Allocation of HIV Resources towards Maximizing the Impact of Funding in Selected Eastern European and Central Asian Countries

UZBEKISTAN

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Executive Summary

The Eastern European and Central Asian region continues to have the fastest increasing HIV epidemic in the world (1). The COVID-19 pandemic and the on-going war in Ukraine threaten economic growth and progress towards HIV targets. To ensure that progress against the HIV epidemic can continue, it is vital to make cost-effective funding allocations decisions to maximize the impact of HIV programs. An allocative efficiency analysis was conducted in partnership with the Republican Sanitary Epidemiological Center, the Global Fund, UNAIDS, Swiss Tropical and Public Health Institute, and the Burnet Institute.

Key recommendations

- Uzbekistan has a concentrated HIV epidemic with a high prevalence among men who have sex with men (4.1%), female sex workers (1.3%), and people who inject drugs (2.9%) based on surveillance data in 2021 (2).
- In 2021 an estimated US$9.3M was spent on targeted HIV interventions, with antiretroviral therapy (ART) accounting for 72% of this.
- In a baseline scenario where 2021 spending on programs was maintained, including a fixed annual spending on ART, there were estimated to be 54,092 new HIV infections, 12,449 HIV-related deaths and 311,993 HIV-attributable disability-adjusted life years (DALYs) over 2023-2030.
- **Given the currently identified key populations in Uzbekistan, existing spending is close to the optimized allocation. Further improvements could be made through deprioritizing the HIV testing program among the general population in order to continue scaling up ART and HIV prevention programs for key populations.**
- Optimized reallocation of 2021 spending was estimated to avert 8,901 new infections (16%), 2,493 deaths (20%) and 59,667 DALYs (19%) over 2023-2030 relative to the baseline scenario of continued 2021 spending.
- **With additional resources available, priorities were identified as continued scale up of programs for key populations including female sex workers, people who inject drugs and men who have sex with men, while ensuring treatment is available for all diagnosed people living with HIV.**
- In Uzbekistan, the relative population size and proportion of new HIV infections among identified key populations is substantially lower than 11 other countries in the EECA region. It is likely that there are additional unidentified key populations in Uzbekistan at elevated behavioral risk of HIV transmission. To focus interventions in reaching these unidentified populations at risk it may be first necessary to explore the barriers to healthcare that limit their access to current services.
- Even with substantial budget increases (i.e. 300% of targeted HIV spending), expansion of current programs is projected to be insufficient to reach 95-95-95 targets by 2030. Additional programs to identify other people at high past or present risk may be necessary to reach the 95% diagnosis target more cost-efficiently. Meeting the 95% treatment and 95% viral suppression targets will require continued expansion of ART coverage through ongoing increases in spending or decreases in procurement costs, and novel programs to improve linkage to care and treatment adherence that are not costed in this analysis.

1 Background

In Uzbekistan, the HIV epidemic has been steadily increasing to 59,985 people living with HIV in 2022, based on national program estimates (3). Uzbekistan is characterized as having a low-level HIV epidemic, with estimated 0.2% HIV prevalence among the adult population (4). Key populations disproportionately affected by HIV include people who inject drugs (PWID), men who have sex with men (MSM) and female sex workers (FSW). Since the start of the epidemic, the main mode of transmission has shifted from transmission through injecting drug use (5) to sexual transmission (6). Based on integrated biological-behavioral surveillance (IBBS) surveys, in 2021 HIV prevalence was estimated to be 2.9% among PWID (reduced from 5.1% in 2017) (7, 8) and 1.3% among FSW (reduced from 3.2% in 2017)(9, 10). Among MSM, prevalence was 3.7% in 2017 and 4.1% in 2021, but there is uncertainty in the trends due to changes in geographical representation between surveys (11, 12). Further, official estimates may underestimate the burden of HIV among key populations, because fear of stigma and prosecution are barriers to people identifying as part of these groups (13, 14).

The Uzbekistan HIV response is guided by a national law (No. 353, 2013) "On combatting the spread of the disease cause by human immunodeficiency virus" and reinforced in the presidential decree (No. 3493, 2018) "On measures to further improve the system of counteracting the spread of disease caused by the human immunodeficiency virus in the Republic of Uzbekistan" (6). HIV programming is largely funded by the Government of Uzbekistan in addition to funding by the Global Fund and other bilateral and multilateral organizations (15), with shared domestic/international funding for both prevention and treatment interventions. In 2020 the total spending on targeted HIV programs was US$9.3M with the Government of Uzbekistan contributing 63%.

Previous HIV allocative efficiency analyses were conducted in 2014 and 2019 using the Optima HIV model, with support from the World Bank, UNAIDS, the Global Fund, and other partners (16, 17). This is the third Optima HIV analysis in Uzbekistan. This updated allocative efficacy modeling analysis was conducted to estimate the optimal allocation of HIV resources based on latest reported values in 2021 with findings described below.

2 Objectives

Objective 1. What is the **optimized resource allocation** by targeted HIV intervention to minimize HIV infections and deaths by 2030 under five funding scenarios of 50, 75, 100, 125 and 150 percentage of the current HIV funding? What is the expected cascade (gap) under these scenarios?

Objective 2. If national governments do not scale up HIV programs identified for prioritization under optimized allocation for different funding envelopes, what will the impact be on the epidemic by 2030? That is, what is the **opportunity lost to avert HIV infections, deaths** and disability-adjusted life years (DALYs)?

Objective 3. What is the **most efficient HIV resource allocation for best achieving 95-95-95 targets** by 2030, and what is the level of resources required for achieving these targets? What is the number of HIV infections prevented and deaths averted under this scenario?

3 Methodology

An allocative efficiency modeling analysis was undertaken in collaboration with the National HIV program of Uzbekistan. Epidemiological and program data were provided by the country team and validated during a regional workshop that was held in September 2022 in Istanbul, Turkey. Country teams were consulted before and after the workshop on data collation and validation, objective and scenario building, and results validation. Demographic, epidemiological, behavioral, programmatic, and expenditure data from various sources including UNAIDS Global AIDS Monitoring and National AIDS Spending Assessment reports, integrated bio-behavioral surveillance surveys, national reports and systems, as well as from other sources were collated. In Uzbekistan, expenditure data were based on Global Fund expenditures and national program data in 2021 (3). Budget optimizations were based on targeted HIV spending for programs with a direct and quantifiable impact on HIV parameters included in the model. This allocative efficacy analysis was conducted using Optima HIV, an epidemiological model of HIV transmission overlayed with a programmatic component and a resource optimization algorithm. A more detailed description of the Optima HIV model has been published by Kerr et al (18).

3.1 Populations and HIV programs

Populations and HIV programs considered in this analysis were:

- Key populations
    - Female sex workers (FSW)
    - Clients of female sex workers (Clients)
    - Men who have sex with men (MSM)
    - People who inject drugs (PWID), male
    - Unidentified male key population (Unidentified male)
    - Unidentified female key population (Unidentified female)
- General populations
    - Males 0-15 (M0-15)
    - Females 0-15 (F0-15)
    - Males 16-49 (M16-49)
    - Females 16-49 (F16-49)
    - Males 50+ (M50+)
    - Females 50+ (F50+)

- Targeted HIV programs
  - Antiretroviral therapy (ART), including prevention of mother-to-child transmission
  - HIV prevention program for PWID, including needle-syringe program (PWID programs) (PWID programs)
  - HIV prevention program for FSW (FSW programs)
  - HIV prevention program for MSM (MSM programs)
  - HIV testing services (HTS), all populations

Unidentified key populations of males and females have been included in the Uzbekistan analysis. This is intended to capture the likelihood that an unknown combination of MSM, PWID, FSW, and clients may not be identified and are therefore not reached by the key population programs.

In Uzbekistan, MSM, PWID and clients of sex workers were estimated to make up 3.2% of the adult male population, which is considerably less than the regional median of 13.1% among 11 countries in EECA. Of note, the estimated number of MSM in Uzbekistan is 0.03% of the male population compared to the regional median of 1.4%. Male key populations collectively were estimated to account for 11.8% of new infections among males in Uzbekistan compared to the regional median of 68.6%. Similarly, FSW were estimated make up 0.3% of the total population compared to the regional median of 0.7% and accounted for 3.5% of new infections among females compared to the regional median of 17.6%.

Given the differences with the regional averages, it is likely that there are additional unidentified key populations in Uzbekistan at elevated behavioral risk of HIV transmission, although further national research would be needed to confirm the size and composition of the unidentified key populations. To estimate the population sizes of these unidentified male and female populations for this analysis, it was assumed that HIV prevalence was in line with other key populations in Uzbekistan of the same gender, and that the percentage of total new infections in all key populations was in line with the regional median.

3.2 Model constraints

Within the optimization analyses, no one on treatment, including ART, PMTCT, or opioid substitution therapy, can be removed from treatment, unless by natural attrition. All other programs were constrained to not reduce by more than 50%, unless optimizing a reduced budget.

3.3 Treatment retention parameters

The model did not include any defined HIV programs aimed at improving linkage or retention in treatment, adherence or viral suppression. Objective 1 (optimizing spending across programs to minimize infections and deaths) maintained the most recent values for time to be linked to care, loss-to-follow-up, return to care and viral suppression until 2030. Subsequently, the projected care cascade with optimized spending may underestimate the second and third pillars if additional programs that are not in the model are implemented or scaled-up.

Unlike Objective 1, which maintained most recent values for a number of care parameters, the optimization in Objective 3 (achieving 95-95-95 targets) *assumed* that the proportion of diagnosed people on treatment and the proportion of people on treatment with viral suppression would linearly increase to reach 95% by 2030. Objective 3 therefore includes the impact of improvements to reach the treatment and viral suppression targets but not the cost of programs required to achieve these gains, which would require further work to quantify.

3.4 Model weightings

Objective 1 aimed to minimize new HIV infections and HIV-related deaths by 2030 for a given budget, with a weighting of 1 to 5 for infections to deaths. Objective 3 weightings were to reach 95% diagnosis by 2030 with the minimal possible total spending.

