Optimizing HIV spending in twelve Eastern European and Central Asian countries – a modelling study

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Abstract

Background

The Eastern European and Central Asian (EECA) region has the fastest growing HIV epidemic globally. The study aimed to identify how HIV resources could be allocated for maximum health impact.

Methods

In 2022 allocative efficiency analyses were undertaken for 12 countries in EECA using Optima HIV: Albania, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Moldova, Serbia, Tajikistan, and Uzbekistan. Country models were calibrated to demographic, epidemiological and programmatic data and validated by national teams. Three scenarios were projected from 2023 to 2030: status-quo (continued 2021 spending on programs); optimized allocation of different spending envelopes to minimize HIV infections and deaths; and achieving 95-95-95 UNAIDS targets by 2030.

Findings

Aggregated across the 12 models, HIV infections attributable to sexual transmission were estimated to surpass those from injection in 2018, with male-to-male sexual transmission accounting for a continuously increasing share. In the status-quo scenario, there were an estimated 111,500 new HIV infections and 34,500 HIV-related deaths between 2023 and 2030. Aggregated optimization results suggest that 35,900 new HIV infections (32%) and 9,200 HIV-related deaths (27%) could be averted over this period compared with status-quo by prioritizing antiretroviral therapy (+10·8 percentage point share of total spending) and targeted key population programs (+6·2 percentage points).

For ten countries, achieving 95% diagnosis was projected to not be possible with the current budget envelope, and for seven countries, this could require more than 3x the current spending. Compared to the status-quo, achieving 95-95-95 or closest possible could avert 73,600 (66%) HIV infections and 19,000 (55%) HIV-related deaths over 2023 to 2030.

Interpretation

. Targeted key population programs should remain high priorities in the EECA region. Achieving 95-95-95 will require more emphasis on implementing appropriate modes of service delivery that reduce the gap in treatment coverage for diagnosed people living with HIV.

Funding

The Global Fund to Fight AIDS, Tuberculosis and Malaria

1 Background

The Eastern European and Central Asian (EECA) region is grappling with a rapidly escalating HIV crisis, marked by alarming rates of new infections and a significant proportion of people living with HIV (PLHIV) unaware of their status.[1] In 2021, there were an estimated 160,000 new HIV infections and 44,000 HIV-related deaths in the region, up from 62,000 and 16,000 in 2000, respectively.

In 2021, most new HIV infections in the EECA region were estimated to have occurred among key populations such as people who inject drugs (39%), female sex workers and their male partners (33%), men who have sex with men (22%), and other populations that include seasonal labor workers and other migrants (5%).[2] Notably, there has been a shift in transmission dynamics over the past decade, with a decline in HIV diagnoses among people who inject drugs and an increase in cases attributed to male-to-male sex (37% in 2012 to 46% in 2021).[3]

Despite the existence of prevention interventions such as needle and syringe programs, coverage remains low among key populations in most countries[2,4]. Where available, coverage of opioid substitution therapy (OST) is below the WHO target of 50%[2]. Additionally, there are significant gaps in HIV prevention and testing programs for MSM, with an average coverage of 37% in the region in 2019 and limited data on the coverage of pre-exposure prophylaxis (PrEP). [2,3,5]

Structural barriers, including stigma, discrimination, and restrictive policies, further hinder access to HIV services among key populations.[6,7] Male-to-male sex is still criminalized in three countries in the EECA region, drug use and sex work remains criminalized in 16 countries in the region.[8,9] Stigmatizing policies such as mandatory testing and punitive measures against key populations are shown to increase HIV risks and vulnerability, and negatively affect access to prevention and treatment services among key populations.[10,11]

Efforts to improve treatment coverage have shown progress regionally, with an increase from 49% in 2015 to 81% in 2021 among PLHIV who know their status.[1] Many countries have successfully reduced the cost of first-line antiretroviral therapy (ART) regimens, but relatively low access to newer fixed-dose combinations contribute to poor adherence and treatment retention.[12] Migration and displacement due to the war in Ukraine, as well as seasonal labor migration, further complicate access to services and retention in care beyond country borders in the EECA region.[13]

The regional economy is significantly impacted by the ongoing conflict in Ukraine while also recovering from the financial repercussions of the COVID-19 pandemic.[14,15] Spending for HIV decreased by 17% from 2019 to 2022 in EECA, while previous UNAIDS modelling work estimated that global 2019 spending was already 2-3 times below the amount required to achieve UNAIDS 95-95-95 targets by 2030.[16] The Global Fund support approximately 40% for key population prevention programs[17], and the Optima HIV model has previously been used to assess the allocative efficiency of this and national spending. In 2019, model findings suggested expansion of antiretroviral therapy (ART) to increase coverage among those already diagnosed as the highest priority, and context-specific priorities for key population prevention and testing programs depending on country.[18] With significant changes in migration, transmission patterns and spending in the region, allocative efficiency analyses were undertaken for 12 countries in the EECA region in 2022, to understand how resources could be optimally allocated for maximum impact.

2 Methods

2.1 Settings

The analyses were undertaken by the Burnet Institute between 1 August 2022 and 23 December 2022 and conducted in 12 countries in the EECA region: Albania, Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kosovo, Kyrgyzstan, Moldova (disaggregated for the Right (West) and Left (East) Bank at the country's request), Serbia, Tajikistan, and Uzbekistan.

