Original Study

Effectiveness of a Quality Improvement Intervention to Improve Rates of Routine *Chlamydia Trachomatis* Screening in Female Adolescents Seeking Primary Preventive Care

Sarah M. Wood MD, MSHP [1,2,3,4,*], Andrea McGeary MD [2,4], Michele Wilson MD [2], April Taylor MS [2], Brenna Aumaier MPH [2], Danielle Petsis BA [1,3], Kenisha Campbell MD, MPH [1,2,4]

[1] *Craig A Dalsimer Division of Adolescent Medicine, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*
[2] *Department of Pediatrics, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*
[3] *PolicyLab, Children's Hospital of Philadelphia, Philadelphia, Pennsylvania*
[4] *Department of Pediatrics, University of Pennsylvania Perelman School of Medicine, Philadelphia, Pennsylvania*

A B S T R A C T

Study Objective: To determine the impact of a multicomponent quality improvement (QI) intervention on *Chlamydia trachomatis* screening for young women in primary care.
Design: Observational cohort analysis.
Setting: Urban primary care site providing adolescent primary and confidential sexual health care.
Participants: Female adolescents aged 15-19 years.
Interventions: From December 2016 to April 2018, we designed and implemented a multiphase QI intervention. The final intervention, beginning March 2017, consisted of the following at all adolescent well visits: (1) dual registration for well and confidential sexual health encounters; (2) urine collection during the rooming process; and (3) electronic health record-based prompts for chlamydia screening.
Main Outcome Measures: Annual chlamydia screening rates before and after the intervention, with a goal of achieving a relative increase of 10%.
Results: There were 1550 well adolescent encounters from December 2016 to April 2018. The preimplementation chlamydia screening rate among 15- to 19-year-old female adolescents was 312/757 (41.2%) (95% confidence interval, 20.9%-61.5%). Postintervention, this increased to 397/793 (50.0%) (95% confidence interval, 28.6%-71.5%; $P < .001$). The clinic chlamydia test positivity rate remained stable, at 10.7% and 11.1% in the pre- and postintervention periods, respectively. There was no significant change in median visit length in the pre- (79.2 minutes; interquartile range, 59.5-103.3) and postintervention periods (80.4 minutes; interquartile range, 61.7-102.8; $P = .63$).
Conclusion: This practice-based QI intervention resulted in a statistically significant 21% relative increase in annual *Chlamydia trachomatis* screening rates among female adolescents, without lengthening median visit time.
Key Words: Sexually transmitted infection, *Chlamydia trachomatis*, Adolescent, Primary care, Screening

Introduction

Chlamydia trachomatis (CT) is the most common reportable sexually transmitted infection (STI) in the United States, with approximately 1.7 million cases reported in 2017.[1] It is a leading cause of pelvic inflammatory disease,[2] which might lead to tubal-factor infertility, ectopic pregnancy, and chronic pelvic pain.[3] Untreated chlamydial infection might also lead to increased biologic risk of HIV acquisition by increasing genital tract inflammation and altering the circulating immune milieu.[4] Adolescents and young adult women have the highest chlamydia prevalence in the United States—approximately 1 in 20 among sexually active, young women aged 14-24 years.[5]

Despite significant health risks, chlamydia infection is often asymptomatic, leading to delays in diagnosis in the absence of routine screening. Previous studies have shown that asymptomatic, routine screening might lead to reductions in the prevalence of pelvic inflammatory disease.[6,7] Therefore, the Centers for Disease Control and Prevention, the US Preventative Services Task Force, American Academy of Pediatrics, and American College of Obstetrics and Gynecology have issued guidelines recommending routine, annual screening of all sexually active women younger than 25 years of age.[8–10]

Unfortunately, routine chlamydia screening rates remain low in pediatric and adolescent primary care.[11] Data from the National Survey of Family Growth show that only 40% of sexually active US women aged 15-21 years had been screened for chlamydia in the preceding year.[12] Compared with other providers, pediatricians have the lowest rates of screening. The National Ambulatory Medical Care Survey identified that only 0.9% of pediatrician visits for 15- to 21-year-old women had chlamydia testing performed.[12] In a review of primary care records of 1 large pediatric hospital system, only 21% of routine adolescent well visits had a documented sexual history and only 2.6% were tested for CT within the preceding year.[2] Commonly identified barriers to screening are lack of clinician knowledge and self-efficacy, confidentiality concerns, and patient insurance.[13] These findings indicate a critical need for efforts to improve

The authors indicate no conflicts of interest.

