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The Cost-effectiveness of Rapid HIV Testing in Substance Abuse Treatment: Results of a Randomized Trial*

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Abstract

BACKGROUND—The President's National HIV/AIDS Strategy calls for coupling HIV screening and prevention services with substance abuse treatment programs. Fewer than half of US community-based substance abuse treatment programs make HIV testing available on-site or through referral.

METHODS—We measured the cost-effectiveness of three HIV testing strategies evaluated in a randomized trial conducted in 12 community-based substance abuse treatment programs in 2009: off-site testing referral, on-site rapid testing with information only, on-site rapid testing with risk reduction counseling. Data from the trial included patient demographics, prior testing history, test

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Conflict of Interest

There are no author conflicts of interest to declare.

Contributors

Dr. Schackman had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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acceptance and receipt of results, undiagnosed HIV prevalence (0.4%) and program costs. The Cost Effectiveness of Preventing AIDS Complications (CEPAC) computer simulation model was used to project life expectancy, lifetime costs, and quality-adjusted life years (QALYs) for HIV-infected individuals. Incremental cost-effectiveness ratios (2009 US \$/QALY) were calculated after adding costs of testing HIV-uninfected individuals; costs and QALYs were discounted at 3% annually.

RESULTS—Referral for off-site testing is less efficient (dominated) compared to offering on-site testing with information only. The cost-effectiveness ratio for on-site testing with information is \$60,300/QALY in the base case, or \$76,300/QALY with 0.1% undiagnosed HIV prevalence. HIV risk-reduction counseling costs \$36 per person more without additional benefit.

CONCLUSIONS—A strategy of on-site rapid HIV testing offer with information only in substance abuse treatment programs increases life expectancy at a cost-effectiveness ratio < \$100,000/QALY. Policymakers and substance abuse treatment leaders should seek funding to implement on-site rapid HIV testing in substance abuse treatment programs for those not recently tested.

Keywords

Rapid HIV testing; substance use; cost-effectiveness

1. Introduction

In 2006, the Centers for Disease Control and Prevention (CDC) released new recommendations for routine HIV screening of all adults in health care settings (Branson et al., 2006). The rationale for these recommendations is that early diagnosis by screening increases the likelihood that HIV-infected individuals will obtain recommended medical care, including antiretroviral therapy, which results in improved life expectancy and quality of life (Mannheimer et al., 2005; Walensky et al., 2006). Awareness of HIV status may also result in decreased HIV transmission risk due to reductions in sexual risk behavior and decreased viral load on antiretroviral therapy (Das et al., 2010; Holmberg et al., 2004; Marks et al., 2005). The cost-effectiveness of extending HIV screening to moderate and high-risk populations in outpatient medical settings compares favorably to the value of recommended routine screening for other common diseases, such as diabetes, colon cancer, and breast cancer (Bartlett et al., 2008; Paltiel et al., 2006; Walensky et al., 2007).

The CDC has also called for expanded testing in non-medical settings (Branson et al., 2006), and the President's National HIV/AIDS Strategy calls for coupling HIV screening and prevention services with substance abuse treatment programs (Office of National AIDS Policy, 2010). Testing in substance abuse treatment programs may be particularly beneficial because substance users often do not receive routine medical care in settings where they might have greater access to HIV testing under the new guidelines (Laine et al., 2001). In 2009, 45% of HIV-infected injection drug users were undiagnosed, and only 49% of injection drug users at risk for HIV report having been previously tested (Centers for Disease and Prevention, 2012). Previous studies have shown that fewer than half of US community-based substance abuse treatment programs make HIV testing available either on-site or through referral agreements with other agencies (Brown et al., 2006; Pollack and D'Aunno, 2010; Strauss et al., 2003). On-site HIV testing requires more resources from substance abuse treatment programs than off-site referral. Programs also need to consider whether or not to provide brief risk-reduction counseling as part of on-site testing. In a major policy shift, the 2006 CDC guidelines suggest that risk-reduction counseling should not be required as part of HIV screening in health care settings (Branson et al., 2006). Although targeted HIV screening with risk-reduction counseling has been reported to be a

more cost-effective strategy than routine screening alone (Holtgrave, 2007), these projections were based on scenario analysis and not data from a direct comparison of HIV testing with risk-reduction counseling versus without risk-reduction counseling. Risk-reduction counseling may have advantages in drug treatment program settings, compared to medical settings, due to the potential for higher acceptance, lower personnel costs, and greater reductions in risk behaviors.