2.2 Model design

HIV epidemic models were developed for each country using the open-source Optima HIV tool (version 2.11.3–available from https://github.com/optimamodel/optima). A detailed description of the Optima HIV model is available in Kerr (2015) and Appendix A.[19] In brief, Optima HIV is a dynamic compartmental model of HIV transmission, disease progression and care cascade progression that includes setting-specific population disaggregation. The epidemic model is overlaid with a set of programs that can impact parameters when their coverage is varied, and an economic framework that links spending on programs to program coverage. The model then employs an optimization algorithm to estimate how resources can be optimally allocated across HIV programs to achieve a desired objective (e.g. minimize infections and deaths).[19]

For this analysis, populations were disaggregated by sex, age and risk of exposure to HIV, resulting in male and female population groups for the general population aged 0-14, 15-49, 50+, with adjustments to align with the age groups in epidemiological data in Belarus (15-24 and 25-49), Serbia (0-17 and 18-49) and Uzbekistan (0-15 and 16-49). Key populations were adapted to each country context and included female sex workers (FSW) and their male clients, men who have sex with men (MSM), males and females who inject drugs (PWID), male prisoners, and male seasonal labor migrants. Due to limited data, transgender people were not included.

In settings where there were a high number of reported male-to-male sexually acquired infections but low HIV prevalence among MSM, country teams estimated that there may be a population of males who do not identify as members of key populations but were engaging in male-to-male sex and/or injecting behavior. This group of non-key male 15-49 population was modelled to have sexual relations with the identified MSM population in Albania, Moldova (Right Bank), and Georgia. Unidentified male and female key populations were included in Uzbekistan as separate groups, as the estimated proportion of MSM of the male population 15-49 was 0.03% versus the regional median of 1.4%, defined as people at higher risk of HIV taken as an average across identified key population groups with the same sex, while FSW were estimated to make up 0.3% of females 15-49, versus a regional median of 0.7%. To estimate population sizes, 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.

Of the 12 participating countries, ten country models already existed from Optima HIV modelling exercises conducted in 2014 and/or 2019 and were updated with new data[18], and for two countries, Albania and Serbia, new models were constructed. Individual country models require demographic, epidemiological, behavioral, and economic input data. Data

were provided by national HIV experts, and collated from surveillance reports, population surveys (e.g. demographic health surveys, integrated biological-behavioral surveillance surveys) and program databases. Further details are available in Appendix A and the 12 individual country model reports.[21]

2.3 Model calibration and data validation

Each country model was calibrated by varying demographic and epidemiological parameters to fit time-varying estimates of population sizes (overall and population group-specific), HIV prevalence among key populations, annual new infections, annual HIV-related deaths, and annual care cascade estimates (please see **Error! Reference source not found.** for HIV incidence figures). Parameters adjusted to calibrate included initial HIV prevalence in 1990, the force of infection (independent parameters for each population group), population-group specific HIV testing rates, overall mortality rate (all-cause and HIV-specific), partnerships between key population groups, and duration at risk (e.g. average length of injecting career).

Model input parameters and calibrations were validated for each country during consecutive three-day workshops organized by GFATM and UNAIDS in Istanbul, Turkey from 19 to 23 September 2022. Model outputs were triangulated with official country Spectrum modelling estimates[22] and discussed with country teams and UNAIDS colleagues where there were discrepancies, resulting in the addition of unidentified populations and increased risk among certain populations.

2.4 HIV programs

This analysis includes HIV prevention, testing and treatment interventions that have a direct impact on the HIV epidemic (i.e. “targeted” HIV programs). Modelled interventions were adapted to each country based on relevance and available data, including: antiretroviral therapy (ART), prevention of mother-to-child transmission (PMTCT), opioid substitution therapy (OST), HIV testing services for the general populations (HTS), HIV testing and prevention programs for female sex workers (FSW programs), HIV testing and prevention programs for men who have sex with men (MSM programs), HIV testing and prevention programs for people who inject drugs, including needle-syringe programs (PWID) for selected countries, standalone needle-syringe programs (NSP) when not included in PWID programs, HIV testing and prevention programs for migrants (migrant programs), HIV testing and prevention programs for prisoners (prisoner programs), condom promotion and distribution (condoms), social and behavior change communication (SBCC), and pre-exposure prophylaxis (PrEP).

The estimated 2021 coverage of each program was based on national data provided by country teams (Appendix C). Each program was modelled to impact one or more parameter, e.g. HIV testing and condom use, and effect sizes are outlined in Appendix D.

2.5 Costs

Spending estimates for each program were obtained from country teams, from the most recent National AIDS Spending Assessment reports, Global AIDS Monitoring reported expenditures, and country-provided programmatic data. For this analysis, only spending on the targeted programs was considered, meaning there is evidence of efficacy for HIV parameters included

in the Optima HIV models (i.e. testing programs increase the proportion of people tested and diagnosed). This spending excludes overhead costs and infrastructure.

