Journal of Urban Health: Bulletin of the New York Academy of Medicine, Vol. 81, No. 3,

doi:10.1093/jurban/jth130

Cost-Effectiveness of Universal Screening for Chlamydia and Gonorrhea in US Jails

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ABSTRACT *Universal screening for the sexually transmitted diseases (STDs) of chlamydia and gonorrhea on intake in jails has been proposed as the most effective strategy to decrease morbidity in inmates and to reduce transmission risk in communities after release. Most inmates come from a population that is at elevated risk for STDs and has limited access to health care. However, limited resources and competing priorities force decision makers to consider the cost of screening programs in comparison to other needs. The costs and cost-effectiveness of universal screening in correctional settings have not been documented. We estimated the incremental cost-effectiveness of universal urine-based screening for chlamydia and gonorrhea among inmates on intake in US jails compared to the commonly used practice of presumptive treatment of symptomatic inmates without laboratory testing. Decision analysis models were developed to estimate the cost-effectiveness of screening alternatives and were applied to hypothetical cohorts of male and female inmates. For women, universal screening for chlamydia only was cost-saving to the health care system, averting more health care costs than were incurred in screening and treatment. However, for men universal chlamydia screening cost $4,856 more per case treated than presumptive treatment. Universal screening for both chlamydia and gonorrhea infection cost the health care system $3,690 more per case of pelvic inflammatory disease averted for women and $650 more per case of infection treated for men compared to universal screening for chlamydia only. Jails with a high prevalence of chlamydia and gonorrhea represent an operationally feasible and cost-effective setting to universally test and treat women at high risk for STDs and with limited access to care elsewhere.*

KEYWORDS *Chlamydia, Cost-effectiveness analysis, Gonorrhea, Jails, Screening.*

INTRODUCTION

The prevalence of sexually transmitted diseases (STDs) is higher among jail inmates than in the general population.[1–6] In jails, reported test positivity rates for *Chlamydia trachomatis* range from 1% to 27% among women and from 1% to 21% among men; those for *Neisseria gonorrhoeae* range from 0.2% to 17% among women and from 0.1% to 32% among men.[7] These positivity rates vary with the underlying prevalence among the population and with the screening strategy employed at the particular institution.[3–6]

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The high prevalence of chlamydia and gonorrhea among jail inmates affects the health of both inmates and the nonincarcerated population. Many inmates are rapidly released back into the community because they post bond or because of jail overcrowding, a trend that has become increasingly common over the last decade.[8,9] If infected inmates are released without treatment, they can transmit these STDs to uninfected sex partners in the community. For example, many of the women in jails were arrested for prostitution; sex workers have a high number of sex partners and are at high risk of acquiring or transmitting STDs if they resume high-risk sexual activities on release.[10,11] In addition, untreated chlamydia and gonorrhea infections have been shown to increase HIV risk from two to five times and may lead to serious and costly sequelae that may further burden publicly funded health care facilities.[12–14]

The National Commission on Correctional Health Care recommends screening all inmates in correction facilities for chlamydia and gonorrhea, regardless of behavioral risk profile for STDs, for two reasons.[15] First, many individuals with chlamydia and gonorrhea may be asymptomatic and unaware that they are infected.[16–22] Second, many persons who become incarcerated have not had continuous access to quality primary health care in the community before incarceration and have either avoided seeking care or have utilized points of care such as hospital emergency rooms.[1,8–10] Therefore, universal screening enables an underserved population at high risk for chlamydia and gonorrhea to receive care that otherwise may be unattainable.

Despite the recommendation by the National Commission on Correctional Health Care, many jails do not universally screen for chlamydia or gonorrhea and test only in the presence of STD signs or symptoms or on inmate request.[4,23] Even in jails with universal screening policies, screening may be incomplete in practice or be delayed for up to 14 days after intake. However, many jail inmates are released within 48 hours and as a result are untested or untreated if infected.[11,24,25] Therefore, universal screening shortly after intake with timely test processing is proposed as the most effective strategy to decrease morbidity in inmates and to reduce transmission risk after release.[4,24,25]

To determine whether universal screening is an effective and cost-effective STD screening strategy in jails, we examined the cost-effectiveness of universal screening on intake for chlamydia and gonorrhea in US jails compared to the commonly used practice of presumptive treatment without laboratory testing of self-identified symptomatic inmates who request it.[23]

METHODS

Methodology and Perspective

We developed decision analysis models (Data 3.5, TreeAge Software Inc., Williamstown, MA) to analyze the cost-effectiveness of three program options: universal screening for both chlamydia and gonorrhea, universal screening for chlamydia only, and presumptive treatment (meaning treatment based on self-reported symptoms, not test results) for chlamydia and gonorrhea. Universal screening for gonorrhea in the absence of screening for chlamydia was not included in this analysis because programs will not typically consider such an option given that chlamydia prevalence is higher in most settings.[26]

Two separate models were created for each infection because the medical outcomes differ by gender. Each model compared universal screening at intake for both

infections, universal screening for chlamydia only, and presumptive treatment of symptomatic inmates who requested it for a hypothetical cohort of 10,000 inmates (Fig. 1). In the model for women, the primary medical outcome was pelvic inflammatory disease (PID), although neonatal sequelae associated with untreated chlamydial infections were also estimated. In men, the outcome was uncured cases of chlamydia or gonorrhea because these may lead to infections in female sex partners, who usually experience more serious and costly sequelae than men. The most common sequela of untreated chlamydia and gonorrhea infection in men, epididymitis, is relatively rare.[27]