* *Address correspondence to:* Sarah M. Wood, MD, MSHP, Craig Dalsimer Division of Adolescent Medicine, Children's Hospital of Philadelphia, 3401 Civic Center Blvd, Philadelphia, PA 19104; Phone: (267) 258-5894
E-mail address: woodsa@email.chop.edu (S.M. Wood).

1083-3188/$ - see front matter
https://doi.org/10.1016/j.jpag.2018.10.004

adherence to chlamydia screening guidelines in pediatric and adolescent primary care.

Previous quality improvement (QI) interventions aiming to improve chlamydia screening have shown mixed efficacy for interventions focusing on provider education and increasing access to emergency department or expedited outpatient sexual health services.[14–18] Universal procurement of urine specimens before the provider visit has been shown to increase screening rates across several studies.[19–21] However, few QI interventions have been specifically linked to the pediatric primary care context, particularly in high-risk chlamydia prevalence areas. In addition, although there is some evidence that QI interventions might improve chlamydia case detection,[22] the effect of improving adherence to screening guidelines on chlamydia prevalence rates remains unknown.

The primary goal of our intervention was to increase CT screening rates for young women receiving well-adolescent care in a high chlamydia prevalence region. Secondary goals included identifying the effect of the intervention on chlamydia test positivity rates, and identifying the effect of the intervention on visit length.

Materials and Methods

Setting

The intervention occurred at an urban, pediatric and adolescent primary care clinic located in West Philadelphia. The clinic is affiliated with a nearby academic tertiary care hospital within a robust primary care network. The clinic has approximately 30,000 visits per year, and 50% of well-visit attendees are adolescents. Eighty percent of patients have Medicaid insurance, and the patient mix is overwhelmingly African American. Clinical services are provided by a multidisciplinary team consisting of medical assistants, nurses, certified registered nurse practitioners (CRNPs), and physicians. At project initiation, the clinic had 12 attending physicians and 2 CRNPs.

In addition to general pediatric and adolescent care, the clinic provides confidential adolescent sexual health services through a Title X grant-funded family planning (FP) program. Adolescents can register for general medical services and/or FP services when scheduling or at visit registration. In FP encounters, the electronic health record (EHR) contains additional privacy protections and no bills are sent to the home.

Participants

The intervention target population was 15- to 19-year-old female adolescents attending annual primary care visits during the study period of January 2016 to April 2018. The preintervention period spanned from January 2016 to February 2017. The postintervention period was from March 2017 to April 2018.

All clinic multidisciplinary staff, including nurses, registrars, and medical assistants were involved in the initial intervention design meetings and implementation process. The core QI implementation team included the clinic medical director (A.M.), 1 adolescent medicine physician from the clinical site (M.W.), an attending physician (K.C.), and a third-year fellow (S.M.W.) from the primary institution's Division of Adolescent Medicine. Consultative support was provided through the institution's Office of Clinical Quality Improvement. All clinic providers and staff were eligible to participate in the intervention and participating physicians could receive Part 4 Maintenance of Certification (MOC) credit from the American Board of Pediatrics.

In accordance with institutional standards, this study was considered QI rather than research, and was deemed exempt from Institutional Review Board oversight.

Intervention Development

We used an existing institutional improvement framework (Supplemental Fig. 1) derived from Lean Six Sigma methodology,[23] including the phases define, diagnose, test, implement, and sustain to develop a multicomponent QI intervention to improve chlamydia screening among 15- to 19-year-old female adolescents. A pilot intervention at a separate West Philadelphia clinic had shown short-term gains in screening rates, and served as the model for this intervention.[24] Using the specific, measureable, achievable, relevant, and time-bound (SMART) criteria for intervention goal-setting,[25] we developed an intervention objective that was specific, measurable, achievable, relevant, and time-bound: to achieve a relative 10% increase in the proportion of 15- to 19-year-old females screened for chlamydia infection at or within 1 year of their annual well-visit by 10% over a 1-year period. The relative increase of 10% was chosen on the basis of feasibility data from a partner clinic showing a similar relative increase in screening after a pilot QI intervention.[24] We used all female adolescents receiving well care as the denominator, rather than those with documented history of sexual activity, because sexual histories are frequently incomplete or missing in the pediatric EHR, and strategies for determining sexual activity from additional features of the EHR might still lead to underestimation of sexual activity.[26] We used ecologic data on sexual activity from the Youth Risk Behavior Surveillance in the Philadelphia area, showing a 57% rate of sexual activity of African American high school girls,[27] to identify a ceiling threshold testing rate after which increases in screening in female adolescents might no longer be efficacious.