Unit expenditures for each HIV program were estimated by dividing total estimated spending in 2021 by number of people reached (Appendix C). Expenditures are presented in 2021 USD and are undiscounted. All costs were supplied in USD, except for in Kosovo, where the Euro was used. A conversion rate of 1 Euro to US$1·18 in 2021 was applied to calculate aggregated spending. A logistic function is applied to establish a non-linear cost-coverage curve relationship between expenditures and coverage, that reflects higher costs as an HIV program is initiated and as programs reach saturation.[19]

2.6 Analysis

This study reports on epidemiological outputs aggregated for the 12 countries under the status quo, optimized spending and 95-95-95 scenarios to identify trends and priority HIV programs in the region. Individual case reports for each country are available online.[21]

2.6.1 Status-quo scenarios (continued 2021 spending)

The status quo scenario for each country assumes that 2021 spending on HIV programs continues from 2023 to 2030 on nominal terms (not adjusted for inflation), to enable comparison with optimized spending scenarios.

If the total number of diagnosed PLHIV increases over time, spending on ART will need to increase just to maintain a constant percentage of people diagnosed on treatment. Therefore, the assumption of fixed spending on ART means that in this status-quo scenario the percentage of people diagnosed who are on treatment reduces over time. Alternative scenarios assuming fixed proportional ART coverage among people diagnosed are shown in Appendix E.

2.6.2 Optimized resource allocation

Optimizations for each country consider how targeted HIV spending could be reallocated between HIV programs to minimize cumulative new HIV infections and HIV-related deaths over 2023 to 2030 at a given budget level relative to baseline spending. A weighting of 1 to 5 for infections to deaths was used in all countries except Albania where a weighting of 1 to 7 was applied based on country team preference, providing a more balanced epidemic response than optimizations that only prioritize either infections or deaths alone. Spending on programs was reallocated in the year 2023 and then fixed from 2023 to 2030.

Optimized resource allocation was assessed with 2021 overall HIV spending continued (100% spending optimized) as well as with 50%, 75%, 125% and 150% of available 2021 spending to assess how priorities changed for different budget envelopes (Appendix F).

Within the optimization analyses, some program constraints were applied so that no one on treatment, including ART, PMTCT, and OST, could be removed from treatment, unless by natural attrition through mortality. All other programs were constrained to not reduce expenditure by more than 50%, as requested by country partners to prevent any programs being reduced to 0% spending. This is an arbitrary assumption but reflects realistic challenges in immediate resource reallocation and considerations of benefits of HIV programs outside of directly modelled parameters.

2.6.3 95-95-95 scenarios – achieving 95% diagnosis among all PLHIV

For each country, an analysis was run to estimate the minimum and optimized budget allocation to achieve 95% of PLHIV diagnosed, or the highest possible diagnosis coverage where 95% was not possible with existing programs at up to 300% of total 2021 spending.

No countries included any defined HIV programs aimed at improving linkage, retention, and adherence to treatment, and viral suppression. Therefore, the impact of a 95-95-95 scenario 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. This means that the impact of improvements to reach the treatment and viral suppression targets are included but not the cost of programs required to achieve these second and third pillars, which would require further work to quantify.

2.7 Role of the funding source

GFATM selected the countries to include in this analysis based on preparation for the 2023 GFATM funding application round, and funded these analyses and supported the September 2022 validation workshop in Istanbul, Turkey.

2.8 Ethics

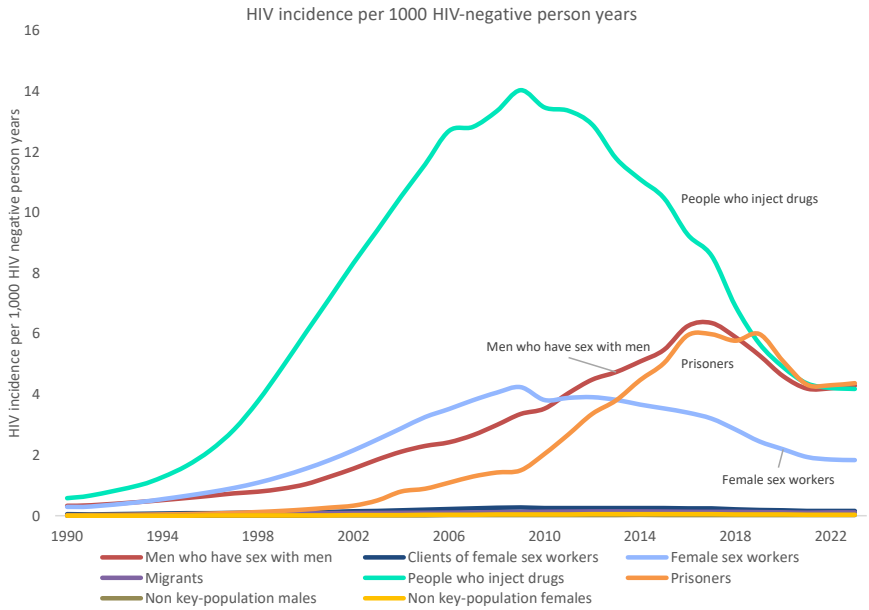
Ethical approval was not required due to no human or animal data involved.