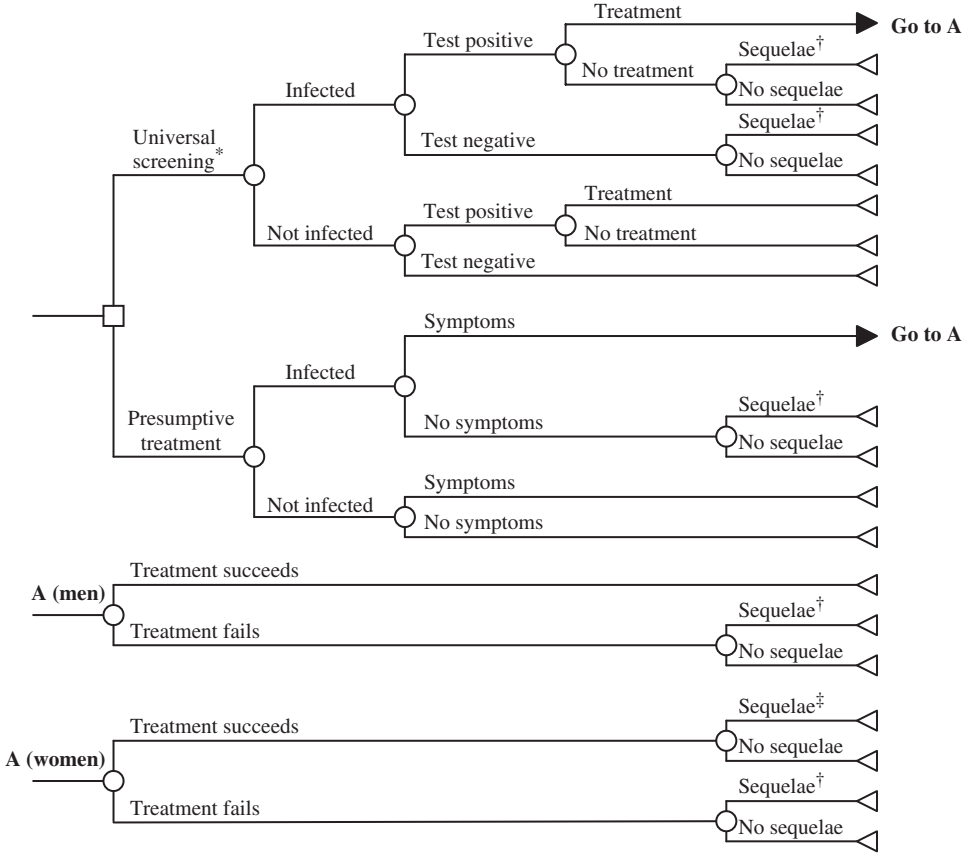

FIGURE 1. Steps modeled in the decision analysis. Inmates may be infected with chlamydia (CT), gonorrhea (GC), or both CT and GC. *The tree construction for universal screening is the same for both options (CT only and both CT and GC). When screening for both CT and GC, inmates are treated based on test results (e.g., they are treated for GC only if GC test is positive and CT test is negative). †The sequelae of untreated (or in cases of failed treatment) CT or GC in men are epididymitis and an increased likelihood of human immunodeficiency virus (HIV) infection. In women, the sequelae are pelvic inflammatory disease (PID), an increased likelihood of HIV infection, and, for CT, the possibility of neonatal sequelae (pneumonia and conjunctivitis) if pregnant. ‡ In women, PID is assumed to develop in some cases of successfully treated lower genital tract CT and GC because the infection may have caused upper genital tract inflammation before treatment. The probability of PID in successfully treated cases of lower genital tract CT or GC is lower than in cases that are untreated or when treatment fails.

Health care costs included the costs associated with implementation of each strategy (program costs) and costs resulting from manifestations of acute infections (disease costs). For the two universal screening strategies, program costs included costs of screening test kit materials, laboratory personnel time for processing tests, and personnel and drug costs to treat inmates with positive tests. Program costs for the presumptive treatment alternative included only personnel and drug costs to treat inmates with symptoms. For all strategies, disease costs included costs of treating sequelae, including PID and its sequelae in women, epididymitis in men, new HIV infections resulting from cases of infectious chlamydia or gonorrhea that facilitated HIV transmission, and neonatal sequelae of conjunctivitis and pneumonia among infants born to chlamydia-infected women.

Probabilities of various events, such as the increased likelihood of HIV transmission facilitated by an STD, the probability of PID, the probability of epididymitis, and the probabilities of various neonatal factors associated with chlamydia were used to calculate the respective number of cases of each sequelae for both women and men. The resulting number of cases was multiplied by the discounted sequelae costs for one case. We discounted sequelae costs that would normally be expected to occur after acute chlamydia or gonorrhea (e.g., ectopic pregnancy) by 3% per year.[28] Costs associated with transmission of chlamydia and gonorrhea from inmates to partners were not included.

