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EVOLUTION OF AN ELECTRONIC HEALTH RECORD BASED–HUMAN IMMUNODEFICIENCY VIRUS (HIV) SCREENING PROGRAM IN AN URBAN EMERGENCY DEPARTMENT FOR DIAGNOSING ACUTE AND CHRONIC HIV INFECTION

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☐ **Abstract—Background: Since 2006, Centers for Disease Control and Prevention guidelines recommend routine opt-out human immunodeficiency virus (HIV) testing among sexually active 13- to 64-year-olds. Earlier diagnosis and treatment of HIV infection reduces morbidity and mortality and can limit transmission to others. Objective: Our aim was to increase HIV testing, diagnosis, and linkage to care in the emergency department (ED). Methods: Beginning May 4, 2015, we utilized our electronic health record (EHR) to enhance HIV testing in patients seen in the Rush University Medical Center emergency department in Chicago, IL, who were 13–64 years of age, did not have HIV listed on their problem list, and did not have an HIV antigen/antibody (Ag/Ab) test in the EHR within the past rolling 12-month period. Strategies included use of a "Best Practice Advisory" and later auto-order screening linked to a complete blood count order. Results: Our baseline HIV test rate was 2.5% of the target population by age (average of 93 tests per month). From May 4, 2015 to January 31, 2019, 137,749 patients of 240,091 ED visits met our test criteria and 23,588 (17.1% of the target population) HIV Ag/Ab tests were performed, resulting in 164 positive tests. We identified 18 acute seroconverters, 51 new chronically infected persons, and 95 known infected, many of who had not disclosed their status. Our positive test rate was 0.70%, which dropped to 0.29% if only newly diagnosed individuals were counted. Conclusions: EHR enhancements in a large urban ED identifies both newly diagnosed acute and chronically HIV-infected persons. Identification of previously diagnosed patients offers an opportunity to relink them to care.** © 2019 Elsevier Inc. All rights reserved.

☐ **Keywords—HIV diagnosis; acute HIV; linkage to care**

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Data Statement: The number of patients seen in the ED, the number of HIV Ag/Ab tests ordered/performed and the HIV Ag/Ab laboratory test results were collected from the Rush University Medical Center's clinical data warehouse. The HIV Ag/Ab laboratory tests were appropriately identified using EMR-specific laboratory codes and the usage of the BPA was tracked by using appropriate EMR-specific alert identifiers to correctly include and track all appropriate patient records. A standardized data abstraction instrument was used to collect patient demographics, reason for ED visit and need for admission, HIV transmission risk(s), laboratory test results, details of linkage to care, and use of antiretroviral therapy.

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INTRODUCTION

Since 2006, Centers for Disease Control and Prevention guidelines have recommended voluntary human immunodeficiency virus (HIV) screening as part of routine medical care in all health care settings for all patients aged 13–64 years unless the local prevalence of undiagnosed HIV infection has been documented to be <0.1% (1). In addition, persons at high-risk for HIV are recommended to be screened at least annually. The 2013 U.S. Preventive Services Task Force recommendation statement similarly recommended clinicians screen adolescents and adults aged 15–65 years for HIV infection and younger adolescents and older adults at increased risk for infection, and pregnant women (2). At year-end 2016 in the United States, an estimated 1,140,400 persons aged ≥ 13 years were living with HIV, of which 162,500 (14.2%) were undiagnosed (3). Earlier diagnosis and treatment of HIV infection reduces morbidity and mortality and can limit transmission to others (4–8).

Rush University Medical Center is a 700-bed hospital/health system located in the west side of Chicago. This is a high-prevalence area for HIV infection where, in 2017, an estimated 1603/100,000 persons were living with HIV infection in our ZIP code (9,10). Recognizing patients from the surrounding area were receiving care in our emergency department (ED), we made modifications to our electronic health record (EHR) to improve the testing and diagnosis of previously undiagnosed HIV-infected persons in our ED. Such strategies have previously been shown to be effective and are necessary to fulfill the 2018 Illinois Getting to Zero campaign and the 2019 Ending the HIV Epidemic: A Plan for America initiative (11–14).