3 Findings

3.1 Model calibrations

Across the 12 calibrated country models, in 2021 there were an estimated 197,600 PLHIV, 9,100 new HIV infections and 3,100 HIV-related deaths. Among the PLHIV in the 12 country models, 77% were diagnosed, 74% of people diagnosed were on treatment and 86% of people on treatment were virally suppressed in 2021.

The model calibrations account for time-varying key population sizes, prevalence estimates and changes in reported risk behavior. Injection was the main mode of HIV transmission from 2000 (54% of all transmission) to 2018, resulting in the high incidence among PWID (**Figure 1A and B**). New HIV infections attributable to heterosexual transmission, including casual, regular and commercial acts among key and non-key populations, were estimated to have increased since 2000 and surpassed those from injection in 2018. Estimated HIV infections transmitted through male-to-male sex are estimated to have been increasing as a proportion of total new HIV infections since 2000 and are projected to account for a continuously increasing share of new HIV infections (7% in 2000 to 24% in 2023), alongside male-female heterosexual transmission, through commercial, regular or casual sex acts among all key and general populations (19% in 2000 to 38% in 2022). The resulting HIV incidence is estimated to be an increasing trend for prisoners and MSM after an initial decline from 2018 to 2021. Vertical transmission has remained at a relatively low, stable level (2% of all incidence) and is projected to remain this way.



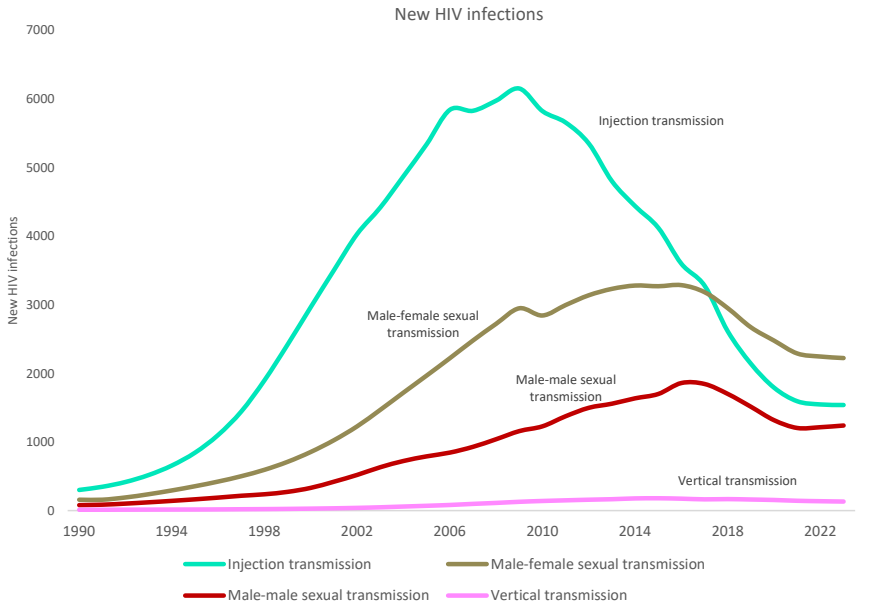


Figure 1A and 1B. HIV incidence per 1,000 HIV negative person years by population (1A) Estimated new HIV infections by mode of transmission (1B) for 11 countries* in Eastern Europe and Central Asia from 1990 to 2022

Notes: * Excludes Uzbekistan due to substantial uncertainty in transmission mechanisms for a significant proportion of new infections in Uzbekistan.

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Change:
- MTCT to "vertical transmission",
- Homosexual sex to "male-male sexual transmission" and "male-male sexual transmission among men who have sex with men"
- Heterosexual sex to "male-female sexual transmission"
- Injection to "transmission through injection"

3.2 Estimated 2021 spending

Total estimated 2021 spending from domestic and international sources was US$194·8M aggregated across the 12 participating countries, including US$119·1M in targeted HIV program spending . The majority of targeted HIV spending (51·4%) was spent on ART, ranging from 2% of the total budget in Kosovo to 85% of the total budget in Serbia. This is due to high unit expenditures for ART in Serbia (US$6,778 compared with the twelve-country median of US$375). The remainder of HIV spending for the 12 countries was allocated towards HIV testing (25·4%), key population programs for PWID (including needle and syringe exchange programs), MSM, FSW and prisoners (13·1%), opioid substitution therapy (7·1%), PMTCT (1·5%), condom programs (1·3%), and PrEP (0·1%).

3.3 Status quo scenario spending

In the status quo scenario of continued 2021 spending, projections from 2023 to 2030 estimate an increase in the annual number of new HIV infections in the absence of additional funding for ART in all included countries, except for Armenia, Georgia and both regions of Moldova. Aggregated across the 12 countries in EECA, 111,500 new HIV infections and 34,500 HIV-related deaths are estimated between 2023 and 2030, with the number of PLHIV predicted to increase by 47,800 (from 197,600 in 2021 to 245,400 in 2030). Without additional spending for ART (i.e. fixed spending on programs from 2023 to 2030), the aggregate care cascade in 2030 was estimated to be 81-60-86 (81% of people diagnosed, 60% of people diagnosed on treatment and 86% of people on treatment virally suppressed).

