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Economic Evaluation

The Cost-Effectiveness of Financial Incentives for Viral Suppression: HPTN 065 Study

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ABSTRACT

Objective: To evaluate the cost-effectiveness of financial incentives for human immunodeficiency virus (HIV) viral suppression compared to standard of care. **Study Design:** Mathematical model of 2-year intervention offering financial incentives ($70 quarterly) for viral suppression (<400 copies/ml^3) based on the HPTN 065 clinical trial with HIV patients in the Bronx, NY and Washington, D.C. **Methods:** A disease progression model with HIV transmission risk equations was developed following guidelines from the Second Panel on Cost-Effectiveness in Health and Medicine. We used health care sector and societal perspectives, 3% discount rate, and lifetime horizon. Data sources included trial data (baseline N = 16,208 patients), CDC HIV Surveillance data, and published literature. Outcomes were costs (2017 USD), quality-adjusted life years (QALYs), HIV infections prevented, and incremental cost-effectiveness ratio (ICER). **Results:** Financial incentives for viral suppression were estimated to be cost-saving from a societal perspective and cost-effective ($49,877/QALY) from a health care sector perspective. Compared to the standard of care, financial incentives gain 0.06 QALYs and lower discounted lifetime costs by $4210 per patient. The model estimates that incentivized patients transmit 9% fewer infections than the standard-of-care patients. In the sensitivity analysis, ICER 95% credible intervals ranged from cost-saving to $501,610/QALY with 72% of simulations being cost-effective using a $150,000/QALY threshold. Modeling results are limited by uncertainty in efficacy from the clinical trial. **Conclusions:** Financial incentives, as used in HTPN 065, are estimated to improve quality and length of life, reduce HIV transmissions, and save money from a societal perspective. Financial incentives offer a promising option for enhancing the benefits of medication in the United States.

Introduction

Barriers to daily oral medication adherence are common and complex for patients with chronic disease.[1] For people living with human immunodeficiency virus (HIV), adherence to antiretroviral therapy (ART) reduces the risk of opportunistic infections, improves quality of life, and extends survival.[2–5] The START Study showed that immediate ART initiation in early asymptomatic HIV infection is associated with a 72% relative reduction in serious AIDS-related events such as tuberculosis and malignant lymphomas, and a 39% relative reduction in serious non-AIDS-related events, when compared to ART initiation delayed until CD4+ cells counts fall below 350 cells per cubic millimeter.[6] Several studies support the role of ART in reducing the likelihood of HIV

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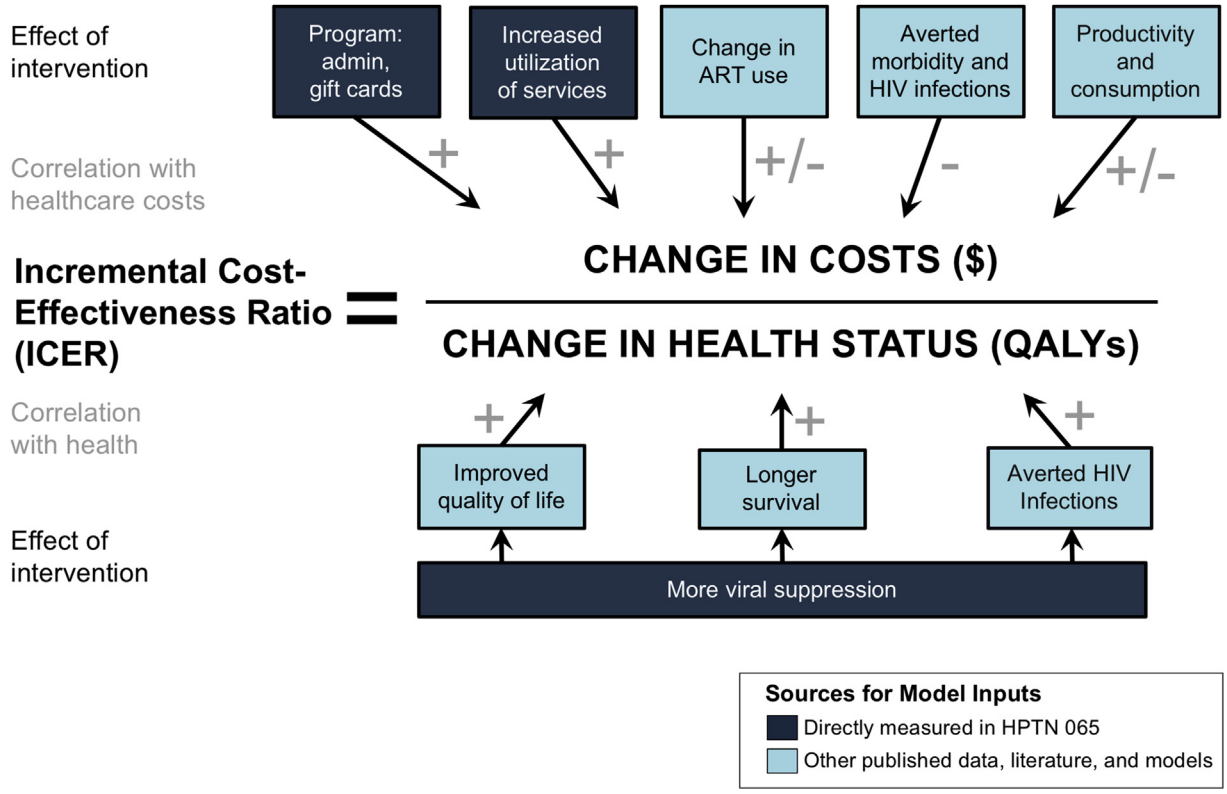