We applied a health care system perspective, including all medical costs (i.e., testing and treatment) and benefits (i.e., savings realized through averted morbidity) associated with a screening program.[28,29] This perspective, rather than a societal perspective, was adopted because it is most useful for decision makers in corrections and public payers of health care (e.g., Medicaid, publicly funded health care facilities), who provide care to many inmates during incarceration and after release, and because patient costs (i.e., inmate time for testing and treatment) are not likely to have an impact on resource allocation decisions.[8–10,30]

Model Assumptions and Parameters

For each model, probabilities of events, outcomes, and costs were collected from published studies, reports, and abstracts (Table 1).

For the universal screening strategies, we assumed use of a nucleic acid amplification test on urine specimens, the BDProbeTec™ strand displacement amplification (SDA) assay (BD Biosciences, Sparks, MD) because urine specimens are more easily collected than cervical or urethral specimens in jail settings. Because they involve less clinician time than would be involved in collecting invasive specimens, use of the SDA assay or other nucleic acid amplification assays performed on urine specimens also offers cost advantages, assuming women are not being given pelvic exams for other reasons.[39,45] In addition, these noninvasive screening tests have been shown to be highly sensitive and specific.[26,44,57] The SDA assay can be used to test specimens for both organisms or for chlamydia alone. Reagents can be purchased either for chlamydia or for both chlamydia and gonorrhea.

We assumed that no inmates in the universal screening strategies would be treated before test results were made available. We therefore assumed only a portion (half at baseline) of inmates who tested positive on intake would be present in jail for test results and treatment because the time needed to process tests often exceeds the interval from intake to release.[10,11,23]

For the presumptive treatment strategy, we assumed that inmates would not request treatment in the absence of symptoms and that only half (at baseline) of

TABLE 1. Probability and cost* parameters used in baseline and sensitivity analyses

Parameter	Baseline values†	Ranges†	Reference
Prevalence			7, 31
Gonorrhea	.03 (M), .03 (W)	.01–.10	
Chlamydia	.04 (M), .08 (W)	.01–.15	
Chlamydia among patients with gonorrhea	.33	.20–.50	
Progression to adverse sequelae			
Epididymitis	.02	.01–.04	27, 32
Pelvic inflammatory disease			
If infection untreated	.20	.15–.30	33, 34
If infection treated	.06	.01–.10	33, 35
Lifetime cost of epididymitis	$273	$158–$749	32, 36, 37
Lifetime cost of pelvic inflammatory disease	$1,900‡	$1461–$,3972	33, 36, 38
Probability of symptoms			
When infected with			18, 20, 22, 32, 39–43
Gonorrhea	.70 (M), .35 (W)	.0–.99 (M), .0–.50 (W)	
Chlamydia	.50 (M), .30 (W)	.0–.80 (M), .0–.50 (W)	
Uninfected	.07 (M), .07 (W)	.01–.10 (M), .01–.10 (W)	18, 43
Percentage of symptomatic inmates who request treatment	.50	.20–1.0	20
Urine test			
Sensitivity			
Gonorrhea	.98 (M), .85 (W)	.95–.99 (M), .76–.92 (W)	44
Chlamydia	.93 (M), .81 (W)	.88–.97 (M), .72–.87 (W)	
Specificity			
Gonorrhea	.99 (M), .99 (W)	.97–.99 (M), .99–1.00 (W)	44
Chlamydia	.94 (M), .98 (W)	.91–.96 (M), .98–.99 (W)	
Cost (public sector price)			45–47
Chlamydia	$8.94	$8.94–$20.00	
Chlamydia and gonorrhea	$16.93	$16.93–$37.80	

Table 1. ***Continued***

Parameter	Baseline values†	Ranges†	Reference
Treatment			
Ciprofloxacin (gonorrhea)			
Efficacy	1.00	.94–1.00	48
Cost (public sector price)	$5.72	$5.53–$12.91	49, 50
Azithromycin (chlamydia)			
Efficacy, chlamydia	.97	.93–1.00	51
Efficacy, gonorrhea	.93	.90–.95	48
Cost (public sector price)	$10.50	$10.50–$44.25	33, 49
Compliance	1.00	.50–1.0	
Percentage receiving treatment before release from jail	.50	.30–1.0	10, 11, 23
Probability that a case of HIV transmission is facilitated by a case of			14
Gonorrhea	.00066		
Chlamydia	.00108		
STD-attributable HIV cost per case of:			14, 52
Gonorrhea	$161	$72–$245	
Chlamydia	$264	$117–$401	
Neonatal factors associated with chlamydia			
Probability of pregnancy	.06	.01–.10	53
Probability of transmission resulting in neonatal pneumonia	.10	.03–.20	36, 54–56
Probability of transmission resulting in neonatal conjunctivitis	.20	.15–0.40	36, 54–56
Cost of treating pneumonia	$2,222	$1,240–$3,204	36, 54
Cost of treating conjunctivitis	$122	$116–$128	36, 54

HIV, human immunodeficiency virus; STD, sexually transmitted disease.

*Costs are valued in year 2002 dollars.

†M, men; W, women.