The National Drug Abuse Treatment Clinical Trials Network (CTN) HIV Rapid Testing and Counseling Study (CTN 0032) was a randomized controlled clinical trial that examined the role of on-site rapid testing and risk-reduction counseling in increasing HIV testing and receipt of HIV test results and reducing HIV risk behaviors among substance abuse treatment program clients (Metsch et al., 2012). Our objectives were to project the life expectancy gains, costs, and cost-effectiveness of the testing strategies evaluated in this trial to provide guidance to policymakers and substance abuse treatment programs.

2. METHODS

2.1 Analytic Overview

We used data from the CTN 0032 clinical trial to define the population in substance abuse treatment being tested, including demographics, injection drug use history, prevalence of undiagnosed HIV, and previous HIV testing history (Metsch et al., 2012). We evaluated a no intervention strategy (for comparison) and the three strategies evaluated in the trial: 1) referral for off-site HIV testing, 2) offer of an on-site rapid HIV test with information that describes the testing procedure but no counseling about risk behaviors, and 3) brief participant-tailored risk-reduction counseling that includes a personalized examination of risk focused on whatever is salient to the risk behavior of the participant (sexual risks, injection risks, or reducing substance use) and creation of an individualized risk-reduction plan (Metcalf et al., 2005) followed by the offer of an on-site rapid HIV test. There were no statistically significant differences among the three groups in the trial ($p=0.66$ for differences across all 3 groups) in the primary outcome of sexually risky behaviors defined as self-reported anal and vaginal sex acts with either primary or non-primary partner measured at 6 months. This outcome was considered during the trial design to be the most appropriate measure of sexual risk in this population; retention at 6 months was 93.7% (Metsch et al., 2012). In secondary analyses there was no difference in changes in sexual risk behavior at 6 months or in the assessed risk behavior in the subpopulation that was sexually active at baseline.

We used the Cost-Effectiveness of Preventing AIDS Complications (CEPAC) computer simulation model to project life expectancy, lifetime costs, and quality-adjusted life years (QALYs) for individuals in this population with undiagnosed HIV in the absence of any offer of HIV testing at the substance abuse treatment program. We then modeled projected changes in these outcomes as a result of earlier HIV diagnosis based on the acceptance and receipt of HIV test results and the testing costs for each testing strategy evaluated in the trial.

Incremental cost-effectiveness ratios for each strategy were calculated from the projected outcomes for HIV-infected individuals and the cost of testing HIV-negative individuals (including adverse quality-of-life effects of false reactive rapid test results). All cost-effectiveness ratios were calculated as the incremental cost per QALY gained compared with the next least expensive strategy after eliminating strategies due to dominance or extended dominance. Dominance occurs when one strategy is said to dominate another one because it is more effective and costs less (Drummond et al., 2005). Extended dominance occurs when one strategy is said to dominate another one because a combination of alternative strategies represents a more efficient use of resources than the dominated strategy

(Cantor, 1994; Drummond et al., 2005). The analysis was conducted from the societal perspective, and all costs and QALYs were discounted at an annual rate of 3% (Gold et al., 1996). We compared the cost-effectiveness ratios to a maximum threshold of \$100,000/QALY that has recently been used in cost-effectiveness analyses in the US (Cutler et al., 2006; Gopalappa et al., 2012; Schackman et al., 2012), although some have argued for an even higher threshold of \$100,000/QALY to \$300,000/QALY (Braithwaite et al., 2008; Ubel et al., 2003). The Weill Cornell Medical College institutional review board (IRB) and Partners Human Research Committee approved the cost-effectiveness analysis; sites obtained approval from their IRBs to conduct the randomized control trial.

2.2 The Cost Effectiveness of Preventing AIDS Complications (CEPAC) Model

The CEPAC model is a first-order state-transition Monte Carlo simulation of the natural history, clinical management, and costs of HIV disease (Freedberg et al., 2001; Paltiel et al., 2006, 2005; Schackman et al., 2006, 2008). Simulated cohorts of HIV-infected adults, with demographic characteristics specified by the user, transition monthly between health states characterized by immune status (current CD4 count), circulating viral burden (HIV RNA level), maintenance (or not) on an antiretroviral therapy (ART) regimen, and additional effects of the presence of an acute AIDS-defining illness. Effective ART results in a reduction in HIV RNA levels and an increase in CD4 cells. The health states are each assigned risks of HIV-related and non-HIV-related mortality, a quality-of-life weight and costs. Quality-of-life weights are from SF-6D data derived from a national survey of HIV-infected individuals (Schackman et al., 2002), and costs are from medical service utilization data from a national cohort and national costs (Schackman et al., 2006).

