**Introduction:** This study aims to assess the public health impact of eliminating a longstanding routine HIV screening program and replacing it with targeted testing. In addition, costs, outcomes, and cost effectiveness of routine screening are compared with those of targeted testing in the Fulton County Jail, Atlanta, Georgia.

**Methods:** A published mathematical model was used to assess the cost effectiveness and public health impact of routine screening (March 2013–February 2014) compared with those of targeted testing (January 2018–December 2018) from a health system perspective. Costs, outcomes, and other model inputs were derived from the testing programs and the published literature, and the cost effectiveness analysis was conducted from 2019 to 2020.

**Results:** Routine screening identified 74 more new HIV infections over 1 year than targeted testing, resulting in an estimated 10 HIV transmissions averted and 45 quality-adjusted life-years saved, and was cost saving. The missed opportunity to diagnose infections because routine screening was eliminated resulted in an estimated 8.4 additional HIV transmissions and $3.7 million in additional costs to the healthcare system.

**Conclusions:** Routine HIV screening in high-prevalence jails is cost effective and has a larger impact on public health than targeted testing. Prioritizing sustained funding for routine, jail-based HIV screening programs in high-prevalence areas may be important to realizing the national HIV prevention goals.

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quickly return to the community. However, the vast majority of the nation’s largest jails do not provide routine HIV screening. The national Ending the HIV Epidemic (EHE) in the U.S. initiative aims to curtail HIV transmission in the U.S. by 90% within 10 years by initially focusing on geographic areas where most new infections are concentrated. Timely diagnosis is the first strategy of the EHE initiative, and CDC has identified large jails in high-prevalence communities as one of the settings to expand routine, opt-out screening. Effective jail-based HIV screening in the 50 targeted EHE local jurisdictions (48 counties, the District of Columbia, and San Juan, Puerto Rico) may therefore be a key component of meeting these national prevention goals because the majority of the nation’s largest jails are located in EHE target areas.

Despite evidence of effectiveness, there are reports of jails reducing or eliminating routine HIV screening programs. One such example is the Fulton County Jail (FCJ), located in Atlanta, Georgia—a high-volume, high-prevalence urban jail located in an EHE-focused jurisdiction that discontinued routine, opt-out screening in 2018. Targeted, laboratory-based testing was instituted after routine screening, which provided a natural experiment to assess the public health impact of eliminating routine, opt-out HIV screening in the FCJ. Costs, outcomes, and cost effectiveness of routine opt-out screening were compared with the subsequently delivered targeted testing in the FCJ, and the public health impact of eliminating the longstanding routine screening program was assessed.

**METHODS**

For each testing strategy, targeted testing, and routine screening, this study estimated HIV infections averted, quality-adjusted life-years (QALYs) saved, HIV testing and treatment costs, and calculated incremental cost effectiveness ratios (ICERs) from the health system perspective. Analyses were conducted with a published mathematical model, the HIV Detection and Transmission Model, to estimate HIV transmissions averted and QALYs saved and assess the cost effectiveness of the HIV testing strategies. The authors adjusted costs and outcomes to 2018 dollars, discounted future costs and effects at a 3% annual rate, and conducted the cost effectiveness analysis in 2019 and 2020.

In addition, authors assessed the public health impact of eliminating routine HIV screening and replacing it with targeted testing in 2018. Counterfactual HIV screening outcomes were estimated by applying routine screening rates from 2013 to 2014 to the number of jail entrants in 2018 to estimate the number of entrants who would have been screened if routine screening had been conducted instead of targeted testing. The authors then applied FCJ HIV routine screening positivity rates (2013–2014) to calculate the number of additional people who were potentially missed with targeted testing and modeled the resulting HIV transmissions in the community and related HIV treatment costs.

**Testing Strategies**

Beginning in 2010, CDC-funded nonresearch demonstration project at the FCJ supported nurse-led, routine, opt-out, point-of-care HIV screening offered to all incarcerated individuals after intake, regardless of risk factors. After the project’s initial funding period, the program was continued with funding from industry, followed by the Fulton County Board of Health. In 2018, the Fulton County Board of Health discontinued funding of routine HIV screening in the jail. Subsequently, the FCJ implemented targeted testing on the basis of clinicians’ determination of need (e.g., symptoms, risk factors, treatment), although there was no systematic assessment of risk. Because laboratory-based diagnostics were used with targeted testing, same-day results were not available.