‡Because there is uncertainty over the accuracy of medical claims data on which the cost estimate for pelvic inflammatory disease was based, we increased our baseline estimate by 30%.[38]

symptomatic inmates would request treatment.[20] High rates of asymptomatic infection have been reported for infections in both men and women, particularly in correctional settings.[20–22,31,40–42] However, we also assumed that some uninfected inmates would present with symptoms.[18,43] We further assumed that patient management would be guided by symptoms and signs only, and that no testing would be performed.

For all three strategies, we assumed the following single-dose oral treatments would be used: 1 g azithromycin for chlamydia and 500 mg ciprofloxacin for gonorrhea.[48] A 1-g dose of azithromycin also treats gonorrhea, although its efficacy for gonorrhea is insufficiently high to be recommended as a primary treatment.[48] Antibiotic costs included public health prices of treatments and personnel time for directly observed therapy.[33,49,50]

Chlamydia and gonorrhea positivity rates in 2000 ranged from 1% to 32% among inmates in adult city/county corrections facilities across rural and urban areas of the United States.[7] We used baseline positivity rates for chlamydia of 4% for men and 8% for women and gonorrhea positivity rates of 3% for both men and women. We assumed 33% of men and women with gonorrhea were also infected with chlamydia.[31]

Baseline models assumed a 20% probability of PID developing from untreated chlamydia or gonorrhea infections.[33,34] We also assumed a 6% probability of PID developing from successfully treated cases of chlamydia or gonorrhea because treatment may have occurred after the infection caused upper genital tract inflammation.[5,33,35] It was assumed that 2% of men with untreated chlamydia or gonorrhea infection would develop epididymitis, and that the epididymitis rate in successfully treated men was zero.[27,32]

The expected cost of PID per case included the direct medical costs of PID and its most common sequelae: chronic pelvic pain, ectopic pregnancy, and tubal-factor infertility. Recent estimates[38] based on medical claims data from privately insured populations (MarketScan Database, MEDSTAT Group, Ann Arbor, MI) are substantially lower than previous estimates.[32,33,39] Because cost data based on the *International Classification of Diseases, 9th Revision* (*ICD-9*) may not include all costs attributable to a given condition (e.g., diagnostic tests may not be associated with a case if they are not coded with a PID-related *ICD-9* code) and because there is uncertainty over how representative privately insured medical claims data are, we increased by 30% our baseline estimate.[38] The expected cost of a case of epididymitis was drawn from previous estimates.[32,36,37]

To model the human immunodeficiency virus (HIV) transmission-facilitating effects of chlamydia and gonorrhea, we assumed that each case of acute chlamydial infection would lead to 0.00108 new cases of HIV, and each case of acute gonococcal infection would lead to 0.00066 new cases of HIV.[12–14] These new cases of HIV were multiplied by a discounted lifetime cost per case of HIV of $244,049 to obtain the HIV-attributable cost per acute gonococcal or chlamydial infection.[52] We assumed that 6% of women entering jail are pregnant.[53] If infected and untreated, these women could deliver infants with neonatal complications. We used published data on the probabilities and costs of neonatal conjunctivitis and pneumonia,[36,45,54–56] but we did not include costs of neonatal gonococcal ophthalmia because it is rare.[58]

All costs were adjusted to year 2002 dollars using the medical care component of the consumer price index.[59]

To assess the effect of varying values of uncertain probabilities and costs on all models and to determine which model parameters most influenced results, we conducted one- and two-way sensitivity analyses by modifying one or two parameters simultaneously over the ranges shown in Table 1.

RESULTS

Female Inmates

Baseline Results Universal screening for chlamydia alone led to more acute infections treated than presumptive treatment of symptomatic inmates (Table 2). Universal screening costs a jail program $9 per inmate, whereas presumptive treatment costs $0.77 per inmate. Under baseline assumptions, universal screening for chlamydia only was a cost-saving alternative to presumptive treatment (Table 3). Universal screening averted 22 cases of PID compared to presumptive treatment and resulted in fewer chlamydia-attributable HIV cases (0.7 vs. 0.9) and neonatal pneumonia and conjunctivitis cases combined (9 vs. 12). Although cost-saving from a health care system perspective, universal screening for chlamydia only costs an individual jail program $267 to treat a case of chlamydia or gonorrhea. With presumptive treatment, it costs a jail $45 to treat a case of chlamydia or gonorrhea.

TABLE 2. Cases of acute infection and sequelae and intervention and sequelae costs, by strategy

	Strategy			
Outcomes	No program	Presumptive treatment	Screen for CT only	Screen for CT and GC
Women				
Untreated cases of disease				
Chlamydia	800	682	489	489
Gonorrhea	300	248	261	167
Sequelae cases				
PID	200	179	157	145
HIV	1.0	0.9	0.7	0.6
Neonatal complications	14	12	9	9
Intervention cost*	—	7,666	93,571	174,349
Sequelae cost†				
PID	380,000	339,587	297,699	275,071
HIV	243,561	206,636	161,677	147,804
Neonatal complications	11,837	10,089	7,240	7,240
Men				
Untreated cases of disease				
Chlamydia	400	294	221	221
Gonorrhea	300	195	252	152
Sequelae cases				
Epididymitis	12.0	8.5	8.4	6.5
HIV	0.6	0.4	0.4	0.3
Intervention cost*	—	8,259	94,440	175,395
Sequelae Cost†				
Epididymitis	3,276	2,318	2,288	1,764
HIV	137,961	98,612	90,154	74,722

All costs are in 2002 US dollars

CT, chlamydia; GC, gonorrhea; HIV, human immunodeficiency virus; PID, pelvic inflammatory disease.