Phase 1: Baseline Assessment

In the first phase of intervention development (January 2016), confidential surveys were administered to site clinicians to identify gaps in knowledge and self-efficacy around chlamydia screening. Questions included knowledge of screening guidelines and regional chlamydia prevalence, and assessed self-efficacy in confidential sexual history-taking and discussing positive results. Answers were provided on a 5-point Likert scale ranging from "strongly agree" to "strongly disagree" (Fig. 1).

Phase II: Staff Education

In the second phase, the team held a multidisciplinary, staff education session to improve knowledge and cultivate

Responses: Strongly Disagree; Disagree; Neither Agree nor Disagree; Agree; Strongly Agree

1) The prevalence rate of chlamydia in West Philadelphia among adolescents is high.
2) I am confident in my knowledge about the AAP screening guidelines for chlamydia in adolescents.
3) I am confident in my ability to take an accurate sexual history in my adolescent patients.
4) I am comfortable in asking the parent or guardian to leave the room in order to take a confidential sexual history in my adolescent patients.
5) I am confident in my ability to document a confidential sexual history in EPIC for my adolescent patients.
6) I am confident in my ability to use a family planning encounter, if needed, for my adolescent patient.
7) I am confident that I can order the correct chlamydia lab test for my adolescent patient based on his/her insurance.
8) I am comfortable delivering positive chlamydia results to my adolescent patient in person or by phone.
9) I am comfortable counseling a patient with a positive chlamydia result.
10) I have a comprehensive understanding about the confidentiality laws for adolescent patients regarding STI testing, notification, and treatment.

Fig. 1. Preintervention provider questionnaire. AAP, American Academy of Pediatrics; STI, sexually transmitted infection.

a culture of change among staff, including clinicians, nurses, medical assistants, and patient services representatives. The session content included screening guidelines, local prevalence, complications associated with chlamydia infection, current clinic screening rates, and potential targets for improving screening rates.

Phase III: Process Mapping

In the third phase, with support from one of the hospital's QI advisors, the multidisciplinary staff completed a process mapping activity to detail the clinic's preintervention chlamydia screening practice and identify areas for intervention. The preintervention screening process and targeted areas for improvement (in dark gray) are shown in Figure 2. Before the intervention, urine collection for chlamydia nucleic acid amplification testing (NAAT) occurred after confidential sexual history-taking.

Phase IV: Intervention Model Optimization

In the final phase, the team developed the model for intervention. A protocol was developed for universal urine collection for adolescent patients at the time of vital signs and before provider interview. Although the intervention target was 15- to 19-year-old female adolescents, the urine collection protocol was designed for all adolescents to facilitate fidelity. The final intervention, deployed in March 2017, consisted of the following components: (1) dual registration of all adolescents for well and FP encounters to streamline confidential STI test-ordering by advanced practice providers and nurses; (2) medical assistants providing labeled specimen cups to all adolescents before history and physical exam; (3) clinic room signage informing families that urine would be routinely obtained from all adolescents; (4) EHR-based prompts for ordering of chlamydia testing on the basis of confidential sexual history-taking (Fig. 3).

Study of the Intervention

To capture intervention effect on a near real-time basis, we developed a clinical application using a commercial business intelligence platform (Qlik, Radnor, PA), which continually captured chlamydia test ordering from the data warehouse that captures our EHR data (Epic Systems, Verona, WI). The application displayed STI test-ordering in electronic run charts which were made available to the QI team throughout the process. Data were reviewed weekly by the project leader, and at bimonthly meetings of the study team. In these meetings, data were reviewed to make iterative revisions to the intervention using the Plan-Do-Study-Act cycle process. Run charts showing current screening rates were sent to the entire clinic team on a monthly to bimonthly basis to encourage sustained behavior change.

