

The HIV Epidemic in the United States – Epidemiological Projections and Public Economic Impact of Achieving Zero Transmission Goals

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Background: The United States (US) HIV/AIDS strategy has targeted a 90% reduction in HIV infections by 2030. Whilst progress has been made in US HIV policy, the persistence of nearly 32,000 new infections annually highlights substantial barriers that still hinder effective treatment and the achievement of national targets. While the humanistic burden of HIV is well documented, there are broader economic effects on employment, disability and retirement. The objective of this study is to evaluate these economic gains when improving various HIV policies.

Methodology: This analysis adapts a published Markov model assessing the role of six key policy parameters related to diagnosis, pre-exposure prophylaxis (PrEP) uptake, treatment initiation, and treatment as prevention (TasP) on the HIV epidemic in the US. Improvements in these parameters were explored to estimate averted HIV infections over 50 years and, subsequently, the feasibility of achieving the 2030 target of a 90% reduction in HIV incidence.

A fiscal economic framework was also applied, linking HIV cases and policy targets to productivity, tax revenue, transfer benefits, and healthcare costs incurred by the US government.

Results: Results were calculated for the general US population and for men who have sex with men (MSM), a subgroup experiencing a high HIV burden. For the general US population, policy improvements led to an average of 5,324 averted HIV infections annually over the 50-year horizon, corresponding to a total net annual fiscal gain of \$397 million or \$74,511 per averted infection. For the MSM subgroup, 911 infections were averted annually resulting in a net fiscal gain of \$96 million, or \$105,031 per averted infection.

Conclusion: This analysis demonstrates that the benefits of HIV policy are not limited to the healthcare setting and show how initial investments provide long-term benefits by preventing HIV transmission and the associated impact on individuals' labor market outcomes. While relying on assumptions and projections that may not capture all real-world complexities, fiscal analyses can provide a useful tool for policy evaluation that facilitate a holistic assessment of the wider costs and benefits that fall on governments as well as benefits of achieving policy targets.

Keywords: HIV/AIDS, burden of disease, public costs, pre-exposure prophylaxis, treatment-as-prevention

Introduction

The United States (US) has made substantial progress in controlling the acquired human immunodeficiency syndrome (HIV/AIDS) epidemic, in particular since the advent of highly effective antiretroviral therapy (ART).¹ Once considered a terminal diagnosis, life expectancy for individuals living with HIV on ART is now approaching that of the general

population.² National efforts in the US have focused on expanding prevention, screening, and treatment services with the aim of eliminating HIV transmission. This is aligned with the UNAIDS 95–95–95 targets, which call for 95% of people living with HIV to know their status, 95% of those diagnosed to receive treatment, and 95% of those on treatment to achieve viral suppression by 2030.³ Achievement of these targets would lead to sufficiently high levels of viral suppression among people with HIV (PWH) that sustained HIV transmission would be unlikely,³ similar to the concept of “herd immunity” discussed within other infectious diseases. “Ending the HIV Epidemic in the US” (EHE), launched in 2019, is an initiative run by the US Department of Health and Human Services (HHS) with the objective of reducing new HIV infections in the US by 75% and 90% by 2025 and 2030, respectively.⁴ Key strategies include widespread use of ART to achieve viral suppression, pre-exposure prophylaxis (PrEP) for high-risk populations, and advanced data techniques to rapidly identify and respond to outbreaks, offering a unique opportunity to end the HIV epidemic.⁴ However, data suggests that the current pace of intervention scale-up, particularly in underserved communities, is insufficient to meet these goals, raising concerns about the sustainability of current approaches and the potential public economic burden of inaction.⁵

As of 2022, approximately 87% of PWH in the US were aware of their status, around 82% of those diagnosed were linked to care within one month of diagnosis, and 65% of individuals had viral suppression at the most recent viral load test.⁵ Concerted efforts to improve HIV prevention are yielding results, as estimated infections have dropped by 12% in 2022 compared to 2018, primarily due to a 30% reduction among the 13 to 24 age category.⁶ Despite this progress, certain populations continue to experience disproportionately high rates of HIV incidence.⁶ In 2022, there were approximately 31,800 new HIV infections in the US, with an infection rate of 11.3 per 100,000 people.⁶ Men who have sex with men (MSM) represented nearly 67% of these cases, despite comprising only 1.26% of the overall US population.^{6–8} Notably, of the 39,201 new HIV diagnoses in 2023, 66% were attributed to male-to-male sexual contact.⁹ Furthermore, certain ethnic groups experience a disproportionate burden of HIV relative to their representation in the overall population.⁶ Black and Hispanic/Latino individuals, who comprise approximately 14% and 20% of the US population respectively, are particularly affected.^{6,9,10} Within these groups, Black and Hispanic/Latino MSM face especially high infection rates, 23% and 26% of all new infections, respectively, substantially exceeding those observed among White MSM populations (16%).