4 Findings

4.1 Objective 1

*What is the **optimized resource allocation** by targeted HIV intervention to minimize HIV infections and deaths by 2030 under five funding scenarios of 50, 75, 100, 125, and 150 percentage of the current HIV funding? What is the expected cascade (gap) under these scenarios?*

2021 HIV spending. Uzbekistan has a latest reported national budget of US$9.3M in 2021 for targeted HIV programs considered above, incorporating both domestic and international sources. The majority (72%) of targeted spending was for ART, followed by 22% for HTS and 4% for PWID programs. (Figure 2; Table A5).

Resource needs to maintain 2021 ART coverage. In 2021, ART coverage among diagnosed people living with HIV was 70%. If ART unit costs (US$196 in 2021) and current coverage of other HIV programs remained constant, annual ART spending would need to increase by US$3.4M (51% of 2021 ART spending) by 2030 to maintain a constant proportion of people who are diagnosed on treatment.

Maintaining the “status quo” proportion of diagnosed people living with HIV on treatment will require additional future investment in HIV (Figure 1a), further reductions in ART unit costs, or reallocation of resources from other HIV programs.

To compare scenarios with optimized allocation of resources within a fixed budget envelope, a counterfactual "Baseline" of fixed annual spending on ART was used. This would result in different epidemic projections to maintaining fixed coverage (Figure 1b) but means that optimizations consider how the needs for additional treatment can be met.

Comprehensive strategic information was not available to define the combination of factors leading to people not being retained in care and on treatment, and specific programs to improve linkage to care or treatment adherence were not modeled or costed in this analysis.

Although treatment is available to all diagnosed people living with HIV in Uzbekistan, there is a gap in strategic information where some diagnosed people living with HIV are neither reported to be on treatment nor lost to follow-up. It was assumed that additional spending on ART would be able to return these people to treatment, but further exploration of the limitations in achieving higher coverage of treatment may be necessary (including migration and acceptability of treatment regimens).

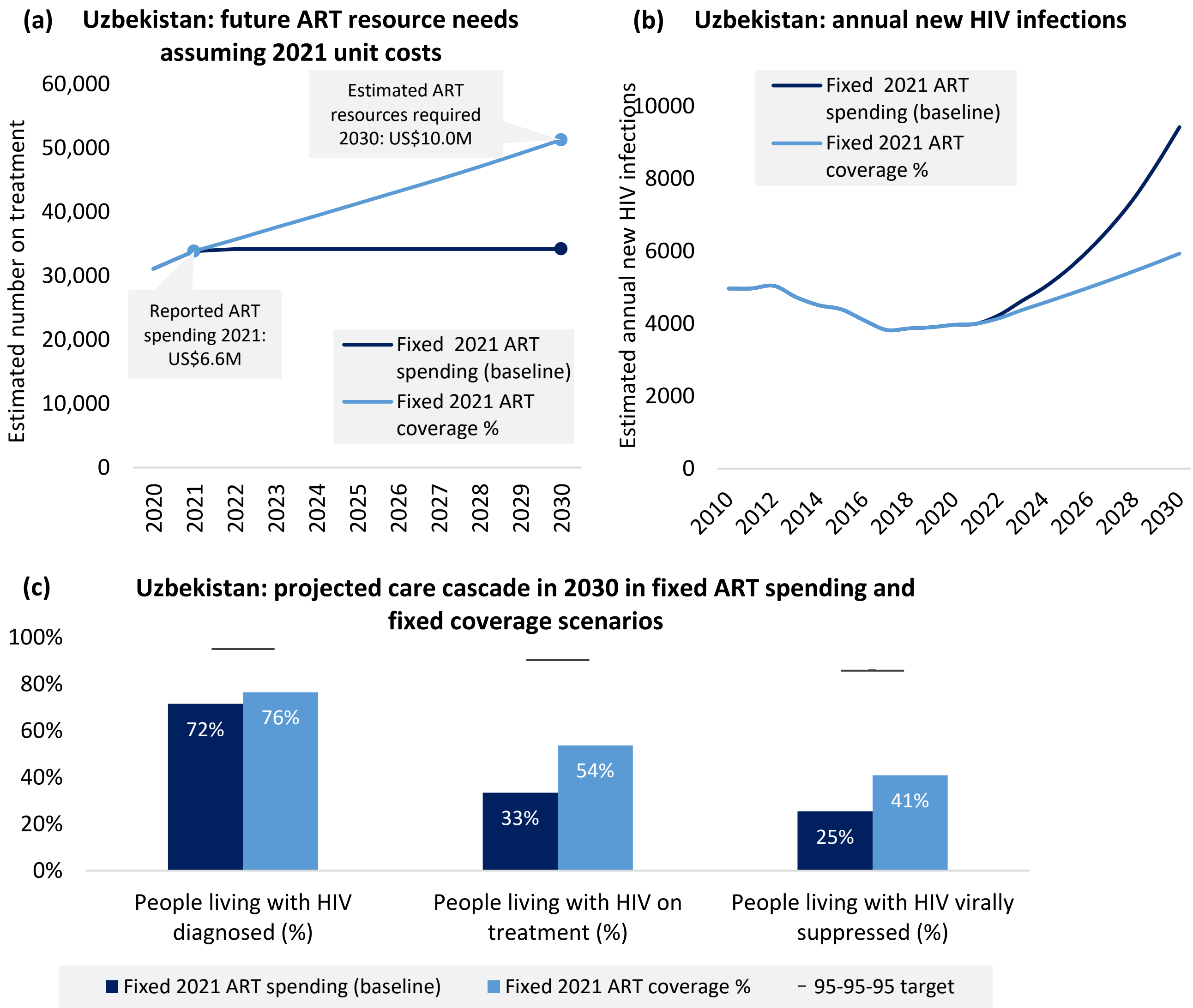

Figure 1. Fixed proportional coverage of people living with HIV on ART compared to fixed ART spending: resource needs and epidemic outcomes by 2030. Panels show (a) Resources required to maintain 2021 proportional coverage of ART among people living with HIV until 2030 if ART unit cost remains constant; (b) Estimated number of annual new HIV infections if ART spending is fixed until 2030 (baseline) compared to if ART

proportional coverage is fixed; and (c) Projected HIV care cascade among all people living with HIV if ART spending is fixed at 2021 values compared to if ART coverage is fixed at 2021 values. ART, antiretroviral therapy.

Baseline scenario. In the baseline scenario maintaining 2021 spending on programs with fixed allocations, the model projects that there would be 54,092 new HIV infections, 12,449 HIV-related deaths and 311,993 HIV-attributable DALYs over 2023-2030. Without additional spending on ART, HIV care cascade was projected to be "72-33-25" in the year 2030 (i.e. 72% of people diagnosed, 33% of diagnosed people on treatment and 25% of people on treatment virally suppressed) (Figure 1c; Table 1).

Optimized resource allocation of 2021 spending. Optimization of 2021 spending identified that additional impact may be possible by reallocating HTS spending to enable further scale up of ART and prevention programs for FSW and PWID, while maintaining coverage of prevention programs for all identified MSM. Assuming that more people could be accessed for treatment through enhanced linkage to care and adherence programs, investing more in treatment could reduce mortality as well as new infection through treatment-as-prevention. The model deprioritized HIV testing to enable greater investment into these higher impact programs.

Given the higher HIV prevalence rates among identified key populations including MSM (4.1%), FSW (1.3%), and PWID (2.9%), relative to the national estimate of 0.2% HIV prevalence among all adults, it is likely that further allocative efficiency in HIV spending could be possible if more unidentified key populations could be reached with HIV services. Reducing spending on HTS may be possible by adapting more targeted testing strategies focused on providing voluntary counselling and testing to population groups with higher risk of HIV instead of population-wide testing (6, 13).

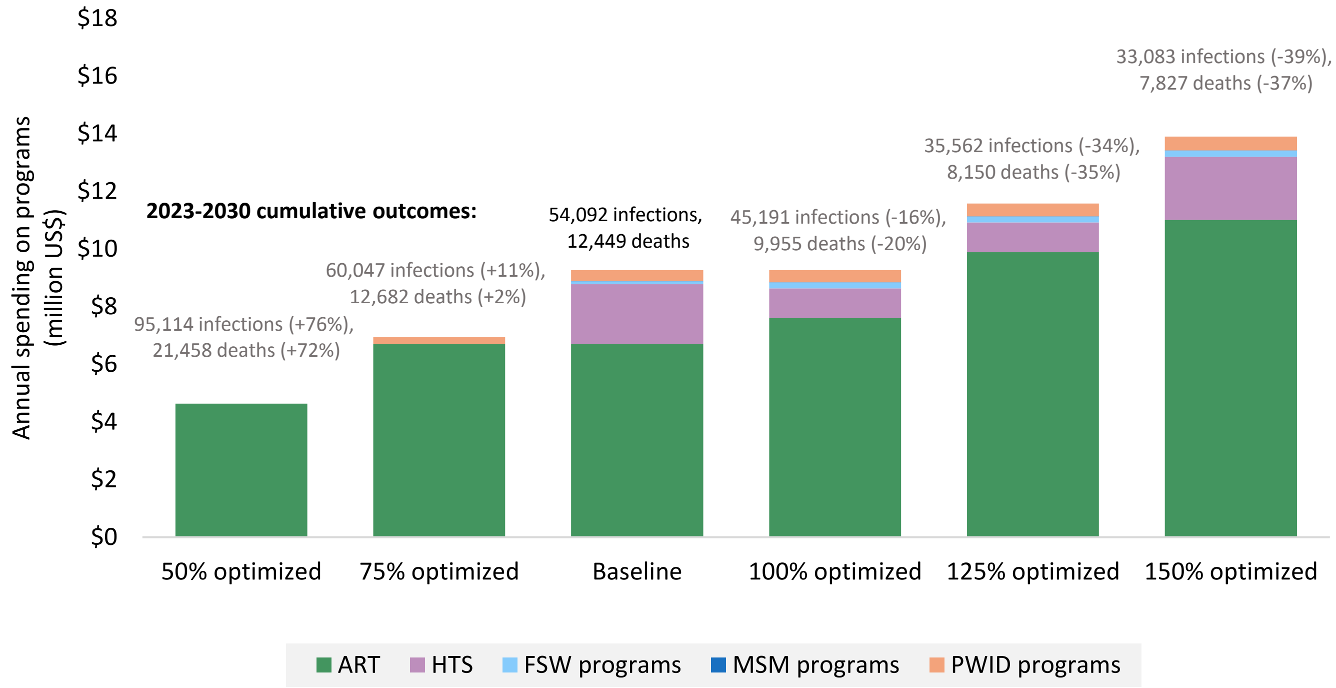

Figure 2. Optimized allocations under varying levels of annual HIV budgets for 2023 to 2030, to minimize new infections and HIV-related deaths by 2030. Percentage optimized refers to the percentage of baseline HIV spending (i.e. 2021 spending). ART, antiretroviral therapy; FSW, female sex worker; HTS, HIV testing services; PWID, people who inject drugs

Optimized resource allocation at different budget levels. As the total budget envelope increased, the priorities were identified as increased investment in HTS as well as the continued scale-up of ART and programs for FSW, followed by investment in programs for PWID. With additional resources HTS can reach unidentified male and female key populations that are not targeted elsewhere. All identified MSM are already reached with the current budget allocation and so programs focused on FSW have a greater potential to impact HIV prevalence.