**Model Overview**

The HIV Detection and Transmission Model is a published Microsoft Excel–based model with Visual Basic for Applications. The model estimates HIV detection, secondary HIV transmissions averted, and QALYs saved derived from HIV transmission rate differences related to diagnosis and awareness of infection, disease stage, treatment, and viral suppression. Costs and outcome data from the FCJ testing programs and the published literature were used to parameterize the model (Table 1). The authors incorporated reductions in HIV transmission because of viral suppression and postdiagnosis behavior change and viral suppression assuming that antiretroviral therapy (ART) is initiated within 3 months of diagnosis. It was assumed that the costs and benefits (transmission rate reduction because of serostatus awareness) of earlier detection because of jail-based screening last 2 (range=1–4) years on the basis of published testing intervals for high-HIV risk groups.

The model utilized Bernoulli model—based HIV transmission rates, from which the authors calculated a weighted average by HIV transmission group (men who have sex with men, heterosexual, and injection drug user) in FCJ. City-specific data on the proportion of people on ART (50%) and virally suppressed (40%) were applied, and those estimates were adjusted downward for consistency with the postrelease jail population. Viral suppression was assumed to confer a 96% reduction in sexual transmission, and it was assumed that postdiagnosis behavior change confers a 53% reduction in sexual transmission.

**Cost Effectiveness Analysis**

The ICERs were calculated from a health system perspective. In addition, the intermediate economic outcome, cost per new diagnosis, was calculated from the program (jail) perspective. Program costs and outcomes were estimated using published data from the nurse-led, routine screening program (March 2013–February 2014) and from a previously reported FCJ cost analysis. FCJ outcome data were used for targeted testing (January 2018 –December 2018); this study used and retrospectively assessed costs from the FCJ programmatic data and the literature.

The ICER represents the difference in costs divided by the difference in effectiveness (QALYs) of one strategy (routine screening) compared with that of the next most effective (targeted testing) strategy: ICER = ΔC / Δ(AQ/Q0), where C is the total intervention costs, A is the number of HIV infections averted, T is the HIV treatment cost saved per infection averted, and Q is the number of QALYs saved per infection averted. Intervention costs (C) included testing program costs: (1) HIV test kits, reagents, controls, and supply costs;
(2) labor costs for testing and results notification; (3) administrative costs for program and data management; and (4) ART costs due to earlier detection (2 years) because of jail-based HIV testing.\(^{15,17,18}\)

Lifetime HIV treatment costs (T) were used to value HIV transmissions averted (\(T\)) for newly diagnosed, serostatus-aware people with HIV.\(^ {16}\) Secondary HIV transmissions averted (\(T\)) based on average wages for a practical nurse ($22.23) and average fringe benefit rate of 31.70%. Appendix (available online) provides the cost detail.

Table 1. Key Model Inputs

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value (range for sensitivity analysis)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth-generation IA, supplies and controls</td>
<td>$9.00 (±50%)</td>
<td>FCJ program data from 12</td>
</tr>
<tr>
<td>Rapid test kit, supplies, controls</td>
<td>$11.00 (±50%)</td>
<td>FCJ program data from 12</td>
</tr>
<tr>
<td>Western blot, reagent, labor, supplies</td>
<td>$50.00 (±50%)</td>
<td>FCJ program data from 12,13</td>
</tr>
<tr>
<td>Nurse labor costs, hours + fringe(^a)</td>
<td>$29.28(^b) (±50%)</td>
<td>From 12,14</td>
</tr>
<tr>
<td>Annual treatment costs</td>
<td>$19,400 (±50%)</td>
<td>Estimated from 15</td>
</tr>
<tr>
<td>Lifetime HIV treatment costs</td>
<td>$441,700 (±25%)</td>
<td>Estimated from 16</td>
</tr>
</tbody>
</table>