Fig. 1 – Conceptual model. The conceptual model describes the accruing long-term costs and benefits from financial incentives for viral suppression, based on a framework from Kahn et al. [51]

transmission to others by decreasing viral load levels.[7–13] Analysis of the HIV Prevention Trials Network (HPTN) 052 clinical trial demonstrated that there were no HIV transmissions between couples when the HIV-infected partner had suppressed viral load (defined as having a viral load less than 400 copies per ml).[14] Even a small increase in viral suppression reduced transmission to the partners, which translates to meaningful reduction in prevalence in the community. Yet, only 58% of persons living with HIV in the United States achieve viral suppression.[15] Access to treatment does not explain this deficiency because The Ryan White HIV/AIDS Foundation supports a successful AIDS Drug Assistance Program administered by states for low-income and uninsured people living with HIV.[16] There is little evidence of effective interventions to improve viral suppression, despite this being a critical step in the HIV care continuum as described in the National HIV/AIDS Strategy for the United States.[17–20]

Promising evidence shows that financial incentives can improve adherence to treatment and viral suppression among people living with HIV.[21–26] The largest of these studies, the HPTN 065 study, assessed the effectiveness of financial incentives on viral suppression among patients on ART at 39 HIV care sites in Bronx, NY, and Washington, DC.[27] The study design was described in detail previously.[28] Clinics were randomized to provide either standard of care (includes adherence counseling) or standard of care plus provision of a gift card (equivalent of $70 in 2011) to eligible patients at quarterly clinic visits with viral suppression (HIV RNA viral load <400 copies/ml). The financial incentives had a statistically significant overall effect on viral suppression with a 3.8 percentage-point (95% confidence interval [95% CI], 0.7%–6.8%; $P = 0.01$) increase in the proportion of patients with viral suppression compared to standard-of-care clinics, after adjusting for the baseline clinic proportion virally suppressed.[27] The main value perceived by patients was feeling rewarded or cared for by their physician.[29]

Mathematic models have helped in estimating the effectiveness of HIV prevention[30–33] and assessing the value of an intervention from an economic perspective by projecting long-term outcomes beyond the trial period and estimating the incremental benefits and costs.[34–38] The World Health Organization has shown through modeling that HIV testing and treatment could be used as a strategy for elimination of HIV transmission.[39] With viral suppression as a surrogate outcome, mathematical modeling is a helpful tool to estimate the impact on important outcomes that accrue longer-term, such as morbidity, mortality, and HIV transmission.[40–42] To inform decisions about efficient public investment in HIV treatment and prevention programs offered at clinics in the United States, we developed and used an economic model, based on HPTN 065 clinical trial data, to evaluate the clinical and preventive benefits, costs, and cost-utility of financial incentives for viral suppression compared to current practice.

Methods

Analytic Overview

We conducted an economic evaluation of the 2-year HPTN 065 financial incentive intervention in order to project the lifetime costs and health outcomes for patients and their sexual partners. A conceptual model enumerates how costs and benefits could accrue in the long term (Fig. 1). The impact of the financial incentives compared to standard of care was estimated by development and use of a mathematical model of disease progression and ongoing transmission (see Appendix Fig. 2 in Supplemental

Materials found at https://doi.org/10.1016/j.jval.2018.09.001). Our analytic methods and reporting follow guidelines from the Second Panel on Cost-Effectiveness in Health and Medicine,[40,41] the International Society for Pharmacoeconomics and Outcomes Research—Society for Medical Decision Making Task Force on Good Research Practices for Randomized Clinical Trials Cost-Effectiveness Analysis,[43] and the Consolidated Health Economic Evaluation Reporting Standards statement (see checklist in Appendix in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001).[44]