If funding were reduced, priorities were identified as maintaining as many people on treatment as possible, followed by prevention programs for PWID.

Impact of optimization on HIV epidemic. Compared with the baseline scenario, optimized reallocation of 2021 spending averted 8,901 new infections (16%), 2,493 deaths (20%) and 59,667 DALYs (19%) over 2023-2030 (Figure 3; Table 1). This benefit increased to 39% infections, 37% deaths and 35% DALYs averted with an optimized 150% budget (Figure 3; Table 1).

Beyond 150% budget the modeled programs had all reached close to their saturation levels, and increased investment had diminishing returns. At this level of spending different approaches may be needed to reach those not accessible by current services.

4.2 Objective 2

*If national governments do not scale up HIV programs identified for prioritization under optimized allocation for different funding envelopes, what will the impact be on the epidemic by 2030? That is, what is the **opportunity lost to avert HIV infections, deaths** and disability-adjusted life years (DALYs)?*

Zero HIV spending. The continued investment in HIV programs is essential to avoid an increasing epidemic. In a scenario with no HIV spending from 2023, the model estimates that there would be 75,789 (+140%) more new infections, 24,268 (+195%) more deaths and 588,090 (+188%) more DALYs over 2023-2030 compared to the baseline scenario of fixed annual spending on programs (Table 1).

Table 1. Cumulative new HIV infection, HIV-related deaths, HIV-related DALYs between 2023-2030 under different scenarios, and differences in impacts compared to the baseline scenario of fixed 2021 spending on programs.

	Cumulative new HIV infections 2023-2030	*Cumulative HIV deaths 2023-2030*	*Cumulative HIV DALYs 2023-2030*	*Difference in infections from baseline*	*Difference in deaths from baseline*	*Difference in DALYs from baseline*
No HIV spending from 2023	129,881	36,717	900,083	140%	195%	188%
50% optimized	95,114	21,458	530,459	76%	72%	70%
75% optimized	60,047	12,682	318,592	11%	2%	2%
Baseline	54,092	12,449	311,993			
100% optimized	45,191	9,955	252,326	-16%	-20%	-19%
125% optimized	35,562	8,150	210,510	-34%	-35%	-33%
150% optimized	33,083	7,827	203,620	-39%	-37%	-35%
*95-95-95**	19,926	5,052	141,928	-63%	-59%	-55%

*Optimization was only able to reach 92-95-95; refer to section 4.3. Percentage optimized refers to percentage of baseline spending.

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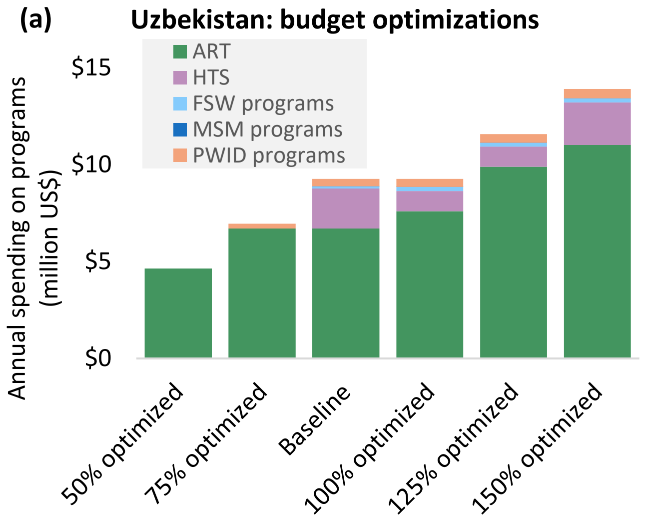

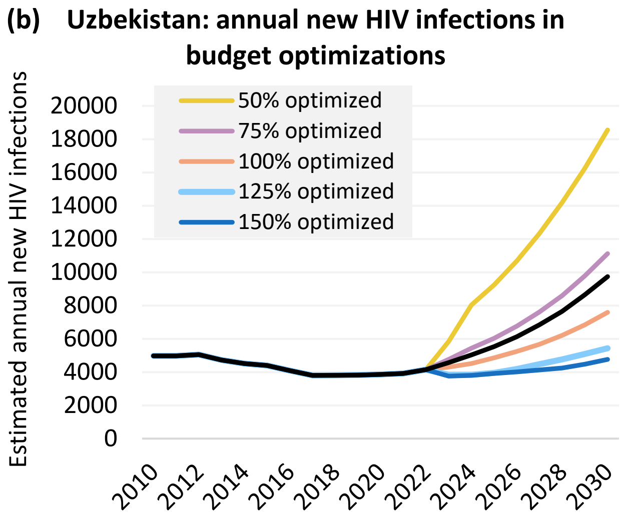

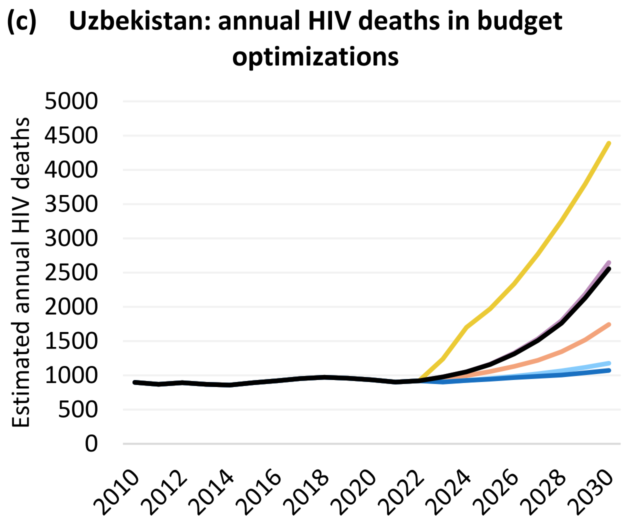

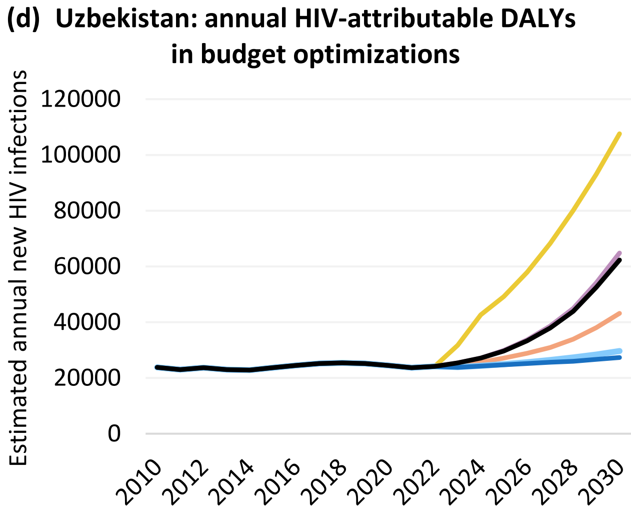

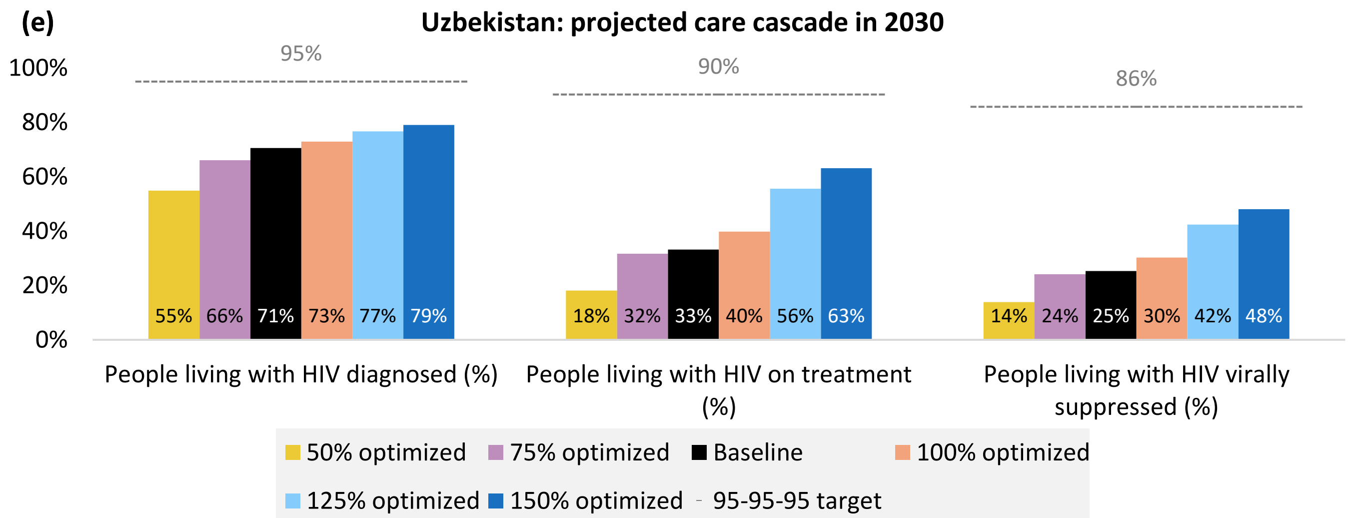

Figure 3. Model outcomes from budget optimization scenarios aiming to minimize infections and deaths. Panels show (a) optimal budget allocations under varying levels of annual HIV budgets according to percentage of estimated 2021 spending; (b) estimated annual new HIV infections; (c) HIV-related deaths; (d) HIV-related disability-adjusted life years; and (c) projected care cascade for the year 2030 among all people living with HIV. ART, antiretroviral therapy; DALY, disability-adjusted life year; FSW, female sex worker; HTS, HIV testing services; PWID, people who inject drugs; PMTCT, prevention of mother to child transmission.