Measures

Our primary outcome metric was the proportion of 15- to 19-year-old female adolescents attending annual well-visits who received chlamydia testing at or within 1 year before their well visit, with a goal of achieving a relative increase of 10%. Well-visit encounters were identified using International Classification of Diseases codes corresponding to annual pediatric preventative visits. Receipt of chlamydia testing was assessed via ordered and completed testing within the 365 calendar days before all well-visits in the observation period. Our baseline measurement period was

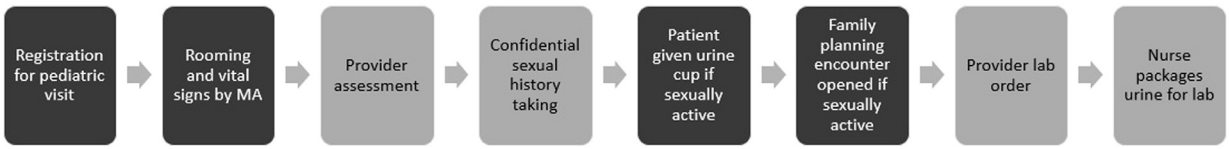

Fig. 2. Preintervention chlamydia screening process. MA, medical assistant.

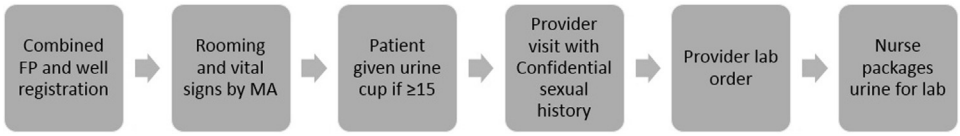

Fig. 3. Intervention chlamydia screening process. FP, family planning; MA, medical assistant.

January 2016 through February 2017 (preintervention). The postintervention measurement period was March 2017 through April 2018 to capture the a priori defined 12-month period to reach goal and an additional 2 months of follow-up to assess continued fidelity to the intervention.

Secondary outcome measures included the chlamydia test positivity rates postintervention. Because some patients received multiple chlamydia screenings in a year and/or had multiple episodes of chlamydia, this was calculated on the case, rather than the individual level (eg, cases identified/screening assays sent), with a different denominator than detailed in the screening outcome metric. Balancing measures included staff participation in the QI process; registration time, defined as time from patient check-in to first vital signs; and visit length, defined as the time of patient registration to the time to printing of the visit summary.

Statistical Analyses

Results of the baseline provider survey and demographic characteristics of clinic patients were summarized via descriptive statistics. The time series analysis of pre- and postintervention screening rates were assessed via the p-chart, a type of statistical process control chart using the binomial distribution, with the following criterion used to determine positive special cause variation due to changes in the process: 8 or more values above the baseline mean.[28] Additionally, the equality of the pre- and postintervention screening rates were assessed using the Pearson χ^2 test. As balancing measures, we compared the time from visit registration to visit vital signs, as well as total visit length for the pre- and postintervention periods using Wilcoxon rank sum testing because the data were non-normally distributed. Statistical significance was set at $P < .05$.

Results

Patient Characteristics

Between January 2016 and April 2018, there were 1550 well-visit encounters among 1190 unique female adolescents. The overall descriptive characteristics of the clinic sample are shown in Table 1. The patient population during the observation period was overwhelmingly African American, with most patients having Medicaid insurance.

Provider Knowledge and Participation

Before the intervention, n = 12/14 (85%) of providers completed the screening knowledge survey. Overall, median scores fell in the "strongly agree" category for questions regarding local chlamydia prevalence, self-efficacy around confidential sexual history-taking, electronic health record documentation, lab ordering, and delivery of results suggesting a high level of competency in these domains. The only item for which the median score fell below the "strongly agree" category was the question assessing knowledge regarding chlamydia screening guidelines for adolescents, where the median score was in the "agree" category. With respect to clinician participation, 9/12 (75%) of attending physicians claimed MOC credit for participation. Although the clinic CRNPs (n = 2) could not obtain MOC credit, which is available to physicians only, both attended and participated in QI meetings, for a total provider participation rate of 11/14 (78%).