METHODS

The first iteration of our non–risk-based ED HIV screening program utilized a hard-stop Best Practice Advisory (BPA) within our Epic EHR. Beginning on May 4, 2015, the BPA would fire for any patient seen in our ED who was 13–64 years of age, did not have HIV listed on their problem list, and did not have an HIV Ag/Ab test in the EHR within the past 12 months when any order was placed. Providers were required to select "order" or "do not order" an HIV Ag/Ab test to close the BPA. They were instructed to state, "we have an HIV screening program in the ED and I am ordering one today unless you decline." If "do not order" was selected, we asked for a reason, but did not require the provider to select one of the following: "did not ask patient," "patient is HIV positive," "can't verbally consent," "patient declines blood draw," "patient doesn't feel at risk," or "patient declines for other reason." Providers were instructed to tell patients that "we routinely test for HIV in our emergency department unless you choose to decline." ED providers were notified ahead of the launch via in-person meetings and an e-mail newsflash. Notices were posted prominently in examination rooms for patient viewing.

We utilized the Abbott Architect fourth-generation HIV Ag/Ab assay, which was performed in real time. Positive results were confirmed with the Multispot HIV-1/2 Ab test within 24 h. All positive HIV Ag/Ab tests were called by the laboratory to a cell phone managed by a single nurse practitioner in the ED utilized for HIV test results only. The result appeared simultaneously in the patient's EHR. Personnel in Infectious Diseases (ID) were then notified and assumed responsibility for informing the patient and arranging follow-up. In July 2018, we created an automated Epic result pool that sent any HIV-positive result to the identifiers (ID) team. ED providers had the option to review test results with patients if they chose but were not mandated to as the confirmatory test was often pending at the time of ED discharge. Patients tested and discharged from the ED received an After Visit Summary that provided them with information about HIV testing and gave them the cell phone number of our nurse practitioner to call for results.

Patients were categorized into five groups. In cases where acute HIV was a clinical consideration, patients were notified of the possibility of acute HIV and a quantitative HIV RNA reverse transcription polymerase chain reaction (RT-PCR) was obtained. Acute seroconvertors were defined as those with a positive HIV Ag/Ag, negative Multispot Ab, and a detectable quantitative HIV RNA RT-PCR. Persons with a positive HIV Ag/Ab and negative Multispot without signs of acute HIV infection were offered the option of a quantitative RNA RT-PCR. A false-positive HIV Ag/Ab was defined as a positive HIV Ag/Ab, negative confirmatory Multispot HIV-1/2 Ab, and a quantitative HIV RNA < 40 cp/mL, negative repeat testing, or no symptoms suggestive of acute HIV, and a low signal to cutoff ratio (S/CO) on the positive HIV Ag/Ab test. Those with both positive HIV Ag/Ab and Multispot Ab were considered to have chronic HIV infection and further categorized as a new diagnosis or previous diagnosis based on laboratory, chart review, or patient self-report. The fifth group included patients with unresolved categorization, as we were unable to obtain follow-up testing to definitively classify them as an acute HIV infection vs. false-positive result.

Individuals were counseled on a confirmed positive test either in person or through telephone conversations. All positive patients were reported to the Chicago Department of Public Health (CDPH) as required by law. Those that did not respond to three telephone calls to discuss their tests results were reported to CDPH in real time

with a request to have their field team seek out the patient. In addition, both a standard letter and a certified letter were mailed to inform the patient that important test results from their ED visit needed to be reviewed with them and provided them with a direct ID physician telephone number to call.

Hard-stop BPA's were eliminated by Rush University Medical Center on October 4, 2016 and our alert moved to a passive section of the provider's workspace. This resulted in a marked decline in test rates and development of alternate screening approaches.

Various strategies to improve test rates but minimize disruption of standard ED work flow were considered. On June 28, 2017, we moved to a test algorithm in which persons who had a complete blood count (CBC) ordered would have an HIV Ag/Ab test auto-ordered if they were 13–64 years of age, did not have HIV on their problem list, and did not have an HIV Ag/Ab test in our EHR within the past 12 months. The nurse drawing the blood was instructed to state, "we have an HIV screening program in the ED and I am drawing one today unless you decline." This was also an opportunity for the patient to ask questions. The nurse was instructed to cancel the test if the patient declined or was unable to respond. We decided to link the HIV screening order to a CBC order, as this is the most frequently ordered blood test in the ED and we wanted to maximize the ability to diagnose acute HIV seroconversion.