The burden of HIV extends beyond the healthcare system, as evidence indicates a link between labor force participation and HIV status, as employed individuals are more likely to seek testing, medical care, and adhere to therapy.^{11,12} This relationship is likely bidirectional, with HIV status and overall quality of life influencing the likelihood of staying in the workforce. The relationship between HIV and productivity outcomes is likely influenced by individuals’ demographic and socioeconomic factors, with stigma, mental health, and social support systems playing critical roles.^{12–15} The fiscal perspective represents a methodology that can capture these labor market effects by adopting the perspective of government finances, and modeling broader fiscal flows beyond the healthcare spending.¹⁶

As with other diseases, the effect of HIV on productivity leads to varying levels of reliance on public benefits and has longer-term effects on families and future generations, which can collectively impact the sustainability of social welfare systems. These cost factors are often overlooked when evaluating the value of preventive or curative healthcare interventions.^{17,18} This can place significant pressure on government fiscal systems, particularly in the form of lost tax revenue and increased spending on transfer benefits.¹⁹ Therefore, it is crucial to model not only the epidemiological outcomes of intensified HIV control measures but also their economic impact on US federal and state budgets. In the US, healthcare funding primarily comes from a combination of taxpayer contributions through federal and state programs, as well as private insurance.²⁰ Considering that improvements in HIV care have been shown to generate significant fiscal returns,¹⁹ assessing the economic impact of HIV on public finances is a valuable tool for informing policy decisions and guiding efficient resource allocation.

Given the potential fiscal impact of HIV infections in the US, this analysis has two primary objectives. The first is to adapt an existing modeling framework to project the progression of the US HIV epidemic over the next 50 years and assess the feasibility of achieving zero HIV transmission, defined as a 90% reduction in HIV incidence from the 2010 baseline, which recorded 41,100 new HIV diagnoses.²¹ The second objective is to evaluate the financial effects of reducing HIV incidence by modeling its impact on tax revenue and government social spending using a fiscal

perspective. This facilitates a more holistic assessment of the costs and benefits of potential HIV policies by accounting for the broader economic consequences of the HIV infection.

Materials and Methods

HIV Markov Model

This analysis expands a previously developed Markov state transition open cohort model of HIV to incorporate the broader impact of HIV on government revenue and expenditure, otherwise known as the fiscal perspective.^{16,17,22} The Markov model uses 15 health states and a three-month cycle length to simulate different disease transitions, including the probability of individuals without HIV becoming HIV positive, diagnosis status, ART treatment status, viral suppression, and death. Using an open cohort modeling approach allows demographic growth to be accounted for through the addition of new individuals to the model in each cycle to replace both HIV- and non-HIV-related deaths.²²

The model examines two populations: the general US population and the subgroup of men who have sex with men (MSM). The MSM subgroup was selected as they bear a disproportionately high burden of HIV, making them a key population for policy analyses.⁶ The cohort model structure is outlined in Figure 1, with further details available in the corresponding publication.²² This structure reflects the key stages and populations in the HIV pathway. This includes individuals without HIV, split between those who would receive benefits from PrEP and those who would not, and PWH, split among those who are undiagnosed, diagnosed and not on ART, on ART, and on ART and virally suppressed.

The model considers the impact of six key policy parameters on HIV transmission. These variables are: (1) the annual probability of starting pre-exposure prophylaxis (PrEP) for individuals without HIV, (2) the proportion of PWH that are diagnosed within three months of acquiring the infection, (3) the probability of getting screened for HIV for both those