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If ART unit expenditures and the coverage of all other included HIV programs remained constant, spending could need to increase from US$61·2M in 2021 to US$78·5M in 2030 to maintain a constant proportion of people diagnosed on ART (**Error! Reference source not found.**). If these resources are not made available and spending on ART remains at 2021 levels, there could be an estimated 29,300 more HIV infections (+36%) across all participating countries from 2023 to 2030.

3.4 Optimized spending scenario

The optimization identified that additional impact may be possible through reallocation of existing resources, maintaining the same total expenditure. Greater investment in ART was suggested in all countries, except for Serbia, where high ART unit expenditures prevented more spending on ART (Error! Reference source not found.). Differences were observed between countries due to differing disease burden among different key populations, cost and effectiveness of programs and baseline care cascades. The second priority was dependent on which key population had the highest incidence, and key population prevention and testing programs were prioritized rather than testing services for the general population.

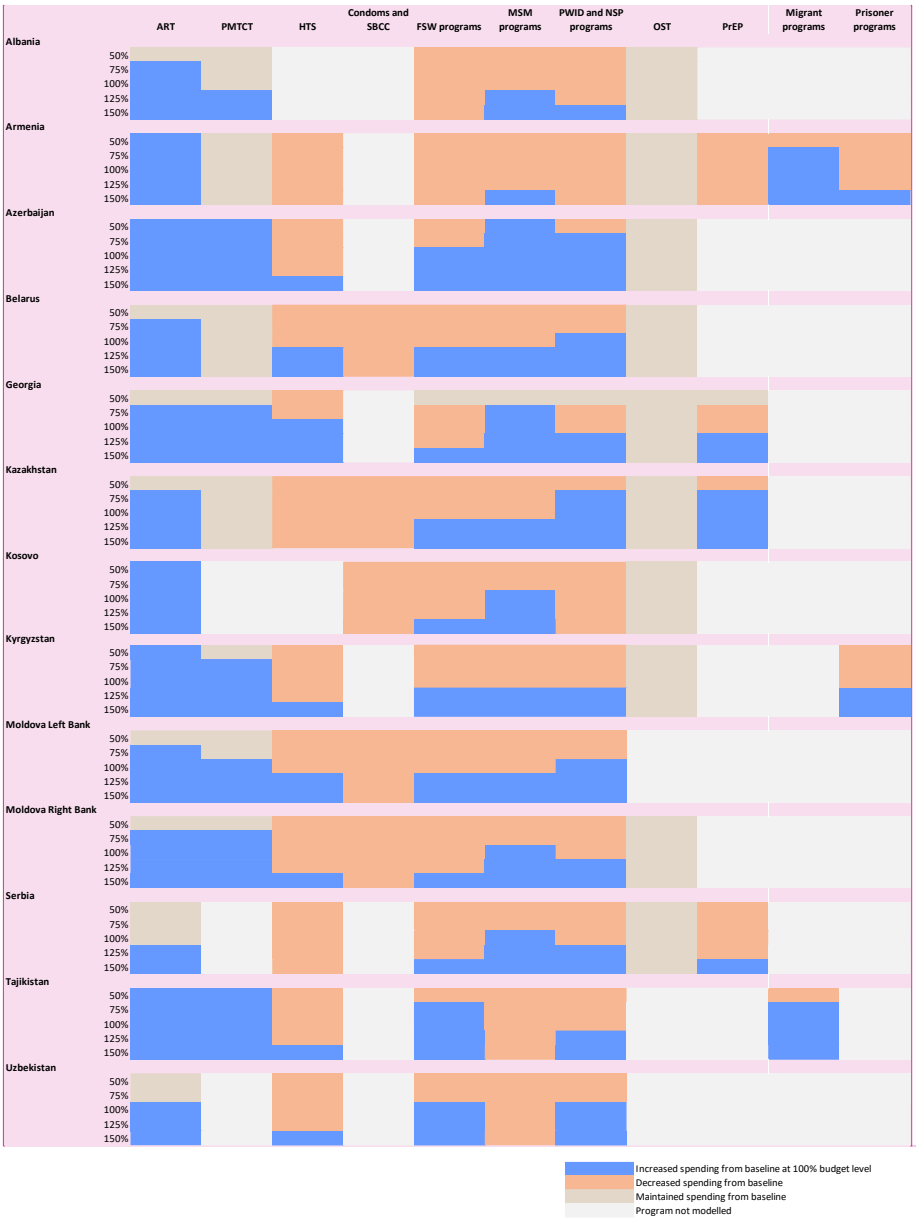

Figure 2. Recommended change in spending allocation by program for the 50%, 75%, 100%, 125%, and 150% spending optimized scenarios for 12 participating countries in the EECA region.

Notes: HIV programs for FSW, MSM, PWID, migrants and prisoners incorporate key population-focused HIV testing and prevention services, excluding PrEP.