Study variables and data sources

The number of patients seen in the ED, the number of HIV Ag/Ab tests ordered/performed, and the HIV Ag/Ab laboratory test results were collected from the Rush University Medical Center's clinical data warehouse. The HIV Ag/Ab laboratory tests were appropriately identified using electronic medical record (EMR)–specific laboratory codes and use of the BPA was tracked by using appropriate EMR-specific alert IDs to correctly include and track all appropriate patient records. A standardized data abstraction instrument was used to collect patient demographics, reason for ED visit and need for admission, HIV transmission risk(s), laboratory test results, details of linkage to care, and use of antiretroviral therapy. Linkage to care was defined as completing an outpatient visit with an HIV provider. The use of any and all Protected Health Information was determined to be exempt by the Institutional Review Board of Rush University Medical Center.

Data analysis

Microsoft Excel was used to tabulate data, determine medians, and calculate percentages.

RESULTS

In 2013, prior to implementation of our HIV screening program, 61,925 unique patients were seen in our ED. Of the 44,076 patients who were in the target age group 1117 underwent HIV testing resulting in a mean of 93 tests per month and a test rate of 2.5% of the target population by age. A total of 8 tests were positive.

From May 4, 2015 to January 31, 2019, there were 240,091 patient visits to our ED, of which 137,749 met our test criteria. If a patient was seen more than once in a given month they were only counted once for that month. In total, 23,588 HIV Ag/Ab tests were performed, representing 17.1% of our targeted test population. The average number of tests ordered per month varied based on the EHR approach (Figure 1). From May 4, 2015 to October 3, 2016, when we had a hard-stop BPA, we averaged a mean of 543 HIV tests per month. After our alert moved to a passive clinical reminder on October 4, 2016, our mean test rate fell to 222 HIV tests per month. During the period of our hard-stop BPA, the number of tests ordered per month varied from a low of 395/month to a high of 732/month. We intervened with periodic reminders to ED providers on the benefits of the program and provided feedback of cases identified through the testing program. Despite this, we noted a decline in our test rate even prior to the removal of the hard-stop BPA. In the last 3 months of our hard-stop BPA, our average fell to 439 tests/month. This immediately declined to 258 tests/month the first month we had a passive clinical reminder. Outreach to ED providers during the period of our passive clinical reminder did not improve testing rates. After linking HIV testing to a CBC order, our test rate increased to a mean of 654 HIV tests per month through January 31, 2019.

During the period of our hard-stop BPA, where we asked for a reason if the HIV test was not ordered, providers did not acknowledge a reason in 67% of our target group. When it was completed, the most common reasons for declining testing were: 43% patient declined blood draw, 29% patient declines reason unspecified, and 19% patient did not feel at risk.

Overall, 164 of the 23,588 HIV and Ag/Ab tests (0.70%) were true positives. This included 18 patients with acute HIV infection, 51 patients with a new diagnosis of chronic HIV infection, and 95 patients who were subsequently determined to have a prior diagnosis of HIV infection. There were 21 false-positive tests determined by HIV RNA quantitative <40 cp/mL (n = 8), repeat testing negative (n = 4), and no symptoms with low S/CO ratio (n = 9). This represented 0.09% of all 23,588 tests and 11.4% of the 185 reactive HIV Ag/Ab tests. Two additional patients were strongly suspected of having acute HIV, but 1 declined further testing and 1 was unable to

be reached by telephone or mail and was reported to CDPH. Because we could not definitively categorize them as acute HIV infection vs. false-positive result, they are not included in the summary numbers.

The characteristics of the 18 patients with confirmed acute HIV are detailed in Table 1. Four women were diagnosed with acute HIV infection, though 2 were lost to follow-up for months prior to confirmation of their diagnosis. All were black and were 20 to 38 years of age. The 14 men with acute infection included 13 who were men who have sex with men (MSM) (1 bisexual) and 1 heterosexual. The race/ethnicity makeup was 8 black, 3 Hispanic/Latino, and 3 white, with age range of 19–50 years. The initial positive HIV Ag/Ab test result modified the ED provider's differential diagnosis to consider the diagnosis of acute HIV infection. Ten patients were symptomatic enough to require hospital admission. All 18 patients were informed of their diagnosis and linked to care, but 2 patients declined follow-up care following hospital discharge and refused assistance for care at an alternate site. Fifteen started antiretroviral therapy and one returned to his home state to seek follow-up care there. Of the 15 who did start HIV therapy, 12 were confirmed to achieve HIV RNA <40 cp/mL, 1 achieved 40 cp/mL at 12 weeks of treatment, and 2 had follow-up at a different site and we were unable to confirm their outcome.