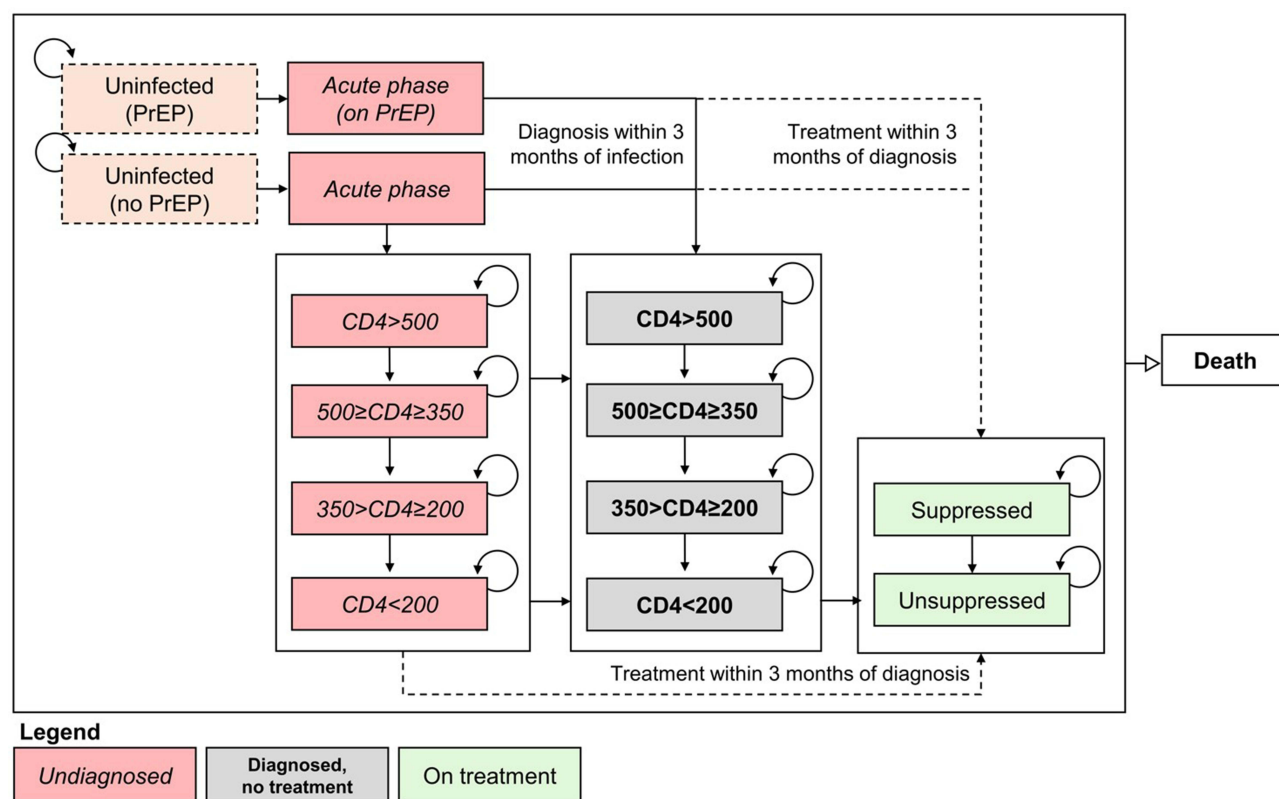


Figure 1 Cohort model structure.

Notes: CD4 counts are in cells/ μ L. Individuals may transition between health states in the directions of the arrows; transition probabilities are calculated from model inputs. Individuals in all health states have a risk of death; this risk is modified by the average age of the population in question (MSM or PWH) and their disease state. Source: Adapted from Massey et al 2023.²²

Abbreviations: CD4, cluster of differentiation 4; PrEP, pre-exposure prophylaxis.

with and without HIV, (4) the probability of starting ART within six months of diagnosis, (5) the probability of starting ART within three months of diagnosis, and (6) the proportion of PWH on ART and virally suppressed. Base case inputs for these parameters within the US context were identified from a combination of published literature and national reports (such as the Center for Disease Control [CDC] HIV Surveillance Reports).⁶ The model subsequently explores the impact of increasing five of these six policy parameters over time, both individually and in combination. The proportion of PWH on ART who are virally suppressed was kept unchanged, as this relates to efficacy of specific treatments and patient adherence rather than policy.

Increasing each parameter has an associated benefit related to HIV infections and outcomes for people without HIV, PWH who are not yet on ART or PWH on ART. For example, higher rates of PrEP uptake and faster ART commencement lead to reduced transmission, while increased screening leads to greater diagnosis rates. As well as the six key variables, the remaining clinical and cost inputs were updated with relevant US inputs. Full details of the Markov model inputs are provided in [Supplementary Appendix S1](#).

Base case values for the six core policy parameters for the general population and MSM subgroup are described in [Table 1](#). Where possible, US sources were utilized, however, the proportion of newly diagnosed HIV infections commencing ART within six months of diagnosis was informed by Canadian data due to a lack of US-specific data. The Canadian estimate for treatment initiation within six months of diagnosis was selected as it showed internal consistency with the US estimate of three-month treatment initiation and previous research has shown broadly comparable treatment initiation patterns between the US and Canada.²³

The model uses a 50-year time horizon (2022–2072) to estimate infection rates for two scenarios. The “current scenario” applies the base case values in [Table 1](#) for all six policy parameters for the entire time horizon, while the “future scenario” reflects a counterfactual scenario assuming an increase in certain parameters by specific milestones. As there are significant challenges in accurately projecting the changes in these six policy parameters over a 50-year time period, a simplified approach was utilized by assuming relative increases in certain values by specific timepoints. Additionally, when considering PrEP uptake, the number of individuals eligible to receive PrEP was capped at 0.36% and 20.10% of the general population and MSM subgroup, respectively, based on published estimates of PrEP-eligible adults in the US.³⁰

The following assumptions were applied to generate the future scenario inputs:

- Annual PrEP uptake is assumed to increase by 5% until 2030 and a further 5% until 2040.
- Viral suppression is assumed to remain constant at 90% for both the general population and MSM subgroup (as it is assumed that the efficacy of ART at maintaining viral suppression will not be altered by policy choices).
- All remaining variables are assumed to increase by 15% until 2030 and subsequently by a further 15% from both 2040 and 2050.

The specific inputs at each timepoint for the future scenario are outlined in [Supplementary Appendix S1](#).

Table 1 Cohort Model Policy Inputs – General Population and MSM Subgroup

Input	Value (GP)	Value (MSM)	Source
Annual probability of adopting PrEP for people eligible who are not already on PrEP	0.018%	1.565%	AIDSVu (2018–2023) ²⁴
Proportion of patients diagnosed within 3 months of infection	29.33%	29.33%	Fellows 2015 ²⁵
Annual probability of screening (PWH and people without HIV)	7.20%	38.3%	Patel 2020 ²⁶
Probability of starting treatment within 6 months of diagnosis	86.58%	87.19%	Public Health Agency of Canada 2022 ²⁷
Probability of starting treatment within 3 months of diagnosis	80.05%	81.51%	Bacon 2021 ²⁸
Proportion of PWH on ART who are virally suppressed (TasP)	90%	90%	Ryan White HIV/AIDS Program ²⁹

Abbreviations: AIDS, acquired immunodeficiency syndrome; ART, antiretroviral therapy; GP, general population; HIV, human immunodeficiency virus; MSM, men who have sex with men; PrEP, pre-exposure prophylaxis; PWH, people with HIV.

Results were generated for the average annual number of HIV infections over the 50-year time horizon between the two scenarios with the key model output being the number of averted HIV infections with the “future scenario” approach.

