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From Theory to Practice: Implementation of a Resource Allocation Model in Health Departments

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Abstract

Objective—To develop a resource allocation model to optimize health departments' Centers for Disease Control and Prevention (CDC)–funded HIV prevention budgets to prevent the most new cases of HIV infection and to evaluate the model's implementation in 4 health departments.

Design, Settings, and Participants—We developed a linear programming model combined with a Bernoulli process model that allocated a fixed budget among HIV prevention interventions and risk subpopulations to maximize the number of new infections prevented. The model, which required epidemiologic, behavioral, budgetary, and programmatic data, was implemented in health departments in Philadelphia, Chicago, Alabama, and Nebraska.

Main Outcome Measures—The optimal allocation of funds, the site-specific cost per case of HIV infection prevented rankings by intervention, and the expected number of HIV cases prevented.

Results—The model suggested allocating funds to HIV testing and continuum-of-care interventions in all 4 health departments. The most cost-effective intervention for all sites was HIV testing in nonclinical settings for men who have sex with men, and the least cost-effective interventions were behavioral interventions for HIV-negative persons. The pilot sites required 3 to 4 months of technical assistance to develop data inputs and generate and interpret the results. Although the sites found the model easy to use in providing quantitative evidence for allocating HIV prevention resources, they criticized the exclusion of structural interventions and the use of the model to allocate only CDC funds.

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Conclusions—Resource allocation models have the potential to improve the allocation of limited HIV prevention resources and can be used as a decision-making guide for state and local health departments. Using such models may require substantial staff time and technical assistance. These model results emphasize the allocation of CDC funds toward testing and continuum-of-care interventions and populations at highest risk of HIV transmission.

Keywords

HIV/AIDS; HIV prevention; resource allocation modeling

HIV resource allocation models can synthesize surveillance, program, cost, and outcome data to guide the distribution of HIV prevention funding among people and programs to achieve high impact. Many models for resource allocation of HIV funds have been developed during the past 2 decades,[1–7] but few have been used to support funding decisions by health departments.[8,9] The complexity of many HIV resource allocation models may reduce their transparency and usefulness to decision makers and ultimately make their adoption less likely.[10,11]

In response to calls for modeling in the National HIV/AIDS Strategy,[12] in 2011, the Division of HIV/AIDS Prevention (DHAP) at the Centers for Disease Control and Prevention (CDC) created a resource allocation model to guide the distribution of CDC resources at the state and local levels to minimize new infections. The effort stemmed from the Enhanced Comprehensive HIV Planning Project that included the 12 US cities with the highest number of people living with AIDS and was designed to reduce HIV infection through improved planning, coordination, and implementation of HIV prevention interventions. The first effort to apply the model was with the AIDS Activity Coordinating Office of the Philadelphia Department of Public Health.

Also, in 2011, DHAP finalized a national-level resource allocation model to estimate the most efficient allocation of CDC's HIV prevention funds across all health departments.[5,6] The model results showed that, compared with DHAP's current allocation, more funds should be spent on testing, particularly on the testing of gay, bisexual, and other men who have sex with men (MSM) and injecting drug users (IDUs). The model also indicated that behavioral risk-reduction interventions should focus on those infected with HIV, rather than those not infected but at risk of acquiring HIV infection. Based in part on those results, DHAP in 2012 provided new direction to health departments receiving federal HIV prevention dollars under its high-impact approach to HIV prevention.[13,14] The new 5-year funding announcement required that health departments spend at least 75% of CDC funds on 4 intervention types: HIV testing, prevention with people living with HIV infection and their partners, condom distribution, and the alignment of public policies to maximize the impact of HIV prevention, care, and treatment services.

In September 2012, the US Department of Health and Human Services, Office of HIV/AIDS and Infectious Disease Policy, and DHAP collaborated on a 1-year pilot project to further evaluate the usefulness in 3 additional health departments of the Philadelphia resource allocation model and assess the needed level of technical assistance. During the pilot, DHAP refined the model and developed materials for health department implementation. The Office

of HIV/AIDS and Infectious Disease Policy awarded a contract to John Snow, Inc (JSI), to provide technical assistance to health departments and to evaluate the feasibility of using the model for funding decisions. The Philadelphia health department was invited to participate in the evaluation. The pilot project was named the HIV Resource Allocation Modeling Pilot (HIV-RAMP) project.