As recently recommended by the Second Panel, our analysis considers both a societal and a health care sector perspective and is accompanied by an impact inventory (see Appendix Table 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The model estimates clinical outcomes (per-patient quality-adjusted life years [QALYs]), primary transmission outcomes, and lifetime costs (intervention, health care, and other societal costs). Factors that are not accounted for are explained in the impact inventory. We simulated 6 months of baseline care, a 2-year intervention period, and then projected the expected outcomes over a lifetime horizon (i.e., until every member of the simulated index cohort died) and assumed viral suppression differences diminish to pretrial levels 6 months after financial incentives discontinue. We analyzed trial data in Stata IC version 13.1 and coded the model using both VBA in Microsoft Excel version 14.7.2 and R version 3.3.1.

Data Sources

The primary data source for our model was the HPTN 065 study (baseline n = 16,208 patients in care), with key model inputs, ranges, and sources summarized in Table 1. Unit costs were calculated using HPTN 065 study budgets, financial incentive utilization reports, and staff interviews. The number, frequency, and characteristics of sexual partnerships were self-reported by a subset (n = 948) of participants, for whom we had individual survey response data.[28] Additional input values were obtained from the Medical Monitoring Project,[45] Centers for Disease Control (CDC) HIV Surveillance reports,[46,47] U.S. Census Current Population Survey[48] and Life Tables[49], the U.S. Bureau of Labor Statistics,[50] and published literature.

Study Population

We defined patients in the cohort as men and women living with HIV who were engaged in care and using ART at study clinics in Bronx, NY, and Washington, DC (see Appendix Table 2 and Appendix Fig. 1 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The study defined engagement in care as having attended the clinic for at least two routine quarterly monitoring visits, aligning with the CDC definition. At study enrollment, these patients were, on average, 47 years of age, 63% male, and infected with HIV for 16 years. Clinics had a mean number of 374 HIV patients in care with 62% virally suppressed. In addition to the patient cohort, we also model a cohort of sexual partners to estimate the impact on HIV transmission.

Disease Model Description

Building on existing HIV prevention frameworks and HIV care continuum models, we developed a Markov model of disease progression (see conceptual diagram in Appendix Fig. 2 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001).[36,51–54] Cohort size reflects the average number of patients in each clinic—allowing flexibility for scenarios to explore economies of scale among heterogeneous clinics. Simulations begin six months before the intervention, corresponding to the baseline study observation period, and continue until the last member of the cohort has died (lifetime horizon). CD4+ T-cell count-defined health states (>500, 350–499, 200–349, and <200 copies per ml) were initialized using individual-level CD4 and viral load laboratory data from the study (see Appendix Figs. 3 and 4 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). As viral suppression improves, the probability of transition into an improved health state (higher CD4+ cell count) correspondingly increases. Health state utility values are based on a systematic review and synthesis of evidence by CDC (see Table 1).[55] We calculate QALYs as the product of the utility value and quarterly person-time in each health state discounted 3% annually and summed over a lifetime horizon. Further details are provided in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001.

HIV Transmission

The Markov model patient cohort was linked to a Markov model sexual partner cohort with a set of HIV transmission risk equations (see Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). Transmission equations for men who have sex with men, heterosexual men, and women included adjustment for patient age, viral suppression, condom use, type of sexual activity (vaginal or anal sex), number of partners per patient, number of sex acts per partnership, and the prevalence of HIV among partners (see Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The partner cohort was also susceptible to infection from sources outside the patient cohort based on age-dependent probabilities of HIV infection (see Appendix Table 3 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The reduction in the number of HIV infections is calculated by comparing the number of infections among the partners of the cohort participants in the presence of financial incentives to the number of infections in counterfactual scenario without financial incentives.

Effectiveness of Financial Incentives

The statistical methods used to estimate the intervention effect on viral suppression have been described previously.[27,28] Consistent with the trial design, the model simulates a 9-month ramp-up period for the scale-up of financial incentives and behavior change. This is followed by a 15-month period with efficacy of 3.8 (95% CI: 0.7–6.8) percentage-point improvement in viral suppression. This implies, for example, that for a clinic randomized to the financial incentives arm, 62% of the patients were virally suppressed at baseline and 65.8% of patients were virally suppressed at the end of the 2-year intervention. We assumed that this effect diminishes to zero over the 6 months after the financial incentives are discontinued and performed sensitivity analyses on this assumption. HPTN 065 also observed an 8.7% increase in the number of clinic visits in the financial incentive group, and the model infers a corresponding increase in outpatient utilization and ART costs during the intervention period.[27,56]

Costs

All costs are reported using a 3% annual discount rate and common currency of 2017 USD.[57,58]

Administration costs

We retrospectively performed clinic-level microcosting of financial incentives using a unit-costing "ingredients-based" approach at the clinic level. Clinics added a full-time staff member in the role of Financial Incentives Coordinator to track and distribute gift cards. The study team defined an implementation process for one quarter, enumerated the resources used as inputs, identified prices for the inputs, and summed the quantity multiplied by the

Table 1 – Key model inputs.