Fiscal Impact of Averted HIV Infections

The main objective of this study is to estimate the broader economic impact of the averted HIV infections from the previously described Markov model through adoption of a government analytic (ie, fiscal) perspective. This involves linking different stages of infection to fiscal indicators, such as employment, income, and social welfare payments, to estimate the total impact on government expenditure and revenues.³¹ In order to achieve this, the Markov model was extended to incorporate a fiscal analytic framework^{17,18} to estimate the economic consequences of HIV in the US. By assigning different stages of HIV infection an associated fiscal cost, the averted infections resulting from the improved policy parameters in the “future scenario” approach could be translated into corresponding fiscal savings.

The distribution of PWH (stratified by CD4 count), people without HIV, viral suppression, and PWH on ART were assigned to occupational consequences and related fiscal costs. As the original Markov model simulates an average cohort of individuals, age distributions were required to identify age-specific outcomes. Age band distributions were therefore implemented as part of the fiscal analysis, in line with Smit et al.³²

Relative Effect of HIV on Occupational Outcomes

The relative effect of HIV infection and infection severity on occupational consequences was sourced from published studies obtained from a targeted literature search. Details of the literature search strategy and extracted data used in the model can be found in [Supplementary Appendix S2](#). Individuals without HIV were assigned to age-specific rates of employment, unemployment, disability, and old age security for the general US population.^{33–36} Subsequently, relative effects identified in the targeted literature search were applied to these general population rates to derive the likelihood of employment, unemployment, disability, and old age security in PWH, according to their viral suppression and CD4 count status. The outcomes of interest and associated publications are listed below:

- Lower probability of employment^{13,37–40}
- Higher probability of unemployment^{14,41–44}
- Lower wages⁴²
- More frequent permanent disability^{39,42,45,46}

Fiscal Costs Estimation

Equations 1 and 3 were used to calculate the incremental fiscal consequences between the two cohorts generated according to the current and future scenario assumptions.

Taxes represent a source of government revenue combining direct and indirect taxes. Direct taxes were calculated by multiplying gross employment earnings by the tax wedge published by the Organisation for Economic Co-Operation and Development (OECD) (34.8%).⁴⁷ The tax wedge is a commonly used index that summarizes the proportion of earnings that corresponds to the total tax burden of an average worker and comprises direct tax on earnings paid by employees and social insurance contributions paid by employees and employers. Indirect taxes were calculated by multiplying the average tax on goods and services in the US (4.33%)⁴⁸ by any form of income (earnings from employment or benefit transfers).

To inform the calculations used to generate the fiscal consequences for both the current scenario and future scenario, a range of age-specific fiscal data were incorporated into the analysis. The primary inputs informing the calculation of direct tax revenue are employment rates and income data, which were sourced from OECD datasets and the US Bureau of Labor Statistics, respectively.^{33,36}

Indirect tax revenue reflects that a portion of all income (whether from employment or government benefits) will be spent on consumption. Government expenditure was assumed to include unemployment benefits, disability benefits and old-age pension. Inputs for the proportion of individuals receiving each of these benefits, as well as the average payments received, were sourced from US Social Security data.^{34,35}

Healthcare costs were considered as government expenditure and included in the final fiscal calculations. Healthcare costs were calculated in the original Markov model and included the following:

- Cost of screening (HIV test) and CD4 measurement
- Cost of PrEP and monitoring
- Cost of ART treatment
- Cost of HIV-related clinical management (for patients with CD4 count > 200 and < 200)

These healthcare costs were sourced from published literature and, where necessary, inflated to 2023 using US inflation indices.⁴⁹ An overview of all key fiscal inputs are provided in [Supplementary Appendix S3](#).

$$IFC = NPV_{Current} - NPV_{Future} \quad (1)$$

$$NPV_i = \sum_{t=1}^n \frac{Taxes_t - Transfers_t - Public\ Healthcare_t}{(1+r)^t} \quad (2)$$

$$Taxes_t = Direct\ tax_t + Indirect\ tax_t \quad (3)$$

IFC, incremental fiscal consequences; NPV, net present value.

Where i is the cohort under the current or future scenario, t is time, n is the time horizon, and r is the discount rate. Costs were discounted at 3% annually.⁵⁰

Sensitivity Analysis

In order to test the core assumptions underpinning this analysis, sensitivity analyses was conducted using three approaches. Firstly, one-way sensitivity analysis was used to test the sensitivity of results to changes in individual inputs. Secondly, a probabilistic sensitivity analysis (PSA) was conducted to explore the joint uncertainty in parameters by assigning each input value a corresponding distribution and then sampling from each distribution for 1,000 iterations.

Finally, a number of scenario analyses were explored in both populations (general population and MSM subgroup). This involved varying the following assumptions:

- Use of alternate sources to inform the efficacy of PrEP (ie, the assumed reduction in HIV incidence for individuals receiving PrEP).^{51–53}
- Assumed that PrEP would be solely based on generic products rather than the combination of generic and branded products used in the base case analysis, leading to a lower net cost of treatment.
- Explore lower pricing for generic PrEP products, reflecting the potential variation in pricing that may be available.
- Alternate sources to inform the three-month HIV diagnosis rate.
- Alternate estimates for the probability of ART initiation within three months of diagnosis.
- Alternate estimates for the probability of ART initiation within six months of diagnosis.
- Reduce the proportion of PWH on ART achieving viral suppression such that 65% of diagnosed PWH are virally suppressed, in line with data from the CDC.⁵
- Reduce viral suppression such that 65% of diagnosed are virally suppressed at baseline, with viral suppression increasing to reach 90% by 2040.