4.3 Objective 3

*What is the **most efficient HIV resource allocation for best achieving 95-95-95 targets** by 2030, and what is the level of resources required for achieving these targets? What is the number of HIV infections prevented and deaths averted under this scenario?*

Based on both baseline and 100% optimized spending, Uzbekistan's care cascade is not projected to reach 95-95-95 targets by 2030 (equivalent to 95-90-86 of all people living with HIV) (Figure 4e).

Increasing resources by an additional US$18.5M per annum, or a total 300% of 2021 spending, will only increase diagnosis of people living with HIV to 92% by 2030. The large number of infections in unidentified key populations in Uzbekistan and the high cost of HTS means that diagnosing 95% of all PLHIV will require a substantial scale-up of the current HIV budget. The HIV testing program is not able to efficiently reach unidentified key populations with undiagnosed HIV, and additional programs may be needed to reach diagnosis targets more cost-effectively.

No programs were modelled to improve linkage and retention in treatment, adherence, and viral suppression, and thus the cost of reaching the second and third cascade pillars is unknown. In addition to ART spending, novel programs may be necessary in Uzbekistan to improve linkage to care, treatment adherence and retention to achieve 95% treatment coverage and 95% viral suppression. In Uzbekistan stigma and discrimination of people living with HIV may be barrier to treatment (13). Programs that address treatment uptake and retention will need to be considered for this scenario, and the 95-95-95 targets, to be realistic.

Achieving "92-95-95" in this optimized scenario could avert 34,166 (63%) new infections, 7,397 (59%) deaths and 170,065 (55%) DALYs compared to the baseline scenario of fixed 2021 spending on programs and no improvements to linkage to care or treatment adherence (Figure 4).

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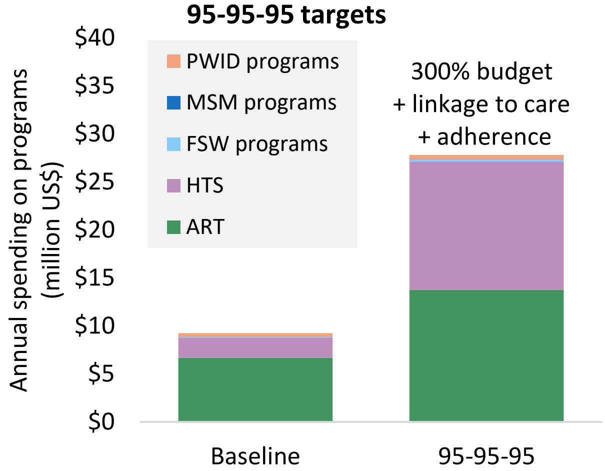
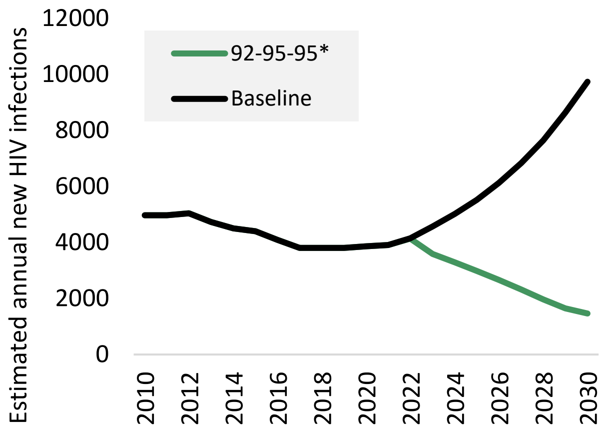
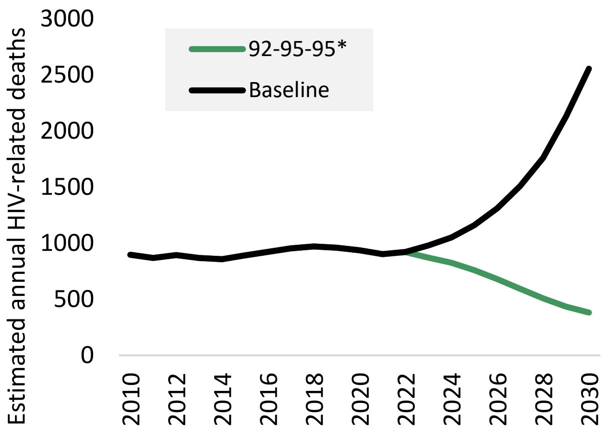
(a) Uzbekistan: optimized budget to reach 95-95-95 targets



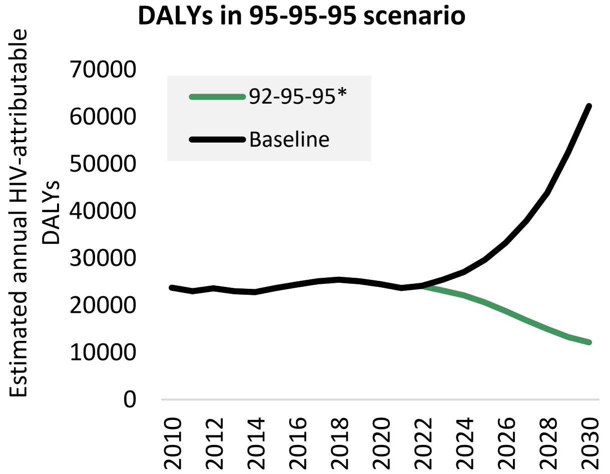
(b) Uzbekistan: annual new HIV infections in 95-95-95 scenario



(c) Uzbekistan: annual HIV deaths in 95-95-95 scenario



(d) Uzbekistan: annual HIV-attributable DALYs in 95-95-95 scenario



(e) Uzbekistan: projected care cascade

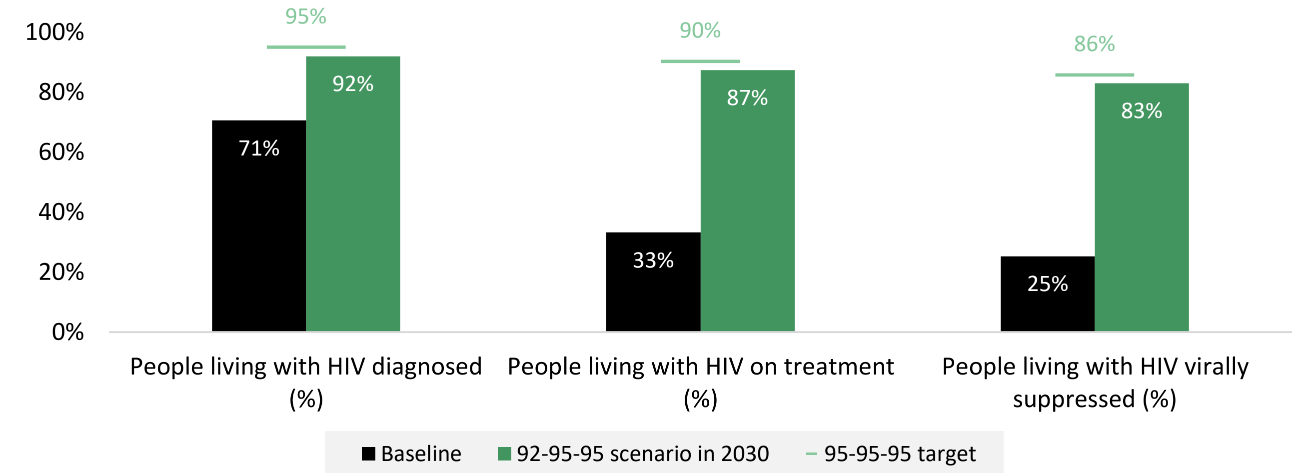


Figure 4. Optimized HIV budget level and allocation to achieve 95-95-95 targets by 2030. *The 95% diagnosis target could not be reached with 300% spending optimized, and impact is shown for the achieved cascade. Panels show (a) optimal budget allocations; (b) estimated annual new HIV infections; (c) HIV-related deaths; (d) HIV-related disability-adjusted life years; and (e) estimated care cascade in baseline year 2021 and projected for the year 2030 as a proportion of all people living with HIV. ART, antiretroviral therapy; DALY, disability-adjusted life year; FSW, female sex worker; HTS, HIV testing services; MSM, men who have sex with men; PWID, people who inject drugs; PMTCT, prevention of mother to child transmission.

5 Comparison with past spending

Spending on targeted HIV programs has increased since 2018, from US$7.9M to US$9.3M in 2021. There has also been a shift in the allocation of funding across programs, with increased emphasis on ART and decreased emphasis on HTS, while maintaining absolute spending on prevention programs focusing on identified key populations. The reduction in spending on PMTCT is due to its integration with the ART program. The changes in allocation for ART and HTS are consistent with recommendations from previous allocative efficiency analyses and would likely have improved the cost-effectiveness and impact of investment (17). However, there has been no notable scale-up of prevention programs for FSW and MSM since the last analysis.

