Evaluating Adolescents in Juvenile Detention Facilities for Urogenital Chlamydial Infection

Costs and Effectiveness of Alternative Interventions

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Context: Adolescents in juvenile detention facilities present a unique opportunity to diagnose and treat sexually transmitted diseases.

Objective: To evaluate the effectiveness and costs of different strategies for the diagnosis and treatment of chlamydial infection in adolescents in juvenile detention.

Design, Setting, and Subjects: For a cohort of adolescents in a juvenile detention facility, sex-specific decision models were developed comparing strategies for diagnosing and treating chlamydial infection. These strategies included not screening, treating everyone, and testing (with leukocyte esterase [LE], ligase chain reaction [LCR], or history and symptoms) followed by treatment for those with positive test results. Two different time horizons were considered: immediate and extended. In the immediate time horizon, we performed a cost-effectiveness analysis looking only at the outcomes associated with treating current infections; in the extended time horizon, we performed a cost-minimization analysis comparing the estimated total costs of diagnosing and treating Chlamydia as well as those associated with complications occurring up to 20 years in the future.

Results: In males, the immediate-time-horizon evaluation revealed that treating on the basis of urine LE results produced the lowest incremental cost-effectiveness ratio ($80 per infection treated). In the extended-time-horizon cost-minimization analysis, treating males on the basis of urine LE results was again found to be the least expensive strategy ($10.11 per person). Two other strategies, confirming urine LE results with LCR ($10.96 per person) and screening with urine LCR ($14.04 per person), were found to be less expensive than not screening ($16.66 per person). In females, the immediate-time-horizon evaluation found that treating on the basis of symptoms and history resulted in treating about half the cases of chlamydial infection and produced the lowest incremental cost-effectiveness ratio ($74 per infection treated). More infections were treated when treatment was based on urine LCR results with only a small increase in the incremental cost per case treated ($95 per infection treated). In the extended-time-horizon cost-minimization analysis, treating all females empirically and treating based on results of urine LCR testing were the least expensive strategies ($18.81 and $18.98 per person, respectively). The results were sensitive to several variables, including prevalence of chlamydial infection, in both males and females.

Conclusions: For adolescent males in juvenile detention facilities, screening with urine LE minimizes the costs associated with diagnosis, treatment, and sequelae of urogenital chlamydial infection. For adolescent females in juvenile detention, empiric treatment and that based on urine LCR test results are the optimal strategies for managing urogenital chlamydial infection.

false-negative and false-positive results. However, the LE test is substantially less costly than LCR testing and has the additional benefit of providing immediate results, which minimizes the risk of losing patients to follow-up. The purpose of this study was to systematically evaluate the trade-offs between different strategies for diagnosis and treatment of chlamydial infection in adolescent males and females in juvenile detention using decision modeling to perform cost-effectiveness and cost-minimization analyses.

**METHODS**

**COHORT**

The models were based on data derived from a cohort study of adolescents in juvenile detention facilities. The study was approved by the institutional review board at Children’s Hospital Medical Center, Cincinnati, Ohio, and the consent of all adolescents participating in the study was obtained. All adolescents aged 13 to 18 years admitted to the Hamilton County, Ohio, juvenile detention center between February 22, 1999, and June 16, 1999, were eligible for the study. Adolescents were excluded if they had been released from the detention center within the previous 10 days or if they had received antibiotics within 2 weeks of evaluation. There were 537 participants in the study, 296 males and 241 females, who generated 601 admissions to the juvenile detention center, of which 592 met the eligibility criteria. A study nurse assessed sexual history, urogenital symptoms (discharge, dysuria, dyspareunia, and abdominal pain), and risk behaviors. All participants provided a urine specimen on which LE (males only) and LCR testing for Chlamydia and gonorrhea were performed. Although participants were instructed to provide a first-catch urine sample, specimen collection was not observed, and not all participants followed the instructions explicitly. Urethral (male) or endocervical (female) specimen studies were offered to participants who tested positive on any of the urine-based screening tests; however, none accepted additional testing. Appropriate treatment was given to all adolescents with positive results on any of the screening tests.

