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Developing a System to Predict Laboratory-Confirmed Chlamydial and/or Gonococcal Urethritis in Adult Male Emergency Department Patients

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Abstract

Objectives—We aimed to create a system for predicting which male emergency department (ED) patients with suspected chlamydial and/or gonococcal urethritis would have laboratory-confirmed infections based on clinical factors available at the initial ED encounter.

Methods—We used statistical models to develop a system to predict either the presence or absence of laboratory-confirmed chlamydial and/or gonorrheal urethritis based on patient demographics and presenting symptoms. Data for the system were extracted from a retrospective chart review of adult male patients who were suspected of having, and were tested for, chlamydial and/or gonococcal urethritis at an adult, urban, northeastern United States, academic ED from January 1998 to December 2004.

Results—Among the 822 patients tested, 29.2% had chlamydia, gonorrhea, or both infections; 13.8% were infected with chlamydia alone, 12.1% were infected with gonorrhea alone, and 3.3% were infected with both. From the statistical models, the following factors were predictive of a positive laboratory test for chlamydia and/or gonorrhea: age $\leq$ 24 years, penile discharge, sexual contact with someone known to have chlamydia and/or gonorrhea, and not having health care insurance. A system using a hierarchical grouping of these factors based on the predicted probabilities of a laboratory-confirmed chlamydial and/or gonococcal urethritis, paired with baseline ED prevalence of these infections, was confirmed through internal validation testing to modestly predict which patients had or did not have a laboratory-confirmed infection.

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Conflict of Interest Statement Roland C. Merchant, MD, MPH, ScD, Dina M. DePalo, BA, Tao Liu, PhD, and Josiah D. Rich, MD, MPH disclose no conflicts of interest. Michael D. Stein, MD discloses conflicts of interest with Bristol-Myers Squibb and Gilead.

Conclusions—This system of a combination of risk factors available during the clinical encounter in the ED modestly predicts which adult male patients suspected of having chlamydial and/or gonorrheal urethritis are more likely to have or not have a laboratory-confirmed infection. A prospective study is needed to create and validate a clinical prediction rule based on the results of this system.

Keywords

chlamydia; gonorrhea; sexually transmitted diseases; emergency medicine; male; urethritis

Introduction

Emergency department (ED) clinicians frequently provide the initial evaluation and treatment of male patients with possible chlamydial and/or gonococcal urethritis. Emergency department clinicians must decide when to empirically treat these patients with antibiotics or await test results. The US Centers for Disease Control and Prevention (CDC) recommends that clinicians consider empirically treating asymptomatic sexual partners of persons with chlamydia or gonorrhea and those with symptoms of these infections, particularly when compliance with treatment and follow-up of testing results is not ensured.^{1–3} The CDC also recommends that symptomatic patients from areas where chlamydia and gonorrhea prevalence are high be treated empirically. These recommendations are challenging to apply in the ED. Prevalence estimates are not always available for the ED or the surrounding community. Assumptions about patient compliance and follow-up might be incorrect. Some patients who present to an ED with a possible infection will not have symptoms, and many might not have enough information about their sexual partners to guide clinical decision making.

The nature of emergency medicine practice can sometimes compel ED clinicians to favor empiric treatment out of a concern that the opportunity to treat a potential infection might be lost by waiting on test results and later trying to recall a patient for treatment. Because many of these patients will not have chlamydia and/or gonorrhea, overtreatment undoubtedly occurs.^{4–6} The probability of empiric treatment with antibiotics in the ED (given that the test results would eventually be negative for chlamydia and/or gonorrhea) was found to be 32% in a study by Levitt et al⁴ and 24.5% in a study by Wiest et al.⁶ Wiest et al⁶ observed that overuse of empiric antibiotics was greater for mid-level providers than physicians, who commonly are tasked with providing medical care for ambulatory patients in many EDs.