In this article, we describe the HIV-RAMP project, its results, and the evaluation from the 3 pilot sites and Philadelphia.

Methods

Pilot site selection and provision of technical assistance

We sought to conduct the pilot in health departments that varied by HIV prevalence, capacity, resources, and geography. On the basis of those criteria, we invited participation by the Chicago Department of Public Health (Chicago), the Nebraska Department of Health and Human Services (Nebraska), and the Alabama Department of Public Health (Alabama). Chicago and Philadelphia represented jurisdictions with higher HIV prevalence, higher capacity, and greater resources, whereas Nebraska and Alabama represented lower HIV prevalence jurisdictions with fewer resources.

The model was piloted sequentially in Chicago, Nebraska, and Alabama so that lessons learned from one deployment could be incorporated into the next. The process began at each site with an introductory call and was followed by the provision of basic information about modeling and resource allocation as well as a codebook for HIV-RAMP data inputs. We then introduced the resource allocation model and demonstrated how to develop inputs, run the model, interpret the results, and conduct, interpret, and understand sensitivity analyses.

Model methods

Using Microsoft Excel, Visual Basic for Applications, and Solver add-ins, we developed a linear programming model combined with a Bernoulli process model to optimize HIV prevention resource allocation for health departments participating in the pilot (see the Technical Appendix, Supplemental Digital Content, available at: http://links.lww.com/JPHMP/A167). We considered HIV prevention interventions that were aligned with the principles of high-impact prevention, were recommended by CDC or other federal agencies, and for which sufficient efficacy data existed. These included (*a*) testing in clinical settings, (*b*) testing in nonclinical settings, (*c*) partner services, (*d*) continuum-of-care–related interventions designed to improve linkage to care, retention in care, and adherence to antiretroviral therapy (ART), and (*e*) behavioral interventions for HIV-positive and HIV-negative persons. Testing in nonclinical settings and behavioral interventions were targeted to specific risk populations such as MSM, IDUs, and sexually active heterosexuals (HETs). Nontargeted interventions included testing in clinical settings, partner services, linkage to care, retention in care, and adherence to ART. We excluded structural interventions such as condom distribution, syringe exchange, and social media campaigns, because we could not identify sufficient data for use in a Bernoulli process model, described in the following text, to estimate a per person reduction in the risk of HIV transmission or acquisition.

We used a Bernoulli process model to estimate the annual risk of HIV transmission or acquisition, which required behavioral data specific to each risk population on the average number of partners per year, the number of sex acts per partner, condom use, estimated HIV prevalence among partners, and partnership overlap. In addition, the model utilized estimated per act HIV transmission probabilities for each type of sex act. For the IDU population, we also considered transmission or acquisition by needle sharing. We estimated the effects of HIV prevention interventions by reducing per act or per partnership transmission probabilities or increasing the proportion of condom-protected sex acts. We estimated an intervention's effect on annual HIV transmission or acquisition risk as the difference in the Bernoulli process model's calculation of annual transmission risk with and without the intervention's effect. Then, we determined the cost per case of HIV infection prevented for each intervention by dividing the cost of the intervention by the intervention effect. Because continuum-of-care parameters—such as the proportion of undiagnosed HIV-infected persons among those living with HIV infection—varied by pilot site, the value and rankings of the same continuum-related intervention could differ across the pilot sites.

We applied various periods of duration to the interventions. We assumed reductions in risky behavior associated with a new diagnosis of HIV infection, including one delivered through partner services, lasted for 5 years. In a meta-analysis by Marks et al,[15] of high-risk sexual behavior in persons aware and unaware of their HIV infections in the United States, the prevalence of unprotected anal or vaginal intercourse was similar among HIV-positive aware men regardless of the length of time between when they were surveyed and when they became aware of their infection (up to 8 years). Because studies evaluating the efficacy of behavioral interventions typically followed participants for 12 months or less[16–20] and few studies on care and treatment-related interventions followed the participants for more than 2 years,[21–25] we assumed a 1-year duration for behavioral interventions and a 2-year duration for continuum-of-care interventions, such as retention in care and adherence to treatment. Further discussion of our assumptions about duration can be found in the Technical Appendix (see Supplemental Digital Content, available at: http://links.lww.com/JPHMP/A167). After accounting for duration, the site-specific cost per case of HIV infection prevented was used as an input to the optimization model.