**DECISION ANALYTIC MODEL**

**Model Description**

Using the decision analysis software program DATA, version 3.5 (TreeAge Software Inc, Williamstown, Mass), and adopting a societal perspective, we developed sex-specific decision models comparing various strategies for diagnosing and treating chlamydial infection in a cohort of adolescents in juvenile detention. In males, 5 strategies were considered: (1) do nothing; (2) treat everyone empirically with oral azithromycin (1 g); (3) screen with urine LE and treat those who have a positive test result with azithromycin; (4) screen with urine LCR and treat those who have a positive test result with azithromycin; and (5) test with cervical LCR and treat those who have a positive test result with azithromycin. These strategies were based on those used in the cohort study; other possible strategies such as urine LE testing in females, self-obtained vaginal swabs for LCR testing, or urethral LCR testing were not evaluated. Reported urogenital symptoms were evaluated for use as a screening tool for further diagnostic testing. In males, only 5 of 28 participants who were infected with Chlamydia had symptoms; that is, 82% of infections with Chlamydia in males were asymptomatic, no individual symptom was associated with chlamydial infection, and males with a previous history of an STD were not more likely to be infected with Chlamydia on admission to the detention center. Given the poor association of infection with urogenital symptoms in males, screening on that basis was not evaluated. In females, an affirmative answer on either of 2 questions—history of an STD or presence of current symptoms—was transformed into a variable we called the history and symptom screen. We used this combined screening method because it had a greater sensitivity than either current symptoms or a history of an STD alone.

In each model, the 5 different strategies were compared (Figure). Strategies included not screening, treating everyone, or testing. In strategies that included testing, the results were either positive or negative. If the results were false positive, treatment was given even though there was no infection. If the results were true positive, patients received treatment; if they were false negative, patients received no treatment. Treatment either eradicated chlamydial infection or did not. Infected males who underwent the do-nothing strategy, males with false-negative test results, and males who did not receive...
The prevalence of urogenital chlamydial infection (Table 1) was determined in the cohort study. When all visits were evaluated, 28 (9.1%) of 308 males had urine LCR results positive for chlamydia, and 47 (16.8%) of 280 females had chlamydial infection diagnosed by urine LCR. These rates of chlamydial infection were similar to those reported previously for other youths in detention facilities and were slightly higher than the rates in a hospital-based adolescent clinic in the same city. Nonetheless, the prevalence estimate was widely varied in the sensitivity analyses to determine its effects on the results.

Test Characteristics

Although the diagnosis of chlamydial infection is often made by LCR, urine LCR and cervical LCR are not perfect tests, so we derived their test characteristics from a review of the literature (Table 1). The sensitivity and specificity of urine LE testing in males were derived from the cohort. There were 308 urine specimens evaluated by LE testing in males; 71 (23%) were positive for Chlamydia, and 22% (28% of 59 females) had chlamydial infection diagnosed by urine LCR. These rates of chlamydial infection were similar to those reported previously for other youths in detention facilities and were slightly higher than the rates in a hospital-based adolescent clinic in the same city. Nonetheless, the prevalence estimate was widely varied in the sensitivity analyses to determine its effects on the results.

Model Assumptions

Modeling required several simplifying assumptions. In the male extended-time-horizon model, costs associated with treatment of infection and complications in female partners were included, although costs of partner notification were not included. In the base case for the male model, we assumed that on average each male had 1 current sexual partner; however, we examined other possibilities in the sensitivity analyses (0-10 partners). In the female extended-time-horizon model, only costs related to the current infection and its sequelae in the infected female were considered. In other words, we did not examine the implications of female-to-male transmission in the models. We assumed that appropriate treatment of chlamydial infection prevented PID and that only women who developed PID could develop its sequelae. Additionally, we considered only the costs and consequences of the current infection and did not consider reinfection by untreated partners. We did not consider the possibility of spontaneous resolution of infection without treatment.

MODEL PARAMETERS

Prevalence of Chlamydial Infection

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Test Characteristics

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Other Parameters

Treatment efficacy (0.96) was derived from the literature. Complication rates (PID in 20%, chronic pelvic pain in 18%, infertility in 22%, and ectopic pregnancy in 8% of women with chlamydial infection) were based on a literature review. The male-to-female transmission rate (0.68) was also derived from the literature.

Costs

Treatment, testing, and examination costs were obtained from the cost-accounting system at the pediatric teaching hospital.
that provided the drugs and performed the tests for the adolescent cohort. We estimated the cost to perform a history and symptom screen based on the time it would take a provider to ask the 2 questions. Complication (PID, infertility, chronic pelvic pain, and ectopic pregnancy) costs were derived from the literature.22 In our model, PID costs accounted for both inpatient and outpatient treatment but were incurred only by those who were symptomatic. As in previous analyses,23,24 we assumed that all costs for evaluation and treatment of PID were incurred in year 1, those for pelvic pain in year 3, those for ectopic pregnancy in year 5, and those for infertility in year 10. We did not include costs associated with the time spent seeking care. All costs were converted to 1998 US dollars, and future costs were discounted at a 3% annual rate according to the base case.