*Intervention cost includes costs of screening tests and treatment of acute infections.

†Cost of acute cases of chlamydia and gonorrhea equals cost of testing and treatment.

TABLE 3. Results of cost-effectiveness analyses of universal screening compared with presumptive treatment of symptomatic persons*

	Women						
	Expected number of PID cases†	Number of PID cases prevented‡	Program cost§	Disease costs‖	Total cost¶	Additional cost‡	Incremental cost per case prevented#
Presumptive treatment	179	—	7,666	556,312	563,978	—	—
Screen for CT only	157	22	93,571	466,616	560,187	–3791	–172
Screen for CT and GC	145	12	174,349	430,115	604,464	44,277	3,690
	Men						
	Expected number of acute cases**	Additional acute cases treated‡	Program cost§	Disease costs††	Total cost¶	Additional cost‡	Incremental cost per case treated‡‡
Presumptive Treatment	489	—	8,259	100,930	109,189	—	—
Screen for CT Only	473	16	94,440	92,442	186,882	77,693	4,856
Screen for CT and GC	373	100	175,395	76,486	251,881	64,999	650

CT, chlamydia; GC, gonorrhea; PID, pelvic inflammatory disease.

*Results shown are for a hypothetical cohort of 10,000; all costs are in 2002 US dollars.

†PID cases rounded up to the nearest unit case.

‡Compared with the next most effective program.

§Includes costs of screening tests and treatment of acute infections.

‖Includes costs to treat PID, STD-attributable cases of human immunodeficiency virus (HIV), and neonatal infections (chlamydia).

¶Total costs = Program costs + Disease costs.

#Incremental impact of investment in the next most effective program, measured as cases of PID prevented; negative cost-effectiveness ratios indicate that total costs are less expensive, and the program is more effective.

**Acute cases of CT and GC; rounded up to the nearest unit case.

††Includes costs to treat epididymitis and STD-attributable cases of HIV.

‡‡Incremental impact of investment in the next most effective program, measured as cases of acute chlamydia and gonorrhea infections treated.

Universal screening on intake for chlamydia and gonorrhea was more expensive to the health care system than universal screening for chlamydia only under baseline assumptions (Table 3). Compared to universal screening for chlamydia only, universal screening for both infections averted 12 cases of PID at a net cost to the health care system of approximately $3,690 per case of PID averted. Universal screening for both infections costs a jail $17 per inmate and $393 per case of chlamydia or gonorrhea treated.

Sensitivity Analyses In univariate sensitivity analysis, universal screening for both chlamydia and gonorrhea prevented more cases of PID than presumptive

treatment over the entire ranges shown in Table 1, and unless the prevalence of chlamydia was very low (below 1.5%), universal screening for chlamydia alone prevented more cases of PID than presumptive treatment. The program cost of the universal screening arms was always higher than the program cost of presumptive treatment.

Our results showed that the health care system cost of screening women for chlamydia only was the lowest cost of three program options. However, this result was sensitive to several of the variables in the model. The variables that had the largest impact on cost are shown in Table 4, along with the threshold values for the variables at which the health care system cost of presumptive treatment and universal screening for chlamydia only were equal. Screening for both chlamydia and gonorrhea was never the lowest-cost strategy, except at gonorrhea prevalences above 9.1%, which are rare in most US jails. Universal screening for chlamydia was the lowest-cost strategy from the health care system perspective when

TABLE 4. Sensitivity analysis results for female inmates: health care system costs at low and high values for variables shown

Variable	Strategy	Cost at low value*	Cost at high value*	Threshold value*,†
HIV cost attributable to CT infection	Presumptive treatment	463,813	657,448	
	Screen for CT only	488,291	627,244	244
	Screen for CT and GC	532,585	671,538	
Test cost‡	Presumptive treatment	563,978	563,978	
	Screen for CT only	560,170	670,770	9.30 (CT test)
	Screen for CT and GC	604,130	813,164	
Lifetime cost per case of pelvic inflammatory disease	Presumptive treatment	485,516	934,307	
	Screen for CT only	491,386	884,818	1,727
	Screen for CT and GC	540,908	904,436	
CT prevalence	Presumptive treatment	156,769	971,187	
	Screen for CT only	244,275	876,065	0.077
	Screen for CT and GC	288,568	920,359	
GC prevalence	Presumptive treatment	502,032	780,791	
	Screen for CT only	487,565	814,286	0.037
	Screen for CT and GC	555,711	775,098	
Treatment before release from jail	Presumptive treatment	564,978	564,978	
	Screen for CT only	626,145	395,232	0.49
	Screen for CT and GC	684,681	403,920	
Percentage symptomatic who request treatment	Presumptive treatment	607,016	492,249	
	Screen for CT only	560,170	560,170	0.53
	Screen for CT and GC	604,464	604,464	
CT test sensitivity	Presumptive treatment	563,978	563,978	
	Screen for CT only	577,600	546,841	0.79
	Screen for CT and GC	621,965	591,080	

CT, chlamydia; GC, gonorrhea.

*Low and high values were taken from Table 1. All costs are in 2002 US dollars.