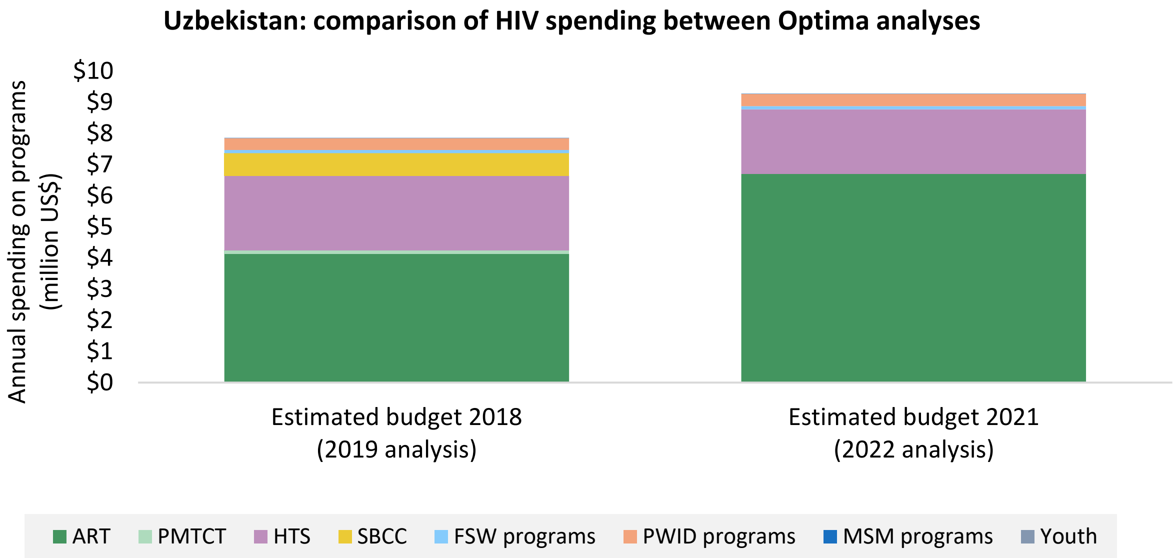


Figure 5. Estimated budget allocations from 2019 and 2022 Optima analyses. (N.B. ART spending in 2021 includes implementation of PMTCT). ART, antiretroviral therapy; FSW, female sex worker; HTS, HIV testing services; MSM, men who have sex with men; PWID, people who inject drugs; PMTCT, prevention of mother to child transmission; SBCC, social and behavior change communication.

6 Study limitations

As with any modeling study, there are limitations that should be considered when interpreting results and recommendations from this analysis.

- **Population sizes:** There is uncertainty in population size estimates; for key populations stigma may lead to underestimation of population size, and for total populations there is instability in migration patterns due to the war in Ukraine. This may influence estimates of people living with HIV and subsequently, service and funding needs for each key population.
- **Epidemiological indicators** come from population surveys or programmatic data that have varying degrees and types of biases. Uncertainty in these indicators combined with uncertainty in population sizes can lead to uncertainty in model calibration and projected baseline outcomes and subsequently, service and funding needs for each key population.
- **Effect (i.e. impact) sizes for interventions** are taken from global literature (e.g. the effectiveness of condom use for preventing infections). Actual program impacts may vary depending on context or quality of implementation.
- **Geographical heterogeneity** is not modeled, and outcomes represent national averages. There may be opportunities for additional efficiency gains through appropriate geographical targeting.
- **Cost functions for each program** are a key driver of model optimizations. Cost functions determine how program coverage will change if funding is reallocated, as well as maximum achievable program coverage. There is uncertainty in the shapes of these cost functions, values which could influence how easily or how high programs could be scaled up.
- **Implementation costs.** Country-provided expenditure data in Uzbekistan for key population prevention programs and HTS are based on procurement costs and do not include implementation costs. Spending estimates therefore may not accurately reflect the distribution of HIV budgets due to potential differences in implementation costs between programs.
- **Currency:** The COVID-19 pandemic, war in Ukraine and global economic crises have led to instability in currencies over the past few years. Spending is reported in US$, but what this value represents in local currency may change over time in unknown ways.
- **Retention in care.** Programs were not considered that could improve retention in care for people diagnosed, or viral suppression for people on treatment. These programs will be essential to achieving the 95-95-95 targets and future analyses should focus on quantifying the spending and impacts of relevant programs.
- **Equity** in program coverage or HIV outcomes was not captured in the model but should be a key consideration in program implementation. Policy makers and funders are encouraged to consider resources required to improve equity, such as through investment in social enablers to remove human rights-based barriers to health, and

technical or implementation efficiency gains. In addition, prevention programs may have benefits outside of HIV, such as for sexually transmitted infections, hepatitis C, and community empowerment. These were not considered in the optimization but should be factored into programmatic and budgeting decisions.

- **Other efficiency gains** such as improving technical or implementation efficiency were not considered in this analysis.
- **Unidentified population estimates:** The unidentified key populations were estimated using the median proportion of total people living with HIV in key populations in the EECA region. While this was carried out to provide a more accurate representation of the HIV epidemic in Uzbekistan, there is considerable uncertainty about the population size, behaviors and HIV prevalence among these groups.
- **Emigration:** Emigration was not considered in this analysis due to insufficient data. Labor migrant populations are at higher risk of HIV in the Central Asia region (19) and are considered a priority population in Uzbekistan. Both outgoing and incoming migrants are required to undergo mandatory testing for HIV in Uzbekistan (20).

7 Conclusions

This modeling analysis evaluated the allocative efficiency of direct HIV programs in Uzbekistan, finding that an optimized resource allocation can have an impact on reducing infections and deaths. Program priorities were identified as increased treatment scale-up where possible and prevention program coverage among FSW and PWID, followed by programs for MSM. More efficient spending on HIV testing may be possible with more focused testing strategies, particularly to reach currently unidentified key populations. New or scaled-up programs focusing on supporting linkage to care, adherence and retention in treatment are needed to reach care cascade targets by 2030, and the cost of these programs will require future exploration.

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8 Appendices

Appendix 1. Model parameters

Table A1. Model parameters: transmissibility, disease progression and disutility weights

Interaction-related transmissibility (% per act)		
	Insertive penile-vaginal intercourse	0.04%
	Receptive penile-vaginal intercourse	0.08%
	Insertive penile-anal intercourse	0.11%
	Receptive penile-anal intercourse	1.38%
	Intravenous injection	0.80%
	Mother-to-child (breastfeeding)	36.70%
	Mother-to-child (non-breastfeeding)	20.50%
Relative disease-related transmissibility		
	Acute infection	5.60
	CD4 (>500)	1.00
	CD4 (500) to CD4 (350-500)	1.00
	CD4 (200-350)	1.00
	CD4 (50-200)	3.49
	CD4 (<50)	7.17
Disease progression (average years to move)		
	Acute to CD4 (>500)	0.24
	CD4 (500) to CD4 (350-500)	0.95
	CD4 (350-500) to CD4 (200-350)	3.00
	CD4 (200-350) to CD4 (50-200)	3.74
	CD4 (50-200) to CD4 (<50)	1.50
Changes in transmissibility (%)		
	Condom use	95%
	Circumcision	58%
	Diagnosis behavior change	0%
	STI cofactor increase	265%
	Opioid substitution therapy	54%
	PMTCT	90%
	ARV-based pre-exposure prophylaxis	95%
	ARV-based post-exposure prophylaxis	73%
	ART not achieving viral suppression	50%
	ART achieving viral suppression	100%
Disutility weights		
	Untreated HIV, acute	0.08
	Untreated HIV, CD4 (>500)	0.01
	Untreated HIV, CD4 (350-500)	0.02
	Untreated HIV, CD4 (200-350)	0.07
	Untreated HIV, CD4 (50-200)	0.27
	Untreated HIV, CD4 (<50)	0.55
	Treated HIV	0.05

Source: Optima HIV User Guide Volume VI Parameter Data Sources

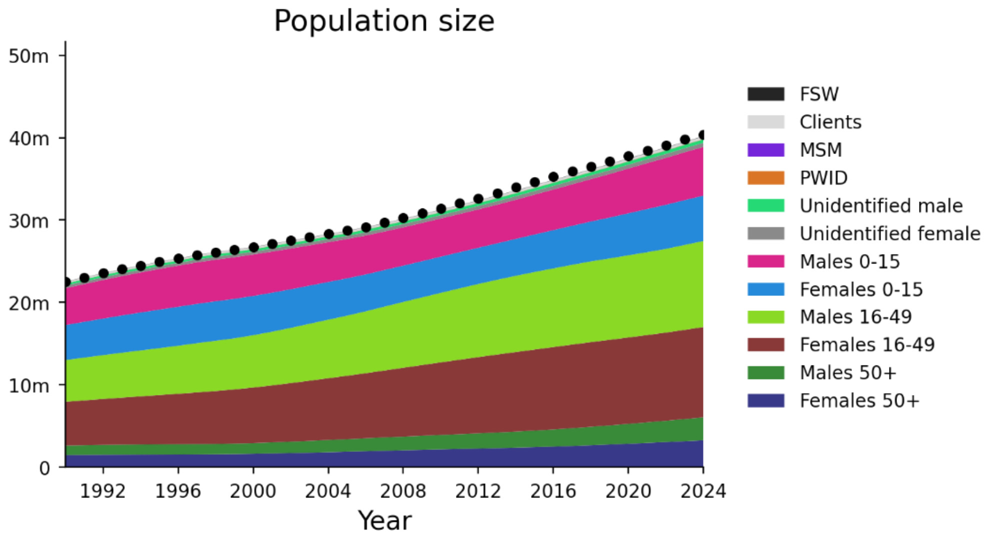
Table A2. Model parameters: treatment recovery and CD4 changes due to ART, and death rates

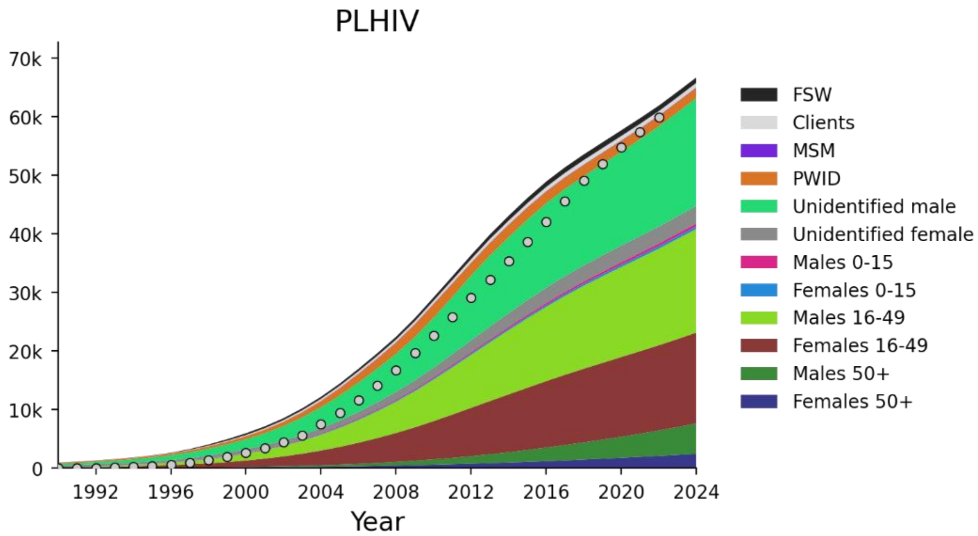
Treatment recovery due to suppressive ART (average years to move)		
	CD4 (350-500) to CD4 (>500)	2.20
	CD4 (200-350) to CD4 (350-500)	1.42
	CD4 (50-200) to CD4 (200-350)	2.14
	CD4 (<50) to CD4 (50-200)	0.66
	Time after initiating ART to achieve viral suppression (years)	0.20
CD4 change due to non-suppressive ART (%/year)		
	CD4 (500) to CD4 (350-500)	3%
	CD4 (350-500) to CD4 (>500)	15%
	CD4 (350-500) to CD4 (200-350)	10%
	CD4 (200-350) to CD4 (350-500)	5%
	CD4 (200-350) to CD4 (50-200)	16%
	CD4 (50-200) to CD4 (200-350)	12%
	CD4 (50-200) to CD4 (<50)	9%
	CD4 (<50) to CD4 (50-200)	11%
Death rate (% HIV-related mortality per year)		
	Acute infection	0%
	CD4 (>500)	0%
	CD4 (350-500)	1%
	CD4 (200-350)	1%
	CD4 (50-200)	6%
	CD4 (<50)	32%
	Relative death rate on ART achieving viral suppression	23%
	Relative death rate on ART not achieving viral suppression	49%
	Tuberculosis cofactor	217%