The downside of overtreatment with antibiotics for patients includes a higher cost of medical care, longer time spent in the ED, the risk of an allergic reaction, inconvenience, an increased risk of *Clostridium difficile* colitis, which is increasing in prevalence and severity,^{7,8} and the anxiety and associated stigma of incorrectly believing one has an infection. For society, overtreatment means higher medical costs, a worsening of antibiotic resistance, and limitation of antibiotic choices.^{9–16} Overuse of antibiotics is an important reason why fluoroquinolones are no longer effective for treatment of gonorrhea.⁹ The ineffectiveness of fluoroquinolones coupled with the lack of availability of spectinomycin in the United States limits the choices for antibiotics for chlamydia and gonorrhea. Of course, these concerns of overtreatment must be balanced against the need to stem the epidemic of chlamydia and gonorrhea and prevent the adverse sequelae of these infections among men and women. A clinical prediction rule that could be employed in the ED to identify which patients will ultimately show laboratory evidence of a chlamydia and/or gonorrhea infection might be helpful in more efficiently providing empiric antibiotic therapy for these infections.

As an initial step toward the eventual creation of a clinical prediction rule, we developed and evaluated a system to predict which male ED patients with suspected chlamydial and/or gonococcal urethritis will have laboratory-confirmed infections based on clinical factors available at the initial ED encounter. We present the findings from a pilot study used to develop and initially evaluate this system.

Materials and Methods

This pilot study involved a retrospective chart review of adult male patients (≥ 18 years) who visited an adult, urban, northeastern United States, academic ED from January 1998 to December 2004. Emergency department clinicians had diagnosed study participants with possible chlamydial and/or gonococcal urethritis prior to receiving the results of laboratory testing for these infections. We included asymptomatic and symptomatic patients in our study sample as they more accurately represent the spectrum of ED patients who are evaluated for, diagnosed with, and potentially empirically treated for these infections. Symptomatic patients had signs or symptoms of urethritis. Only adult male patients who were tested for chlamydia and gonorrhea were included in this analysis because the endpoint of the study was a laboratory-confirmed infection. We used the combined endpoint of laboratory evidence of infection with either or both organisms because coinfection with these organisms can occur and empiric treatment for both organisms is recommended by the CDC.¹⁻³ The hospital's institutional review board approved the study.

Search for Cases

The study hospital and ED providers maintain separate computerized billing databases. We searched the hospital and the ED provider billing record computerized databases for cases for this study using 13 *International Classification of Disease, Ninth Revision, Clinical Modification* (6th edition, 2001) (ICD-9) codes. These codes were for chlamydia (099.41, 099.50, 099.51, 099.52, 099.55), contact with someone with a venereal disease (V01.6), gonorrhea (098.0), nongonococcal urethritis (099.40, 099.49), other venereal disease (099.9, 099.8), trichomonas (131.02), and urethritis (597.80). We queried the databases for all 13 codes simultaneously and without regard to the billing order so that we could identify all possible visits for chlamydial and/or gonococcal urethritis.

Data Collection

Two study authors reviewed the medical records of the patients identified in the search. We included only the first ED visit for the same complaint for those patients who presented more than once in a 4-week period. For the patients who met the inclusion criteria, we extracted and recorded the following data onto a standardized form: patient age, race/ethnicity, type of medical insurance, reason for presentation, signs and symptoms of a possible infection (dysuria, discharge, and penile pain), history of sexual contact with someone known to have a sexually transmitted disease (STD) or infection, and diagnostic tests performed. We retrieved the laboratory results for all patients independently of the medical record by direct inquiry of the hospital's laboratory database. At this hospital, the APTIMA COMBO 2[®] Assay (Gen-Probe, Inc., San Diego, CA) urine ligase nucleic acid amplification tests (NAATS) are performed for chlamydia and gonorrhea. According to the manufacturer, this urine NAAT for males demonstrates a sensitivity and specificity of 97.9% and 98.5%, respectively, for chlamydia and 98.5% and 99.6%, respectively, for gonorrhea. Two trained data entry personnel entered the data from the forms into an Epi Info 2002 (CDC, Atlanta, GA) database that we created, and performed a data comparison analysis to verify that all forms were entered correctly. Incorrect entries were corrected, and we performed all subsequent analyses using this verified database. We transferred the database to STATA 9.2 (Stata Corp., College Station, TX) for analysis.