†The threshold value shown is the value for the sensitivity analysis variable at which the health care system costs of presumptive treatment and screen for CT only are equal.

‡The costs of the urine test for CT and the dual test were varied together.

1. The prevalence of chlamydia exceeded 7.7% or the prevalence of gonorrhea exceeded 3.7%.
2. The HIV cost attributable to an untreated case of chlamydia exceeded $244.
3. The lifetime cost per case of PID exceeded $1,727.
4. The treatment rate before release from jail for the universal screening arms exceeded 49%.
5. The percentage of symptomatic inmates who requested treatment was less than 53%.

Even if the chlamydia prevalence was too low to make the health care system cost of universal screening for chlamydia only less than presumptive treatment, the cost per additional case of PID prevented by universal screening for chlamydia only compared to presumptive treatment fell as the chlamydia prevalence increased (Fig. 2).

In addition to chlamydia prevalence, the treatment rate before release from jail for the universal screening arms had a strong impact on the total cost of universal screening for chlamydia. We varied these two variables simultaneously in a two-way sensitivity analysis (Fig. 3). Achieving a rate of treatment before release higher than the baseline value of 50% enabled universal screening for chlamydia to be lower in cost than presumptive treatment at a chlamydia prevalence rate lower than the threshold value of 7.7% (shown above for the baseline value of 50% treatment before release).

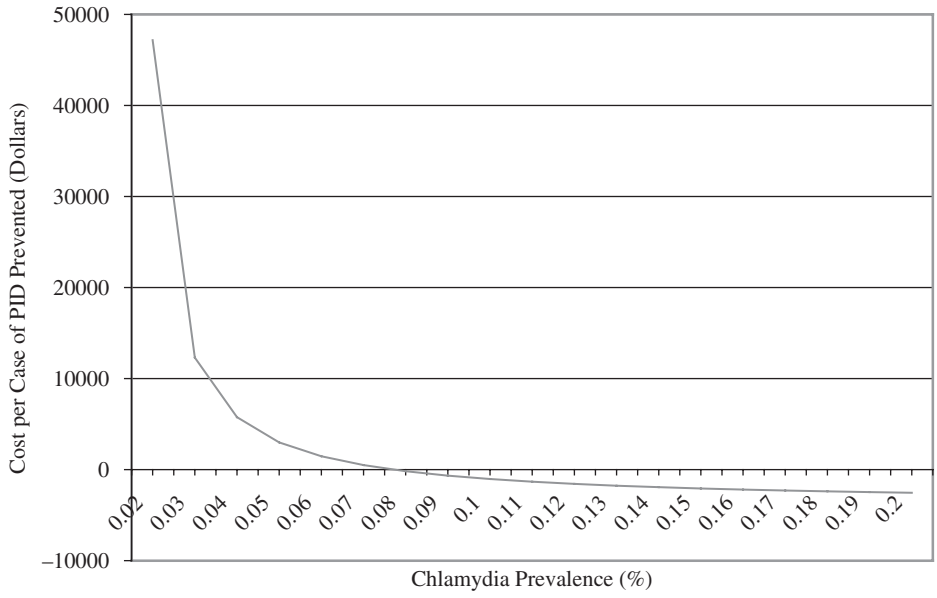

FIGURE 2. Health care system cost per additional case of pelvic inflammatory disease (PID) prevented for universal screening for chlamydia versus presumptive treatment in a hypothetical cohort of 10,000 women. The incremental cost-effectiveness ratio (the additional cost per additional case of PID prevented when switching from the presumptive treatment strategy to the strategy of universal screening for chlamydia only) is shown. Values below zero indicate that universal screening both prevents more PID than presumptive treatment and is less costly.

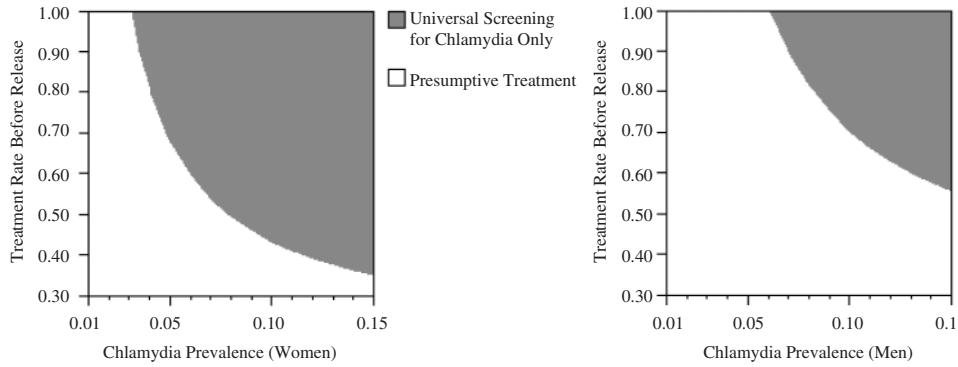

FIGURE 3. Two-way sensitivity analyses. Shown are the combinations of treatment rate before release (vertical axis) and prevalence of chlamydia (horizontal axis) at which universal screening for chlamydia only (gray) and presumptive treatment (white) are lowest in cost for managing women (left) and men (right). The graph color at the intersection of any prevalence and treatment rate before release shows the lowest-cost strategy for that combination of values. For example, if the treatment rate is 60% and the chlamydia prevalence is 8%, universal screening for chlamydia only is lowest cost for women, but presumptive treatment is lowest cost for men. All other variables in the model are set to the baseline values provided in Table 1.