The 51 patients with newly diagnosed chronic HIV infection are summarized in Table 2. They ranged in age from 18 to 63 years; 73% were men and 27% women. Men tended to be younger (62% younger than 35 years of age) vs. women who were evenly spread through the age ranges. Overall, 73% were black and MSM was the most common transmission category for men and heterosexual sex was the most common transmission category for women. The most common reasons for presenting to the ED in order of frequency were sexually transmitted infection (n = 11), gastrointestinal complaint (n = 11), fever and other symptoms suggestive of infection excluding opportunistic infection (n = 8), pain (n = 6), genitourinary issue (n = 3), dermatologic complaint (n = 3), opportunistic process (n = 3, 2 with shingles and 1 with pneumocystis jirovec pneumonia), requesting HIV testing (n = 2), psychiatric issue (n = 2), drug use (n = 1), and blurred vision (n = 1). Of the 41 patients who were linked to care, 29 achieved an undetectable viral load, 10 were linked to outside sites for which we did not have outcome data, 1 started treatment but had insufficient time to achieve an undetectable viral load, and 1 patient refused treatment. Of the remaining 10 patients, 5 refused follow-up care, 2 returned to their home state, 1 died, 1 was referred for care at an outside site due to insurance requirements but we were unable to confirm linkage to care, and 1 patient could not be reached to disclose his positive test result.

The remaining 95 patients who tested positive were eventually determined to have been previously diagnosed. Testing was still useful, as the patient did not always disclose their HIV status and ED providers broadened their differential diagnosis when assessing their symptoms. ID staff attempted to contact all patients after discharge to assess whether they were in or out of care and, if needed, offered assistance in linking them back to care. Forty-five patients were in care and did not need follow-up assistance. Of the remaining 50 patients, 29 were successfully linked back to care, 4 were transferred to an outside psychiatric hospital with unknown subsequent follow-up, and 2 returned to their home state. The 15 patients who were not successfully relinked included 6 patients who either declined follow-up (n = 4) or were given follow-up appointments and did not

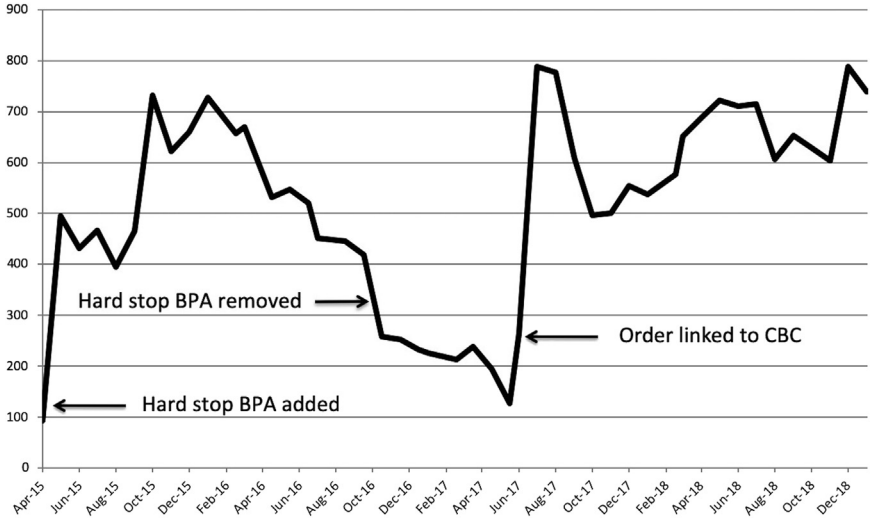

Figure 1. Number of tests ordered in emergency department May 2015 through January 2019. BPA = Best Practice Advisory; CBC = complete blood count.

