Optimizing Investments in Bulgaria's HIV Response

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ACKNOWLEDGMENTS

The HIV Allocative Efficiency Program, of which this study is part, is managed by the World Bank and supported by the Global Fund, UNAIDS and UNDP. The Steering Committee of the program comprising Feng Zhao (Chair and World Bank Task Team Leader), Emiko Masaki (World Bank), Shufang Zhang (Global Fund), Manoela Manova (UNAIDS), and Christoph Hamelmann (UNDP)—provided overall guidance to the country studies. The four agencies also co-sponsored the various study activities.

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The Optima model applied in this study was developed by the University of New South Wales and the World Bank. Data collection for Bulgaria was carried out by UCL and national stakeholders, and facilitated by UNAIDS and the World Bank. Michael Borowitz (The Global Fund), David Wilson (World Bank), Christoph Hamelmann (UNDP), Jean-Elie Malkin and Vinay P. Saldanha (UNAIDS) conceptualized this regional initiative on HIV Allocative Efficiency.

The study team, would like to thank all stakeholders and colleagues who provided insight and support.

This report is subject to final peer review, editorial review and layout changes.

ABBREVIATIONS

AE	Allocative Efficiency
AIDS	Acquired immune deficiency syndrome
ART	Antiretroviral therapy
BOD	Burden of disease
Care	HIV Care
Case Mgt	Case Management
CCOCs	Cost-Coverage Outcome Curves
Clients	Clients of sex workers
Condom PD	Condom Promotion and Distribution
DALY	Disability-adjusted life year
ECA	Europe and Central Asia
ENV	Enabling Environment
Females 15-49	Females 15–49 years old, excluding the other population groups in this age group
Females 50+	Females 50 years and older, excluding the other population groups in this age group
FSW	Female Sex Workers
GDP	Gross domestic product
Global Fund	The Global Fund to Fight AIDs, Tuberculosis and Malaria
HIV	Human Immunodeficiency Virus
HTS	HIV Testing Services
IBBSS	Integrated bio-behavioral surveillance survey
IDU	Injecting drug use
Males 15-49	Male 15–49 years old excluding the other population groups in this age group
Males 50+	Males 50 years and older excluding the other population groups in this age group
MGMT	Management
MSM	Men who have Sex with Men
M&E	Monitoring and Evaluation
NHA	National health accounts
NSP	Needle and syringe exchange program
OST	Opiate Substitution Therapy
PLHIV	People Living with HIV
PMTCT	Prevention of Mother-to-child Transmission
PWID	People Who Inject Drugs
SBCC	Social Behavior Communication Change
THE	Total Health Expenditure
YLL	Years of life lost

EXECUTIVE SUMMARY

Bulgaria has a concentrated but growing HIV epidemic, in which HIV prevalence increased among all population groups over the past decade. This increasing trend in HIV prevalence is particularly marked among men who have sex with men (MSM). For men and women who inject drugs, assuming stable behaviors and program coverage, HIV prevalence is expected to remain above 8% and 5% respectively,

Under current conditions of the HIV response, the epidemic is expected to stabilize among female sex workers (FSWs). HIV prevalence among people who inject drugs (PWID) and clients of FSWs may increase, but at a slower rate than in the past. Optima analyses suggest that there is a need to increase investment in programs for people who inject drugs (PWID) at higher levels than the current spending, including needle-syringe programs (NSP) and opiate substitution therapy (OST).

Men who have sex with men (MSM) account for the largest proportion of new infections but prevention programs targeted specifically at MSM currently only account for about 1.7% of HIV spending. Increasing resources to and coverage of MSM programs could be particularly beneficial given the high number of new infections in this key affected population.

The HIV epidemic among PWID is relatively stable in Bulgaria due to significant and prolonged efforts to reach this population. The key PWID and MSM populations should, however, be reached as far as possible with strong preventive efforts complemented by a comprehensive HIV testing and treatment program.

The HIV epidemic in the general populations is expected to grow, largely due to the increasing HIV prevalence among MSM and existing HIV prevalence among PWID, which will imply continued HIV transmission to female sexual partners of MSM and PWID. Prevention and treatment for MSM and PWID are expected to be the most cost-effective approaches to minimize these downstream effects on female sexual partners.

Testing of key populations and their sexual partners is the most cost-effective strategy to identify those requiring antiretroviral therapy (ART). Widespread HIV testing and counselling for the general population was not part of the optimized mix of interventions due to the high cost of testing and counselling in a population currently experiencing low HIV prevalence. However, testing of pregnant females should be retained in the context of maternal health services.

Effective ART scale-up is needed, with a strong focus on HIV diagnosis in key populations. Bulgaria has expanded ART coverage over the past years and expects further improvements in coverage. According to Optima analyses, ART will remain an essential component of the HIV response but will not be sufficient to halt the epidemic on its own. Coverage must be increased if global targets are to be met: In 2014, 23% of Bulgaria's model-estimated 3,100 people living with HIV (PLHIV) received treatment, compared with a global target of 81% by 2020. Achieving global targets would cost approximately US$36 million in 2020 for treatment alone (at 2014 unit costs, in real terms).