Parameter	Value (range)	Source
HIV-positive patients in care, mean number per site (SD)	347 (478)	Trial[27,28]
Age at baseline, mean y	47 (35–55)	Trial[27,28]
Fraction of patients in risk category*, %		
Men who have sex with men	32.6	Trial[27,28]
Heterosexual men	32.3	Trial[27,28]
Women	35.1	Trial[27,28]
Proportion virally suppressed* at baseline, median % patients in care	61.9 (22.5–80.1)	Trial[27,28]
Financial incentives distributed per clinic quarter, mean No.	286 (21–1331)	Trial[27,28]
Duration of financial incentives intervention, years	2 (1–5)	Trial length (range for sensitivity analysis)[27,28]
Discount rate for costs and outcomes, %	3 (0–5)	Neumann et al.[41]
Costs, median (range), 2017 US$		
Financial incentives coordinator, per clinic per year	49,997 (39,998–59,996)	Trial[27], Inflated to US$ 2017
Equipment: laptop and printer in year 1, per clinic	1600 (1280–1920)	Trial[27], Inflated to US$ 2017
Office supplies, per clinic per year	160 (130–192)	Trial[27], Inflated to US$ 2017
Financial incentive gift card value, each	74.66 (20–500)	Trial[27], Inflated to US$ 2017
HIV-related health care costs, quarterly†		
ART costs, by CD4 stratum	3983–4359 (3752–4500)	Gebo et al.[60], calculated
Outpatient costs, by CD4 stratum	162–224 (155–240)	Gebo et al.[60], calculated
Labs and other health care costs, by CD4 stratum	1360–4328 (1092–4459)	Gebo et al.[60], calculated
AIDS death	4328 (2229–6426)	Gebo et al.[60], calculated
Earnings from productivity, annual age-specific	37,344–53,392	U.S. Census Current Population Survey[48]
Fringe benefits, % of total compensation	36%	Bureau of Labor Statistics[48]
Consumption costs outside of health care, annual age-specific	38,123–69,753	U.S. Census Consumer Expenditures Survey[50]
Clinical Inputs		
Efficacy‡, mean percentage points increase from baseline proportion virally suppressed at clinic	3.8 (0.7–6.8)	Trial[27,28]
Increase in outpatient visits with incentives, %	8.7 (4.2–13.2)	Trial[27,28]
Hazard ratio of death from all causes if CD4 <500	1.77 (1.17–2.55)	Rodger et al.[5]
Baseline probability of death from all causes, given age	Appendix	U.S. Life Tables[65]
Utilities		
General population, age-specific	0.782–0.928	Hanmer et al.[66]
HIV patients in care		
CD4+ T-cells >500	0.73 (0.63–0.83)	Evidence synthesis by Whitham et al.[55]
CD4+ T-cells 350–500	0.71 (0.59–0.82)	Whitham et al.[55]
CD4+ T-cells <350	0.69 (0.58–0.80)	Whitham et al.[55]
HIV Transmission, age specific		
Average No. sexual partners per year	1.7 (0.5–11)	Trial[27,28]
Probability of partner HIV infection from outside cohort, age 45–54, quarterly	3.9E-05 (3.3E-5–4.6E-5)	CDC Surveillance Report Vol. 27[47]
Probability of partner HIV infection from outside cohort, age ≥55, quarterly	8.2E-06 (6.3E-6–1.0E-5)	CDC Surveillance Report Vol. 27[47]
Transmission probability per unsuppressed and unprotected insertive vaginal act of female participant with male partner	0.004 (0.003–0.005)	Boily et al.[67]
Transmission probability per unsuppressed and unprotected insertive anal act with male or female study participant as recipient of partner being insertive	0.006 (0.005–0.007)	Jin et al.[68]
Transmission probability per unsuppressed and unsuppressed and unprotected vaginal receptive act of infected participant transmitting to female partner	0.003 (0.002–0.004)	Boily et al.[67]
Transmission probability per unsuppressed and unprotected anal receptive act	0.014 (0.011–0.017)	Baggaley et al.[69]
Risk reduction of transmission probability for virally suppressed HIV-infected patient	1.00 (0.80–1.00)	
Condom efficacy per vaginal act	0.94 (0.87–0.97)	Pinkerton and Abramson[70]
Condom efficacy per anal act	0.7 (0.58–0.79)	Smith et al.[71]

* Viral suppression defined as viral load <400 copies/ml.