Data Analysis

We calculated summary statistics for the demographic characteristics, medical history components, and results of the laboratory tests. We also calculated the probabilities of being treated with antibiotics, given the laboratory test results. We first conducted bivariate analyses to identify which clinical factors should be further considered as potential predictors of laboratory-confirmed chlamydial and/or gonococcal urethritis. We then evaluated several alternative forms of these factors and compared them by their ability to distinguish between patients with and without a chlamydia and/or gonorrhea infection. When alternate forms for a factor existed, we selected the best functional form for the factor through Pearson's χ^2 testing, by estimating likelihood ratios (LR) with corresponding 95% confidence intervals (CIs), or through receiver-operator characteristic (ROC) curve plots. Differences were considered statistically significant at the $\alpha = 0.05$ level. We considered factors significant in the bivariate analysis for the next stage of the analysis.

Next, we divided the data set into training and testing data sets through computerized-assisted random selection of participants. The training data set included 75% of the patients. We used the training data set to create a systematic approach of hierarchically arranged clinical factors grouped in order of importance so that they could be used to identify patients with laboratory-confirmed chlamydial and/or gonococcal urethritis. The remaining 25% of the patients formed the testing data set, which we used to internally validate the systematic approach we created using the training data set. We first identified a best-fitting multivariate logistic regression model composed of the potential predictors plus interaction terms that were statistically significant using the training data. Odds ratios (ORs) and 95% CIs were estimated. We employed a stepwise model selection process by maximizing the Akaike Information Criteria (AIC). Using the selected model, we calculated the predicted probabilities for the presence of laboratory-confirmed chlamydial and/or gonococcal urethritis for all possible combinations of the factors chosen. We then ranked the combinations of factors hierarchically according to their predictive abilities and grouped them into 5 risk levels. These 5 risk levels formed the basis of the system for predicting a laboratory-confirmed chlamydial and/or gonococcal infection. We calculated likelihood ratios with corresponding 95% CIs for the presence or absence of a laboratory-confirmed infection of each risk level using the training data set.

We internally validated the system we created using the testing data set by comparing the predicted probabilities and the observed probabilities of infection for each risk level. For this internal validation, we calculated the "optimism" of each risk level in the system, which is a measure of how well the risk level over- or under-predicts the presence or absence of an infection. The "optimism" is the difference between the predicted and observed probabilities of infection. We created separate plots of the predicted probabilities of an infection or the absence of infection using the system we created across different potential baseline prevalences of infection in the ED.

Results

Participant Profile

We identified 1218 ED visits from the ICD-9 code search, of which 1166 (95.7%) could be located for review. Of these 1166 visits, 985 were for patients diagnosed at the time of the initial ED encounter with possible chlamydial and/or gonococcal urethritis. The remaining 181 visits were for other STDs, non-STD-related conditions, or follow-up visits for the same STD. Of the 985 possible chlamydia and/or gonorrhea-infected patients, 825 (83.8%) underwent chlamydia and gonorrhea testing. Untested males were not significantly different from those tested for infection in terms of age, race, and insurance status (results not

shown). We did not include 25 additional patients in this analysis because they were not tested for both infections. Three of the 825 patients (0.4%) were excluded from this analysis because either the chlamydia or gonorrhea test results could not be located.

Of the 822 males tested for both chlamydia and gonorrhea, 29.2% had chlamydia or gonorrhea or both infections. Of the 822 males, 13.8% were infected with chlamydia alone, 12.1% were infected with gonorrhea alone, and 3.3% were infected with both. Of the 822 males, 91% were empirically treated in the ED for chlamydia and/or gonorrhea. As shown in Table 1, the probability of patients receiving empiric antibiotic treatment was high regardless of the eventual laboratory results.

Table 2 shows the demographic and history of presenting illness profiles of the 822 adult males. The median age of the patients was 28 years old, most were black, and the majority did not have health care insurance. The majority of patients had symptoms of an infection (88.8%), the majority of those with signs or symptoms reported discharge (61.7%), and a minority reported having had sex with someone whom they knew was diagnosed with some type of STD (24.7%).