The CEPAC model contains a screening module that is used to compare HIV testing strategies. The screening module is used to determine whether and when HIV-infected individuals are offered and accept an HIV test, are diagnosed as HIV-infected and receive their test results, and are linked to care. HIV diagnosis occurs in the model as a result of one of three mechanisms: 1) a specific testing program, 2) within the context of HIV testing elsewhere (e.g., testing in routine medical care, sexually transmitted disease clinics, correctional institutions, or for employment or insurance reasons) that results in linkage to HIV care, or 3) because the HIV-infected individual presents clinically with an AIDS-defining complication that necessarily results in linkage to care. The probabilities of test acceptance, receipt of results and linkage to care are identified for each of the testing strategies being evaluated.

HIV treatment is modeled according to current US guidelines, including initiating antiretroviral therapy (ART) at 500 CD4 cells/ μ l (Department of Health and Human Services, 2011). When ART failure is detected the ART regimen is switched. Six sequential ART regimens are specified in the model, each with decreasing efficacy of virologic suppression (Department of Health and Human Services, 2011; Gallant et al., 2006; Grinsztejn et al., 2007; Johnson et al., 2005; Lalezari et al., 2007; Nelson et al., 2005) that can be varied to reflect less than optimal care. Death may be attributed to HIV-related or non-HIV-related causes. The risk of non-HIV-related death is adjusted for age, sex, race/ethnicity, and HIV risk factors including injection drug use history (Losina et al., 2009). The model records the life months, quality adjusted life months, and costs from entry into the simulation until death. Data inputs for HIV disease progression without treatment and the effectiveness and cost of HIV treatment are from published sources and HIV cohort data. Additional CEPAC model specifications have been published elsewhere in detail (Paltiel et al., 2005; Schackman et al., 2008).

2.3 Model Inputs

Table 1 describes the model inputs derived from the CTN 0032 trial and other sources (Control and Prevention, 2002; Gallant et al., 2006; Grinsztejn et al., 2007; Johnson et al., 2005; Lalezari et al., 2007; Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995; Nelson et al., 2005). The design and enrollment criteria of CTN 0032 have been described elsewhere (Metsch et al., 2012). Briefly, 1,281 participants were recruited from 12 participating community-based substance abuse treatment programs that were geographically diverse and provided a variety of drug treatment modalities. Eligible programs had not previously offered on-site rapid HIV testing. Participation was limited to individuals who reported being HIV negative or of unknown status and who had not received results of an HIV test initiated in the previous 12 months. The trial was conducted from January to December 2009.

Age, sex, race/ethnicity, injection drug use history, and the proportion previously tested for HIV were from the trial population. Among trial participants who self-reported exactly two previous HIV tests ($n=158$), the interval between these tests was 5.3 years. The interval between HIV tests occurring elsewhere was modeled as a constant monthly probability such that approximately two-thirds have tested by 5.3 years. We used this testing interval for all members of the cohort, even those who were never previously tested, to reflect the current trend towards wider availability of HIV testing in the community including to those never tested.

HIV rapid test specificity (99.3%) was from the trial, and HIV rapid test sensitivity (99.6%) was from a published source (Control and Prevention, 2002). For the base case, we assumed for each strategy 0.4% prevalence of undiagnosed HIV, which was the prevalence after confirmatory testing among those tested on-site in the trial. Model inputs for test acceptance and receipt of results for each intervention were self-reported results measured 1 month after enrollment in the trial (Table 1); retention at 1 month was 99.2%. Because the on-site interventions included specific training to ensure linkage to care after HIV diagnosis that has been shown to be effective in drug-using patients (Gardner et al., 2005), we assumed all those who received a diagnosis of HIV infection would be linked to care. Under this assumption, the proportion of HIV-infected individuals tested who would be identified and linked to care is equal to the proportion who accept multiplied by the proportion who receive results; in the base case we used the trial results: 18.4% for off-site referral, 84.8% for on-site testing with information only, and 79.7% for on-site testing with counseling ($p=0.003$ for differences across all 3 groups).