Over and above funds for ART scale up, continued funding for HIV prevention programs for key populations remains critical beyond 2015. These programs are currently supported by the Global Fund and implemented by Non-Governmental Organizations (NGOs). Without these programs, an additional 1,150 new infections (19%) would occur by 2030, leading to additional treatment and health costs of approximately US$60 million. It is essential to plan for transition of these programs for key populations to other funding sources. This will require establishing budgets, procurement and institutional mechanisms for continued domestic financing and management of prevention programs. The Government will need to maintain and reinforce investment in community systems that enable needs-based, cost-effective and integrated prevention and health care programs for HIV-negative and HIV-positive key populations.

Opportunities exist to further optimize investment in the Bulgarian HIV response. The allocative efficiency of Bulgaria's current programs could be further improved by increasing investments in MSM and PWID programs. If the current annual budget of around 14.8 million USD were allocated more optimally among key populations and interventions, an additional 1108 (21%) new infections (mainly among PWID and MSM) and 197 (7%) additional deaths could be averted between 2016 and 2030.

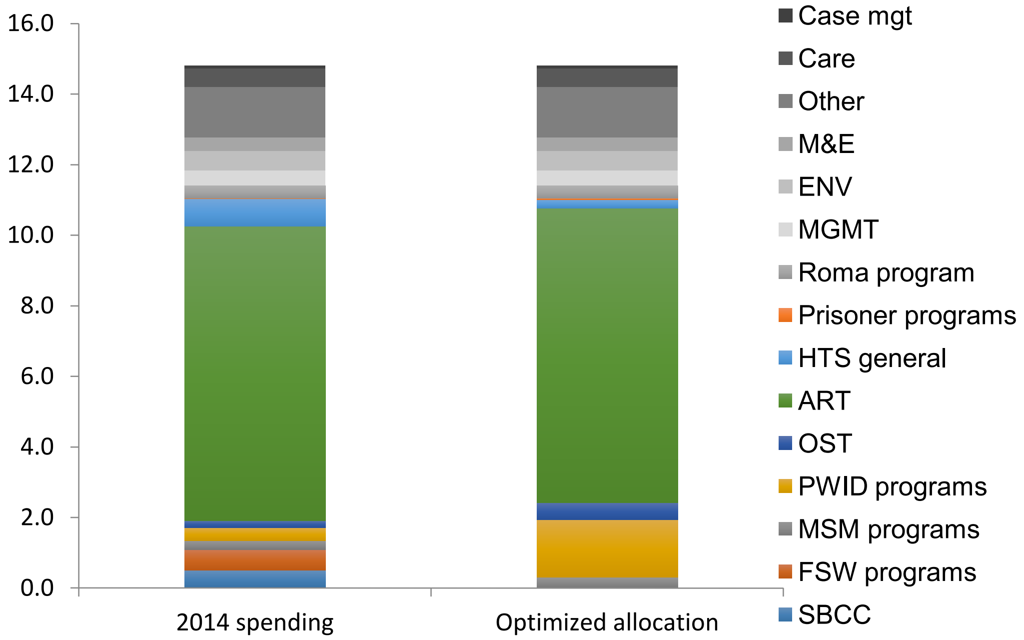
Improvements in technical efficiency may provide additional gains. Although this study did not include detailed analyses of technical efficiency and unit costs, the total cost per person reached within Bulgaria's programs suggests there could be an opportunity for technical efficiency gains. Further technical efficiency analysis is therefore recommended, particularly for ART, as the unit costs are significantly higher than other countries in the region at approximately US$11000 per person per year. ART currently absorbs a very large proportion (56%) of the overall HIV funding (56%) and 85% of the domestic contribution to the HIV response.

The health and economic burden of HIV in Bulgaria is growing. If the current combination of HIV programs continue within the remit of the current budget, without improvements in allocative or technical efficiency, HIV incidence is expected to increase at a faster pace. The care and treatment of people living with HIV in Bulgaria will therefore lead to a substantial and increasing burden of disease, with all associated direct and indirect financial costs. The optimal resource allocation can reduce the number of new infections but will not stop the increase in HIV incidence.

In the long term, the model predicts that HIV resource needs will increase with rising incidence and prevalence. However, the analysis estimates that optimizing current allocations by increasing spending on key populations and sustaining investment in ART provision, could save approximately $2.2 million annually compared with the current, non-optimized allocation. The results also show that annual spending commitments for new infections under the optimized allocation of current spending, will be around 26% lower between 2016 and 2030 than under the current allocation.