Male Inmates

Baseline Results Under baseline assumptions, including a chlamydia prevalence rate of 4% and a gonorrhea prevalence rate of 3%, universal screening on intake for chlamydia only was both more effective, treating 16 additional cases of chlamydia and gonorrhea, and more expensive than presumptive treatment (Tables 2 and 3). Universal screening for chlamydia only cost the health care system approximately $4,856 per additional case of acute infection treated compared to presumptive treatment. Presumptive treatment costs a jail $0.83 per inmate, and it costs $39 to treat a case of chlamydia or gonorrhea. A jail offering universal screening for chlamydia only incurs costs of $9 per inmate, and it costs $416 per case of chlamydia or gonorrhea treated.

Universal screening on intake for both infections was more effective, treating 100 additional cases, but substantially more expensive than universal screening for chlamydia only, costing the health care system approximately $650 more per additional case treated (Table 3). The impact on HIV infections resulting from untreated cases of chlamydia or gonorrhea was limited; universal screening for both chlamydia and gonorrhea prevented 0.1 case of HIV compared to either universal screening for chlamydia only or presumptive treatment. Universal screening for both infections costs a jail $18 per inmate, and it costs $536 to treat a case of chlamydia or gonorrhea.

Sensitivity Analyses In univariate sensitivity analysis over the variable ranges presented in Table 1, the health care system perspective cost of universal screening for both chlamydia and gonorrhea was always higher than that of universal screening for chlamydia only, which in turn was always higher than that of presumptive treatment. The program cost of the universal screening arms was always higher than the program cost of presumptive treatment.

In general, the order of effectiveness in Table 3 held over the variable ranges presented in Table 1 (universal screening for both chlamydia and gonorrhea resulted in fewer untreated cases of chlamydia and gonorrhea than universal screening for chlamydia only, which resulted in fewer untreated cases of chlamydia and gonorrhea than presumptive treatment). However, presumptive treatment was more effective than universal screening for chlamydia only when

1. The prevalence of chlamydia was less than 3.3% or the prevalence of gonorrhea was less than 3.8%.
2. The probability of symptoms among men infected with chlamydia or gonorrhea exceeded 79%.
3. The treatment rate before release from jail for the universal screening arms was less than 47%.
4. The percentage of symptomatic inmates who requested treatment exceeded 54%. If this percentage exceeded 78%, presumptive treatment was also more effective than universal screening for both chlamydia and gonorrhea (this was the only circumstance for which this was true).

Although there was no circumstance in univariate sensitivity analysis in which universal screening for chlamydia only had a lower health care system cost than presumptive treatment, the same was not true in two-way sensitivity analysis. Universal screening of men for chlamydia only had a lower heath care system cost than presumptive treatment at chlamydia prevalences toward the upper value of the range if a high rate of treatment before release could be achieved (Fig. 2).

DISCUSSION

Universal screening on intake in jails for chlamydia and gonorrhea is effective and cost-effective for female detainees. Under the baseline assumptions of our analysis, universal screening for chlamydia only is cost-saving at a chlamydia prevalence of 8% compared to presumptive treatment. Universal screening for both infections imposes a net health care system cost of $3,690 per case of PID prevented compared to universal screening for chlamydia alone. Universal screening in men tends not to be less costly than presumptive treatment, but this is at least partly because of an assumption of a relatively large percentage of symptomatic infections as a baseline (70% for gonorrhea, 50% for chlamydia). Numerous studies have documented a much greater percentage of asymptomatic gonococcal and chlamydial infections in men in correctional or other settings.[19,20,22,42] A higher proportion of asymptomatic infections, coupled with a higher rate of treatment before release for those inmates screened, could make universal screening for chlamydia cost-saving in men.

In fact, the one variable under programs' control that exerts a strong influence on the cost-effectiveness of universal screening (for both men and women) is rate of treatment before release (Fig. 3). The prevalence at which universal screening for chlamydia becomes less costly than presumptive treatment falls rapidly as the treatment rate before release rises. If test results are not available before release, the full benefits of universal screening cannot be realized. The data suggest that, to be more effective and cost-effective, screening programs should attempt to test and treat inmates as early after intake as possible. Although some rapid, on-site tests for chlamydia and gonorrhea have been developed, they are not yet suitable for large-scale screening of asymptomatic individuals in jail health centers.[60–62]

When considering conventional lab-based tests, the time required to prepare and test urine specimens is only a fraction of the several-day delay between specimen collection and reporting of results that is typical. Operational changes to process specimens and make results available more rapidly would assist in ensuring inmate treatment. These measures could include regular courier service at more frequent intervals to transport specimens to off-site labs and electronic reporting of lab results. When inmates are released before treatment, efforts should be made to coordinate with local community-based health facilities to ensure treatment.[63–65] Collaborations among correction facilities, community-based organizations, and health care providers in the public and private sectors are needed to facilitate this process.