Identification of Factors for Laboratory-Confirmed Chlamydial and/or Gonococcal Urethritis

Table 2 provides a comparison of the distribution of clinical factors between those with and without laboratory-confirmed chlamydial and/or gonococcal urethritis. Table 3 shows the results of identifying specific demographic characteristic and presenting illness factors predictive of an infection. The median age (28 years) for an infection was first considered as the dichotomous form for this demographic characteristic. However, an ROC curve plot with age as a continuous variable versus probability of an infection revealed that age 24 years might be a better discriminator between the presence or absence of an infection (data not shown). The dichotomous form of the factors shown in Table 3 that was statistically significant in the Pearson's χ^2 analysis and had the highest LR for infection were chosen as candidate predictors.

The ORs for an infection using these factors were estimated and are also shown in Table 3. In the final multivariable model, 4 factors (age $\leq$ 24 years, having no insurance, having penile discharge, and having sexual contact with someone with a known chlamydia and/or gonorrhea infection) were associated with the presence of laboratory-confirmed chlamydial and/or gonococcal urethritis. In addition, the model included an interaction term of penile discharge and sexual contact. The variable for race was not associated with an infection in the multivariable analysis and was not considered further.

System of Predicting Laboratory-Confirmed Chlamydial and/or Gonococcal Urethritis

Table 4 displays the final form of the system we created to predict the presence or absence of laboratory-confirmed chlamydial and/or gonococcal urethritis. The system consists of a hierarchical grouping of factors (0 through 4) in the order of their ability to predict the presence or absence of a laboratory-confirmed chlamydial and/or gonococcal urethritis based on the results of the multivariable logistic regression model. For this system, the type and not just the number of risk factors impact the predicted probability of infection. For example, the likelihood of infection is greater for patients who have either discharge or a chlamydia/gonorrhea sexual contact than if they are aged $<$ 24 years, have no insurance, or have both risk factors.

To implement the system we created into clinical practice, the ED clinician examining a patient suspected of having chlamydial and/or gonococcal urethritis would determine the type and number of risk factors, find the row on this table that corresponds with the patient's

combination of risk factors, and then read the likelihood ratio. The clinician would next use the baseline prevalence (converted to odds) of chlamydial and/or gonococcal urethritis among adult males at his/her ED (or surrounding community) to calculate the predicted probability of infection. This baseline prevalence might come from the proportion of laboratory tests for chlamydia and/or gonorrhea that are positive in this ED population at that hospital. As an example, a patient with ≥ 3 risk factors (LR, 2.70) at an ED with a baseline prevalence of infection of 30% (which corresponds to a pre-test odds of $0.43 = 30\%/[1\% - 30\%]$), the predicted probability for the presence of an infection is 55% (or a post-test odds of 1.2) (ie, pre-test odds $0.43 \times \text{LR } 2.70 = \text{post-test odds } 1.2$; post-test probability $= 1.2/[1 + 1.2] = 0.55$). For a patient with no risk factors (LR, 15.6) at an ED with a baseline prevalence of infection of 40% (pre-test prevalence of “no infection” of 60% and odds of $1.5 = 60\%/40\%$), the predicted probability for the absence of infection is 96% (post-test odds of 23.4).

Figure 1 provides a plot demonstrating the expected predicted probabilities for the presence or for the absence of chlamydial and/or gonococcal urethritis over an array of baseline ED population prevalences of infection. The above 2 examples are as circles in Figure 1. The diagonal lines indicate when the pre-test and post-test probabilities of infection are equal. These diagonal lines also show which groups of risk factors at a given prevalence indicate that the probability for an infection exceeds the baseline prevalence. Figure 1 also shows with the horizontal lines in the plot when the post-test probability is equal to 50%. These horizontal lines depict which group of predictors at a given prevalence improves post-test prediction beyond a coin toss.

Internal Validation of the System

Table 4 displays the results of internally validating the system we created for predicting laboratory-confirmed chlamydial and/or gonococcal urethritis using the testing data set. The observed probabilities of infection for patients in the testing data set with a given group of risk factors are compared with the predicted probabilities of infection when applying the system we created on the testing data set. The optimism indicates how well the number of predicted cases compares with the observed cases when applying the system we created to the test data set. As shown, the system we created fared well overall and the optimism was low (ie, over-prediction and under-prediction were low). The system we created appeared to perform best for the higher risk groups for the presence of infection and the lower risk groups for the absence of infection.