There is an urgent need to shift additional domestic resources towards HIV. Bulgaria was already financing 67% of its HIV/AIDS response in 2014 with domestic funding. However, there is an urgent need to fill resource gaps in the overall HIV budget envelope with increased domestic financing. Current annual spending will not, according to this analysis, be sufficient to realise the proposed National Strategic Plan and international targets. The budget will need to be increased to achieve these targets and the increase will need to be larger if technical and allocative efficiency gains are not made. Bulgaria's HIV response requires a shared, long-term vision for sustainable HIV financing that harnesses wider health sector reforms and emerging financing models.

Figure ES 1 Comparison of the allocation of 2014 spending against its optimized allocation.



Source: Authors

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1. BACKGROUND: WHY ALLOCATIVE EFFICIENCY ANALYSIS NOW?

1.1 Bulgaria's health and health financing context

1.1.1. Burden of disease

Non-communicable diseases (NCDs) are the leading cause of burden of disease in Bulgaria.[1] Among 15-49 year olds, the age group most affected by HIV, NCDs make up 80% of DALYs, followed by injuries (14%), maternal, neonatal and nutritional diseases (3%) and communicable diseases (3%). HIV accounts for 4,068 DALYs, tuberculosis accounts for 1,365 DALYs and Hepatitis (A,B and C) accounts for 399 DALYs[2].

1.1.2. Health care financing

Following the Health Insurance Act of 1998, the Bulgarian health system restructured into a health insurance based system, with compulsory social and voluntary private health insurance. Both health insurance systems cover treatment, diagnostic procedures and medication for insured individuals, while the Ministry of Health funds public health services and services such as emergency care, tuberculosis treatment and inpatient mental health care[3]. Healthcare financing in Bulgaria is thus a mixed public–private system. The main sources of financing are the compulsory social health insurance (SHI) contributions, taxes and out of pocket payments (OOP) payments.

Bulgaria's total health expenditure as a percentage of GDP was approximately 8% in 2013 (Table 1.1), comparable with the average for the WHO European region (Figure 1.1). As the country's GDP has grown, so too has per capita health expenditure, from $97 in 2000 to $555 in 2013 (Table 1.1), although, it remains far below the WHO European region average[4]. Bulgaria's public expenditure on health as a share of total health expenditure has gradually decreased since 2005, while at the same time private expenditure on health has gradually increased (Table 1.1).

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1 http://www.healthdata.org/bulgaria

2 Source: University of Washington, Institute for Health Metrics and Evaluation (2013): 2013 Global Burden of Disease, Injuries and Risk Factors Study. Data Visualizations. http://vizhub.healthdata.org/gbd-compare/patterns

3 Dimova A, Rohova M, Moutafova E, Atanasova E, Koeva S, Panteli D., van Ginneken E. Bulgaria: Health system review. Health Systems in Transition, 2012, 14(3):1–186.

4 Source: WHO National Health Accounts Database (http://apps.who.int/nha/database/Select/Indicators/en)

Table 1.1 Trends in health expenditure in Bulgaria, 2000–13[5]

Indicator	2000	2005	2010	2011	2012	2013
GDP (*current prices, US$, millions*)	12,904	28,895	47,727	53,544	51,305	53,011
Total health expenditure (*US$, millions*)	798	2,111	3,618	3,937	3,807	4,043
Total health expenditure (*US$ per capita*)	97	272	488	534	520	555
Total health expenditure as % of GDP	6	7	8	7	7	8
Government health expenditure as % of total health expenditure	61	61	56	55	56	59
Private health expenditure as % of total health expenditure	39	39	44	45	44	41
Government health expenditure as % of total government expenditure	9	12	11	11	12	12
External resources for health as % of total health expenditure	2	–	–	–	–	–
Social security expenditure on health as % of government health expenditure	12	54	68	68	76	76
Private Insurance as % of Private Health Expenditure	0	1	1	1	1	1
Out-of-pocket health expenditure as % of private health expenditure	100	97	97	97	97	97
Out-of-pocket health expenditure as % of total health expenditure	39	38	43	44	43	40

Source: Authors.

1.2 The HIV epidemic is growing in Bulgaria

Despite relatively low overall HIV prevalence, the HIV epidemic remains a significant public health concern in Bulgaria. Between the detection of the first PLHIV in 1986 and the end of 2014, 2,043 people were diagnosed with HIV in Bulgaria[6]. The HIV epidemic is largely concentrated among key affected populations including people who inject drugs (PWID), female sex workers (FSW), men who have sex with men (MSM), young Roma and prisoners.