Our results should be interpreted in light of several issues and limitations. Our models did not consider morbidity and medical costs associated with secondary transmission from an inmate to a sex partner in the community, the possibility of reinfection of index patients by infected partners who are not treated, or the possibility of reinfection by the time of delivery if infected pregnant women are treated earlier in pregnancy. Providing notification and treatment services for partners of infected inmates, particularly for the female partners of infected men, may help reduce reinfection and be a cost-effective adjunct to a jail screening program.[48]

There are other possible testing and treatment options that we did not consider. For example, some programs that do not universally screen inmates may test those who present with symptoms or who request testing.[23] However, such a strategy would be more expensive and no more effective than presumptive treatment without testing. Treating based on test results would eliminate the clinical advantage of immediate treatment before release that presumptive treatment offers. We also did not incorporate dual treatment for chlamydia among detainees testing positive for gonorrhea. This has been shown to be a cost-effective treatment approach in some settings for women, even when the rate of dual infection is relatively low.[66] In jails with high intake volume, pooling of urine specimens may reduce per-test cost and improve the cost-effectiveness of a screening program.[26,67–71] Age-based screening has been shown to be a viable option in some instances, offering lower costs with little reduction in effectiveness.[50]

We did not consider adverse reactions to ciprofloxacin and azithromycin because they have been minimal.[36] With the withdrawal of cefixime from the market, fluoroquinolones (ciprofloxacin, ofloxacin, or levofloxacin) are the only oral treatments for gonorrhea recommended by the Centers for Disease Control and Prevention.[48,72] Fluoroquinolones are not recommended for the treatment of gonorrhea infections acquired in California, Hawaii, Asia, or the Pacific because of a greater prevalence of fluoroquinolone-resistant strains of *N. gonorrhoeae* in those areas.[48,73–75] Universal screening programs may be more cost-effective if lower program costs could be achieved. For example, we considered only azithromycin for treatment for chlamydia, but use of doxycycline, a less-expensive multiple-dose regimen, may make universal screening more cost-effective if treatment could be administered in a way that would ensure reasonable adherence.[76–77]

Given the high prevalence of chlamydia and gonorrhea in many jails, jails represent a worthwhile setting to test and treat people who are at high risk for STDs and who may have little access to care elsewhere. Introducing universal screening on intake can substantially improve detection and treatment among inmates. Of course, this hinges on whether inmates accept voluntary testing in states where STD testing in jails is not mandatory. Low rates of acceptability may impede the effectiveness of universal screening. However, the high rates of informed consent

(87%–98%) found in a study of urine-based screening of women entering jails in Chicago, Illinois; Birmingham, Alabama; and Baltimore, Maryland, lead us to expect that actual rates of refusal to participate in STD testing are low.[3] Jails that can provide rapid on-site treatment for inmates with positive tests or that assist inmates in getting treatment in free or low-cost community settings after release are more likely to have high acceptance of screening than jails that do not.

Although universal screening for chlamydia can be shown to be cost-effective compared to presumptive treatment, this finding relies on a health care system perspective that considers the averted sequelae costs of untreated lower genital tract gonorrhea or chlamydia. Because jails rarely incur treatment costs for the most common and costly sequela (PID), STD screening is rarely cost-saving when considered from the jail's perspective. Because STD screening will never "pay for itself" in terms of savings from a program's budget, this may be a barrier to implementation. The program cost of screening will always exceed the program cost of presumptive treatment. This may explain why few jails currently offer universal STD screening.[23] The same is not necessarily true for a regional public health system, which may, in addition to funding jail medical care, also fund emergency departments at public hospitals and public clinics and pay for Medicaid enrollees' health care; the last three commonly care for the sequelae of PID. Given this broader perspective, STD screening may appear to be more cost-effective than when considered from just the perspective of a jail. Even when facing the most limited perspective, an awareness of the health care system costs involved in the various options presented here provides a basis for including jail STD screening in resource allocation decisions.

Screening for chlamydia, or for both chlamydia and gonorrhea, is most cost-effective in settings with a high prevalence of disease, and in which high rates of treatment before release can be achieved. Although at low prevalences of chlamydia and gonorrhea universal screening may not generate savings over presumptive treatment of symptomatic inmates, universal screening for chlamydia is likely to be considered a good use of resources—to be cost-effective—in both male and female populations in jails because of the serious and costly nature of sequelae in women. Screening for both infections may be cost-effective in settings with relatively high gonorrhea prevalences. These findings are consistent with those found in cost-effectiveness studies of universal screening for gonorrhea and chlamydia in other populations, such as emergency department patients, family planning clinic clients, and STD clinic patients.[54,78,79] Although the study of different populations and the use of different assays to detect infection limit comparability, in general these studies find universal screening for chlamydia and gonorrhea cost-effective for women at prevalence rates similar to those assumed in our study.

This study suggests that the disease burden can be lowered if infected inmates are identified through universal screening and receive treatment before they are released. In many cases, a screening program can pay for itself through averted sequelae costs. If this can be accomplished, STD screening in jails can be an effective and cost-effective strategy for reducing the overall burden of STD in a community.

ACKNOWLEDGEMENT

We thank John Miles; Julia Schillinger; Sherilyn Spear; Cathleen Walsh; members of the Expert Panel on Communicable Diseases, Health Needs of Soon to be Released Inmates Project, National Commission on Correctional Health Care; and two anonymous referees for their helpful comments.

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