† Mean costs and SD of HIV-related health care categories are summarized across CD4+ strata. The expanded table of disaggregated costs is provided in Appendix Table 6 (see Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001).

‡ Overall efficacy across all clinics. Efficacy for eight clinic subgroups is provided in Appendix Table 7 (see Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001).

price across inputs.[41,59] Total clinic cost divided by the average number of HIV patients in care produced the administration cost per patient. Because of the randomization of heterogeneous clinics, facility-level calculations provided the possibility to estimate potential economies of scale using subgroups.

Health care and other societal costs

The trial did not collect data on health care costs. We incorporated published quarterly health care expenditures for people living with HIV, which shows that people living with HIV in health states with low viral load and higher CD4+ counts have lower total health care costs than people with high viral load and lower CD4+ counts.[60] The societal perspective, as described by the Second Panel,[40,41] additionally included individuals' productivity and consumption. As there was no representative data available on workforce participation among people living with HIV that are using ART, we assume that people with AIDS (CD4+ count <200) are too sick to work, whereas others living with HIV fully participate in the workforce. Productivity was included as the sum of the national average age-specific earnings plus fringe benefits (36% of total compensation).[48] Consumption included the national average age-specific non–health-care-related expenditures.[50]

Cost-Effectiveness

Without a generally agreed upon willingness to pay for health care in the United States, we followed value assessment guidelines from the Second Panel[41] and Institute for Clinical and Economic Review[61] by assuming a cost-effectiveness threshold range from $50,000 to $150,000 per QALY gained based on 1 to 3 times the US GDP per capita. We calculate the net monetary benefit for the intervention when potential cost-savings result in non-interpretable incremental cost-effectiveness ratios (ICERs).

Sensitivity and Scenario Analyses

We conducted univariate, scenario, and probabilistic sensitivity analyses to characterize the impact of important model assumptions and uncertainties. In the univariate sensitivity analysis, parameters were set to the lowest and highest values for reasonable ranges (see Table 1) in order to observe the impact on model outputs and to identify drivers of uncertainty in cost-effectiveness results. A multiway sensitivity analysis evaluated protocol prespecified[28] clinic subgroups based on study community (Bronx, NY, vs. Washington, DC), smaller versus larger sites (≤/> median number of patients), hospital versus community-based sites, and lower versus higher percent with viral suppression at baseline (≤/> median percent), where financial incentive effectiveness varied by subgroup according to the trial results (see Appendix Table 6 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). A threshold analysis was conducted to determine the minimal level of effectiveness and the maximum financial incentive value, holding all other variables constant, for financial incentives to be considered cost-effective in this population.

A probabilistic sensitivity analysis evaluated the impact of stochastic uncertainty in the model inputs on the cost-effectiveness results. We selected and fit parameter distributions using 95% CIs from published studies or a reasonable input range. Probabilistic draws used the beta distribution for utility values and probabilities, gamma distribution for costs, and log-normal distribution for relative risks. We sampled parameter sets for 10,000 Monte Carlo simulations and estimated the outcomes for each scenario.

Results

Health Outcomes

Based on the HPTN 065 study results, the model projected that patients offered 2 years of financial incentives for viral suppression survive 1 month longer than standard-of-care patients (18.46 vs. 18.38 life years, respectively). Financial incentives patients had slightly better health outcomes than standard-of-care patients (9.35 vs. 9.31 lifetime discounted QALYs respectively) and gained 0.04 QALYs per patient. Financial incentive patients had 9.5% fewer HIV transmissions to their sexual partners. We estimate that 1 HIV infection was prevented per 200 patients offered financial incentives for viral suppression (Table 2). This spillover benefit to partners gained an additional 0.02 QALYs per patient. This produced an impact total of 0.06 QALYs gained per patient by combining benefits to patients and partners. Over the lifetime horizon, 94% of the health gains occurred during the trial period. Partner benefit accounted for 36% of total QALYs gained.

Costs

The total discounted lifetime societal cost was $4,210 lower for financial incentive patients than for the standard-of-care patients ($268,255 vs. $272,464 per patient, respectively). From a health sector perspective, excluding productivity and non–health care expenditures, financial incentives for viral suppression cost $3,033 more per patient compared to the standard-of-care cost ($487,993 vs. $484,961). Disaggregated costs in Appendix Tables 6 and 7 (see Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001) show how spending changed with a 2% increase in ART drugs, 0.5% decrease in visits and laboratory tests, and 0.3% increase in earnings.