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ART, antiretroviral therapy; FSW, female sex worker; HTS, HIV testing services for general populations; MSM, men who have sex with men; NSP, needle-syringe program; OST, opioid substitution therapy; PMTCT, prevention of mother-to-child transmission; PrEP, pre-exposure prophylaxis; PWID, people who inject drugs

When decreasing or increasing the amount currently spent on HIV, priorities changed. In all countries, at decreased budget levels it was essential to maintain all people on treatment, thereby prioritizing ART. As budgets increased, funding ART to link all PLHIV to care, followed by country-specific highest priority key population programs, after which spending for a broader set of key population programs in favour of programs for the general population was recommended. This included PrEP programs, which was prioritized as budgets increased after programs for key populations were fully funded. For each country, outcome optimizations of decreased or increased budget envelopes of 50%, 75%, 100%, 125%, and 150% of baseline budgets are outlined in Error! Reference source not found..

3.5 95-95-95 scenario

In ten of the 12 countries included in this analysis, it was estimated that achieving 95% diagnosis may not be possible with the existing set of programs and current levels of expenditure (**Table 1**); Georgia and Kazakhstan were projected to be on-track from 2023 onwards in the optimized spending scenario. Belarus, Serbia, Albania and Kyrgyzstan were estimated to reach the 95% diagnosis target by 2030 with less than a 200% increase in 2021 spending. Meeting the 95% diagnosis target may be possible under optimized spending at 300% in Azerbaijan, Kosovo, Moldova (Left Bank), Tajikistan and Uzbekistan. Optimized budget at 300% spending was projected to be insufficient to reach the 95% diagnosis target in Armenia and Moldova (Right Bank) by 2030.

Table 1. Estimated ability and resource needs to achieve 95% diagnosed with current programs for 12 countries included in this analysis.

Country	Achieving 95% diagnosed by 2030?	Optimized budget level
Albania	Yes	163%
Armenia	No (<90%)	300%
Azerbaijan	Within reach (94%)	300%
Belarus	Yes	132%
Georgia	Yes	101%
Kazakhstan	Yes	104%
Kosovo	Within reach (91%)	300%
Kyrgyzstan	Yes	187%
Moldova (Left Bank)	Yes	300%
Moldova (Right Bank)	No (<90%)	300%
Serbia	Yes	135%
Tajikistan	Within reach (92%)	300%
Uzbekistan	Within reach (92%)	300%

Note: Over 90% is considered to be within reach

In the aggregated model across the 12 countries, to achieve 95% diagnosed, or nearest possible proportion diagnosed with existing programs, required a 163% increase in 2021 spending (an additional US$74·9 million per annum) from 2023 to 2030, with most additional spending for testing and ART.

Compared with the status quo scenario, optimized allocation of funding is estimated to avert an additional cumulative 35,900 (32%) of new HIV infections and 9,200 (27%) of HIV-related deaths over the 2023 to 2030 period for all 12 countries (**Error! Reference source not found.**), and improve the aggregate 2030 care cascade to from 81-60-86 in 2030 to 86-80-86. This ranges from minimal improvement in new HIV infections (+1 percentage points) in Serbia to +37 percentage points in Kazakhstan. Minimal improvement in Serbia is due to the aforementioned high unit expenditure for ART, resulting in high spending allocation to treatment with a limited increase in the number of additional people on ART, and no further spending available for reallocation to other programs.

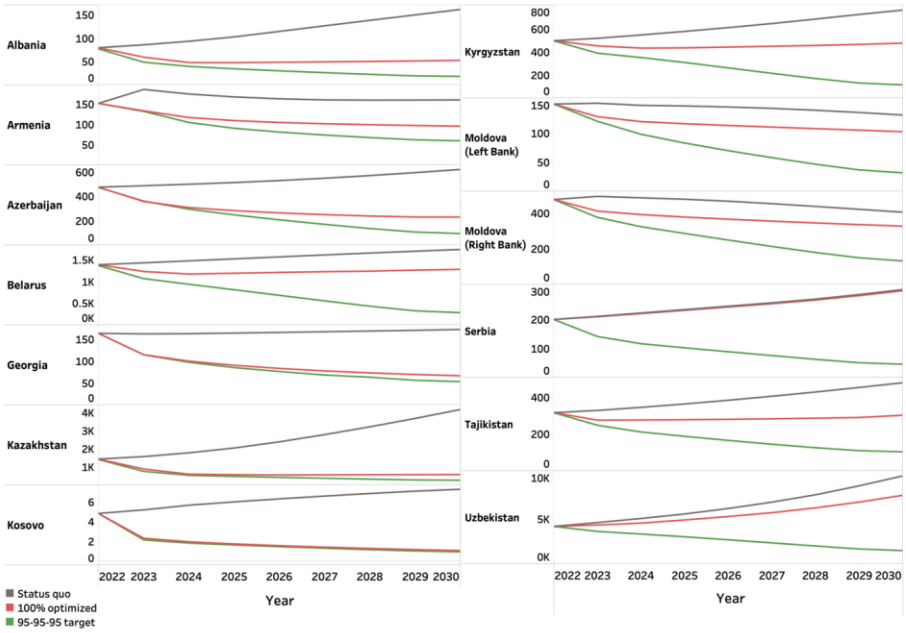

Figure 3. Estimated new HIV infections from 2023 to 2030 by country for three scenarios: status quo 2021 spending remains fixed, 100% of the latest report spending is optimized, and reaching X-95-95 targets by 2030 in 12 countries in the EECA region.