Source: Optima HIV User Guide Volume VI Parameter Data Sources

Appendix 2. Model calibration

Figure A1. Calibration outputs. Dots represent official country estimates based on World Population Prospects, Spectrum model, surveillance surveys, program data and UNAIDS.





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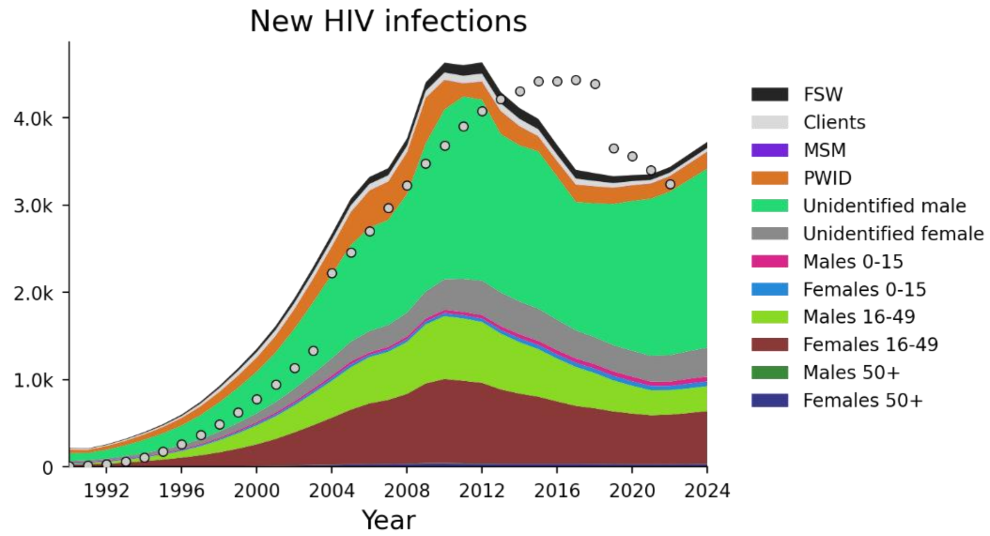

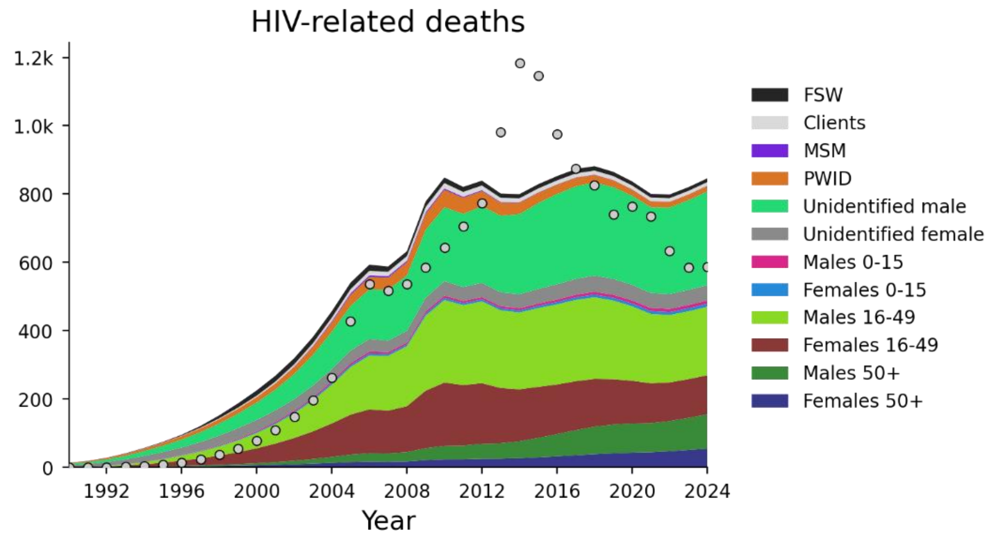

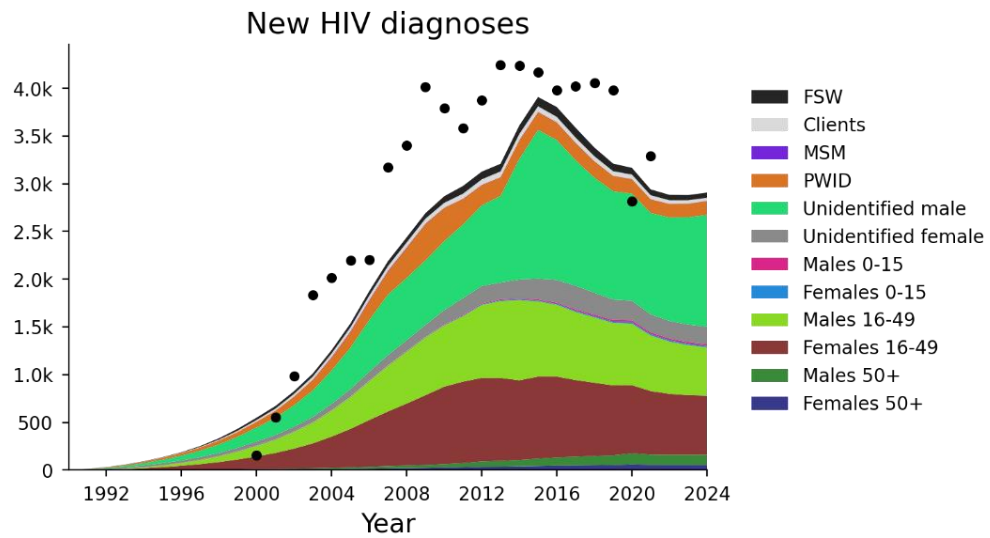

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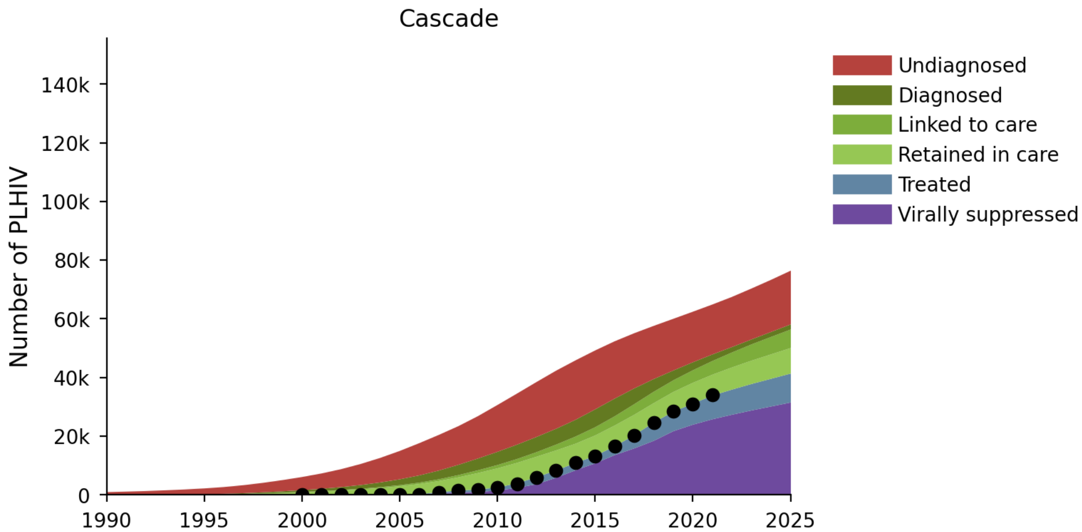