CD4 counts for newly diagnosed HIV cases were not available from the trial. We therefore used the CEPAC model to estimate CD4 counts at the time of the intervention for HIV-infected individuals, based on data from the Multicenter AIDS Cohort Study (MACS) on CD4 count progression from the time of infection in the absence of treatment: mean (standard deviation) 580 (271) cells/ μ l for those previously tested and 484 (255) cells/ μ l for those never tested (Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995). The HIV RNA levels for these individuals were also from the MACS cohort, which is the largest US cohort study that contains data on untreated HIV starting from the time of infection (Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995).

2.4 Intervention Costs and Adverse Effects

We applied micro-costing methods similar to those used in other HIV prevention studies (Ruger et al., 2010) to project the cost of each HIV testing strategy delivered in the trial (Table 1, Supplemental Tables 1–3¹). Micro-costing is a technique in which all of the inputs consumed in a health care intervention are identified and quantified in detail, and then these

resources are converted into value terms to produce a cost estimate (Gold et al., 1996). Substance abuse treatment program and off-site testing program costs are classified as variable (counselor labor, test and materials, overhead associated with counselor time) or time-dependent (running HIV test controls, supervision and quality control, and associated overhead). Patient costs include counseling, testing, and waiting time on-site, as well as testing time and travel time and costs for off-site and confirmatory testing. All costs are reported in 2009 US dollars, and all research-related and start-up costs were excluded from the analysis (Gold et al., 1996).

Individuals experiencing a false-reactive test (0.5% based on the clinical trial) were also assigned the cost of confirmatory testing and a quality-of-life decrement of 0.32 for 7 days (Coco, 2005). These were the only quality-of-life weights assigned to HIV-uninfected individuals, since no other quality-of-life differences between interventions would be expected for these individuals based on the adverse events reported in the trial (Metsch et al., 2012).

2.5 Sensitivity Analyses

In sensitivity analyses, we varied the prevalence of undiagnosed HIV infection from 0.1% to 1.0%, the CD4 count at the time of the intervention from 200 cells/ μ l to 700 cells/ μ l, and the probability of accepting an offer of on-site HIV testing. We varied testing intervention costs by excluding patient costs and by including only variable costs. We also varied model inputs for calculating HIV test frequency, HIV test sensitivity and specificity, CD4 count standard deviation and HIV RNA at diagnosis for HIV-infected individuals, and ART efficacy and cost based on data reported in the literature or clinical judgment (Table 1).

We considered scenarios that assumed HIV prevalence is higher among those who are tested and receive their results off site compared to those who are tested on-site, reflecting a potentially higher motivation to obtain results among individuals who correctly perceive themselves to be at higher risk of HIV infection. We also considered an implementation scenario where individuals who had received an HIV-negative test result from a test conducted in the last year were also eligible for the interventions; based on trial screening data this would increase the cohort population size by 47%. We conservatively assumed that none of these recently tested individuals would have become HIV-infected in the intervening period since their last test but that they would accept the HIV test offer at the same rates as the trial participants, thereby reducing the prevalence of undiagnosed HIV in the tested population.

Because there were no statistically significant differences in sexual risk behaviors among the three groups in the trial, all analyses assumed no impact of risk-reduction counseling on sexual risk behavior and sexual risk behavior was not a model input. We report the incremental cost of providing risk-reduction counseling, including provider and patient costs.

3. RESULTS

3.1 Base Case

Table 2 presents the results of the Base Case analysis. The life expectancy of an HIV-infected substance abuse treatment patient currently unaware of his or her HIV status is 17.1 years with no intervention, and an offer of referral for off-site HIV testing in substance abuse treatment programs increases this life expectancy by 0.8 years to 17.9 years. Offering

¹Supplementary material can be found by accessing the online version of this paper at <http://dx.doi.org> and by entering doi:...

on-site HIV testing with information only or with counseling increases life expectancy to 20.8 years and 20.5 years, respectively.

Taking into account outcomes for both HIV-uninfected and HIV-infected individuals, an offer of off-site referral adds \$102 in lifetime cost per person offered and increases quality-adjusted life expectancy by 0.02 months compared to no intervention. The cost of the off-site referral is \$11 per person offered, including the cost of an HIV test only for those who accept the referral. The remaining cost of \$91 results from earlier treatment and longer life expectancy on average among HIV-infected individuals, applied to the total population offered the referral. An offer of on-site testing with information adds an additional \$360 and 0.07 quality-adjusted life months; the additional cost of the on-site test is \$30 per person offered. Off-site referral is dominated by on-site testing with information only (extended dominance), because the additional cost per quality-adjusted life years is lower with on-site testing. The cost-effectiveness ratio for on-site testing with information only compared to no intervention is \$60,300/QALY.