Results

Results for the General Population

By assuming an improvement in five policy parameters related to PrEP uptake, screening rates, diagnosis rates and treatment initiation rates described previously in [Table 1](#) (the proportion of PWH on ART who are virally suppressed was left unchanged), it is estimated that, by 2072, 260,859 HIV infections would be averted across the US population

compared to the scenario where these policy parameters are left unchanged, corresponding to an average of 5,324 averted cases annually. The fiscal consequences accruing from these offset HIV infections are outlined in Table 2.

The reduction in HIV infection rates between both scenarios leads to reductions across all social transfers as well an increase in both direct and indirect tax revenue. There is a substantial reduction in overall healthcare costs over the model

Table 2 Annual Fiscal Results (General Population)

	Current Scenario	Future Scenario	Incremental**
<i>Earnings from employment*</i>	\$28,496 M	\$29,302 M	\$806 M
Employment Insurance benefits	-\$91 M	-\$86 M	\$4 M
Disability benefits (Pension Plan)	-\$55 M	-\$52 M	\$3 M
Old age security	-\$4 M	-\$4 M	\$0 M
Direct taxes	\$9,917 M	\$10,197 M	\$280 M
Indirect taxes	\$811 M	\$833 M	\$22 M
Healthcare costs (Total)	-\$27,482 M	-\$27,396 M	\$87 M
ART costs	-\$14,052 M	-\$14,175 M	-\$123 M
PrEP costs	-\$8,732 M	-\$8,755 M	-\$23 M
Other Healthcare costs***	-\$4,698 M	-\$4,465 M	\$233 M
Incremental fiscal consequences	-\$16,905 M	-\$16,508 M	\$397 M

Notes: *Foregone earnings from employment represent a societal loss. Its value was used to calculate direct and indirect taxes. It is shown for completeness; **Positive and negative results indicate government revenue and expenditure, respectively. Positive incremental results denote fiscal gain, negative incremental results denote fiscal loss. ***Other healthcare costs include cost of monitoring (both diagnosed patients and PrEP users) and HIV screening/testing.

Abbreviations: ART, antiretroviral therapy; PrEP, pre-exposure prophylaxis.

Table 3 Annual Fiscal Results (MSM Subgroup)

	Current Scenario	Future Scenario	Incremental
<i>Earnings from employment</i>	\$11,153 M	\$11,245 M	\$92 M
Employment Insurance benefits	-\$41 M	-\$41 M	\$1 M
Disability benefits (Pension Plan)	-\$26 M	-\$25 M	\$0 M
Old age security	-\$2 M	-\$2 M	\$0 M
Direct taxes	\$3,881 M	\$3,913 M	\$32 M
Indirect taxes	\$318 M	\$320 M	\$3 M
Healthcare costs (Total)	-\$16,796 M	-\$16,736 M	\$60 M
ART costs	-\$8,184 M	-\$8,151 M	\$33 M
PrEP costs	-\$6,379 M	-\$6,383 M	-\$4 M
Other Healthcare costs***	-\$2,233 M	-\$2,202 M	\$31 M
Incremental fiscal consequences	-\$12,666 M	-\$12,570 M	\$96 M

Notes: *Foregone earnings from employment represent a societal loss. Its value was used to calculate direct and indirect taxes. It is shown for completeness; **Positive incremental results denote fiscal gain, negative incremental results denote fiscal loss. ***Other healthcare costs include cost of monitoring (both diagnosed patients and PrEP users) and HIV screening/testing.

Abbreviations: ART, antiretroviral therapy; PrEP, pre-exposure prophylaxis.

horizon, which consists of increased spending on both PrEP and ART combined with savings across other healthcare cost categories (including testing and monitoring costs).

These changes in policy parameters result in a net average annual fiscal gain of \$397 million, reflecting a net average fiscal gain of \$74,511 per averted HIV infection.

Results for the MSM Subgroup

A similar fiscal gain is observed for the MSM subgroup, with an average of 911 HIV infections averted annually resulting in an annual fiscal gain of \$96 million, or \$105,031 per averted infection (Table 3). In the MSM subgroup, a decrease in ART costs is observed, due to the ART cost savings from averted infections being greater in magnitude than the increase in costs from earlier ART commencement (while the opposite is observed in the general population).

Sensitivity Analysis

One-way sensitivity analyses were also conducted for both analyzed populations. The resulting tornado diagram for the general population and MSM subgroup are presented in Figures 2 and 3, respectively. Among the general population, the