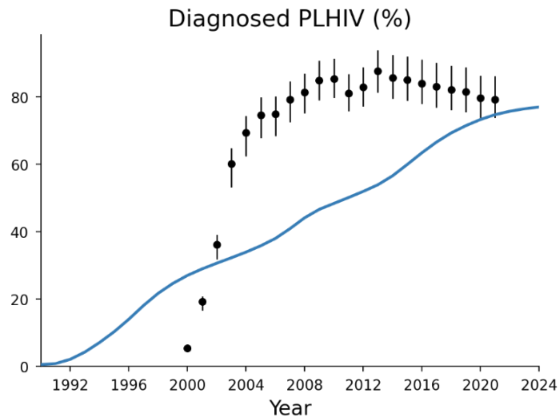

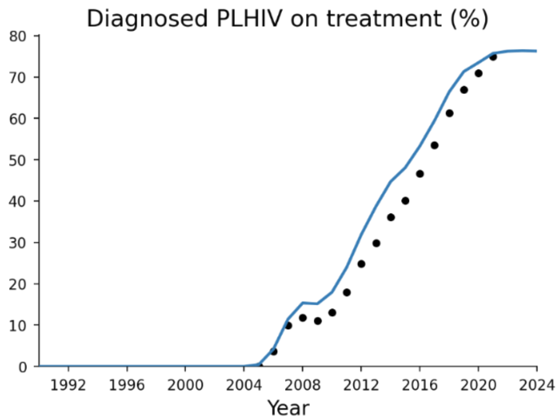

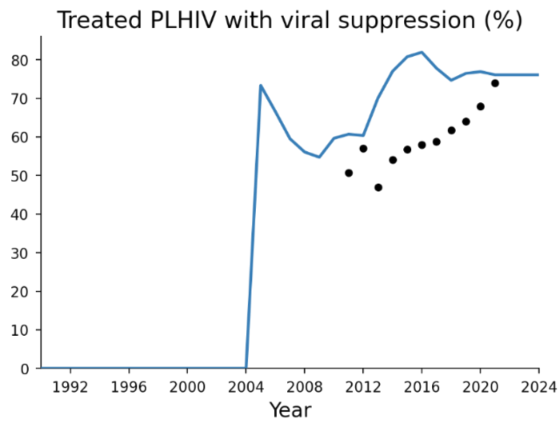

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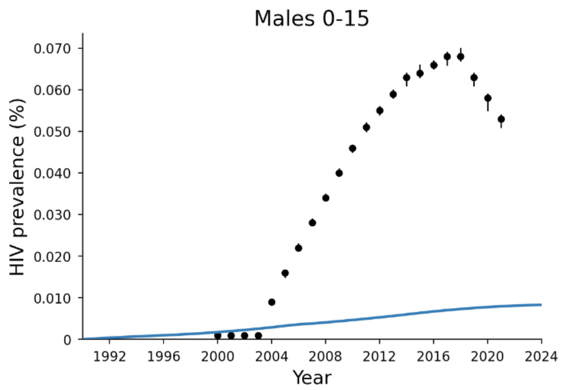

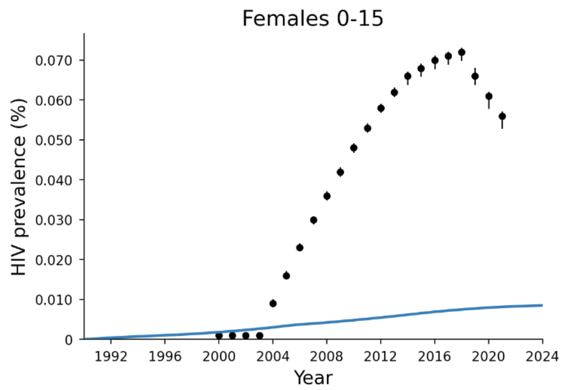

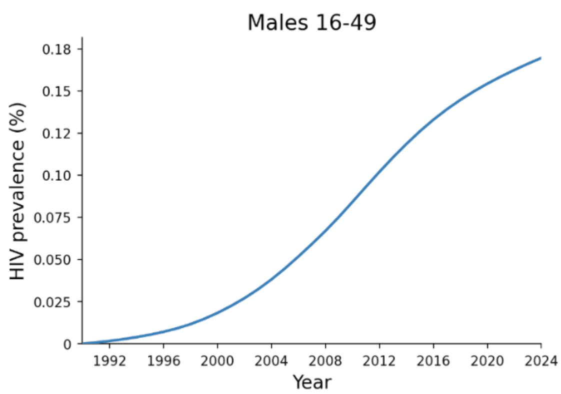

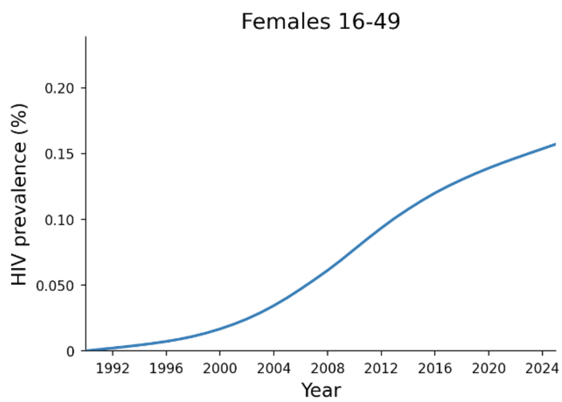

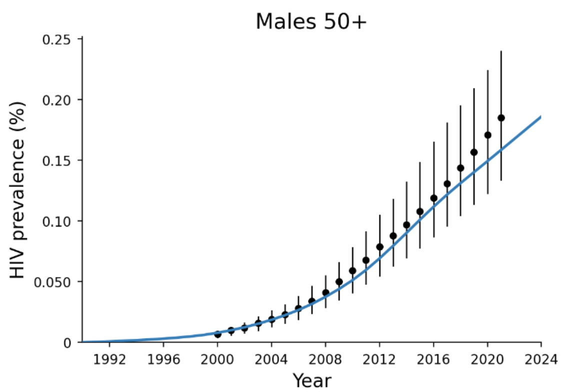

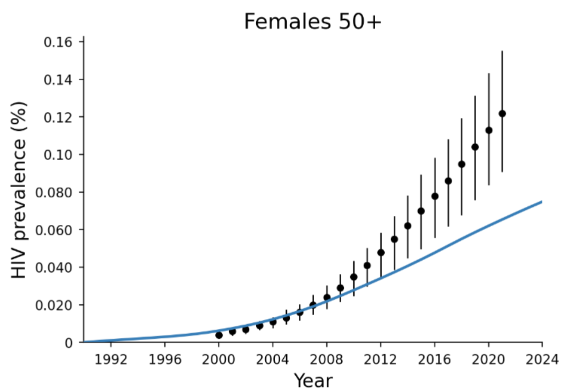

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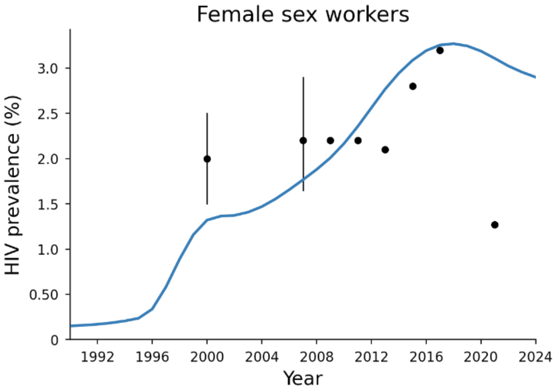
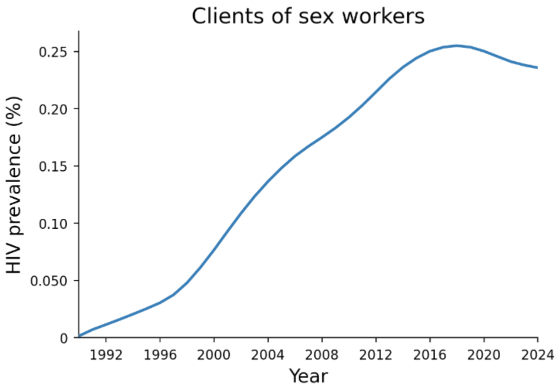
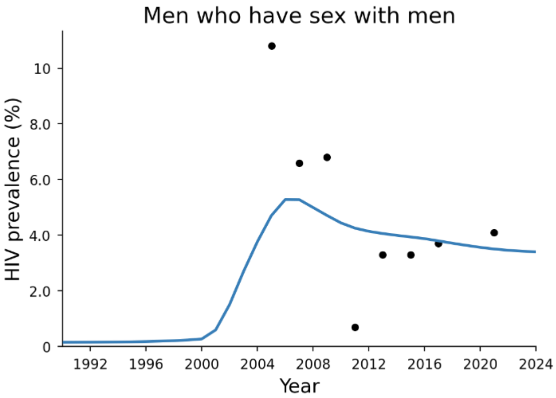
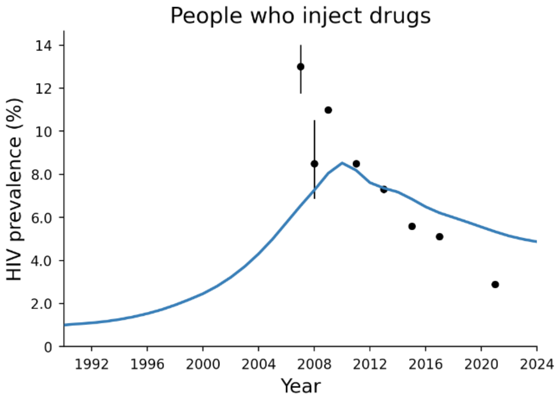
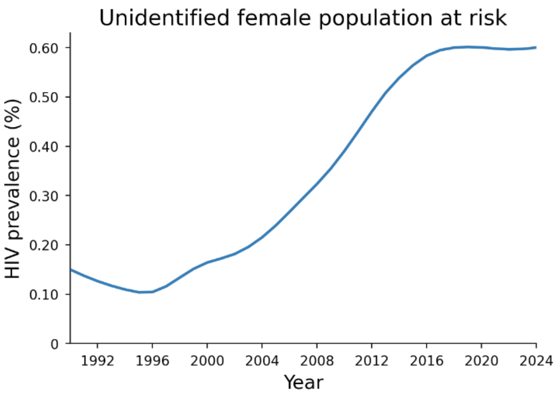
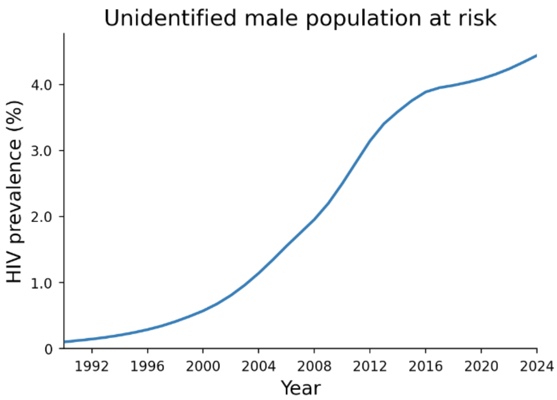












Appendix 3. HIV program costing and impacts

Table A3. HIV program unit costs and saturation values

HIV program	Unit cost (USD)	Saturation (low)	Saturation (high)
Antiretroviral therapy	$195.95	85%	95%
FSW programs	$6.67	85%	95%
MSM programs	$1.34	100%	100%
PWID and NSP programs	$12.78	85%	95%
HIV testing services	$0.60	85%	95%