For the optimization model, we also set the maximum reach, or the maximum proportion of the eligible population that could be reached by the intervention. The proportion reflected assumptions about the fraction of the eligible population that would avail itself of the intervention during the course of a year and intervention scalability. We also considered the proportion served by HIV prevention interventions funded by the Philadelphia health department during a 1-year period. We set the maximum reach at 20% for continuum-of-care interventions and behavioral interventions for HIV-infected persons, 10% for testing and behavioral interventions for uninfected persons, and 5% for partner services. Given lack of data from the 3 pilot sites, we set the maximum reach consistently for each intervention across the sites.

The objective of the optimization model was to maximize the number of new infections prevented for a given health department budget, achieved through the following steps:

i. The model ranked the cost per case prevented by intervention for each site, that is, the most cost-effective intervention was ranked highest and the intervention that had the largest cost per case prevented was ranked lowest.

ii. Given the target population reachable by the intervention and the budget, the model allocated funding to each intervention starting with the most cost-effective intervention. When model allocation for an intervention achieved the maximum reach for that intervention, the next most cost-effective intervention received funds remaining in the budget.

iii. The allocation process terminated when the budget was exhausted or when all interventions were funded and covered the maximum reach for each.

Model inputs

The model inputs included epidemiologic, behavioral, budgetary, and programmatic data. The Bernoulli process model used behavioral data and intervention efficacy to determine annual transmission and acquisition risk, with and without each intervention. The optimization model used the budget amount, intervention costs, and each health department's epidemic profile, including the maximum reach of each intervention.

Pilot site data included their total CDC HIV prevention budget, site-specific HIV prevalence and annual incidence by risk group, and the proportion of those infected or diagnosed with HIV infection who achieved steps along the continuum of care: diagnosed, linked to care, retained in care, and adherent to treatment (Table 1).

The data CDC provided included behavioral data and estimates of intervention costs and efficacy. The behavioral data included per act HIV transmission or acquisition probabilities by sex act and contaminated needle sharing, the annual number of partners and injections, the number of sex acts per partner, the proportion of sex acts protected by condoms, the proportion of needle/syringe shared among users, and the proportion of infected persons having more than 1 infected partner at a time. We derived parameter estimates from the National Survey of Sexual Health and Behavior[26–28] and the National Survey of Family Growth.[29–31] We used expert opinion when relevant data were unavailable.

Using program expenditures reported by health departments and costs from trials and published studies, we estimated the cost to a health department to deliver an intervention. All costs were converted to 2009 US dollars using the medical care component of the Consumer Price Index.[32] Philadelphia supplied its own program costs and some program efficacy data based on health department–specific budget and outcome data.

We conducted the analysis from a health department perspective. Model inputs for duration of effect, maximum reach, and behavior change following a new diagnosis were evaluated in sensitivity analyses. Those methods and results are reported in the Technical Appendix (see Supplemental Digital Content, available at: http://links.lww.com/JPHMP/A167).

Model outcomes

The model generated the optimal allocation of funds, the site-specific cost per case of HIV infection prevented rankings, the total number of persons served, the expected number of HIV cases prevented, and the total HIV life time treatment cost saved if the optimal allocation was realized for each site. Total HIV life time treatment costs saved typically are not incurred by health departments. However, this measure quantifies the health department's prevention efforts and presents the overall benefit of the intervention.

We estimated the cost and efficacy of interventions compared with the baseline/status quo that would have occurred without the intervention. This baseline/status quo reflects the impact of previous HIV prevention funding. We measured the number of HIV cases prevented compared with baseline/status quo for each intervention.

Evaluation methods

We focused on 4 evaluation research questions:

1. What resources did the health department require to implement HIV-RAMP?
2. What aspects of HIV-RAMP were the most useful to the health department?
3. What were the HIV-RAMP project's greatest limitations?
4. On the basis of lessons learned, what recommendations would the health department have for other departments considering the use of HIV prevention resource allocation models?

We evaluated the health departments' experience during site visits and through interviews conducted by JSI. Although JSI provided the technical assistance and evaluated the health departments' experience using the model, different teams within JSI were assigned to conduct those 2 tasks to avoid conflict of interest.

Results

Model results

The model output indicated funding for HIV testing and continuum-of-care interventions in all 4 sites but not for behavioral interventions for HIV-positive or HIV-negative persons (Table 2). As a result, we combined behavioral interventions for HIV-positive and HIV-negative persons in Table 2. In 3 of the 4 health departments, results suggested that the majority of funds be allocated to continuum-of-care interventions, with less than half allocated to HIV testing. The exception was Philadelphia, where 60% of the budget was allocated to testing.