SENSITIVITY ANALYSES

To assess the stability of the results, we conducted sensitivity analyses by varying the parameters in the decision model across plausible ranges (Table 1).

| Table 2. Cost Effectiveness of Strategies in the Immediate Time Horizon |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Strategy**                     | **Average Testing and Treatment Cost** | **Treated Infection Rate, % per Infection Treated** | **Incremental Cost-effectiveness, $ per Infection Treated** |
| Male model                       | **Do nothing (strategy 1)**          | **0.00**                         | **0**                            | **Reference**                  |
|                                 | **Urine LE/LCR (strategy 5)**       | **4.86**                         | **0.06 (66)**                     | Dominated†                     |
|                                 | **Urine LE (strategy 3)**           | **5.44**                         | **0.07 (75)**                     | **80**                         |
|                                 | **Urine LCR (strategy 4)**          | **11.45**                        | **0.08 (88)**                     | **501**                         |
|                                 | **Treat everyone (strategy 2)**     | **17.00**                        | **0.09 (100)**                    | **505**                         |
| Female model                     | **Do nothing (strategy 1)**         | **0.00**                         | **0**                            | **Reference**                  |
|                                 | **Symptoms and history (strategy 3)** | **5.88**                      | **0.08 (47)**                     | **74**                         |
|                                 | **Urine LCR (strategy 4)**          | **12.70**                        | **0.15 (90)**                     | **95**                         |
|                                 | **Treat everyone (strategy 2)**     | **17.00**                        | **0.17 (100)**                    | **253**                         |
|                                 | **Cervical LCR (strategy 5)**       | **32.81**                        | **0.16 (93)**                     |                                 |

Abbreviations: LCR, ligase chain reaction; LE, leukocyte esterase.
†Extended dominance, meaning that the next most expensive strategy had a better incremental cost-effectiveness ratio.
‡True dominance, meaning that this strategy is more costly and less effective than at least 1 other strategy.

| Table 3. Cost-Minimization Results |
|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| **Strategy**                     | **Average Testing Cost** | **Average Treatment Cost** | **Average Sequela Cost** | **Average Total Cost** |
| Male model                       | **Urine LE (strategy 3)**      | **1.50**                        | **3.94**                        | **4.67**                        | **10.11**                |
|                                 | **Urine LE/LCR (strategy 5)**  | **3.82**                        | **1.04**                        | **6.10**                        | **10.96**                |
|                                 | **Urine LCR (strategy 4)**     | **10.00**                       | **1.45**                        | **2.59**                        | **14.04**                |
|                                 | **Do nothing (strategy 1)**    | **0.00**                        | **0.00**                        | **16.66**                       | **16.66**                |
|                                 | **Treat everyone (strategy 2)** | **0.00**                      | **17.00**                       | **0.67**                        | **17.67**                |
| Female model                     | **Treat everyone (strategy 2)** | **0.00**                        | **17.00**                       | **1.81**                        | **18.81**                |
|                                 | **Urine LCR (strategy 4)**     | **10.00**                       | **2.70**                        | **6.28**                        | **18.98**                |
|                                 | **Symptoms and history (strategy 3)** | **1.00**                  | **4.88**                        | **24.82**                       | **30.70**                |
|                                 | **Cervical LCR (strategy 5)**  | **30.00**                       | **2.81**                        | **4.72**                        | **37.53**                |
|                                 | **Do nothing (strategy 1)**    | **0.00**                        | **0.00**                        | **45.24**                       | **45.24**                |

Abbreviations: LCR, ligase chain reaction; LE, leukocyte esterase.
*Values are presented in 1998 US dollars per person.

RESULTS

MALES

In the immediate-time-horizon evaluation (Table 2), treating males on the basis of urine LE results (strategy 3) would cost an average of $5.44 per person to screen and treat those with positive results; this strategy produces the lowest incremental cost-effectiveness ratio ($80 per infection treated). Screening with LE and confirming positive LE test results by LCR (strategy 5) had a lower average testing and treatment cost ($4.86 per person) but was eliminated because it had a higher incremental cost-effectiveness ratio than the more effective strategy of screening with LE (ie, strategy 5 was eliminated by extended dominance). More infections would be treated if treatment were based on urine LCR results (strategy 4), but the average testing and treatment cost ($11.45 per person) and the incremental cost per infection treated would increase ($501 per infection treated). Although treating everyone (strategy 2) would cost the most, it would result in the most cases being treated and would have an incremental cost-effectiveness ratio similar to that of treating based on urine LCR results. In the extended-time-horizon cost-minimization analysis, treating all males on the basis of urine LE results would be the least expensive strategy ($10.11 per person) followed by screening with LE and confirming positive LE test results by LCR at $10.96 per person (Table 3).