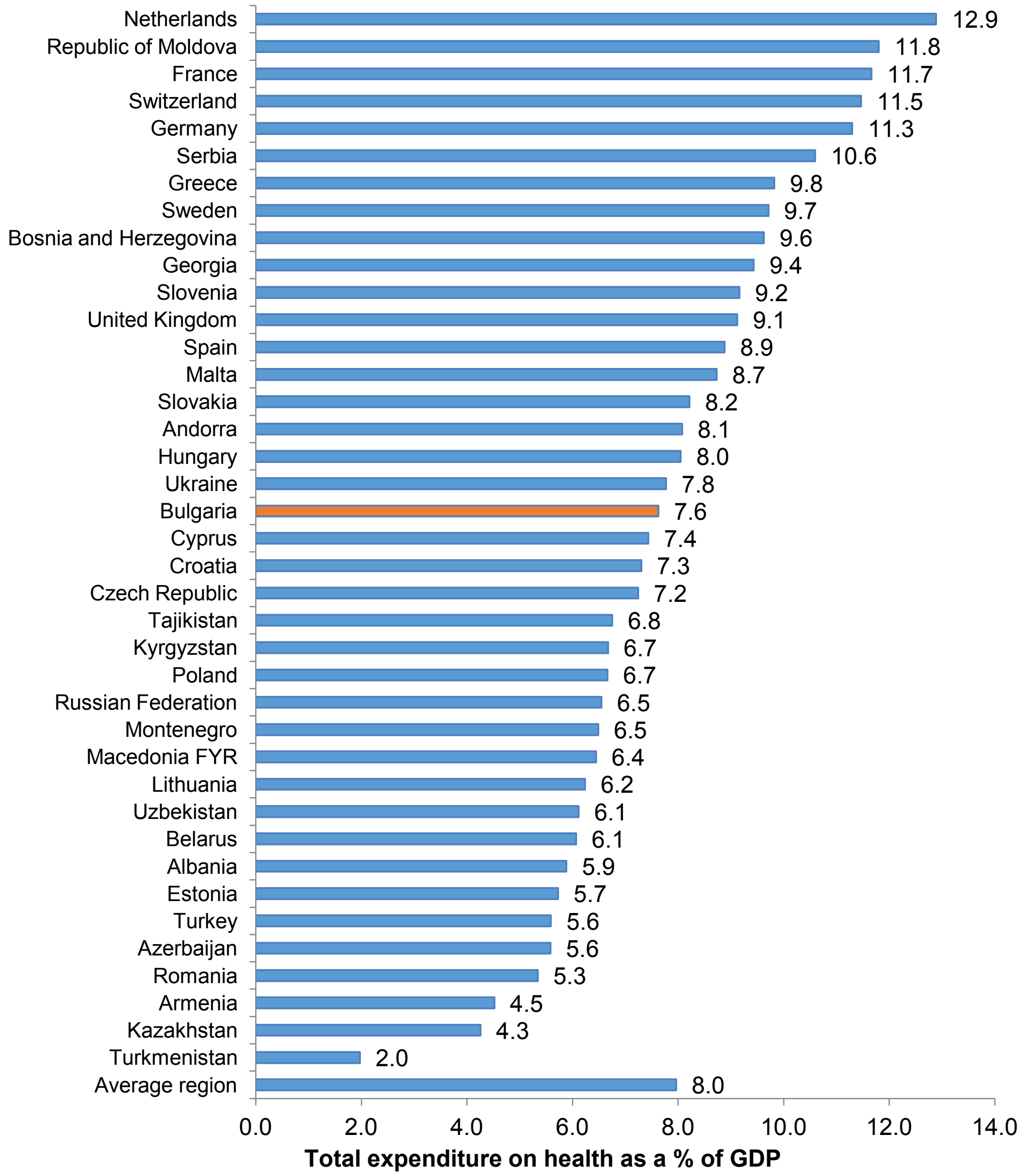
There has been an increase in new diagnoses of PLHIV over the past 14 years, with 213 registered new diagnoses in 2014. Of these, 44% were among MSM and 11% were among PWID. In 2014, the Optima model estimates that there were 3,111 PLHIV, of which MSM and PWID made up an estimated 80%. At the end of 2014, 741 people living with HIV were on ART[7]. This is approximately 71% of the diagnosed PLHIV, but only 23% of the model-estimated number of PLHIV.

[5] Source: WHO National Health Accounts Database (http://apps.who.int/nha/database/Select/Indicators/en)

[6] HIV register data

[7] HIV register data.

Figure 1.1 Total expenditure on health as a percentage of GDP in the WHO European Region (selected countries), 2013, WHO estimates



Source: Authors.