This scenario assumes linkage to care and treatment adherence could improve such that 95% of diagnosed PLHIV are on treatment and 95% viral suppression of PLHIV on treatment targets are simultaneously achieved by 2030. Compared with the status quo, this was estimated to avert a cumulative 71,000 (64%) new HIV infections and 18,800 (54%) HIV-related deaths between 2023 and 2030 (**Table 2**).

Table 2. Estimated public health impact of status quo, optimization, and achieving 95 targets on cumulative new HIV infections and HIV-related deaths from 2023 to 2030.

	New HIV infections 2023-2030			HIV-related deaths 2023-2030		
Country	Status quo	Optimization	95-95-95	Status quo	Optimization	95-95-95
Albania	1,000	400	200	300	100	100
Armenia	1,300	900	700	1,200	800	600

Azerbaijan	4,400	2,200	1,600	2,700	1,700	1,300
Belarus	12,700	9,800	5,100	5,300	4,900	2,700
Georgia	1,300	700	800	600	300	400
Kazakhstan	21,600	4,800	5,900	3,800	1,400	1,200
Kosovo	100	<20	<20	<40	<10	<10
Kyrgyzstan	5,100	3,600	1,900	2,400	1,700	1,000
Moldova (Left Bank)	1,100	900	500	700	500	300
Moldova (Right Bank)	3,600	2,900	1,900	2,800	2,100	1,600
Serbia	2,000	2,000	700	300	300	100
Tajikistan	3,200	2,300	1,300	2,000	1,600	1,100
Uzbekistan	54,100	45,200	19,900	12,400	10,000	5,100
Total	111,500	75,600	40,500	34,500	25,400	15,700

Note: 95-95-95 scenario assumes that the proportion of diagnosed people, diagnosed people on treatment and the proportion of people on treatment with viral suppression would linearly increase to reach 95% by 2030.

4 Discussion

This study examines HIV epidemiology in 12 Eastern European and Central Asian countries, aiming to optimizing resource allocation within HIV programs. While there have been strides in scaling up antiretroviral therapy (ART) and implementing harm reduction strategies for people who inject drugs (PWID), ten out of 12 countries are projected to not meet the 95-95-95 targets. Concerningly, incidence among men who have sex with men (MSM) are on the rise. Optimizing resource allocation prioritizes ART and key population programs, in lieu of testing programs for the general population, for greater impact in reducing HIV infections and deaths for the same spending.

Not all countries were able to achieve 95% diagnosis by 2030 with current spending levels and existing programs. This was due to multiple factors, including limited reach of current testing programs (as advised and validated by country teams), and undiagnosed infections among people with no reported risk factors. Country experts in some settings hypothesized that HIV transmission was occurring through same-sex partnerships among males who do not identify as gay, bisexual or other MSM. This emphasizes the challenges in providing prevention and testing services for at-risk populations, in addition to complex social and structural barriers, supporting the findings that achieving the 95% diagnosis rate is unlikely.

The model calibrations to epidemiological trends over time show that injection-related infections among PWID have stabilized in the region, and there seems to be a shift towards growing incidence among MSM. In Armenia, Georgia and Moldova (Left and Right Bank), new HIV infections are even decreasing in the status quo scenario, potentially attributable to decreased needle-sharing, increased opiate substitution coverage, and increased condom use among key populations. Between 2000 and 2010, most new infections were injection-related[6,23], but the scale-up of needle and syringe programs and opioid substitution therapy alongside changes in drug use patterns[24] may have led to reductions in annual injection-acquired infections since 2010, against a backdrop of slowly increasing infections from sexual transmission. From 2010 to 2021, data from the European Centre for Disease Control (ECDC) and WHO HIV surveillance revealed a shift in transmission trends: male-to-male sex transmission increased from 0·7% to 3·1%, while transmission through injecting drug use decreased from 43% to 28%.[25]. It is important to note that there are still a large number of people at risk of HIV, including PWID, not being reached by accessible, available, and sustainably financed harm reduction and HIV services.[26-28] This is impeded through structural barriers that persist through stigma, discrimination, and criminalization of male-to-male sex, drug use and sex work.[8,9]

Optimizing spending to reduce new HIV infections and deaths mostly prioritizes ART over spending on key population programs, particularly for countries where there are PLHIV diagnosed but not on treatment. This is in line with recent evidence identifying the impact of treatment-as-prevention, indicating zero transmission risk for people who are on treatment and virally suppressed.[29] Lower prices for antiretroviral drugs through generic alternatives will be necessary to ensure access and affordability to all people living with HIV. Nevertheless, gaps in treatment coverage and viral suppression, however, may not be fixed by simply allocating more funding to ART, and new or expanded programs that understand reasons for lack of retention and adherence may be required. Barriers may include stigma, concerns about adverse effects, prevalence of substance use, or out-of-pocket costs[30]. While further work is needed to assess the costs and impacts of retention programs, our findings from the 95-95-95 scenario, where we assumed (without specifying how) that the treatment and viral suppression targets were met, indicate that reaching the 95-95-95 targets has the potential for major reductions in HIV infections and deaths.