Discussion

In this pilot study we created a system for predicting which adult male ED patients suspected of having chlamydial and/or gonococcal urethritis ultimately had laboratory evidence of these infections. The gain in determining the presence of infection using this system was modest. The system performed best for predicting the presence of an infection when the ED prevalence was $> 25\%$ and the patient had ≥ 3 risk factors. For these patients only, the probability of infection was greater than a coin toss. Regardless, in clinical practice, most ED clinicians would likely empirically treat these patients anyway, so the system for predicting the presence of an infection would likely be helpful in only a few cases. On the other hand, the gain in determining the absence of an infection using the system was better. The system might be more useful in determining which patients would be less likely to have a laboratory-confirmed infection. In clinical practice, this means that the system might be more useful in avoiding overtreatment.

This study has a number of limitations. First, the largest limitation of the study findings is due to the retrospective data collected for the study. We could only use the data available in

the medical records, which is limited in its depth and precision. We could only base the system we created on patients who were diagnosed by the ED clinician as potentially having and who were tested for chlamydial and/or gonococcal urethritis, so we could not include patients who might have been empirically treated and not tested, those who were not tested or treated, and those who were not suspected of having an infection. As a result, the factors we identified were crude markers of the presence or absence of an infection. Prospectively collected data for the purpose of identifying factors that predict the presence or absence of a laboratory-confirmed chlamydia and/or gonorrhea infection is clearly preferable to data collected from a medical record review. We are hopeful to use this study as a pilot for a larger prospective study that involves a larger range and greater depth of possible factors predictive of the presence or absence of these infections. It should be noted that the list and the form of these factors from such a prospective study might be different than the ones we identified in this pilot study. The system we created and the factors identified must be considered presumptive. A valid clinical prediction rule requires construction based on prospectively collected data and requires validation before it can be considered appropriate for clinical decision making. A prediction rule designed for determining who should be screened for chlamydia in the general population was recently constructed and reviewed in The Netherlands.^{17,18} This rule was designed for targeted screening and not diagnosis of chlamydia, did not include gonorrhea infections, and employed demographic characteristic factors specific to the general population in The Netherlands. We know of no prediction rules for chlamydia and/or gonorrhea diagnosis in the ED, despite the importance of attempting to improve diagnostic accuracy and efficiency of empiric antibiotic treatment.

Second, the study does not examine the presence of other organisms that cause urethritis, such as mycoplasma or trichomonas. Future studies may be designed that address these infections. Third, laboratory testing might not detect recently acquired infections. Patients who present soon after a sexual encounter out of concern of an infection might form a risk group for which the system we created might not be applicable. However, urine ligase NAATs are highly accurate and can reliably detect infections within a few days after transmission. Fourth, the role of health care insurance in the prediction of infections might be specific to this ED. Other communities probably have different health care payer systems. The importance of this factor might be increased or diminished in other settings. Fifth, until a clinical prediction rule is developed using prospectively collected data and independently validated, we cannot determine to what extent the system we developed or a future clinical prediction rule improves clinical decision making. As such, we do not yet know if such a rule can improve on clinical gestalt in deciding who should or should not be empirically treated for chlamydia and/or gonorrhea in the ED. However, given that the majority of patients in this ED are treated and most do not have an infection, there is a clear opportunity to reduce overuse of antibiotics in this population.

Despite the limitations of this pilot study, we believe that this investigation helps direct future efforts toward creating a clinical prediction rule using prospectively collected data. The ultimate goal of the future decision rule would be to reduce overtreatment and improve efficiency of empiric antibiotic therapy. There are many clinical prediction rules available for emergency medicine practice, but none that addresses empiric antibiotic treatment decision making for patients with suspected chlamydial and/or gonococcal urethritis.^{19–26} The results of this study assist in directing the potentially important factors in predicting a positive chlamydia and/or gonorrhea test in this population and some factors that must be better delineated through a prospective observational study. It also provides a framework for how the rule might be composed based on the structure used in the system we created. It also shows how a future rule might best be used, which is likely to predict for which patients antibiotics might be deferred than to predict for which patients antibiotics should be prescribed.