1.3 Financing the HIV response in Bulgaria

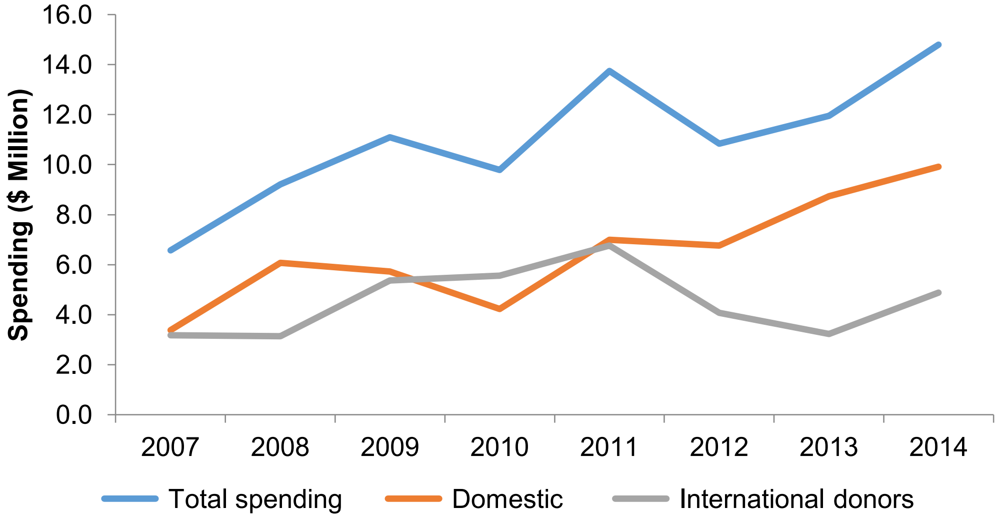
1.3.1. Domestic HIV funding has increased significantly

Total HIV spending in Bulgaria has increased by nearly 150% between 2007-2014 (Figure 1.2, Figure 1.3). Much of this increase is due to substantial growth in domestic funding from public sources (Figure 1.2). In fact, since 2007, domestic funding has tripled while international funding increased by around 70% (Figure 1.2, Figure 1.3). The Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund) has been the country's key international donor, contributing virtually 100% of all donor funds in 2014.

In 2014, total funding for Bulgaria's HIV response was US$14.8 million, of which 67% was financed from domestic resources and the remainder funded by the Global Fund. In this context, domestic funding on HIV includes only spending by the public institutions including national and sub-national organizations, social security funds and spending by the Development Bank of Bulgaria. Domestic spending does not include spending from charitable institutions, non-governmental organizations or household (out-of-pocket) spending. As these organizations may fund some aspects of the HIV response in Bulgaria, domestic spending is likely to be underestimated in this context.

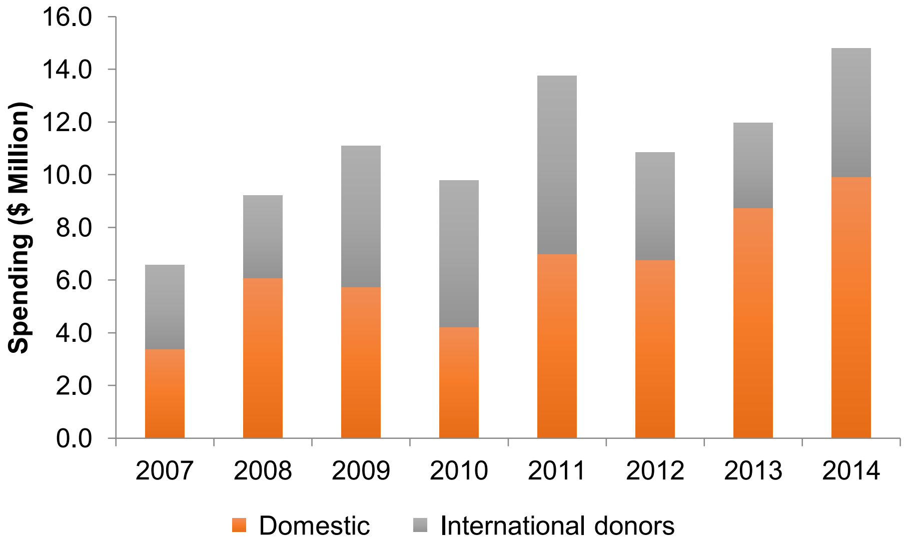
Although domestic public funding is the main source of HIV spending and has grown substantially since 2007, Global Fund support - together with 33% of the budget in 2014—expired at the end of 2015. Notably, the Global Fund funding supported programs targeted specifically at non-ART key population prevention programs, whilst domestic funding did not. Bulgaria's HIV response therefore requires urgent transition planning.

Figure 1.2 Overall spending on HIV/AIDS in Bulgaria[8]



Source: Authors.

Figure 1.3 Funding for HIV in Bulgaria, by funding source[9]



Source: Authors.