Effectiveness

- HIV+ results notification, laboratory: 80% (60%−100%) FCJ program data from 17
- HIV+ results notification, rapid: 100% (90%−100%) FCJ program data from 10
- ART coverage: 50% (30%−70%) From 18
- Viral suppression: 40% (25%−75%) Estimated from 18
- HIV transmission, annual rate\(^{16}\)
  - Unaware: 0.121
  - Aware, not suppressed: 0.069
  - Aware, suppressed: 0.008
- Transmission rate reduction due to postdiagnosis behavior change: 0.53 (25%−75%) Calculated from 20

Note: Costs are reported per person with HIV in $2,018.\(^a\) Based on average wages for a practical nurse ($22.23) and average fringe benefit rate of 31.70%. Appendix (available online) provides the cost detail.\(^b\) Weighted average, by transmission group.

ART, antiretroviral therapy; FCJ, Fulton County Jail; IA, immunoassay.

In multiway sensitivity analysis, pessimistic and optimistic scenarios were tested for each testing strategy. Under the pessimistic scenario, testing parameters were as follows: transmission rate reduction due to postdiagnosis behavior change, 25%; viral suppression, 0%; results notification laboratory test, 60%; and results notification rapid test, 90%. Under the optimistic scenario, testing parameters were transmission rate reduction due to postdiagnosis behavior change, 75%; viral suppression, 60%; and results notification conventional test, 100%; and results notification rapid test, 100%.

RESULTS

The HIV testing rates and new diagnoses were lower under targeted testing than under the routine screening program, with 4,130 (16%) of 25,810 jail entrants tested, yielding 15 new HIV diagnoses, although 3 of the 15 did not receive results before release. Under routine, opt-out

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sensitivity analyses, when key parameters were set to values for the pessimistic scenario for routine screening, the ICER exceeded $50,000 per QALY saved, although routine screening remained cost effective (Figure 1). This scenario included simultaneously reducing the transmission rate reduction because of postdiagnosis behavior change from 53% to 25%, viral suppression from 40% to 0%, and the notification rates for HIV-positive test results from 99% to 95% for rapid testing. When ranged to extreme values in threshold analysis, program costs for routine screening would have to increase 15-fold before the ICER crossed the $100,000 per QALY threshold. If program costs for targeted testing were reduced to $0, routine screening would still be cost saving compared with targeted testing.

**DISCUSSION**

Routine, opt-out HIV screening in FCJ was cost saving compared with the targeted testing program that was initiated after routine screening was discontinued. The cost effectiveness findings were robust as routine screening remained cost saving under all but 1 scenario in sensitivity analysis in which the benefits of treatment on HIV transmission were removed. Even for this scenario, routine screening remained cost effective (ICER < $100,000 per QALY saved). Likewise, routine screening remained cost saving when total program costs for targeted testing were eliminated because of the additional HIV infections averted and the associated treatment costs saved with routine screening. The public health impact of eliminating this longstanding, jail-based routine HIV screening program for 1 year is noteworthy, with an estimated 61 HIV diagnoses potentially missed and an additional $3.7 million in HIV treatment costs to society. The large differences in the proportion of jail entrants screened (routine screening, 56% vs targeted testing, 16%) were an important factor in the results in this high-prevalence jail. Likewise, 20% of people testing positive with targeted, laboratory-based testing did not receive results before release, which emphasizes that timely receipt of results, particularly for settings with short lengths of stay such as jails, is an important component of program effectiveness.

The finding of this study is consistent with those of others that report higher HIV testing rates and diagnostic yield with routine opt-out screening than with opt-in screening or targeted testing in correctional and other clinical settings. Cost per new HIV diagnosis was lower for routine screening than for targeted testing, which differs from the findings of Castel and colleagues, although cost per case detected does not provide a full valuation of costs and outcomes. Although