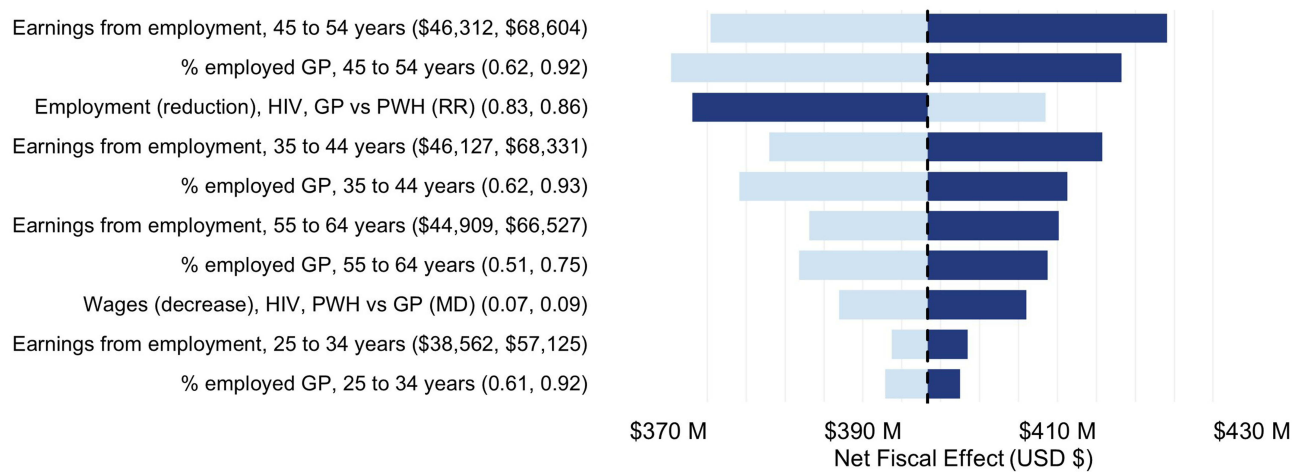


Figure 2 One-way sensitivity analysis (General Population).
Abbreviations: GP, general population; HIV, human immunodeficiency virus; MD, mean difference; PWH, people living with HIV; RR, relative risk; USD, United States dollars.

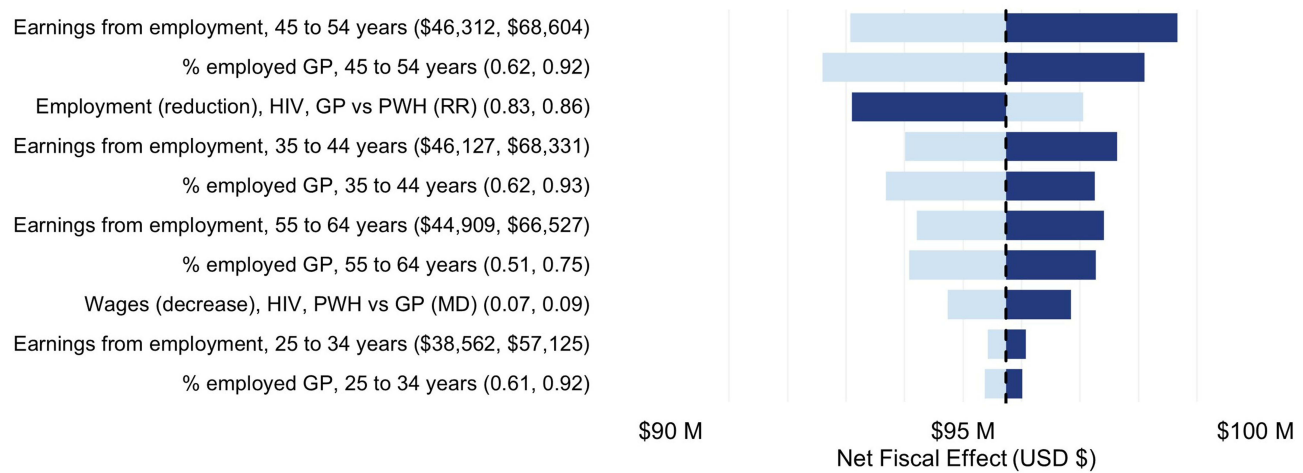


Figure 3 One-way sensitivity analysis (MSM Subgroup).
Abbreviations: GP, general population; HIV, human immunodeficiency virus; MD, mean difference; PWH, people living with HIV; RR, relative risk; USD, United States dollars.

most impactful variables were earnings, employment rates and the impact of HIV on employment. These variables were also the most impactful within the MSM subgroup.

A probabilistic sensitivity analysis was also conducted for both populations, using 1,000 iterations. For the general population, a probabilistic net fiscal benefit of \$366M (95% credible interval [CrI]: \$213M, \$526M) was calculated in comparison to the deterministic result of \$397M. For the MSM subgroup, the probabilistic result was \$91M (95% CrI: \$72M, \$120M), closely relating to the deterministic output of \$96 million. For both populations, all 1,000 iterations resulted in a positive net fiscal benefit. Further details on the PSA including disaggregated results and plotted results distributions are provided in [Supplemental Appendix S4](#).

Results of the scenario analyses which explored changes to underlying model assumptions are presented for the general population and MSM subgroup in [Tables 4](#) and [5](#), respectively.

Table 4 Scenario Analysis Results (General Population)

Scenario	Base Case Input	Scenario Value	Incremental Fiscal Effect
Base Case Results			\$397 M
PrEP Efficacy (relative reduction in HIV incidence)	86% ⁵⁴	80% ⁵²	\$397 M
		85% ⁵¹	\$397 M
		73% ⁵³	\$397 M
Distribution of basket of PrEP products	43% branded, 57% generic	100% Generic	\$415 M
Cost of generic PrEP product (per pack)	\$70.07 (30 tabs)	\$40 (30 tabs)	\$397 M
3-Month Diagnosis Rate	29.33%	18% ⁵⁵	\$300 M
		23.8% ⁵⁶	\$349M
		20% increase in base value	\$447 M
3-Month Treatment Initiation Probability	80.05%	20% increase	\$410 M
		20% decrease	\$386 M
6-Month Treatment Initiation Probability	- 86.58% (>200 CD4) - 87.40% (<200 CD4)	Set to 100%	\$402 M
		20% decrease	\$392 M
Viral suppression among PWH on ART	90%	68.13%	\$552 M
		68.13% increasing to 90% by 2040	\$981 M

Abbreviations: HIV, Human immunodeficiency virus; PrEP, pre-exposure prophylaxis.