The results suggested that as much as 50% of the prevention budget be allocated to specific continuum-of-care interventions. The site-specific allocation depended upon the proportion of HIV-infected people who already had achieved each step of the continuum, as well as the size of the site's CDC budget.

The largest proportion of overall testing funds was allocated to testing in clinical settings. Funds were also allocated to HIV testing of specific risk groups outside of clinical settings based on the relative size of the risk group's infected but undiagnosed population. The model allocated funding for HIV testing through partner services only in Chicago. It did not allocate funding to HIV testing of HETs in any nonclinical settings.

The cost-effectiveness ranking of HIV prevention interventions varied little across the 4 health departments. The most cost-effective intervention for all sites was HIV testing for MSM in nonclinical settings, whereas behavioral interventions were the least cost-effective in all sites. Behavioral interventions for HIV-positive persons ranked higher than those for HIV-negative persons, and behavioral interventions for MSM were more cost-effective than those for IDUs and HETs. The cost-effectiveness of the targeted interventions reflects the underlying differences in the probability of HIV transmission or acquisition by risk group.

The expected number of persons served with all interventions ranged from 248 in Nebraska to 2723 in Chicago (Table 2). The expected number of HIV cases prevented, given the optimal allocation of 1 year of CDC prevention funds, ranged from 33 in Nebraska to 430 in Chicago. The average cost per case prevented ranged from $25 350 in Alabama to $48 765 in Philadelphia, and life time HIV treatment costs saved from 1 year of prevention funding ranged from $12 million in Nebraska to $158 million in Chicago.

Evaluation results

Health departments required skilled staff to use Microsoft Excel and to collect the budgetary, surveillance, and program data inputs needed to implement the model. Four to 7 health department staff members participated in the project at each site. Their tasks included developing model inputs, running the model, and reviewing and presenting the results. Technical assistance provided by JSI ranged from 84 to 110 days across the 3 pilot sites. The sites varied in their ability to assemble the necessary data inputs for continuum-of-care outcomes, new diagnoses of HIV infection, and the total number of persons living with HIV infection in their jurisdictions by transmission risk group (ie, MSM, IDUs, HETs).

Once trained and with the best available inputs supplied to the model, health department staff found the quick run time of the model and its ease of use and interpretation to be most useful. Participants reported that the model had the potential to guide them on allocating their budget efficiently to maximize the number of HIV infections prevented. The average cost per case of HIV infection prevented by an intervention was one of the most useful outputs. In some instances, the pilot project enhanced collaborations between health department surveillance and program staff. The model results provided rigorous and quantitative evidence for decision making about how to distribute HIV prevention resources among programs and populations. The results were useful for justifying funding allocations to program managers, people living with HIV infection, and HIV prevention advocacy groups. On the basis of its results, Philadelphia planned to reduce funds for behavioral interventions and interventions targeting HETs. Alabama planned to increase funds for retention in care. Alabama and Chicago planned to reduce funds for behavioral interventions, particularly for HIV-negative individuals.

Participants identified the greatest limitations of HIV-RAMP as the exclusion of structural interventions, the inability to incorporate non-CDC funds for HIV prevention and treatment interventions, and the lack of integrated interventions that encompassed several steps of the continuum of care. In addition, some sites found that they could not respond to the model recommendations in a timely manner if the model results became available only after multiyear contracts were established.

Participants recommended that future model users should be clear about the model's purpose and limitations, data inputs required, and inclusion and exclusion criteria for interventions. The participants also stated it would be important for future users to realize that models offer guidance on relative allocations of funds rather than on precise amounts to be allocated and that models may not incorporate important factors such as feasibility and equity.

Discussion

We describe an HIV resource allocation model developed to optimize the CDC HIV prevention budgets of state and local health departments to prevent the most cases of HIV infection. We also present findings from an evaluation of the model's implementation in 4 health departments. The model recommendations for funding allocations focused on funding HIV testing, especially for MSM and IDUs, and on funding the care-related continuum interventions. The amount allocated to individual continuum-related interventions varied considerably across health departments on the basis of the proportion of people living with HIV infection who already had achieved the related step of the continuum of care and the size of the health department's CDC funding.