In this analysis, it was assumed that those lost to follow-up remained constant, as there was no data regarding adherence programs. At the same time, all those not lost to follow-up were assumed to be able to be treated. Therefore, additional strategic information may be needed to understand the extent to which ART can be scaled up in practice. For example, anecdotal data from our country partners suggests there are instances where people have been diagnosed and then migrated outside of the HIV care area, but are still counted in overall care cascade or not registered at all. Data from Eastern Europe reflects this, where migrants have been reported as the second most hard-to-reach population after PWID,[27] which may be further complicated by the ongoing conflict in Ukraine.

There were several key limitations to this analysis. First, there is uncertainty related to population size estimates, exacerbated by increased migration due to labor and conflict and unidentified key populations. Many epidemiological indicators for key populations come from surveys or data that have varying degrees of biases. Second, there were no data to inform any programs related to viral suppression, such as ART adherence and viral load monitoring, meaning that the 95-95-95 scenarios could not cost the additional requirements to improve the care cascade. Third, due to ongoing conflict, this analysis did not include Ukraine or Russia, therefore results are not generalizable to the entire region. Fourth, this analysis did not consider subnational spending, geographical heterogeneity or equity concerns of deprioritizing programs that may have benefits outside of their impact on HIV. Fifth, this analysis is limited to targeted HIV programs with a direct and quantifiable impact on modelled HIV parameters and available program cost and coverage data, and does not consider impacts outside of these. The programs considered in each country were selected by country teams to accurately reflect current and future HIV interventions informed by national priorities and available data, which limits the generalizability of these findings to the region. It could be of additional value to assess the impact of programs such as PrEP in all settings in future analyses. . Sixth, 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. Finally, these results could be influenced by model misspecification bias.

5 Conclusions

For twelve countries in the EECA region, the shift towards increased transmission among MSM underscores the need for targeted interventions tailored to the evolving epidemiological landscape. Achieving 95% diagnosis targets may not be possible if key populations are not reachable due to social or structural barriers. Increasing coverage of ART and targeted key population programs should remain high priorities, with country-specific programs prioritized based on local population dynamics and epidemiology. Additional work is required to identify undiagnosed cases and to determine strategies to improve linkage and retention to care.

Data sharing

Reports and selected data for underlying country models are published and openly available in the through the Optima website (http://optimamodel.com/). Optima HIV is an open-source model available from https://github.com/optimamodel/optima

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Research in context

Evidence before this study

We searched PubMed from 1 Jan 2000 to 1 June 2023 with search terms HIV AND (fund* OR optim* OR resource*) AND (model* OR “math* model*) AND (“East* Europe” OR “Central Asia” OR Albania OR Armenia OR Azerbaijan OR Belarus OR Georgia OR Kazakhstan OR Kosovo OR Kyrgyzstan OR Moldova OR Serbia OR Tajikistan OR Uzbekistan OR Ukraine OR Russia). Though Ukraine and Russia were not included in this analysis, considering a significant proportion of people living with HIV reside in both countries, any findings from these countries could provide insights for the region.

Modes of transmission have been assessed through cross-sectional survey data and through large studies such as the Global Burden of Disease study, using the UNAIDS Spectrum model. The UNAIDS Modes of Transmission tool exists to estimate major modes of transmission in all contexts, and has been published in Armenia and Moldova in 2011 , and we are aware it may be used by other countries but not published. We found several epidemiological modelling studies looking into HIV transmission in the region, though not in the countries included in this analysis. In Estonia and Latvia, reported incidence is decreasing in Estonia, while HIV incidence persists in Latvia . In Russia, Nikoloski et al found the HIV epidemic is evolving to a generalized epidemic, with more infections occurring among the general population .

Cost-effectiveness studies in the region are inclined to focus on one HIV program or key population. Trickey et al estimated that Ukraine’s non-governmental programs for men who have sex with men are highly cost-effective, at an incremental cost-effectiveness ratio of US$600.15 per DALY averted . Similarly, the same authors estimated the importance of NGO’s in Ukraine for people who inject drugs, noting the disappearance of these programs could increase HIV incidence by 52% .

We are aware that outside of the literature, countries in the region use the UNAIDS Spectrum suite of modelling tools to project their HIV epidemics, however this tool does not account for behavioral change (such as condom use or changes in injecting practices). The Goals model exists to assess cost-effectiveness of HIV programs, but there is no publication of such an analysis in the region.

Added value of this study

This is the most recent allocative efficiency modelling study that includes 12 countries in the Eastern European and Central Asian region. It includes all known key populations that are significant in the local context, as well as injecting and sexual behaviors that may reflect populations not identifying as key populations, and has been validated by country teams. Our optimization includes a comprehensive package of all HIV programs currently included in the HIV response in the 12 countries. Our findings estimate that new HIV infections may be increasingly occurring among men who have sex with men, as well as among men who have who have sex with men and women. Our optimization recommends increased spending for ART, as other studies have identified, however it also emphasizes the importance of prioritizing programs for key populations to identify the high proportion of undiagnosed people living with HIV.

Implications of all the available evidence

Our findings provide evidence for national, regional and global stakeholders to target their resources for the HIV epidemic in the Eastern European and Central Asian region towards finding unidentified (key) populations, increasing investment for ART and key population programs, addressing linkage and retention to care issues, and supporting viral load monitoring. Subsequently, it provides incentive to include migrants in strategic planning in the region.