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Figure 1.

Predicted probabilities of laboratory-confirmed chlamydial and/or gonococcal urethritis, based on the system and baseline emergency department prevalence for these infections. Diagonal lines indicate when pre-test and post-test probability of infection are equal. Horizontal lines indicate when the post-test probability of infection is equal to chance (ie, the probability is 50%).

Abbreviations: DC, discharge; C/G contact, sexual contact with someone known to have chlamydial and/or gonococcal urethritis.

Table 1

Probability of Empiric Antibiotic Treatment by Infection Status

		Laboratory-Confirmed Infection		
		Yes	No	
Empiric Antibiotic Treatment Prescribed	Yes	231	517	748
	No	9	65	74
		240	582	822

Probability (Antibiotic treatment|infection): 96.3%.

Probability (No antibiotic treatment|infection): 3.8%.

Probability (Antibiotic treatment|no infection): 88.8%.

Probability (No antibiotic treatment|no infection): 11.2%.

Table 2

Study Participant Demographic and History of Present Illness Profiles

	All Participants N = 822	Results of Laboratory Testing for Chlamydia and/or Gonorrhea		P Value ^a
		Infection Confirmed n = 240	No Infection n = 582	
Median Age (range)	28 (18–64)	25 (18–49)	30 (18–64)	0.001
Race/Ethnicity (%)				0.16
Black	48.1	53.6	45.9	
Hispanic	15.2	15.5	15.1	
White	26.0	22.2	27.5	
Unknown/Other	10.7	8.8	11.5	
Health Care Insurance (%)				
Governmental	22.3	14.2	25.6	0.001
Medicaid	14.1	10.8	15.5	
Medicare	0.9	0.0	1.2	
Medicaid/Medicare	5.0	1.7	6.4	
Hospital-provided free medical care	2.3	1.7	2.6	
Private	24.4	25.8	23.9	
None	53.3	60.0	50.5	
Reasons for Presentation (%)				0.21
Symptoms only	76.3	75.4	76.6	
Symptoms and known STD contact	12.4	15.4	11.2	
No symptoms and known STD contact	9.6	8.4	10.1	
No symptoms and no known STD contact	1.7	0.8	2.1	
Signs and Symptoms (%)				0.001
None	11.2	9.2	12.0	
Penile discharge only	16.8	23.8	13.8	
Dysuria only	22.1	5.0	29.2	
Penile discharge and dysuria	44.9	60.7	38.2	
Penile pain only	2.1	1.3	2.4	
Lesions only	2.1	0.0	3.2	

	Results of Laboratory Testing for Chlamydia and/or Gonorrhea			
	All Participants	Infection Confirmed	No Infection	P Value ^a
Other	0.9	0.0	1.2	0.15
History of Known STD Contact (%)				
None/not stated	75.3	73.3	76.1	
Chlamydia	8.2	11.7	6.7	
Chlamydia/trichomonas	0.2	0.4	0.2	
Chlamydia/gonorrhea	0.2	0.4	0.2	
Gonorrhea	2.6	2.5	2.6	
Herpes	0.6	0.0	0.9	
HIV	0.1	0.4	0.0	
Syphilis	0.2	0.0	0.3	
Trichomonas	1.8	0.8	2.2	
Venereal warts	0.1	0.0	0.2	
STD type unknown	10.6	10.5	10.6	

^a P value indicates results of the comparison of factors for those with and without a laboratory-confirmed chlamydial and/or gonococcal urethritis infection.