**Table 2. Program Costs and Outcomes of Routine Screening Versus Those of Targeted Testing in FCJ**

<table>
<thead>
<tr>
<th>Testing outcomes</th>
<th>Routine screening March 2013—February 2014</th>
<th>Targeted testing January 2018—December, 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jail admissions</td>
<td>30,316a</td>
<td>25,810</td>
</tr>
<tr>
<td>Number tested</td>
<td>17,035a (56%)</td>
<td>4,078 (16%)</td>
</tr>
<tr>
<td>HIV positivity: new, overall</td>
<td>89a (0.52%); 226a (1.3%)</td>
<td>15b (0.37%)</td>
</tr>
<tr>
<td>Transmissions averted</td>
<td>11.7 (5.9–23.6)</td>
<td>1.6 (0.8–3.2)</td>
</tr>
<tr>
<td>QALYs saved</td>
<td>51.9</td>
<td>7.0</td>
</tr>
<tr>
<td>Testing costs, $</td>
<td>263,200</td>
<td>78,300</td>
</tr>
<tr>
<td>Averted HIV treatment costs, $</td>
<td>5,153,600</td>
<td>694,900</td>
</tr>
<tr>
<td>Total intervention costs, $</td>
<td>1,992,000</td>
<td>311,400</td>
</tr>
<tr>
<td>Cost per new diagnosis, $</td>
<td>3,000</td>
<td>5,200</td>
</tr>
</tbody>
</table>

Note: Costs are reported in $2,018, discount rate of 3% for the lifetime treatment cost estimate.

*Previously reported by Spaulding et al.10; 69% offered routine screening.

At total of 12 of 15 notified of positive results.

Duration of transmission benefit of 2 years (1–4 years).

Testing costs + early-detection HIV treatment costs (targeted, $233,100; routine, $1,728,800).

Calculated from the program (FCJ) perspective.

FCJ, Fulton County Jail; QALY, quality-adjusted life-year.

screening, Spaulding et al.10 reported 16,977 (56%) of the 30,316 jail entrants screened, yielding 89 new diagnoses (Table 2). Diagnosis of the additional 74 people through routine screening resulted in 45 QALYs saved and was cost saving compared with that through the targeted testing program (Table 3). Although total program costs were greater for routine screening than for targeted testing ($263,200 vs $78,300), the cost per new HIV diagnosis was lower ($3,000 vs $5,200 for the 1-year intervention period). The Appendix (available online) provides the details on the total program costs for routine and targeted testing (Appendix Tables 1 and 2, available online).

The public health impact of eliminating the routine screening program in 2018 and replacing it with targeted testing was estimated to be 61 additional people with new HIV infections who could have been diagnosed if routine screening was not discontinued. This was calculated using the number of entrants from 2018 and historical FCJ testing rates for routine screening. The missed opportunity to diagnose these infections potentially resulted in an estimated 8.4 secondary HIV transmissions and $3.7 million in additional costs to the healthcare system.

**Sensitivity Analysis**

In 1-way sensitivity analyses, routine screening remained cost saving in all scenarios (Figure 1). In multiway
the authors are not aware of other studies of jail-based testing that used ICERs, the cost per new diagnosis for routine screening ($3,000) was at the lower end of the range of other studies ($2,451−$25,288). Regardless, the ICER is the preferred metric for cost effectiveness analysis because it facilitates comparability across programs.

Correctional settings are unlike all other settings where HIV testing is conducted because their primary mission is public safety, not provision of healthcare services. Thus, procuring and sustaining funding for effective HIV screening programs in these settings is difficult even though positivity rates can far surpass other venues. Demonstration projects in correctional settings have been supported with time-limited federal funds, but other funding sources are necessary to sustain effective testing programs, which has been a difficult challenge. In addition, funding for HIV screening does not cover treatment costs for newly diagnosed individuals, although these costs are typically limited because the median length of stay in jail is 2−5 days. Similar to FCJ, a large, urban jail in Los Angeles has reported having to reduce an HIV testing program targeting men who have sex with men because of limited resources. An additional potential barrier to obtaining funding for jail-based HIV screening programs is that jails usually incur the costs of the HIV screening program, whereas the benefits of averted HIV infections accrue to the health system and the larger community. Thus, even programs that are shown to be cost saving in economic evaluation may not be undertaken by the programs that must bear the cost. Although funding for other public health and prevention interventions face similar barriers, jails in high-prevalence settings are uniquely positioned to impact public health by identifying HIV in a population that may not otherwise access HIV prevention services. Solving this funding challenge—potentially through long-term commitments with funding partners