The average cost per case of HIV infection prevented under the optimal allocation in the 4 health departments ranged from $25 350 to $48 765. Some of the variation was due to the fact that health departments with larger budgets were able to fund interventions with higher cost-effectiveness ratios, thereby driving up the cost per case prevented. However, given an HIV life time treatment cost estimate of $418 000, the optimal allocation was cost saving in all 4 health departments.[33]

The results from the 4 pilot sites were consistent with those from a national HIV resource allocation model.[5,6] In addition, the emphasis on funding interventions along the continuum of care was similar across the 4 pilot sites. Because the pilot sites varied with respect to size of HIV burden and budget, we believe these results can be generalized to most health departments in the United States. However, future work should explore potential scenarios where the optimal allocation might be markedly different.

The pilot sites faced varying degrees of challenges in implementing the HIV-RAMP project, including assembling the necessary site-specific data inputs. Identifying the proportion of people living with HIV infection who had progressed along each step of the continuum of care (ie, having been linked to care, retained in care, and adherent to ART) was the most problematic step for some health departments.[34–38] Published definitions for the proportion of people who had reached individual steps along the continuum varied by the denominator

(eg, total number living with HIV infection vs total number diagnosed with HIV infection), the observation period (eg, retained in care for 12 months vs 24 months), and the allowable time frame between medical visits for the retention estimate (eg, 3 months vs 6 months). Even when definitions for each estimate were provided by CDC, 2 of the health departments still lacked sufficient data to estimate the number of people living with HIV infection who were retained in care and adherent to ART. In those cases, health departments relied on national-level data for the proportions achieving each step of the continuum, which may have resulted in an over- or underallocation of funds to the intervention.

Although all health departments generally found the model helpful, the limitations of models, and this model in particular, should be noted. First, rather than being a prescriptive last step, this model should be viewed as one of the first steps in the process of gathering data to inform jurisdictional allocation of HIV prevention funding. In addition, this model was designed to optimize the allocation of CDC HIV prevention funds. Thus, it did not consider funding from non-CDC sources. Health departments receive HIV prevention and care funds from multiple federal and state agencies, and some of the funding is restricted. For instance, HIV funds from the Health Resources and Services Administration are intended for HIV infection care and treatment. Future refinements of the model could have multiple funding streams, including restricted funding streams. In addition, having a comprehensive picture of funds available to health departments for HIV prevention and treatment, by source, amount, and purpose, would be useful for federal and local planners.

The model also considered continuum-of-care interventions as discrete rather than combined interventions due to limited data on the total effect of combined interventions on achieving viral load suppression. Comprehensive interventions have the potential to be less expensive and perhaps more effective than those delivered separately. As data on the costs and effectiveness of comprehensive interventions become available, and as other refinements are made to the model, including the capture of restricted funding streams, the results of the model could change.

Each intervention included in the model required data on the magnitude and duration of efficacy in preventing HIV transmission or acquisition. The scientific evidence supporting the efficacy for some interventions is stronger than it is for others. Thus, the level of scientific evidence for intervention efficacy should be taken into consideration when making decisions about resource allocation.

HIV-RAMP required many inputs expressed as point estimates, and all of those estimates included some degree of uncertainty. Our sensitivity analysis on some of the least certain parameters, duration of efficacy, maximum reach, and behavior change following a new diagnosis, as reported in the Technical Appendix (see Supplemental Digital Content, available at: http://links.lww.com/JPHMP/A167), indicated reasonable robustness of model results.

The model was static rather than dynamic. Advantages of dynamic models are the ability to incorporate future generations of infections and to understand synergies between intervention outcomes over time. Disadvantages include greater obstacles to using the model

and interpreting results. We sought to implement a model that would best combine accuracy with usability. Because health departments make funding decisions every few years that remain in effect during those years, we believe a static model that could be reformulated every few years to accommodate the latest epidemic, behavioral, effectiveness, and cost data is appropriate.