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

Table 3

Bivariate and Logistic Regression Analyses to Identify Factors Predictive of a Laboratory-Confirmed Chlamydia and/or Gonorrhea Infection

Factor	Bivariate Analyses			Logistic Regression Analyses		
	Number in Each Group	Percentage Infected with a Chlamydia and/or Gonorrhea	P Value	LR for Chlamydia and/or Gonorrhea Infection	Univariable Models	Multivariable Model
Age	N	%	P <	LR+ (95% CI)	OR (95% CI)	OR (95% CI)
Age < 28 vs age > 28 years	414 vs 408	38.2 vs 20.1	0.001	1.50 (1.32–1.70)		
Age < 24 vs age > 24 years ^a	285 vs 537	40.4 vs 23.3	0.001	1.64 (1.37–1.97)	2.23 (1.64–3.04)	2.38 (1.69–3.35)
Race						
Non-white vs white	608 vs 213	30.6 vs 24.9	0.114	1.07 (0.99–1.17)		
Black or Hispanic vs white or unknown/other ^a	520 vs 301	31.7 vs 24.6	0.030	1.13 (1.02–1.26)	1.43 (1.03–1.97)	1.21 (0.85–1.72)
Insurance status						
No insurance vs any insurance ^a	384 vs 438	32.9 vs 25.0	0.013	1.19 (1.04–1.35)	1.47 (1.08–1.99)	1.58 (1.13–2.20)
Private vs all others	201 vs 621	30.9 vs 28.7	0.554	1.08 (0.84–1.40)		
Symptoms						
Any symptoms vs no symptoms	729 vs 93	29.9 vs 23.7	0.212	1.03 (0.98–1.09)		
Any discharge vs no discharge ^a	506 vs 316	40.1 vs 11.7	0.001	1.62 (1.48–1.79)	5.05 (3.43–7.43)	6.45 (4.24–9.81)
Dysuria or discharge vs no dysuria or discharge	689 vs 133	31.2 vs 18.8	0.004	1.10 (1.04–1.17)		
History of a known STD contact						
Any STD contact vs no/not stated STD contacts	203 vs 619	31.5 vs 28.4	0.400	1.12 (0.87–1.44)		
Any chlamydia and/or gonorrhea contact vs other or none/not stated contacts ^a	92 vs 730	39.1 vs 27.9	0.026	1.56 (1.05–2.30)	1.66 (1.06–2.60)	2.41 (1.43–4.06)

^aIndicates variables selected for the subsequent model-building process.

Abbreviations: CI, confidence interval; LR, likelihood ratio; OR, odds ratio; STD, sexually transmitted diseases.

Table 4
Performance and Internal Validation of the System for Predicting Laboratory-Confirmed Chlamydial and/or Gonococcal Urethritis

Performance of the System for Predicting a Laboratory-Confirmed Infection ^a		Internal Validation of the System ^b		
Hierarchical Grouping of Risk Levels	LR	Observed Probability of Infection	Predicted Probability of Infection	Optimism
Predicting Presence of an Infection				
4	LR (95% CI)	%	%	Δ (pred-obs)
≥ 3 risk factors	2.84 (2.15–3.77)	57.1	56.1	–1.0
3				
Any 2 risk factors including discharge, chlamydia/ gonorrhea contact, or both	1.64 (1.42–1.89)	38.4	35.0	–3.4
2				
Discharge or chlamydia/ gonorrhea contact	1.27 (1.15–1.41)	23.8	20.3	–3.5
1				
Age < 24 years, private/no insurance, or both	1.16 (1.01–1.33)	12.9	17.7	4.8
0				
No risk factors	Reference	0.0	4.0	4.0
Predicting Absence of an Infection				
4	LR (95% CI)			
No risk factors	25.3 (1.55–4.10)	99.9	98.3	–1.6
3				
Age < 24 years, private/no insurance, or both	5.79 (3.22–10.4)	87.1	92.3	5.2
2				
Discharge or chlamydia/ gonorrhea contact	2.44 (1.4–4.25)	76.2	75.7	–0.5
1				
Any 2 risk factors including discharge, chlamydia/ gonorrhea contact, or both	1.3 (1.07–2.84)	61.6	58.9	–2.7
0				
≥ 3 risk factors	Reference	42.9	41.0	–1.9

^aSystem created using the training data set (n = 613).

^bInternal validation performed using the testing data set (n = 209).

Abbreviations: CI, confidence interval; LR, likelihood ratio.