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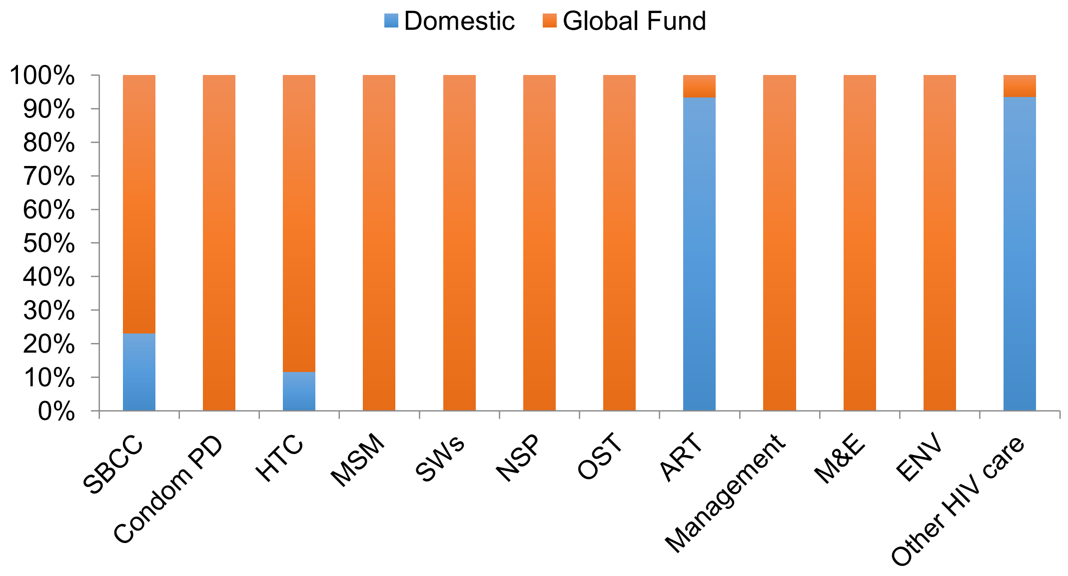
8 Source: National HIV/AIDS Spending report 2012-2014. HIV spending figures for 2007-2011 was received from the country team.

9 Source: National HIV/AIDS Spending report 2012-2014. HIV spending figures for 2007-2011 was received from the country team.

Funding for Bulgaria's HIV response, including the component funded by the Global Fund, is further explained in Figure 1.4 below. The programs currently funded by the Global Fund are of particular significance given the phasing out of financial support from the Global Fund.

Figure 1.4 HIV spending in Bulgaria, by type of spending and funding, 2014[10]



Source: Authors.

1.4 A need for allocative efficiency

Current HIV programs are faced with the need to scale up prevention, while providing on-going treatment to a larger number of people living with HIV than ever before. In an environment of increasingly limited resources for HIV epidemic responses, focused design and efficiency in program delivery are essential to ensure that programs can do more with less.

A shift towards investment thinking in the design of HIV responses is being promoted by UNAIDS and co-sponsors globally, in order to maximize the impact of program investment and best realize the long-term health and economic benefits of HIV programs. Investment cases are currently being developed by a number of countries to understand HIV epidemics as well as to design, deliver and sustain effective HIV responses. In support of HIV investment cases, a group of countries in the ECA region are in the process of conducting allocative efficiency analyses. In 2014, allocative efficiency analyses were carried out in Armenia, Belarus, Kazakhstan, Kyrgyzstan, Moldova, Georgia, Macedonia, Tajikistan[11], Uzbekistan[12] and Ukraine[13]. This report summarizes the results of a similar allocative efficiency analysis for Bulgaria.

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10 Source: National HIV/AIDS Spending report 2014

11 Republic of Tajikistan (2014). Modelling an optimized investment approach for Tajikistan: Sustainable financing of national HIV responses. Authors: Hamelmann C., Duric P., Kerr C., Wilson D.P., Dushanbe, Ministry of Health. http://www.eurasia.undp.org/content/dam/rbec/docs/UNDP%20Modelling%20Tajikistan_English.pdf

12 Republic of Uzbekistan (2015) Modelling an Optimised Investment Approach for Uzbekistan: Sustainable Financing of National HIB Responses. Lead authors: Duric, P., Hamelmann, C., Wilson, D., Kerr, C. http://optimamodel.com/pubs/uzbekistan-report.pdf

13 This study is part of the Eastern Europe, Caucasus and Central Asia round of country studies. Aspects of the analytical process and the presentation of findings have been based on the Optima analyses and accompanying reports for other countries in the region. Findings have been based on the Optima analyses and accompanying reports for other countries in the region.

This report also provides critical insight into the progress toward achieving key international commitments, and the gaps that remain. In the 2011 UN Political Declaration countries agreed to reduce sexual and injection-related transmission by 50%, virtually eliminate mother-to-child-transmission, initiate 80% of eligible PLHIV on treatment as well as end HIV-related discrimination by 2015.[14] The 2014 Gap Report[15] illustrated that substantial additional efforts will be required in most countries to achieve these targets. Against this background, UNAIDS globally defined a Fast-Track[16] strategy in order to achieve the goal of *Ending AIDS by 2030.* This includes new initiatives such as the 90-90-90 targets.[17] These set out to ensure that 90% of all PLHIV are diagnosed, 90% of diagnosed PLHIV are on ART and 90% of PLHIV on ART are virally suppressed. The Fast-Track approach also emphasizes the need to focus on the geographical areas and communities most affected by HIV and recommends that resources be concentrated on programs with the greatest impact.