Table 1. Characteristics and Outcome of the 18 Patients Diagnosed with Acute Human Immunodeficiency Virus Infection

Age, years	Sex	Race/ Ethnicity	ED Chief Complaint	Risk	CD4 Cells/μL (%)	HIV RNA (Copies/mL)	Follow-Up	Admission
33	M	H	Flu symptoms, seizures	Bisexual	396 (46)	516,663	<40	Y
25	M	B	Fever, abdominal pain	Heterosexual	457 (51)	3,196,348	Refused follow-up	Y
19	M	W	Fever, sore throat, syncope	MSM	787 (20)	9,528,888	<40	Y
20	M	B	Fever, syncope	MSM	NA	9,446,045	Returned to home state on no Rx	Y
22	M	W	Sore throat	MSM	82 (15)	1,470,388	Returned to home state on Rx	Y
19	M	B	Nausea/vomiting, myalgias	MSM	485 (29)	>10,000,000	Refused follow-up	Y
38	F	B	Nausea/vomiting, fever	Heterosexual	538 (25)	55,253	<40	N
23	F	B	Sore throat, fever/chills, myalgias	Heterosexual	219 (13)	51,554	<40	N
24	M	B	Nausea, diarrhea, fever, malaise	MSM	825 (25)	>10,000,000	<40	N
21	M	W	Cough, fever, headache, fatigue, myalgias	MSM	198 (36)	3,337,715	<40	Y
30	M	B	Sore throat, dizzy, lightheaded	MSM	292 (37)	3,493,709	<40	N
35	F	B	Diarrhea, fever × 4 weeks	Heterosexual	290 (26)	8,896,445	<40	Y
20	F	B	Nausea/vomiting, diarrhea, fever × 3 days	Heterosexual	360 (34)	8,150,000	<40	N
34	M	B	Nausea/vomiting, fever, myalgias, headache	MSM	399 (30)	1,836,521	<40	Y
34	M	B	Nausea/vomiting, diarrhea × 2 months	MSM	674 (24)	>10,000,000	40 cp/mL post 12 weeks Rx	N
50	M	H	Chest pain, fatigue, SOB	MSM	474 (50)	>10,000,000	<40	N
27	M	B	Nausea/vomiting, fever	MSM	203 (26)	1,380,824	<40	Y
28	M	H	Fever, myalgias, sore throat	MSM	NA	4,795,240	on Rx 2/13/19	N

B = black; cp/mL = copies per milliliter; ED = emergency department; F = female; H = Hispanic; M = male; MSM = men who have sex with men; N = no; NA = not available; Rx = HIV medications; SOB = shortness of breath W = white; Y = yes.

show (n = 2) and 9 patients who did not respond to phone calls or letters.

DISCUSSION

In 2016, it was estimated that there were 38,700 new HIV infections in the United States. Recent estimates are that the 14.2% of HIV-infected persons who are undiagnosed account for 37.6% of new infections and that those who are diagnosed but not in care (42.6%) or in care but not suppressed (19.8%) account for 62.4% of new infections (15). Thus, 80% of new HIV transmissions are from people who have not been diagnosed or are not receiving regular care. Multiple studies have now shown that HIV-infected persons who are undetectable for 6 months or more and remain adherent to treatment do not transmit HIV to their sexual parnters (6–8). The 2019 plan to end the HIV epidemic in the United States requires the early diagnosis of HIV and achieving viral suppression in greater numbers of patients (14).

An HIV screening program that meets the criteria set forth in the 2007 American College of Emergency Physicians HIV Testing and Screening in the Emergency Department policy statement is feasible through modification of an EHR (16). We were able to design a program that did not "interfere with the primary acute care mission of emergency medicine," was "integrated with the resources of the entire health care system," and provided counseling and linkage to care. Other centers have reported on successful non–risk-based and risk-based HIV ED screening programs (11–13).

We demonstrated that EHR modifications can increase HIV screening and the identification of new HIV infections, including those with acute HIV seroconversion in an ED. To be successful, these modifications need to minimize any additional work of ED staff and minimize the impact on patient time in the ED. Our program evolved to achieve these goals. Over time we determined that there was provider fatigue with a hard-stop BPA and ED staff frustration when a screening HIV test was the only blood test ordered. This led us to link the HIV test to a CBC order in our target population. While this algorithm restricted the screening to persons already getting blood drawn, provider satisfaction improved and the number of screening tests ordered increased. The percent of patients screened for HIV infection who met our test criteria increased from 2.5% before our program started to 21.1% during the period the HIV order was linked to a CBC order.