On-site testing with information only is less costly, does not have a lower acceptance rate, and is more effective than on-site testing with counseling; therefore, on-site testing with counseling is dominated and on-site testing with information only is preferred. The additional cost of delivering the risk-reduction counseling strategy is \$36 per person (\$77 versus \$41 with information only, an increase of almost 90%) after taking into account the lower HIV test acceptance rate with risk-reduction counseling.

3.2 Sensitivity Analyses

In one-way sensitivity analyses, cost-effectiveness ratios for offering on-site testing with information only compared to no intervention are higher at lower prevalence of undiagnosed HIV (\$76,300/QALY at 0.1% prevalence) and higher CD4 count at the time of the intervention (\$71,700/QALY at 700 cells/ μ l; Table 3). When the probability of testing elsewhere is increased so that 99% of individuals would be tested by 5.3 years, the cost-effectiveness ratio for on-site testing with information only is \$82,800/QALY. Varying HIV testing costs, HIV test sensitivity and specificity, quality-of-life impact of a false-reactive test result, CD4 count standard deviation, HIV RNA at diagnosis for HIV-infected individuals, and ART efficacy has little impact on cost-effectiveness ratios, whereas increasing or decreasing ART costs by 50% results in cost-effectiveness ratios of \$83,300/QALY and \$37,300/QALY respectively (Table 3). In sensitivity analyses varying both prevalence of undiagnosed HIV and CD4 count at the time of the intervention, cost-effectiveness ratios range from \$96,300/QALY at 0.1% prevalence at 700 cells/ μ l to \$45,200/QALY at 1.0% prevalence and 200 cells/ μ l (Figure 1).

When HIV test acceptance for on-site testing with information only are varied, HIV test acceptance has to be less than 22% (compared to 86% in the base case) in order for the cost-effectiveness ratio of the on-site testing with information only strategy to exceed \$100,000/QALY. In scenarios where HIV prevalence is increased among those who receive results after referral for off-site testing by 0.1% (for example from 0.4% to 0.5%, reflecting a possible greater motivation to test off-site among those most at risk), on-site testing with information only is no longer preferred, either because it is dominated or because it has a cost-effectiveness ratio >\$100,000/QALY. In an implementation scenario where individuals who report receiving an HIV-negative result from a test conducted in the last year are also eligible, the cost-effectiveness ratio for on-site testing with information is \$67,000/QALY and exceeds \$100,000/QALY once the prevalence of undiagnosed HIV falls below 0.1%.

4. DISCUSSION

We used data from a randomized trial of HIV testing conducted in community-based substance abuse treatment programs and the CEPAC computer simulation model to examine the cost-effectiveness of HIV testing strategies in this setting. The randomized trial found higher rates of receipt of HIV test results with on-site testing than with off-site referral. We found that on-site testing with information, but not risk-reduction counseling, provides better value for money than off-site referral, with a cost-effectiveness ratio of \$60,300/QALY compared to no intervention. On-site HIV testing with risk-reduction counseling increases the cost per participant by almost 90%, and in the trial had no significant effect on self-reported sexual risk behavior 6 months later. Hence it is not a cost-effective strategy in this population based on this endpoint.

The CDC recommends expanding HIV testing beyond traditional testing sites such as medical care settings and community-based testing sites in order to identify HIV-infected persons and enroll them in care earlier (Branson et al., 2006). Earlier care results in improved life expectancy and reduced risk of HIV transmission (Das et al., 2010; Department of Health and Human Services, 2011; Holmberg et al., 2004). Introducing on-site rapid HIV testing to substance abuse treatment programs could be a centerpiece of this strategy, and is endorsed by the President's National HIV/AIDS Strategy (Office of National AIDS Policy, 2010). At a minimum, federal and state funders should have evidence about the cost-effectiveness from a societal perspective of on-site rapid HIV testing programs in substance abuse treatment settings before considering providing additional financial support to implement testing in these settings. Evidence of societal value can also help to overcome financial and operational barriers within substance abuse treatment programs to implementing on-site HIV testing.