### Table 3. Cost Effectiveness of Routine HIV Screening Versus That of Targeted Testing in Fulton County Jail

<table>
<thead>
<tr>
<th>Cost effectiveness analysis</th>
<th>Total costs, $</th>
<th>Inc. costs, $</th>
<th>Inc. QALY</th>
<th>ICER, $ QALY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Targeted testing</td>
<td>(383,500)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routine screening</td>
<td>(3,161,600)</td>
<td>2,778,100</td>
<td>45</td>
<td>Cost saving</td>
</tr>
</tbody>
</table>

Note: Costs are reported in $2,018, discount rate of 3% for the lifetime treatment cost estimate.

aTotal costs are negative because averted treatment costs are larger than program costs.

ICER, incremental cost effectiveness ratio; Inc., incremental; QALY, quality-adjusted life-year.

### Figure 1. Tornado diagram of 1-way and multiway sensitivity analyses of the cost effectiveness of routine screening versus of targeted testing in Fulton County Jail.

Note: The legend shows that the parameter values varied in the sensitivity analysis. The horizontal axis shows ICERs in U.S. dollars per QALY saved. The vertical line shows the base case cost effectiveness. The bars show the ICERs given the variation in model parameter(s) and are arranged from largest to smallest ICER.

aLeast-effective testing parameters: transmission rate reduction due to postdiagnosis behavior change, 25%; viral suppression, 0%; results notification conventional test, 60%; results notification rapid test, 90%.

bMost effective testing parameters: transmission rate reduction due to postdiagnosis behavior change, 75%; viral suppression, 60%; results notification conventional test, 100%; results notification rapid test, 100%.

ICER, incremental cost effective ratio; QALY, quality-adjusted life-year.
may be necessary to fully routinize HIV screening. There are several reports of successful and sustained collaborations between jails and state and local health departments to provide HIV screening.\textsuperscript{30,31} By contrast, continued reduction or elimination of routine HIV screening in correctional settings in high-prevalence communities, even if temporary, could result in increases in HIV transmission and potentially incidence.

Limitations
The analysis compares 1 year of outcome data for each testing strategy in a single jail and may not be representative of other jails or years. However, newly identified HIV positivity for routine, opt-out screening in FCJ (0.52%) was similar to those in other large, urban jails (0.3%–0.7%), and overall HIV positivity in FCJ has remained around 4% for >10 years.\textsuperscript{30} In addition, the analysis was limited to first-generation transmissions and did not consider the benefits of relinking HIV-infected individuals who are not in care, both of which could further improve cost effectiveness. Finally, targeted testing in this study may differ from other approaches, especially those that include systematic risk assessment.

CONCLUSIONS
Jail-based HIV screening programs offer important public health benefits, including the ability to detect undiagnosed HIV and link or re-engage out-of-care people with HIV into care, which facilitates retention in care and viral suppression after release.\textsuperscript{32,33} In addition, modeling studies have shown the public health benefits of routine HIV screening in correctional settings. Lima et al.\textsuperscript{34} found that expanded HIV screening in the criminal justice system in Fulton County, Atlanta, Georgia could reduce HIV incidence, prevalence, and mortality over 10 years in the community. In an agent-based modeling study, incarceration of African American men in Philadelphia was associated with increased HIV acquisition of African American women on a population level, suggesting that routine screening in correctional settings could interrupt the chain of transmission in vulnerable populations.\textsuperscript{35} Likewise, minority populations are disproportionately affected by both HIV and incarceration, with an estimated 20% of Black people with HIV passing through correctional facilities annually.\textsuperscript{36} Thus, correctional facilities such as FCJ can serve as valuable partners in identifying HIV infection in communities that are impacted by disparities in HIV care.\textsuperscript{37,38} Routine, opt-out HIV screening in this high-HIV prevalence, urban jail was cost saving and had greater public health impact than targeted testing, even with higher screening costs and treatment costs associated with earlier detection. Prioritizing sustained funding for routine, opt-out HIV screening programs in jails in high-prevalence areas such as those in EHE jurisdictions, which account for most new HIV diagnoses in the U.S., may be important to realizing the national HIV prevention goals and to reducing HIV incidence in the U.S.

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SUPPLEMENTAL MATERIAL
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