Table A4. Data inputs of impact of programs

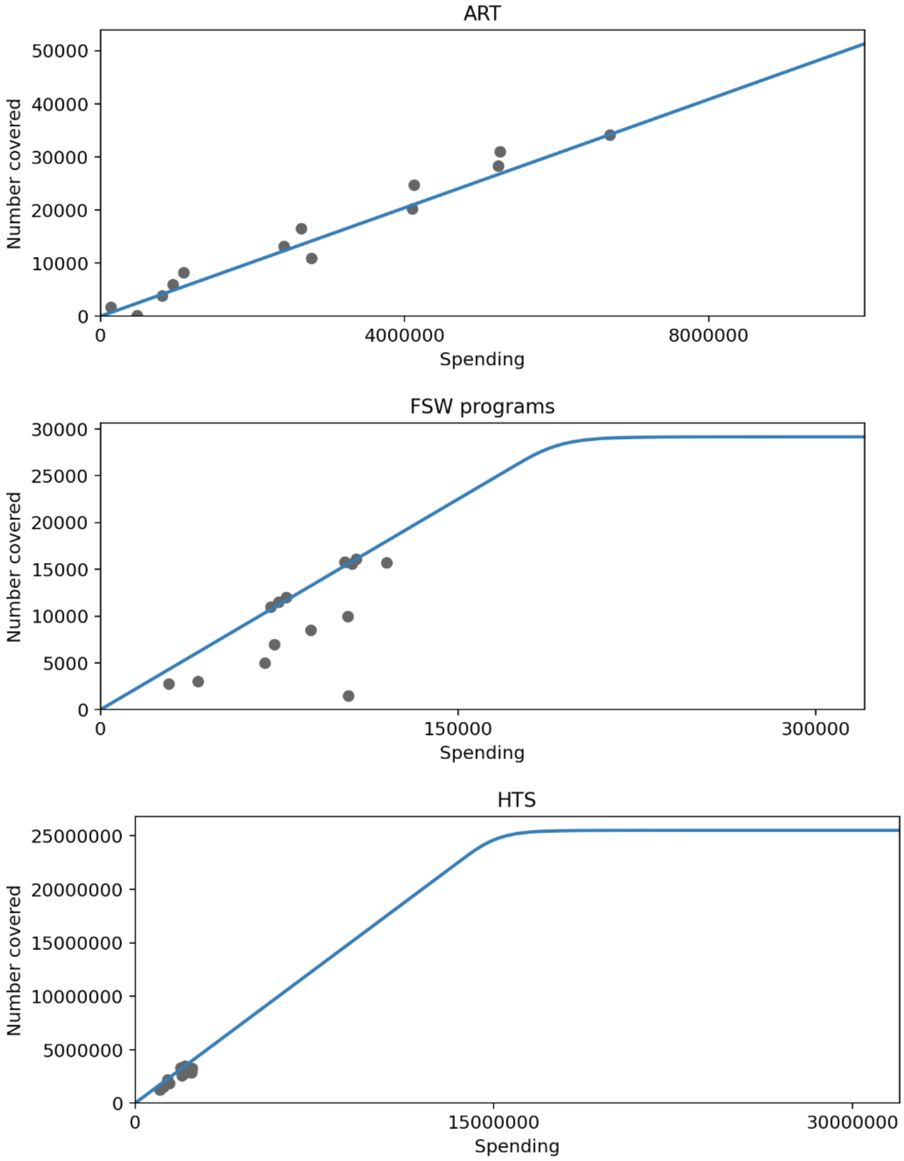
HIV program	Parameter	Population interactions or population	In absence of any programs		For each individual reached by this program	
			Low	High	Low	High
FSW programs	Condom use for casual acts	PWID, FSW	23%	23%	64%	64%
FSW programs	Condom use for casual acts	PWID, Unidentified female	23%	23%	64%	64%
MSM programs	Condom use for casual acts	MSM, MSM	22%	22%	50%	50%
MSM programs	Condom use for casual acts	MSM, PWID	30%	30%	55%	55%
MSM programs	Condom use for casual acts	MSM, Unidentified male	24%	24%	53%	53%
MSM programs	Condom use for casual acts	PWID, MSM	24%	24%	55%	55%
MSM programs	Condom use for casual acts	Unidentified male, MSM	24%	24%	52%	52%
PWID programs	Condom use for casual acts	MSM, PWID	30%	30%	55%	55%
PWID programs	Condom use for casual acts	PWID, FSW	23%	23%	64%	64%
PWID programs	Condom use for casual acts	PWID, MSM	24%	24%	55%	55%

PWID programs	Condom use for casual acts	PWID, Unidentified male	30%	30%	60%	60%
PWID programs	Condom use for casual acts	PWID, Unidentified female	23%	23%	64%	64%
PWID programs	Condom use for casual acts	PWID, Females 16-49	24%	24%	65%	65%
PWID programs	Condom use for casual acts	Unidentified male, PWID	30%	30%	60%	60%
FSW programs	Condom use for commercial acts	Clients, FSW	60%	60%	85%	85%
FSW programs	Condom use for commercial acts	Clients, Unidentified female	60%	60%	85%	85%
FSW programs	Condom use for commercial acts	PWID, FSW	55%	55%	75%	75%
FSW programs	Condom use for commercial acts	PWID, Unidentified female	55%	55%	75%	75%
FSW programs	Condom use for commercial acts	Unidentified male, FSW	60%	60%	85%	85%
FSW programs	Condom use for commercial acts	Unidentified male, Unidentified female	60%	60%	85%	85%
FSW programs	HIV testing rate (average tests per year)	FSW	0.10	0.10	0.40	0.40
MSM programs	HIV testing rate (average tests per year)	MSM	0.10	0.10	0.30	0.30
PWID programs	HIV testing rate (average tests per year)	PWID	0.10	0.10	0.47	0.47
HTS	HIV testing rate (average tests per year)	FSW	0.10	0.10	0.40	0.40
HTS	HIV testing rate (average tests per year)	Clients	0.15	0.15	0.38	0.38
HTS	HIV testing rate (average tests per year)	MSM	0.10	0.10	0.35	0.35
HTS	HIV testing rate (average tests per year)	PWID	0.10	0.10	0.15	0.15

HTS	HIV testing rate (average tests per year)	Unidentified male	0.11	0.11	0.37	0.37
HTS	HIV testing rate (average tests per year)	Unidentified female	0.10	0.10	0.43	0.43
HTS	HIV testing rate (average tests per year)	Males 16-49	0.15	0.15	0.39	0.39
HTS	HIV testing rate (average tests per year)	Females 16-49	0.25	0.25	0.59	0.59
HTS	HIV testing rate (average tests per year)	Males 50+	0.02	0.02	0.10	0.10
HTS	HIV testing rate (average tests per year)	Females 50+	0.02	0.02	0.10	0.10
PWID programs	Probability of needle sharing (per injection)	PWID	17%	17%	6%	6%
PWID programs	Probability of needle sharing (per injection)	Unidentified male	5%	5%	2%	2%
ART	Number of people on treatment	Total	0	0	-	-

- The number of people modeled as receiving ART is equal to the coverage of the respective programs.

Figure A2. Cost functions. Figures show relationship between total spending and number covered among targeting population of each program.



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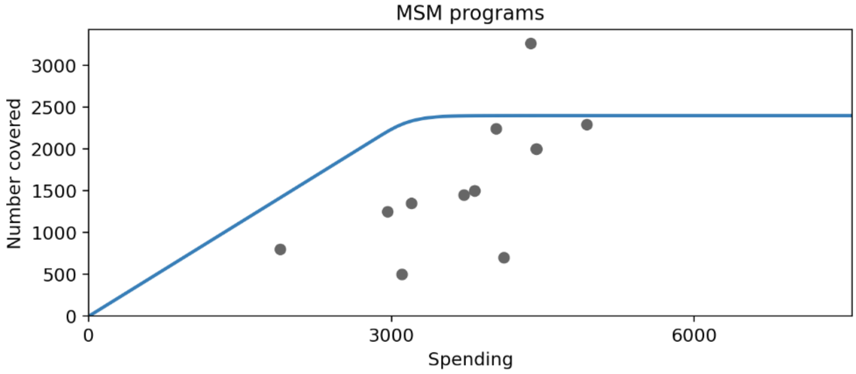

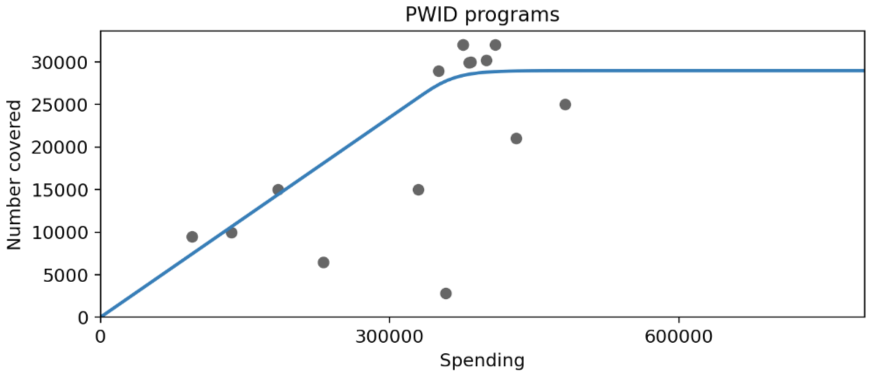

Appendix 4. Annual HIV budget allocations at varying budgets

Table A5. Annual HIV budget (US$) allocations among targeted HIV programs at varying budgets for 2023 to 2030

	100% latest reported (2021)	50% optimized	75% optimized	100% optimized	125% optimized	150% optimized
Antiretroviral therapy (ART)	$6,699,000	$4,633,446	$6,699,000	$7,598,430	$9,886,922	$11,007,723
FSW program*	$107,332	$0	$0	$208,702	$210,135	$210,283
HIV testing services	$2,074,000	$0	$0	$1,037,000	$1,037,000	$2,195,522
MSM program*	$4,379	$0	$0	$3,250	$3,495	$3,736
PWID program*,#	$382,180	$0	$251,168	$419,509	$446,061	$483,072
Total targeted HIV program budget	$9,266,891	$4,633,446	$6,950,168	$9,266,891	$1,072,242	$13,900,337

* Incudes prevention services (condom and information, education and communication)
# Includes needle-syringe program
FSW, female sex worker; MSM, men who have sex with men; PWID, people who use inject drugs

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