Sensitivity analyses revealed that the findings were robust for many of the variables examined (Table 4). The prevalence of urogenital chlamydial infection was a key variable. With a prevalence of infection lower than 0.03, the strategy that minimizes cost is to neither test nor treat (strategy 1). If the prevalence of chlamydia is 0.03 to 0.05, the least expensive strategy is to screen with LE and confirm the positive results with LCR; at a preva...
rence higher than 5%, the least costly strategy is to treat on the basis of LE results. The sensitivity analysis also revealed other key variables, including LCR cost, screening test characteristics, and number of sexual partners, to which the results are sensitive (Table 4).

**FEMALES**

In the immediate-time-horizon evaluation (Table 2), treating females on the basis of symptoms and history (strategy 3) costs an average of $5.88 per person, results in treating about half the cases of chlamydial infection, and produces the lowest incremental cost-effectiveness ratio ($74 per infection treated). Although the mean testing and treatment costs are greater ($12.70 per person) when treatment is based on urine LCR results (strategy 4), more infections are treated with this strategy with only a small increase in the incremental cost per infection treated ($95 per infection treated). Empiric treatment (strategy 2) results in the most cases being treated but has a higher cost ($17 per person) and a higher incremental cost-effectiveness ratio compared with other strategies ($253 per infection treated vs $95 or $74 per infection treated). Basing treatment on cervical LCR testing (strategy 5) is more expensive ($32.81 per person) and less effective than empiric treatment. In the extended-time horizon cost-minimization analysis for females, the strategy that minimizes costs for managing chlamydial infection and its complications is to treat everyone empirically, although treatment on the basis of urine LCR results is nearly equivalent (Table 3).

**COMMENT**

Sensitivity analyses showed that several factors affect the relative costs of empiric treatment and urine LCR screening. Higher drug costs, lower prevalence rates of infection, lower LCR costs, higher LCR sensitivity, lower PID rates and costs, lower complication rates and costs, and lower treatment success rates all favor urine LCR screening vs empiric treatment. Sensitivity analyses also revealed that only 2 model parameters, when varied, could yield optimal strategies other than empiric treatment or treatment based on the results of urine LCR screening: prevalence of chlamydial infection and PID rate (Table 4). At a very low prevalence of chlamydial infection (<0.04), the least expensive strategy is to neither test nor treat (strategy 1); between 0.04 and 0.05, screening with history and symptoms minimizes costs; between 0.05 and 0.16, basing treatment on urine LCR results is the least expensive; and at a high prevalence (>0.16), the least expensive strategy is to treat all adolescents in juvenile detention facilities. With all of the ranges tested, cervical LCR testing was never the optimal strategy.

In this study, we sought to determine the optimal strategy for diagnosing and treating urogenital chlamydial infection in adolescents housed in a detention center, through modeling both immediate and future implications of various strategies. Our results remained consistent regardless of the time horizon evaluated.

In males, we found that treating based on urine LE test results was relatively cost-effective and minimized

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**Table 4. Sensitivity Analyses for Cost Minimization**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Range Evaluated (Baseline Value)</th>
<th>Thresholds</th>
<th>Preferred Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male model</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Prevalence rate</td>
<td>0-0.20 (0.09)</td>
<td>&lt;0.03</td>
<td>Do nothing (strategy 1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;0.03 and &lt;0.05</td>
<td>LE/LCR (strategy 5)</td>
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<tr>
<td></td>
<td></td>
<td>&gt;0.05</td>
<td>LE (strategy 3)</td>
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<tr>
<td></td>
<td></td>
<td>&lt;6.00</td>
<td>LCR (strategy 4)</td>
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<tr>
<td></td>
<td></td>
<td>&gt;6.00 and &lt;6.30</td>
<td>LE/LCR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt;6.30</td>
<td>LE</td>
</tr>
<tr>
<td>LCR cost, 1998 US $</td>
<td>5-20 (10)</td>
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<td></td>
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<tr>
<td>LCR sensitivity</td>
<td>0-1 (0.88)</td>
<td>&lt;0.96</td>
<td>LE</td>
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<tr>
<td></td>
<td></td>
<td>&gt;0.96</td>
<td>LE/LCR</td>
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<tr>
<td>LE specificity</td>
<td>0-1 (0.83)</td>
<td>&lt;0.48</td>
<td>LCR</td>
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<td>&gt;0.48 and &lt;0.68</td>
<td>LE/LCR</td>
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<td>&gt;0.68</td>
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<tr>
<td>LE sensitivity</td>
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<td></td>
<td></td>
<td>&gt;0.48</td>
<td>LE</td>
</tr>
<tr>
<td>No. of current sexual partners</td>
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<td>Do nothing</td>
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<tr>
<td></td>
<td></td>
<td>1, 2</td>
<td>LE</td>
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<tr>
<td></td>
<td></td>
<td>≥3</td>
<td>Empiric therapy (strategy 2)</td>
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<tr>
<td>Female model</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Prevalence rate</td>
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<td>Do nothing (strategy 1)</td>
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<td>&gt;0.19</td>
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<tr>
<td>PID rate</td>
<td>0-1 (0.2)</td>
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Abbreviations: LCR, ligase chain reaction; LE, leukocyte esterase; PID, pelvic inflammatory disease.
costs. This finding was robust in sensitivity analyses, and 
only dramatic changes in the model parameters substanc-
tially affected our results. Additionally, our conclusion 
supporting the treatment of adolescent males based on 
LE results is consistent with that of another study in-
volving adolescent males with a high prevalence of chla-
mydial infection.23