In this study, the cost-effectiveness ratio for on-site rapid testing with information only in substance abuse treatment programs fell below a \$100,000/QALY threshold unless the prevalence of undiagnosed HIV was <0.1% and those with undiagnosed HIV were all at a very early stage of HIV disease (>700 CD4 cells/ μ l). In comparison, cost-effectiveness ratios of \$42,400/QALY-\$50,600/QALY have been reported for one-time HIV screening in outpatient settings (Paltiel et al., 2006, 2005; Sanders et al., 2005) and \$48,700/QALY in inpatient settings (Walensky et al., 2005; all ratios converted to 2009 US dollars). These previous studies used higher HIV prevalence and lower HIV testing costs than in this study and were done at a time when there was less ongoing testing outside of the screening programs. We also modeled current US guidelines for antiretroviral treatment initiation at 500 CD4 cells/ μ l, which results in higher lifetime drug costs for patients on antiretroviral therapy than in previous studies that used older guidelines.

There are limitations to our analysis. Data were collected in a clinical trial conducted in community-based substance abuse treatment programs that were diverse, but are not representative of all programs in the US, and rates of test acceptance and receipt of results may not be generalizable outside the context of a randomized clinical trial. The trial was not powered to detect prevalence of undiagnosed HIV so the 0.4% prevalence used in the base case is only an estimate. Prevalence of undiagnosed HIV may be higher in settings where there is higher overall HIV prevalence and fewer substance users have been tested previously. In addition, both the CD4 count at diagnosis and the frequency of testing elsewhere were unobserved. We addressed these limitations by conducting sensitivity analyses for these parameters over a wide range of values. Our model did not incorporate future HIV transmission behavior; including potential benefits from reduced HIV transmission by those whose HIV is diagnosed could result in a lower (more attractive) cost-effectiveness ratio for on-site rapid testing. There was some evidence from the trial that

among the small number of participants who reported needle sharing there was a greater reduction in needle-sharing risk behavior in the risk-reduction counseling arm. This suggests that risk-reduction counseling targeted at individuals who are currently engaging in high-risk injection drug use behavior might be valuable. We did not evaluate such a strategy because data from the trial on this target population are limited; evaluating the cost-effectiveness of a rapid HIV testing and counseling intervention targeted at individuals who share needles is beyond the scope of the current study.

The CEPAC model is a representation of current HIV clinical care, and we assumed HIV-infected individuals would consistently receive care according to current US standards. We did not project future advances in HIV care that improve life expectancy, which could result in a more attractive cost-effectiveness ratio for on-site testing depending on the cost of these advances, nor did we project future gaps in treatment that reduce life expectancy and could result in a less attractive ratio.

In summary, a one-time streamlined offer of on-site rapid HIV testing with a description of the testing procedure increases life expectancy for newly diagnosed HIV-infected individuals at an acceptable cost-effectiveness ratio of \$60,300/QALY. Adding risk-reduction counseling increases testing costs, did not increase test acceptance, and was not effective in reducing sexual risk behavior in the trial. Policymakers and substance abuse treatment leaders should seek funding to implement on-site rapid HIV testing in substance abuse treatment programs for those not recently tested.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.

Cost-Effectiveness ratio for offer of on-site HIV test with information only in substance abuse treatment programs compared to no intervention, varying prevalence of undiagnosed HIV infection and CD4 count at the time of the intervention.

Table 1

Model input parameters

Variable	Base Case	Range	Reference
Baseline cohort characteristics			
Mean age, years (standard deviation)	39.2 (11.2)	-	CTN 0032
Sex, male (%)	60.7	-	CTN 0032
Race/Ethnicity			
White (%)	63.5	-	CTN 0032
Black (%)	22.3	-	CTN 0032
Hispanic (%)	11.5	-	CTN 0032
Injection drugs in lifetime (%)	48.6	-	CTN 0032
Previously tested for HIV (%)	69.9	(0.0–100.0)	CTN 0032
Time between HIV tests elsewhere (years)	5.3 ^a	(2.0–5.3)	CTN 0032
Rapid test characteristics			
Sensitivity (%)	99.6	(98.4–100.0)	(CDC Prevention, 2002)
Specificity (%)	99.3	(95.7–100.0)	CTN 0032
Prevalence of undetected HIV infection (%)	0.4	(0.1–1.0)	CTN 0032
Test acceptance (%)			
Off-site referral	24.3	-	CTN 0032
On-site HIV test with information only	86.1	-	CTN 0032
On-site HIV test with counseling	81.1	-	CTN 0032
Receipt of test results (%)			
Off-site referral	75.7	-	CTN 0032
On-site HIV test with information only	98.6	-	CTN 0032
On-site HIV test with counseling	98.3	-	CTN 0032
Variable cost of intervention (2009 US \$/person)			
Off-site referral	15.76 ^b	-	CTN 0032
On-site HIV test with information only	34.03	-	CTN 0032
On-site HIV test with counseling	55.25	-	CTN 0032
Time dependent cost of intervention (2009 US \$/person)			
Off-site referral	0.00	-	CTN 0032