Intervention Evolution

In QI core team meetings, we reviewed barriers and facilitators to implementation through the Plan-Do-Study-Act process to refine the intervention. For example, we identified that specimens were not consistently packaged for laboratory transport after ordering. This was ameliorated by creating a work flow in which laboratory technologists ensured that nurses had appropriately packaged specimens for all patients for whom urine testing had been ordered. In addition, patients were not consistently being registered for well and FP encounters. To facilitate rapid dual registration, a system was developed in which charts were flagged within the EHR to alert patient service representatives that an FP encounter was needed.

Chlamydia Screening Rates

For the preintervention period, the mean annual chlamydia screening rate among 15- to 19-year-old female adolescents presenting for well-visits was 41.2% (95% confidence interval, 20.9%-61.5%), representing 312

Table 1
Characteristics of Patient Encounters (n = 1550)

Characteristic	n (%) or Mean (SD)
Patient age	16.6 (1.29)
Patient race	
African American	1472 (95.0%)
Caucasian	14 (0.9%)
Asian	8 (0.5%)
Other	56 (3.6%)
Hispanic ethnicity	36 (2.3%)
Provider type at visit	
Adolescent medicine attending	353 (22.8%)
General pediatrics attending	564 (36.4%)
General pediatrics resident	207 (13.4%)
CRNP	423 (27.3%)
Nurse only	3 (0.2%)
Insurance coverage	
Government	933 (64.1%)
Commercial	457 (29.5%)
None	100 (6.5%)

CRNP, certified registered nurse practitioner.

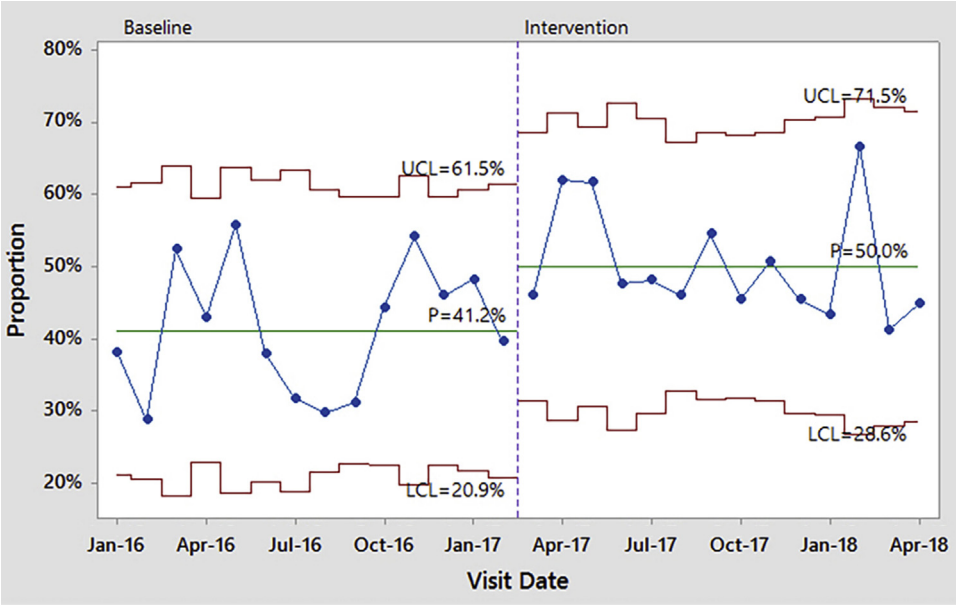

Fig. 4. Proportion of 15- to 19-year-old women receiving chlamydia testing. LCL, lower confidence limit; UCL, upper confidence limit.

screenings among 757 visits. Postimplementation, there was a statistically significant increase in screening rate to 50.0% (95% confidence interval, 28.6%-71.5%), representing 397 screenings among 793 visits (P = .001; Fig. 4). This represents a relative 21% increase from the baseline screening rate, exceeding the established goal of a 10% increase in screening of the baseline 41.2% rate. Although rates overall improved, increased variability in screening rates was noted in the summer and early fall, before and after the intervention. In review by the QI leadership team, it was determined that this was likely because of provider vacations and the influx of new general pediatric residents into the clinic, which might have increased competing time and training demands on the clinic's attending physicians. Despite this variation, the statistical process control methodology showed 12 values above the baseline mean in the postintervention period, confirming that the change in chlamydia screening rates before and after the intervention was not because of "normal" variation but because of a deliberate or planned change.[28]

Chlamydia Test Positivity

The proportion of positive chlamydia NAATs in the preintervention period among 15- to 19-year-old female adolescents receiving chlamydia screening at the clinic was 10.7% (n = 144 cases and 1350 screenings). The chlamydia positivity rate after the intervention remained relatively stable, at 11.1% (146 cases and 14320 screenings).