Whereas other investigators have suggested that screening asymptomatic women might be more cost-
effective than screening men,26 our results indicate impor-
tant cost implications for screening and treating high-
risk males. Additionally, there are potential benefits of 
addressing STDs in both adolescent males and females 
beyond health issues, such as promoting a better per-
sonal understanding of sexuality26 and potentially in-
creasing responsibility for sexual behaviors. An addi-
tional benefit of the LE screening strategy is the immediacy 
of LE test results, which minimizes the risk of losing pa-
tients to follow-up (or in this scenario, the risk of re-
lease from detention prior to treatment).3 On the other 
hand, syndromic diagnosis based on LE results would lead 
to overtreatment due to false-positive results. Based on 
this analysis, for every 1000 adolescent males in deten-
tion, up to 152 would be given unnecessary treatment 
based on LE results, although some of these false-
positive results would actually represent gonorrhea in-
festions (data not shown). Choosing a reasonable over-
treatment rate depends on several salient issues in addition 
to cost, such as the gravity of infection and its sequelae 
and the adverse sequelae of treating or receiving a false-
positive diagnosis of an STD.27 All of which were beyond 
the scope of this study.

In females, we found that treating based on urine 
LCR results and treating empirically were relatively cost-
effective and minimized costs when future complica-
tions of the infections were considered. The results were 
fairly robust and were sensitive only to substantial changes 
in either of 2 model parameters: the prevalence of chla-
mydial infection and the subsequent rate of PID in in-
adequately treated cases. Of note, screening with cervi-
cal LCR was never the optimal strategy regardless of the 
time horizon. Although treatment based on urine LCR 
results (strategy 4) and empiric treatment (strategy 2) were 
essentially equivalent, LCR testing has advantages com-
pared with empiric treatment. If one treats empirically, 
those who are infected will not be identified and will po-
tentially return to their partners and become reinfected. 
Additionally, empiric treatment would likely contribute 
to drug-resistant bacteria.

This study has several limitations. First, the test char-
acteristics of LE and the symptom and history screen were 
based on a cohort study that used urine LCR as the gold 
standard to identify chlamydial infections; because urine 
LCR testing is not a perfect standard, some test results 
may have been misclassified (thus affecting the test char-
acteristics). However, the sensitivity analyses showed 
that changes in those test characteristics would have mini-
mal effects on the results of this study. In the female de-
cision model, we assumed no transmission (sexually or 
perinatally). Including costs associated with transmis-
sion would have favored strategies that treated more 
people who were infected (ie, empiric treatment). Also, 
other possible screening and treatment strategies such 
as self-obtained vaginal swabs or urethral LCR testing were 
not included in the decision models; rather, this study 
analyzed only strategies examined in the cohort study. 
Finally, noneconomic health outcomes such as quality 
of life were not considered in the decision models. The 
models did not explicitly consider the personal issues in-
volved in receiving a false-positive diagnosis of an STD, 
and did they include changes in future behavior that might 
have occurred after receiving a diagnosis of a specific STD 
(eg, “You have Chlamydia”) rather than a syndromic di-
agnosis (eg, “You have urethritis, an inflammation of the 
penis typically caused by an STD”).

In conclusion, for adolescent males in juvenile deten-
tion facilities, screening with urine LE minimizes costs as-
sociated with the diagnosis, treatment, and sequelae of uro-
genital chlamydial infection. For adolescent females in 
juvenile detention, empiric treatment and treatment based 
on urine LCR test results are the preferred strategies.

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