In the context of this report, the investment case is complemented with a human rights-based approach to health care. Bulgaria is one of the countries In ECA to have signed up to the 2004 'Dublin Declaration of Partnership to fight HIV/AIDS in Europe and Central Asia'[18]. This is to be achieved through a range of methods including; improved accessibility and quality of essential services including opioid substitution treatment, optimized treatment regimens, strengthened surveillance and monitoring, removal of legislative and regulatory obstacles to effective service delivery, protection of human rights, and implementation of stigma reduction as these are significant barriers to effective diagnosis and care in Bulgaria's context. This is explained more fully later in the report but in short, key programs are protected within the optimized design to ensure that for example, people on treatment do not lose access to that treatment.

1.4.1. Allocative efficiency in HIV

The concept of allocative efficiency in health refers to the maximization of health outcomes, with the least costly mix of health interventions - within a defined budget envelope. HIV allocative efficiency studies generally try to answer the question "*How can* a given *HIV funding amount be optimally allocated to the combination of HIV response interventions that will yield the highest impact?*"

There is wide consensus that better outcomes could be achieved in many settings with a given amount of HIV funding, or that given outcomes could be achieved with less funding, if resources are distributed optimally or used in the most efficient ways. Mathematical modelling is one way to determine optimized HIV resource allocation within defined budget envelopes. The HIV allocative efficiency (AE) analysis in this study was carried out using the Optimization & Analysis Tool (Optima). The results can be utilized to better serve the needs of decision-makers and health planners.

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[14] United Nations General Assembly (2011) Resolution adopted by the General Assembly 65/277. Political Declaration on HIV and AIDS: Intensifying Our Efforts to Eliminate HIV and AIDS. New York.

[15] UNAIDS (2014). The Gap Report. Geneva.

[16] UNAIDS (2014). Fast-track. Ending the AIDS epidemic by 2030. Geneva.

[17] UNAIDS (2014). 90-90-90 An ambitious treatment target to help end the AIDS epidemic. Geneva.

[18] Dublin Declaration on Partnership to fight HIV/AIDS in Europe and Central Asia. Breaking the Barriers – Partnership to fight HIV/AIDS in Europe and Central Asia conference; 2004, Feb 23-24; Dublin, Ireland.

2. HOW WILL THIS REPORT ANSWER KEY QUESTIONS?

This report summarizes how Bulgaria may be able to better allocate current HIV spending, to maximize health outcomes. The findings of this report can assist the government of Bulgaria in further strengthening its HIV investment case, through which it attempts to increase the effectiveness of HIV investments and define corresponding priorities, strategies and impacts of the HIV response.

2.1 The Optima Model

To assess HIV epidemic trends we use Optima's epidemic module, which consists of a mathematical model of HIV transmission and disease progression. Optima uses best-practice HIV epidemic modelling techniques and incorporates evidence on biological transmission probabilities, detailed infection progression, sexual mixing patterns and drug injection behaviours. Data relating to programs and costs associated with programs are used in an integrated analysis to determine an optimized distribution of investment under defined scenarios.

Data from the National HIV Strategic Plan 2008-2015 and the Mid-term Evaluation of the National Programme for Prevention and Control of HIV/AIDS and STIs (2013-2015) were supplemented with published data and information from national registers to populate the Optima Model. The Optima model was then used to describe the likely trajectory of the epidemic in Bulgaria and how that epidemic may best be contained and treated with available financial resources.

Optima is calibrated to HIV prevalence data points available from different sub-populations at specific time points, as well as to data points on the number of people on ART, which was performed in consultation with experts on the Bulgarian epidemic. **Section 2** and **Appendix 2** provide further details regarding the calibration process.

To assess how incremental changes in spending affect HIV epidemics and thus determine the optimized funding allocation, the model parameterizes relationships between the cost of HIV intervention programs, the coverage level attained by these programs and the resulting outcomes. These relationships are specific to the country, population and program being considered.

Using the relationships between cost, coverage and outcome - in combination with Optima's epidemic module - it is possible to calculate how incremental changes in funding allocated to each program, will impact overall epidemic outcomes. Furthermore, by using a mathematical optimization algorithm, Optima is able to determine the "optimal" allocation of funding across different HIV programs.

2.2 Analytical framework

To tailor the model to a given context, analysts select a number of parameters that describe the country population, levels of expenditure, programs to be included or excluded, time frames and the baseline scenario. The parameters appropriate to the Bulgarian context are listed in **Table 2.1** below. All adults have been defined according to their highest risk behavior, but other risky behavior is incorporated into the model. For example, female PWID's most risky behavior is injecting drugs, but a high number of commercial sex acts has been incorporated into the modeling of this population. The Roma population has not been modeled as a separate population but is included in all population groups. It is acknowledged that Roma men make up a significant portion of the MSM and male PWID population groups.