Registration Time and Visit Length

Registration data were available for 1419/1550 (92%) of the patient visits. The median time from arrival at the registration desk to first vital signs was 8 minutes (interquartile range, 4-16) before and after the intervention. Visit length data were available for 1503/1550 (97%) of visits. The preintervention period visit length was 79.2 minutes (interquartile range, 59.5-103.3). The postintervention visit length was 80.4 minutes (interquartile range, 61.7-102.8). There was no statistically significant difference in registration time (P = .59) or visit length (P = .63) before and after the intervention.

Discussion

This practice-based QI intervention to improve chlamydia screening in adolescent young women resulted in a statistically significant 21% relative increase in routine chlamydia screening in a high chlamydia prevalence clinic. Our data show that practice-based QI interventions can be an important tool in improving chlamydia screening in populations at highest risk of chlamydia infection.

A central component of our intervention was universal urine collection before clinician history and physical. In a meta-analyses by Taylor et al., automatic collection of urine specimens as part of routine visits was identified as a moderately to highly effective and low-cost intervention to improve STI screening rates.[21] Our data reaffirm this finding, and provide additional support on how to implement this change in routine pediatric care. Other strengths of our intervention, and likely contributors to a higher than anticipated level of success, included the involvement and engagement of all levels of multidisciplinary clinical staff, the use of process mapping to identify site-specific barriers to facilitators of screening before intervention development, and the use of practice feedback to motivate ongoing behavior change. Provider education has been a mainstay of previous QI interventions to improve STI screening.[18,29] However, the data are mixed on the efficacy for interventions using provider education as the sole or central component.[15,21] In addition to provider education, we used several strategies to enhance provider engagement, including providing MOC credit and sending screening run

charts to the clinic staff to motivate ongoing behavior change. The strategy of providing continuing education credit has been demonstrated to improve human papillomavirus vaccination coverage in our network as well, and should be considered in future QI interventons.[30]

Our results are consistent with a moderate intervention effect per the criteria identified by Taylor et al. in their meta-analysis of STI screening interventions,[21] and are similar to the effect sizes identified in other recent screening interventions in the pediatric and adolescent clinical setting. We identified challenges in implementation largely related to role definition and work flow. No intervention is without potential strategic costs, and the gains in screening achieved in this high-risk population likely offset the challenges in changing work flow. Importantly, we found no statistically significant difference in length of visit time in the pre- and postintervention periods, suggesting that there was no loss in clinically efficiency as a result of the intervention.

Our findings have strengths and limitations. The intervention site was a combined primary care and FP clinic with Title X funding, which allowed for confidential service delivery. Clinical sites without integrated sexual health services might face more extensive challenges to confidentiality management. However, many of the components of our intervention, including universal urine collection, provider education, and EHR optimization can be tailored to general pediatric practices. With respect to confidentiality, because most Medicaid plans do not send out explanation of benefits statements that could inadvertently disclose testing, in many settings confidential service delivery is possible even without Title X funding. The intervention site serves a population that is largely homogenous with respect to race and socioeconomic status. However, clinic patients, who are primarily African American and low-income, represent the population most disproportionally affected by chlamydia in the United States. This is highlighted by the fact that in Philadelphia, the prevalence of chlamydia among adolescent girls ages 15-19 years is approximately 7%[31]; our test positivity rate was 11%. Thus, our data show that our intervention model can work in high-risk settings, where the effect might be greatest. Our study design did not include a control site, because of the fact that similar chlamydia screening QI work had been previously attempted at the network clinic with the closest age, race, and payer patient match. Last, our data did not allow us to determine whether individual patients were sexually active and instead used an ecologic approach using background rates of sexual activity in the local population. Because rates of sexual activity among female adolescents did not increase nationally during the study period, we would not expect an increase in sexually active young women presenting to care at the clinic to lead to our results.[27]