At the facility level, intervention supplies and financial incentive coordinator salary cost $167,714 per clinic. Distributed incentives averaged $169 per patient each year offing financial incentives. Financial incentive program implementation for 2 years costs, on average, $706 per patient, varying between clinics and ranging $558–$1546 per patient at large and small clinics owing to the economies of scale for a full-time financial incentives coordinator. By preventing some HIV infections, partners of financial incentive patients had substantially lower health care costs. From a societal perspective, a majority of financial incentive cost savings were attributable to lifetime productivity gains of $10,686 per patient. Limited to a health care sector perspective, the greatest change among cost categories was the $3685 per patient increase in lifetime ART drug costs for financial incentives compared to standard of care.

Cost-Effectiveness

From a societal perspective, financial incentives for viral suppression gained 0.06 QALYs per patient and avoided $4210 per patient compared to the standard of care (Table 2). Financial incentives "dominated" the standard of care because patients and partners had better health outcomes for a lower cost. Restricted to a health care sector perspective, excluding non–health care costs and productivity, financial incentives for viral suppression were cost-effective with an ICER of $49,877 per QALY gained compared to the standard of care (see Appendix Figs. 5–7 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The incremental cost of preventing one HIV infection was $401,541. In subgroup scenarios, ICERs ranged from cost-saving to $53,818 per QALY using a societal perspective and ranged from cost-saving to $182,801 per QALY using a health care sector perspective. Of eight subgroups, DC sites and the sites with a low proportion of patients

Table 2 – Cost-effectiveness results.

Perspective	Comparator	HIV transmissions, per 100 patients*	Total lifetime costs, per patient† (2015 USD)	Total QALYs per patient†	ICER ($/QALY)
Societal	Standard of care	7.94	$272,464	38.51	
	Financial incentives	7.19	$268,255	38.57	
	Incremental	−0.76	−$4,210	0.06	Dominant
Health care sector	Standard of care	7.94	$484,961	38.51	
	Financial incentives	7.19	$487,993	38.57	
	Incremental	−0.76	$3,033	0.06	$49,877

QALYs, quality-adjusted life years; ICER, incremental cost-effectiveness ratio.
* Average cumulative number of HIV infections in the partner cohort per 100 patients, including transmissions from partners outside the study population.
† Lifetime horizon and 3% annual discount rate.

virally suppressed at baseline achieved the greatest value from financial incentives for viral suppression compared to similar standard-of-care sites (see Appendix Table 7 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). Financial incentives were cost-effective in New York from a societal perspective but not from a health care sector perspective, given a $150,000 per QALY cost-effectiveness threshold; financial incentives were cost-saving in DC.

Sensitivity Analyses

Intervention effectiveness was the main driver of net monetary benefit variability in the univariate sensitivity analysis because of the large efficacy uncertainty interval from the trial (Fig. 2). When ignoring the benefits of infections prevented, the finding of cost-effectiveness associated with financial incentives as used in this study remains. In the threshold analysis, varying efficacy while keeping other variables constant, financial incentives that achieve at least a 0.73% percentage-point improvement in viral suppression within 2 years would be cost-effective compared to standard of care. In the threshold analysis of the maximum financial incentive amount that would produce positive net monetary benefit, assuming that higher value gift cards had the same effectiveness, we found quarterly incentives up to $1,035 for a willingness to pay of $150,000 per QALY. Other than efficacy, financial incentives for viral suppression were cost-effective over entire parameter ranges in the univariate analysis (Fig. 2). The increase in use of clinic services was an important driver of cost-effectiveness. Results were also sensitive to the inclusion of partners in the cohort, depending on the threshold and perspective. Excluding partners from the analysis and limiting it to a health care sector perspective, the ICER increased to $139,256/QALY—remaining cost-effective given a $150,000/QALY threshold.

The sensitivity analysis scenarios with financial incentives provided longer than 2 years found the net monetary benefit to double when the program was extended to 5 years, assuming that the same pattern of costs and effectiveness continues. Stochastic simulations revealed great uncertainty in the cost-effectiveness estimate with a median ICER $34,252/QALY and 95% credible range from cost-saving to $501,610/QALY (Fig. 3, and see Appendix Table 8 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001). The cost-effectiveness acceptability curve (see Appendix Fig. 8 in Supplemental Materials found at https://doi.org/10.1016/j.jval.2018.09.001) shows that 73% of simulations are cost-effective and 38% highly cost-effective or cost-saving.

Discussion

We conducted a cost-effectiveness analysis of the use of financial incentives for viral suppression in the HPTN 065 study. Our findings provide evidence that financial incentives can be cost-effective and potentially cost-saving in the United States. We found financial incentives to be cost-effective for a patient because improved viral suppression can extend life (adding productivity) and improve CD4+ counts (lowering health care costs and spending more time in healthier states). Modeled outcomes from financial incentives yielded better health and quality of life as well as 9% fewer HIV transmissions to sexual partners. Although the absolute changes in health and costs were relatively small, each unit of health gained came at a very small cost.