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Variable	Base Case	Range	Reference
On-site HIV test with information only	6.73	-	CTN 0032
On-site HIV test with counseling	20.86	-	CTN 0032
Patient cost of intervention (2009 US \$/person)			
Off-site referral	20.44	-	CTN 0032
On-site HIV test with information only	4.90	-	CTN 0032
On-site HIV test with counseling	8.52	-	CTN 0032
Total cost of intervention (2009 US \$/person)			
Off-site referral	36.14 ^d	(4.76–25.20)	CTN 0032
On-site HIV test with information only	45.66 ^d	(34.03–45.66)	CTN 0032
On-site HIV test with counseling	84.63 ^d	(55.25–84.63)	CTN 0032
HIV+ characteristics			
CD4 count at HIV infection, cells/ μ l (SD)	664 (294)	-	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
CD4 count at time of intervention for previously tested for HIV, cells/ μ l (SD) ^e	580 (271)	(200–700)	CEPAC
CD4 count at time of intervention for never tested for HIV, cells/ μ l (SD) ^e	484 (255)	(200–700)	CEPAC model
Median HIV RNA in chronic HIV infection			
>100,000 copies/ml	12.9%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
30,001–100,000 copies/ml	12.9%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
10,001–30,000 copies/ml	25.0%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
3,001 – 10,000 copies/ml	25.2%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
501 – 3,000 copies/ml	16.3%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
<500 copies/ml	7.7%	(0.0%–100.0%)	(Multicenter AIDS Cohort Study (MACS) Public Dataset: Release PO4, 1995)
HIV Treatment regimen efficacy (% patients with HIV RNA suppression at 24 weeks, CD4 cell increase at 48 weeks) and monthly cost (2009 US \$)			
First line			
Efficacy	86.0%, 190 cells/ μ l	(73.1%–98.9%)	(Gallant et al., 2006)
Monthly cost	1,430	(720–2,150)	
Second line			

Variable	Base Case	Range	Reference
Efficacy	73.3%, 110 cells/ μ l	(62.3%–84.3%)	(Johnson et al., 2005)
Monthly cost	2,050	(1,030–3,080)	
Third line			
Efficacy	61.3%, 121 cells/ μ l	(52.1%–70.5%)	(Johnson et al., 2005)
Monthly cost	2,040	(1,020–3,060)	
Fourth line			
Efficacy	64.5%, 102 cells/ μ l ^f	(54.8%–74.2%)	(Grinsztejn et al., 2007)
Monthly cost	2,630	(1,320–3,950)	
Fifth line			
Efficacy	40.0%, 121 cells/ μ l	(34.0%–46.0%)	(Lalezari et al., 2007; Nelson et al., 2005)
Monthly cost	4,000	(2,000–6,010)	
Sixth line			
Efficacy	15.0%, 45 cells/ μ l	(12.8%–17.3%)	(Nelson et al., 2005)
Monthly cost	1,740	(870–2,610)	

^aModeled as 0.0157 probability per month of testing elsewhere in base case (approximately two-thirds are tested elsewhere by 5.3 years) in the base case and 0.070 probability of being tested elsewhere (99% are tested elsewhere by 5.3 years) in sensitivity analysis (see text)

^bOff-site non-rapid HIV antibody test costs an additional \$76.91

^cPatient cost includes travel to and time at off-site location

^dIf rapid test indicates a reactive result, the additional cost is \$76.91

^eBase case standard deviation also reduced by 50% and by 90% in sensitivity analyses

^fIncrease in CD4 count for 4th line regimen was measured at 24 weeks

Table 2

Base Case Cost-Effectiveness Results (per person receiving an HIV test offer)