Table 5 Scenario Analysis Results (MSM Subgroup)

Scenario	Base Case Input	Scenario Value	Incremental Fiscal Effect
Base Case Results			\$96 M
PrEP Efficacy (relative reduction in HIV incidence)	86% ⁵⁴	80% ⁵²	\$96 M
		85% ⁵¹	\$96 M
		73% ⁵³	\$95 M

(Continued)

Table 5 (Continued).

Scenario	Base Case Input	Scenario Value	Incremental Fiscal Effect
Distribution of basket of PrEP products	43% branded, 57% generic	100% Generic	\$99 M
Cost of generic PrEP product (per pack)	\$70.07 (30 tabs)	\$40 (30 tabs)	\$96 M
3-Month Diagnosis Rate	29.33%	18% ⁵⁵	\$96 M
		35.5% ⁵⁶	\$95 M
		20% increase in base value	\$95 M
3-Month Treatment Initiation Probability	81.51%	20% increase	\$90 M
		20% decrease	\$99 M
6-Month Treatment Initiation Probability	- 86.58% (>200 CD4) - 87.40% (<200 CD4)	Set to 100%	\$93 M
		20% decrease	\$98 M
Viral suppression among PWH on ART	90%	68.13%	\$93 M
		68.13% increasing to 90% by 2040	\$304 M

Abbreviations: HIV, Human immunodeficiency virus; PrEP, pre-exposure prophylaxis.

Assessing Zero Transmission Targets

The final component of the analysis explored whether the US target of achieving a 90% reduction in HIV incidence (from 2010 levels) by 2030 is possible within both modeled populations by setting policy targets for both 2025 and 2030. For the general population, zero transmission is achievable by 2030 only when substantially higher policy targets are used. A similar pattern is observed in the MSM population, with annual PrEP uptake required to more than double by 2030 alongside considerable increases in all other parameters to achieve a 2030 zero transmission target. Table 6 presents a summary of the required policy targets for both 2025 and 2030 to achieve a 90% reduction in incidence by 2030 in both the general population and MSM subgroup.

Table 6 Policy Targets Required to Achieve 90% Reduction in HIV Incidence by 2030

Target Year	Annual Probability of Adopting PrEP for People Eligible Who are not Already on PrEP	% Patients Diagnosed Within 3 Months of Infection	Annual Probability of Screening (PWH and People Without HIV)	Probability of Starting Treatment Within 6 Months of Diagnosis	Probability of Starting Treatment Within 3 Months of Diagnosis	Proportion of PWH on ART Who are Virally Suppressed
General Population						
Base Value (2022)	0.02%	29.33%	7.20%	86.58%	80.05%	90.00%
2025 Target	0.1%	50%	78%	88%	85%	99%
2030 Target	0.9%	55%	85%	90%	90%	100%
MSM Subgroup						
Base Value (2022)	1.56%	29.33%	38.30%	87.19%	81.51%	90.00%
2025 Target	3.75%	60%	70%	90%	90%	98%
2030 Target	4.00%	80%	85%	95%	95%	100%

Abbreviations: ART, Antiretroviral therapy; HIV, Human immunodeficiency virus; MSM, Men who have sex with men; PrEP, pre-exposure prophylaxis; PWH, people living with HIV.

Discussion

The US has made great strides in tackling the HIV epidemic over the last 40 years and now has the objective of achieving a 75% reduction in HIV infections by 2025 and a 90% reduction by 2030.¹ While there has been progress toward achieving these goals, with a reduction in the number of new infections, increase in PrEP uptake, and increased numbers of virally suppressed patients, there are still barriers hindering effective prevention and treatment in priority populations.⁵⁷ This study explores how further improvement in key policy parameters can translate to a further reduction in HIV incidence as well as the broader economic effects of this reduction. Within two populations of interest, the general US population and the MSM subgroup, averted HIV infections over a 50-year time horizon provided substantial cost savings, including reduced spending on healthcare and social transfers, combined with increased tax revenue. Within the general population, annual savings of \$397 million may be achieved while annual savings of \$96 million were calculated among the MSM subgroup, corresponding to savings of \$74,511 and \$105,031 per averted infection, respectively. The substantial benefit of HIV management, including prevention, diagnosis and treatment, is well recognized.^{1,58} However, this analysis shows that there are even greater benefits to be realized when consideration is given to the fiscal impact of HIV infections, and how averting HIV infections avoids not only the healthcare burden, but also employment reduction and its wider economic effects. This is shown in the model results as improvements in the policy parameters translate to increased government tax revenue due to higher employment and income levels. At the same time, government expenditure on support programs such as unemployment insurance and disability benefits are reduced. As well as demonstrating the broader economic effects of improving HIV policy, this analysis explored the feasibility of achieving the US policy target of a 90% reduction in HIV incidence by 2030. This target, similar to the UNAIDS 95–95–95 targets, reflects an aim to suppress HIV transmission to levels that can prevent sustained outbreaks, similar to how herd immunity disrupts transmission chains within other infectious diseases. While this target was shown to be theoretically achievable in the model, it will require significant improvement in the approach to all facets of HIV policy, including prevention, screening, diagnosis and treatment. Considering the improvements required for each policy component to hit 2030 targets, it is highly implausible that zero transmission targets will be achieved unless there is an immediate structural change to US HIV policy.