There are two main implications of this study. First, financial incentives can be cost-effective and potentially cost-saving in the United States. Notably, the $70 gift card value of incentive used in this study was a relatively small contributor to the cost, considering that a threshold analysis found incentives less than $1000 would be cost-effective from a health care sector perspective using a $150,000/QALY threshold and the same efficacy. This can inform public health resource allocation decision makers by showing how an investment in financial incentives programs can reap long-term health gains and cost-offsets. Second, these findings held even if the benefits of partner transmissions, productivity gains, and assumed durability are ignored. The main cost-effectiveness drivers were the magnitude of the incentive efficacy, the cost of ART drugs, and the lifetime earnings of individuals. Effective financial incentives may affect the lifetime spending on ART for the following three reasons: 1) increased ART adherence requires patients to refill prescriptions more often, 2) patients who live longer use ART for longer durations, and 3) the demand for ART is reduced with HIV transmissions prevented. Another economic evaluation reached similar conclusions: an 18-month study using electronic medication monitors to improve viral load was also found to be cost-effective with a per person QALY gain only 15% different than the lifetime estimate in this analysis.[62]

The study has several strengths and limitations. The strengths include the large study size, the availability of patient-level laboratory data, and the use of two reference cases (societal and health care sector). The economic model we used has some limitations. The key driver of uncertainty in health impact that may alter policy decisions is the efficacy of the intervention—in this case in enhancement of viral suppression. In the HPTN 065 study, the 95% CI for effectiveness of the financial incentives for achieving viral suppression ranged from 0.7% to 6.8%. If the true effectiveness is close to the lower bound, then the use of financial incentives for

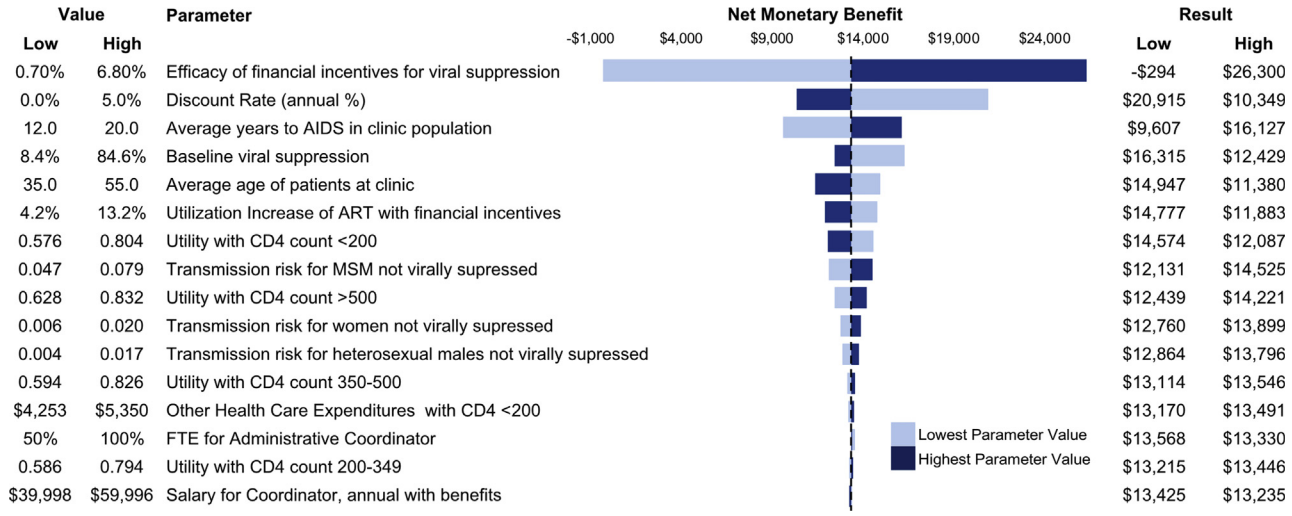

Fig. 2 – One-way sensitivity analysis. Univariate sensitivity analysis examining parameter uncertainty impact on the net monetary benefit assuming a willingness to pay $150,000/QALY.