During the first 3.75 years of our ED HIV screening program, we demonstrated that EHR modifications do increase the diagnosis of HIV infections, including both acute infections and chronic infections of unknown duration. The identification of multiple patients with acute

Table 2. Characteristics of the 51 Patients Diagnosed with Chronic Human Immunodeficiency Virus Infection

Characteristic	Men	Women	Total
n (%)	37 (73)	14 (27)	51
Age at diagnosis			
Median (range), years	30 (19–63)	40.5 (18–56)	32 (18–63)
13–24 years	13	3	16
25–34 years	10	2	12
35–44 years	6	4	10
45–54 years	5	3	8
≥ 55 years	3	2	5
Race/ethnicity			
Black/African American	26	11	37
Hispanic/Latino	6	0	6
White	4	2	6
Black/Hispanic	0	1	1
Refused	1	0	1
Transmission category			
MSM (5 bisexual)	27	—	27
IDU			
Male	0	—	0
Female		2	2
MSM and IDU	1	—	1
Heterosexual			
Male	6	—	6
Female		12	12
Unknown	3		3
Baseline laboratory data			
No. available	25	12	37
CD4 median (range), cells/μL	269 (7–759)	518 (9–1140)	381 (7–1140)
CD4% median (range), %	23 (1–48)	33 (1–47)	25 (1–48)
No. available	23	12	35
$\log_{10}$ HIV RNA median (range)	4.61 (1.6–5.94)	3.83 (2.84–6.01)	4.14 (1.6–6.01)

IDU = i.v. drug use; MSM = men who have sex with men.

HIV infection was another positive outcome of our program. Because the emergency department is a place where many individuals seek care when they do not have a regular physician, identification of previously diagnosed patients offers an opportunity to relink them to care. We were able to use the ED encounter to relink to care 58% of patients identified through our HIV screening program who had a prior HIV diagnosis and were out of care.

Close coordination between the ED and ID team was necessary for the program to be successful. Because the ID team assumed the responsibility of reviewing positive test results with all patients and arranging follow-up, ED providers were supportive of the program.

Limitations

Our institution uses the Epic EHR and not all EHRs have the capabilities to create a similar program. We had incomplete follow-up of patients we diagnosed with HIV infection, as we were limited to records available within our medical system. Some patients were unable to receive outpatient care at our site due to insurance restrictions. These issues would underestimate the outcome data and linkage to care rates. Definitive characterization of a false-positive HIV Ag/Ab test would require a negative quantitative HIV RNA. Not all patients chose to undergo follow-up testing. We still categorized them as a false positive if they were asymptomatic and their S/CO ratio was low. Because we are located in an urban locale with a high HIV prevalence rate, our findings may not be generalizable to other settings.

CONCLUSIONS

In a large urban hospital located in a high HIV prevalence area, modifications to an EHR increased non-targeted HIV screening and the diagnosis of new HIV infections. Evolution to a program that minimized the impact on ED providers and patient time in the ED was the most successful version. Coordination between the ED and ID teams was critical to the success of the program. In addition, the infrastructure created to counsel and link newly diagnosed patients to care was also utilized to relink previously diagnosed HIV-infected persons who were out of care.

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ARTICLE SUMMARY

1. Why is this topic important?

Persons with undiagnosed human immunodeficiency virus (HIV) infection continue to suffer morbidity and are an ongoing source of new HIV infections. Strategies to increase the diagnosis of these patients is critical to ending the HIV epidemic in the United States.

2. What does this study attempt to show?

Simple modifications of an electronic health record (EHR) can increase the testing and diagnosis of both new acute and chronic HIV infections. Identification of out of care HIV-infected persons can provide opportunity to relink them to care.

3. What are the key findings?

Modifications to our EHR increased HIV testing by more than eightfold and identified both newly diagnosed acute and chronically HIV-infected persons. Strategies that minimize ED providers' time are more likely to be successful.

4. How is patient care impacted?

With our EHR modifications and notification program, we were able to identify previously undiagnosed HIV infected persons and link them to care. We were also able to relink a substantial number of out of care previously diagnosed HIV infected persons to care.