The lack of standardized tools for identifying sexual activity within electronic health records remains an ongoing challenge in adolescent health services research. A recent study by Tao et al. showed substantial discrepancies in estimates of sexual activity in young women between self-report, Medicaid claims data, and Healthcare Effectiveness Data and Information Set (HEDIS) definitions.[32] Because sexual history information was not included in our data tracking process, we could not determine whether absence of screening was because of provider nonadherence to guidelines, deferral of testing in non-sexually active patients, cancelled tests, screening at another clinical site, or patient refusal. However, our final screening rate of 50% is still below the likely proportion of sexually active young women seen at the clinical site, because of the 57% rate of sexual activity of African American high school-aged female adolescents in Philadelphia,[33] suggesting that lack of sexual activity was not the sole reason for nonscreening. In the future, health systems might consider requiring documentation in the EHR for reasons for not performing guideline-based testing to systematically identify reasons for non-screening in key populations.

In conclusion, we used practice-based universal urine collection, provider education and feedback, and EHR-based utilities to successfully improve chlamydia screening rates within a high chlamydia prevalence pediatric primary care clinic. Our intervention development and implementation processes were designed to be replicable, and might serve as a template for diffusion of the intervention to additional pediatric and adolescent care sites.

Acknowledgments

Funding for the investigator's effort was provided through National Institute of Mental Health F32 MH111341 (PI: Wood) and the Children's Hospital of Philadelphia Research Institute K23 Readiness Award (PI: Wood).

The authors acknowledge the efforts of Maura Powell, The Office of Clinical Quality Improvement, Priya Dhar, MD, Caroline Salas-Humara, MD, and the clinical care providers and staff at the Children's Hospital of Philadelphia Care Network Cobbs Creek Care Primary Care Clinic.

Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jpag.2018.10.004.

References

1. Centers for Disease Control and Prevention: New CDC analysis shows steep and sustained increases in STDs in recent years. Atlanta, U.S. Department of Health and Human Services, 2017
2. Centers for Disease Control and Prevention: Chlamydia. Atlanta, U.S. Department of Health and Human Services, 2017
3. Wiesenfeld HC: Screening for Chlamydia trachomatis infections in women. N Engl J Med 2017; 376:765
4. Johnson LF, Lewis DA: The effect of genital tract infections on HIV-1 shedding in the genital tract: a systematic review and meta-analysis. Sex Transm Dis 2008; 35:946
5. Centers for Disease Control and Prevention: Chlamydia - CDC Fact Sheet (Detailed). Atlanta, U.S. Department of Health and Human Services, 2016
6. Owusu-Edusei K Jr, Bohm MK, Chesson HW, et al: Chlamydia screening and pelvic inflammatory disease: insights from exploratory time-series analyses. Am J Prev Med 2010; 38:652
7. Scholes D, Stergachis A, Heidrich FE, et al: Prevention of pelvic inflammatory disease by screening for cervical chlamydial infection. N Engl J Med 1996; 334:1362
8. Carmine L, Castillo M, Fisher M: Testing and treatment for sexually transmitted infections in adolescents–what's new? J Pediatr Adolesc Gynecol 2014; 27:50
9. U.S. Preventative Services Task Force: Final Recommendation Statement: Chlamydia and Gonorrhea: Screening. Available: https://www.uspreventiveservicestaskforce.org/Page/Document/RecommendationStatementFinal/chlamydia-and-gonorrhea-screening. Accessed November 15, 2018.
10. American College of Obstetrics and Gynecology: Chlamydia, Gonorrhea, and Syphilis. Available: https://www.acog.org/Patients/FAQs/Chlamydia-Gonorrhea-and-Syphilis. Accessed November 15, 2018.