The deterministic results of this study were tested using a range of sensitivity analyses. The one-way sensitivity analysis illustrated that inputs related to employment and income had the largest impact on results, which is expected given that direct taxes are calculated based on employment income and represent one of the main drivers of results. The probabilistic analysis investigated the joint uncertainty in model inputs and showed results were relatively stable. While there was some deviation from deterministic values, this is likely due to the use of observational data to inform model inputs, which naturally incorporates real-world heterogeneity and uncertainty. Despite this, the overall cost estimates for both cohorts remained stable, and the direction and magnitude of differences between cohorts were consistent across simulations. A range of scenario analyses supported these conclusions, with all scenarios showing either increased fiscal benefits or slight reductions.

There are several limitations to this analysis. The hypothetical “future scenario” assumed an increase in parameters related to US policy on HIV prevention, diagnosis and treatment. While an attempt was made to ensure that these improvements resulted in plausible targets, there is uncertainty related to the practical reality of achieving these policy parameters. Due to limited published evidence relating to the long-term projections of each policy component, a more simplified approach was taken by applying relative increases by specific timepoints, however, this may not reflect the exact trajectory of these parameters. Furthermore, costs do not include strategic and administrative costs related to upscaling public health interventions which are likely to be significant and may differ between US States. Modeling over a 50-year time horizon also leads to some uncertainty regarding how certain inputs evolve over time. For example, ART and PrEP drug costs were assumed to remain stable over time with regard to the breakdown of products used. However, it is likely that these costs will evolve along with the introduction of new innovative products combined with the loss of exclusivity of current treatment options. It was not possible to find nationally aggregated data for all model inputs. Some inputs, such as the three-month diagnosis rate, were sourced from smaller US state-specific studies which may not be representative of the national HIV landscape. Scenario analyses were conducted on these variables to help understand the

impact of the uncertainty with these parameters and showed that they were not primary drivers of model results. Additionally, using a national, aggregate perspective for the US may not capture the nuances of different funding mechanisms, such as commercial insurance, Medicare, and Medicaid, and how each affects costs and access to HIV testing, PrEP, and treatment. A final limitation of the model is the use of Canadian data to inform treatment initiation probabilities due to limited U.S.-specific estimates. While Canada and the US have been shown to have broadly similar trends of ART initiation,²³ differences in healthcare delivery systems or epidemiology may affect the generalizability of these inputs.

It is well recognized that HIV policy, including access to ART and PrEP, varies by US state, with particular gaps occurring in the southern region of the US.⁶ In 2022, data for the southern region of the US showed that, for every 100 individuals with HIV, 14 did not know their HIV status.⁶ This variation in HIV transmission is caused by a variety of elements, including socioeconomic factors, with the South possessing both the highest poverty rate and lowest median household income in the US.⁵⁹ As this analysis utilizes aggregated national data related to HIV epidemiology, it is likely that there would be both greater costs, as well as greater benefits, from implementing successful HIV prevention and treatment among more vulnerable geographic regions. HIV access and outcomes also vary considerably across different populations and subgroups. This analysis explored the subgroup of MSM, who carry a disproportionately high burden and accounted for 67% of new HIV infections in 2022.⁶ Certain ethnic groups, namely Black/African American and Hispanic/Latino individuals also experience elevated risk and require focused attention.⁶ These disparities highlight the need for innovative approaches to reach key populations, beyond simply scaling up existing policy infrastructure, to ensure equitable prevention and care. A key element of ending the HIV epidemic is successful utilization of PrEP. While there continues to be improvement in PrEP utilization in the US, there are still disparities in PrEP uptake and access, particularly among those who would benefit from it.^{60,61} This reflects both a geographic imbalance, with the US South experiencing lower rates of PrEP usage and uptake, and disparities across subgroups, in particular Black/African American and Hispanic/Latino individuals.⁶⁰ These inequities may be driven by a range of factors including access challenges, lack of infrastructure, or the cost of PrEP. This issue may be exacerbated by the provision of PrEP through multiple different stakeholders in the US, where mechanisms such as prior authorization may discourage clinicians from prescribing PrEP.^{62,63} Adopting a centralized approach to the provision and funding of PrEP may facilitate a more holistic and equitable approach, ensuring populations at highest risk of HIV transmission have sufficient PrEP access.

This research provides a novel perspective by expanding the economic impact of improving HIV policy by considering wider impacts of HIV on employment and social transfers. This complements existing research exploring the economic consequences of HIV policy related to PrEP use,⁶⁴ ART use,^{19,65} and improving HIV testing and retention in care.⁶⁶ Utilizing the fiscal perspective can allow a more comprehensive overview of the benefits that can be realized from HIV policy, which are likely to offset the costs of implementing these policies, leading to a net gain for the US government.

Conclusion

While there has been significant progress in the development of US HIV policy in recent years, additional concerted efforts are required to achieve the US government's 2030 target of reducing HIV infections by 90%. When evaluating new policies, focus can often be limited to the clinical and healthcare implications from averting HIV infections. However, given the observed links between HIV infection and broader economic effects such as employment and disability, adopting a holistic fiscal perspective allows the full range of benefits to be captured, thus showing the possible cost savings that could be realized from these policies. This analysis demonstrates that enhancing various components of HIV policy generates benefits beyond healthcare cost savings alone. Improvements in HIV outcomes provide substantial financial gains for the government by increasing tax revenue from employment income and reducing expenditure on both healthcare services and social support programs.

Data Sharing Statement

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study. The economic model was populated with data taken from published sources.

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