.
53. Handsfield HH, Dalu ZA, Martin DH, Douglas JM Jr, McCarty JM, Schlossberg D. Multicenter trial of single-dose azithromycin vs. ceftriaxone in the treatment of uncomplicated gonorrhea. Azithromycin Gonorrhea Study Group. Sex Transm Dis 1994;21:107–11.
54. Maryland Department of Health and Mental Hygiene. Maryland Medical Assistance Program Physicians' Services, Provider Fee Manual. Available at: http://www.dhmh.state.md.us/mma/providerinfo/pdf/05physmancombinedparts_de2.pdf. Retrieved February 10, 2006.
55. Howell MR, Kassler WJ, Haddix A. Partner notification to prevent pelvic inflammatory disease in women: cost-effectiveness of two strategies. Sex Transm Dis 1997;24:287–92.
56. Ginocchio RH, Veenstra DL, Connell FA, Marrazzo JM. The clinical and economic consequences of screening young men for genital chlamydial infection. Sex Transm Dis 2003;30:99–106.
57. National fee analyzer: charge data for evaluating fees nationwide. Salt Lake City (UT): St. Anthony Publishing/Medicode; 2004.
58. Drug topics redbook and updates. 108th ed. Montvale (NJ): Medical Economics Co., Inc.; 2004.
59. Aledort JE, Hook EW 3rd, Weinstein MC, Goldie SJ. The cost effectiveness of gonorrhea screening in urban emergency departments. Sex Transm Dis 2005;32:425–36.
60. Mehta SD, Shahmanesh M, Zenilman JM. Spending money to save money. Sex Transm Infect 2003;79:4–6.