11. Goyal MK, Teach SJ, Badolato GM, et al: Universal screening for sexually transmitted infections among asymptomatic adolescents in an urban emergency department: high acceptance but low prevalence of infection. J Pediatr 2016; 171:128
12. Hoover KW, Leichliter JS, Torrone EA, et al: Chlamydia screening among females aged 15-21 years–multiple data sources, United States, 1999-2010. MMWR Suppl 2014; 63:80
13. Mark H, Irwin K, Sternberg M, et al: Providers' perceived barriers to sexually transmitted disease care in 2 large health maintenance organizations. Sex Transm Dis 2008; 35:184
14. DiVasta AD, Trudell EK, Francis M, et al: Practice-based quality improvement collaborative to increase chlamydia screening in young women. Pediatrics 2016; 137:e20151082
15. McKee MD, Alderman E, York DV, et al: A learning collaborative approach to improve primary care STI screening. Clin Pediatr (Phila) 2018; 57:895
16. Kettinger LD: A practice improvement intervention increases chlamydia screening among young women at a women's health practice. J Obstet Gynecol Neonatal Nurs 2013; 42:81
17. Rukh S, Khurana R, Mickey T, et al: Chlamydia and gonorrhea diagnosis, treatment, personnel cost savings, and service delivery improvements after the implementation of express sexually transmitted disease testing in Maricopa County, Arizona. Sex Transm Dis 2014; 41:74
18. Tebb KP, Wibbelsman C, Neuhaus JM, et al: Screening for asymptomatic chlamydia infections among sexually active adolescent girls during pediatric urgent care. Arch Pediatr Adolesc Med 2009; 163:559
19. Guy RJ, Ali H, Liu B, et al: Efficacy of interventions to increase the uptake of chlamydia screening in primary care: a systematic review. BMC Infect Dis 2011; 11:211
20. Shafer MA, Tebb KP, Pantell RH, et al: Effect of a clinical practice improvement intervention on chlamydial screening among adolescent girls. JAMA 2002; 288:2846
21. Taylor MM, Frasure-Williams J, Burnett P, et al: Interventions to improve sexually transmitted disease screening in clinic-based settings. Sex Transm Dis 2016; 43(2 suppl 1):S28
22. Kalwij S, French S, Mugezi R, et al: Using educational outreach and a financial incentive to increase general practices' contribution to chlamydia screening in South-East London 2003-2011. BMC Public Health 2012; 12:802
23. Barone S, Franco ELIn: Six Sigma methodology. Statistical and managerial techniques for Six Sigma methodology: theory and application. John Wiley & Sons, West Sussex, United Kingdom, 2012
24. Dhar CP, Salas-Humara C, Campbell K: Improving CT screening rates at an urban primary care clinic. Presented at the Society for Adolescent Health and Medicine Annual Meeting 2016, Washington, DC.
25. Centers for Disease Control and Prevention: Public Health Information Network Communities of Practice: Develop SMART Objectives. Available: https://www.cdc.gov/phcommunities/resourcekit/evaluate/smart_objectives.html. Accessed May 17, 2018.
26. Berlan ED, Ireland AM, Morton S, et al: Variations in measurement of sexual activity based on EHR definitions. Pediatrics 2014; 133:e1305
27. Kann L, McManus T, Harris WA, et al: Youth Risk Behavior Surveillance — United States, 2017. MMWR Surveill Summ 2018; 67:1
28. Benneyan JC, Lloyd RC, Plsek PE: Statistical process control as a tool for research and health care improvement. Qual Saf Health Care 2003; 12:458
29. McLean HQ, VanWormer JJ, Chow BD, et al: Improving human papillomavirus vaccine use in an integrated health system: impact of a provider and staff intervention. J Adolesc Health 2017; 61:252
30. Fiks AG, Luan X, Mayne SL: Improving HPV vaccination rates using maintenance-of-certification requirements. Pediatrics 2016; 137:e20150675
31. Philadelphia Department of Public Health: Rate of Chalmydia per 100,000 Population by Age and Gender: Philadelphia, 2016. Philadelphia, PA, Philadelphia Department of Public Health, 2016
32. Tao G, Walsh CM, Anderson LA, et al: Understanding sexual activity defined in the HEDIS measure of screening young women for Chlamydia trachomatis. Jt Comm J Qual Improv 2002; 28:435
33. Centers for Disease Control and Prevention: High School YRBS: Philadelphia, PA 2015 Results 2015. Available: https://nccd.cdc.gov/youthonline/App/Results.aspx?LID=PH. Accessed November 19, 2018.