In this article, we summarize findings from an evaluation of an HIV prevention resource allocation tool developed for use by state and local health departments. The model results were consistent across the 4 health departments—to prioritize HIV prevention dollars for testing and treatment with an emphasis on populations at highest risk of HIV transmission. The health departments were able to implement the model and interpret its results, although doing so often required a considerable amount of staff time and outside technical assistance. Three of the 4 pilot sites found the model and its results useful and sought to implement them in their budget allocation decisions. Our findings lend support to the use of quantitative allocation models to inform decision making to optimize the impact of limited public health resources.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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TABLE 1

Summary of Site-Specific Input Parameters

	Chicago[a]	Nebraska[b]	Alabama[c]	Philadelphia[d]
Number of newly diagnosed HIV infections in year	991	55	409	909
HET	221	8	58	339
IDU	69	1	8	134
MSM	701	46	343	433
Number of persons diagnosed with HIV infection by year-end	21 657	1 679	8 875	19 248
HET	3 990	419	2 542	6 821
IDU	3 603	165	903	5 739
MSM	14 064	1 095	5 430	6 685
HIV prevention budget considered	$12 104 222	$1 139 491	$2 991 304	$12 191 140
Continuum of care				
Proportion of undiagnosed HIV-infected persons among all PLWH	18.0%	18.1%	18.1%	20.0%
Proportion of diagnosed HIV-infected persons who are linked to care	68.1%	51.5%	69.2%	77.0%
Proportion of diagnosed HIV-infected persons who are retained in care	63.7%	33.3%	35.1%	50.8%
Proportion of diagnosed HIV-infected persons who are prescribed ART	53.7%	33.3%[e]	33.1%[f]	44.7%
Proportion of diagnosed HIV-infected persons who achieve viral load suppression	45.2%	33.3%[e]	31.3%[f]	34.4%

Abbreviations: ART, antiretroviral therapy; HET, sexually active heterosexual; IDU, injecting drug user; MMP, Medical Monitoring Project; MSM, gay, bisexual, and other men who have sex with men; PLWH, people living with HIV.

[a] Total prevalence and incidence and HIV prevention budget considered were based on 2011 data and continuum of care were based on 2009 data.

[b] Total prevalence and incidence and continuum of care were based on 2011 data and HIV prevention budget considered were based on 2013 data.

[c] All input values were based on 2011 data.

[d] All input values were based on 2009 data.

[e] Assumption based on all HIV-infected persons retained in care are prescribed ART and they all have perfect adherence.

[f] Calculated on the basis of assumption that Alabama has the same ratio of the percent prescribed ART to the percent retained in care with the national MMP values.

TABLE 2

Optimal Budget Allocation, Cost per Case of HIV Infection Prevented Rankings per Intervention, and Other Model Outcomes for 4 Pilot Sites of Chicago, Nebraska, Alabama, and Philadelphia

	Optimal Allocation, $ (% of Total Budget Allocated[a])							
Interventions	**Chicago**		**Nebraska**		**Alabama**		**Philadelphia**	
Testing in clinical settings	$2 218 522 (18)	2[b]	$173 162 (15)	2[b]	$907 141 (30)	2[b]	$4 788 662 (39)	3[b]
Testing in nonclinical settings: HET	$0 (0)	8	$0 (0)	8	$0 (0)	8	$0 (0)	8
Testing in nonclinical settings: IDU	$552 577 (5)	4	$25 477 (2)	4	$139 429 (5)	4	$1 618 384 (13)	4
Testing in nonclinical settings: MSM	$1 078 469 (9)	1	$84 537 (7)	1	$419 213 (14)	1	$974 946 (8)	1
Partner services	$809 201 (7)	6	$0 (0)	7	$0 (0)	6	$0 (0)	7
Linkage to care	$6 050 597 (50)	5	$535 804 (47)	6	$0 (0)	7	$0 (0)	8
Retention in care	$0 (0)	7	$320 511 (28)	5	$1 412 558 (47)	5	$3 952 292 (33)	5
Adherence to ART	$1 394 660 (12)	3	$0 (0)	3	$112 963 (4)	3	$856 856 (7)	2
Behavioral interventions	$0 (0)	9	$0 (0)	9	$0 (0)	9	$0 (0)	9
Total budget	$12 104 026		$1 139 491		$2 991 304		$12 191 140	
Total persons served	2 723		248		640		1 930	
Total cases prevented	430		33		118		250	
Average cost per case of HIV infection prevented	$28 149		$34 530		$25 350		$48 765	
Total HIV life time treatment cost prevented	$157 895 524		$12 062 761		$43 321 812		$91 749 792	

Abbreviations: ART, antiretroviral therapy; HET, sexually active heterosexual; IDU, injecting drug user; MSM, gay, bisexual and other men who have sex with men.

[a] Because of rounding, the percent values may not sum to 1.

[b] Site-specific cost per case of HIV infection prevented rank by intervention.