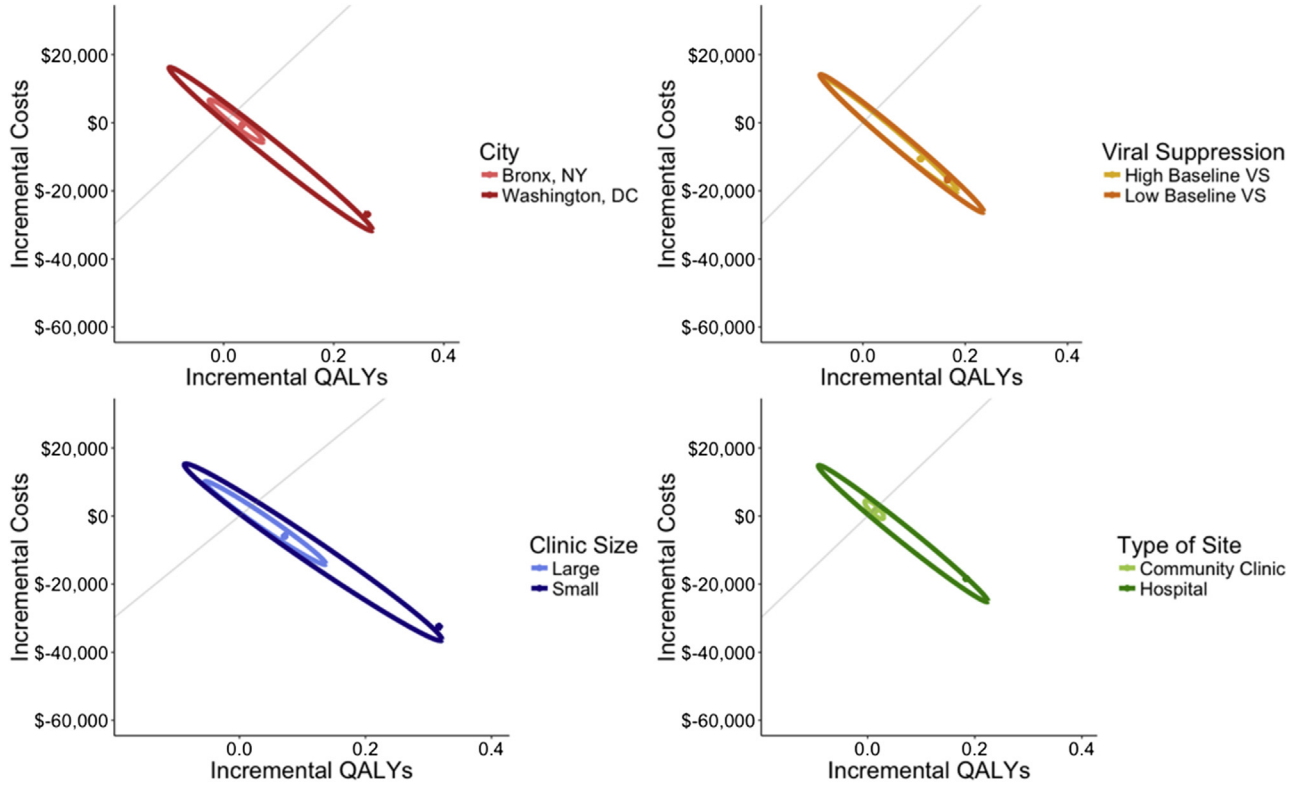

Fig. 3 – Probabilistic sensitivity analysis. Probabilistic sensitivity analysis of subgroups plotted on the cost-effectiveness plane. Ellipses represent 95% credible range from 10,000 Monte Carlo simulations of each subgroup; the gray line represents a $150,000/QALY cost-effectiveness threshold.

viral suppression would not be cost-effective. This creates some risk that implementation would not be the optimal decision, and an alternative intervention may be a better investment. Findings from another financial incentives program may provide further data to inform cost-effectiveness analyses.[63] It is important to note that the model does not capture the potential emotional benefit from the financial incentives effect on quality of life or the potential health benefits from the diagnosis and treatment of other diseases with more frequent visits, and thus may underestimate QALYs gained. Qualitative interviews demonstrated that the main value participants with financial incentives perceived was feeling emotionally cared for and rewarded.[29] In addition, HIV transmission is limited to a cohort of partners and does not capture the dynamics of the full sexual network, injection drug use, or mother-to-child transmissions. As a result, the model likely underestimates the reduction in HIV transmission by not taking into

account the indirect effects of the intervention by preventing future infections, and therefore our analysis provides a conservative estimate of the value of financial incentives. There remains structural uncertainty given that only one model was developed.[64] Lastly, generalizability of the study results may be limited to urban settings in the United States, consistent with where this study was conducted. These findings may not be transferrable to other epidemic settings where key inputs such as staff salary, the cost of HIV drugs, and willingness to pay for health gains may differ substantially.

Conclusions

Findings from this study showed that financial incentives, as used in the HPTN 065 study, could be a cost-effective and potentially cost-saving tool yielding individual and societal benefits. Investment in a financial incentive intervention, which incentivizes adherence and viral suppression, could be an efficient application of health care resources when striving to reach the goals set out in the US National Strategic Plan for HIV.

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Supplemental Materials

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