Screening Strategy	Undiscounted Life Expectancy per HIV-infected Person (Years)	Cost per HIV-infected Person (2009 US \$)	Cost per HIV-uninfected Person (2009 US \$)	Weighted Average Total Cost per Person ^a (2009 US \$)	Weighted Average Total QALY per Person ^d	Incremental Cost per Person (2009 US \$)	Incremental QALY per Person	Cost-effectiveness ratio (\$/QALY)
Background screen	17.05	274,013	-	1,096	0.0412	-	-	-
Offer of off-site test	17.85	296,627	11	1,198	0.0429	102	0.0016	dominated ^b
On-site test + information	20.75	379,126	41	1,558	0.0489	360 ^c	0.0060 ^c	60,300
On-site test + counsel	20.52	372,802	77	1,569	0.0484	11	-0.0005	Dominated ^d

Note: All costs and QALYs are lifetime and discounted at an annual rate of 3%

^aWeighted by prevalence: 0.4% HIV-infected, 99.6% HIV-negative^bCost-effectiveness ratio of offer of off-site test compared to no intervention is \$62,400/QALY and cost-effectiveness ratio of on-site HIV test with information only compared to offer of off-site test is \$59,700/QALY; offer of off-site test is dominated (extended dominance) (Cantor, 1994; Drummond et al., 2005)^cCompared to No Intervention, the Incremental Cost per Person is \$462 and the Incremental QALY per Person is 0.0076, resulting in a cost-effectiveness ratio of \$60,300/QALY^dCost of on-site testing with information is lower and QALYs are higher than on-site testing with counseling; on-site testing with counseling is dominated (Dominance) (Drummond et al., 2005)

Table 3
Sensitivity Analyses: On-site HIV Testing With Information Only Compared to No Intervention

Screening Strategy	Weighted Average Total Cost per Person ^a (\$)	Weighted Average Total QALY per Person ^a	Incremental Cost per Person Compared to No Intervention	Incremental QALY per Person Compared to No Intervention	Cost-effectiveness ratio (\$/QALY)
Base Case	1,558	0.0489	462	0.0077	60,300
Varying prevalence of undiagnosed HIV					
0.1% prevalence	420	0.0122	146	0.0019	76,300
1.0% prevalence	3,833	0.1222	1,092	0.0191	57,100
Varying CD4 count at detection					
700 cells/ μ l	1,460	0.0497	358	0.0050	71,700
200 cells/ μ l	1,606	0.0434	671	0.0143	46,900
Varying Inputs for HIV testing elsewhere					
99% tested by 5.3 years	1,616	0.0500	154	0.0019	82,800
99% by tested by 2.0 years	1,628	0.0502	81	0.0006	129,300
Varying HIV testing strategy costs					
Excluding patient costs	1,553	0.0489	457	0.0077	59,700
Variable cost only	1,546	0.0489	450	0.0076	58,900
Varying HIV test sensitivity					
98.4% sensitivity	1,552	0.0488	456	0.0076	60,400
100.0% sensitivity	1,560	0.0489	465	0.0077	60,200
Varying HIV test specificity					
95.7% specificity	1,560	0.0487	465	0.0075	62,300
100.0% specificity	1,557	0.0489	461	0.0077	60,100
Varying false-positive quality-of-life decrement (base case = 0.32 for 1 week)					
Quality-of-life decrement = 0	1,558	0.0489	462	0.0077	60,100
Quality-of-life decrement = 0.32 for 2 months	1,558	0.0489	462	0.0076	60,400
Varying CD4 count standard deviation (SD)					
SD = 0.5x Base case	1,631	0.0500	466	0.0069	67,500
SD = 0.1x Base case	1,670	0.0503	471	0.0064	73,100
Varying HIV RNA at detection					
<500	1,505	0.0503	409	0.0059	68,900

Screening Strategy	Weighted Average Total Cost per Person ^a (2009 US \$)	Weighted Average Total QALY per Person ^a	Incremental Cost per Person Compared to No Intervention	Incremental QALY per Person Compared to No Intervention	Cost-effectiveness ratio (\$/QALY)
>100,000	1,577	0.0479	496	0.0088	56,200
Varying ART efficacy					
15% lower efficacy	1,539	0.0477	453	0.0073	62,300
15% higher efficacy	1,568	0.0498	468	0.0080	58,800
Varying ART cost					
50% higher	2,116	0.0489	638	0.0077	83,300
50% lower	999	0.0489	286	0.0077	37,300

Note: All costs and QALYs are lifetime and discounted at an annual rate of 3%

^aWeighted by prevalence: 0.4% HIV-infected, 99.6% HIV-negative unless otherwise specific
ART, antiretroviral therapy; QALY, quality-adjusted life year