Table 2.1 Modelling parameterization

Category	Parameterization in the Optima model	Description/ assumptions
Populations defined in the model	1. Female sex workers 2. Clients of sex workers 3. Men who have sex with men 4. Males who inject drugs 5. Females who inject drugs 6. Prisoners 7. Males (15-49 years) 8. Females (15-49 years) 9. Males 50+ (Males 50 years and older) 10. Females 50+ (Females 50 years and older)	1. Females, aged 15-49 2. Males, aged 15-49 3. Males, aged 15+ [19] 4. Males, aged 15-49 5. Females, aged 15-49[20] 6. Males, aged 15-49 7. Males 15-49 years excluding MSM, clients, prisoners and males who inject drugs in this age group 8. Females 15-49 years excluding FSW and females who inject drugs in this age group 9. Males, aged 50+ excluding MSM 10. Females, aged 50+
Program expenditure areas defined in the model and included in optimization analysis[21]	1. Social behavior and communication change 2. Programs for female sex workers and clients (package) 3. Programs for men who have sex with men (package) 4. Opiate substitution therapy[22] 5. Needle-syringe program (NSP) and other prevention for PWID (package) 6. HIV testing services (general population)[23]	1. Mass media programs, behavior change, HIV education 2. Service package including interpersonal communication and counselling, condom provision, peer education, HIV testing and counseling 3. Service package including interpersonal communication and counselling, condom provision, peer education, HIV testing and counselling 4. Provision of substitution drugs, related counselling and clinical services 5. Service package including needles, syringes, interpersonal communication and counselling, condom provision, peer education, HIV testing and counselling

[19] This group includes a representation of MSW

[20] This group includes females who inject drugs and who also sell sex.

[21] "ART" programs include services for key populations

[22] Since OST has substantial benefits outside of HIV (as will be explained further in the "limitations of the analysis"), a constraint was establish by putting a limit of 0% reduction in OST budget allocation (i.e., funding not reduced in all optimization analysis (analyses 2-5) in order to prevent the optimized budget allocation from removing or reducing allocations to OST.

[23] Testing among pregnant women is to be continued and therefore a constraint was established by putting a limit of 27% reduction in HTS general population.

Table 2.1 Modelling parameterization (continued)

Category	Parameterization in the Optima model	Description/ assumptions
Program expenditure areas defined in the model and included in optimization analysis[24]	7. Antiretroviral therapy[25] 8. HIV prevention programs for prisoners	6. Provider-initiated and voluntary testing and counselling (delivered outside programs for specific key populations). Includes testing of pregnant women. Testing of key populations is included in the key population programs. Condom distribution and promotion is included in this program as condoms are distributed together with testing and counselling, and the budget was very small in 2014 (approximately $120,000). 7. Antiretroviral drugs, related laboratory monitoring and clinical visits 8. Condom distribution, HIV testing and counselling
Expenditure areas not optimized (because the effect on HIV incidence, morbidity/mortality not clear or because the expenditure is central systems expenditure that is essential for several program areas)	1. Non-program costs, also called enablers and synergies, have not been optimized (as they do not have measurable epidemic impact) but instead were fixed at agreed amounts. The components of HIV spending that will not be included in the optimization analysis include: 2. Clinical care 3. Case management 4. Roma community outreach program[26] 5. Management 6. Enabling environment 7. Monitoring, evaluation, surveillance and research 8. Other costs	1. Opportunistic infection treatment and other care for PLHIV including psycho-social support 2. Psychosocial support to encourage testing and treatment adherence 3. Community mobilization, demand generation for prevention programs 4. Co-ordination and response management 5. Includes legal and regulatory frameworks 6. Monitoring, evaluation, surveillance and research 7. Expenditure areas not classified elsewhere
Time frames over which the optimization was considered	8. 2000 – starting year for data entry 9. 2016-2020 (government's timeline for achievements of national strategic plan targets) 10. 2020 (interim timeline for international targets) 11. 2030 (new UNAIDS horizon for ending AIDS)	
Baseline scenario funding	12. 2014 Global AIDS Response Progress Report values	

Source: Authors.

24 "ART" programs include services for key populations

25 No one who initiated ART is to stop receiving ART, except through natural attrition. Therefore a constraint was established by putting a limit of 0% reduction in ART.

26 The Roma community outreach program relates specifically to outreach programs to Roma that are different from other service programs that are delivered to key population groups, which include Roma people.

2.3 Calibration

A key stage in the Optima modelling process is a stage known as 'calibration'. Calibration aims to align the Optima-projected trends with the historically observed trends in HIV prevalence in different population groups in a given context. Given the challenges inherent in fitting epidemiological and behavioral data, the calibration for Bulgaria was performed manually by varying relevant model parameters to attain a best-fit between model-projected and historic HIV prevalence. This process was conducted in close collaboration with in-country stakeholders.

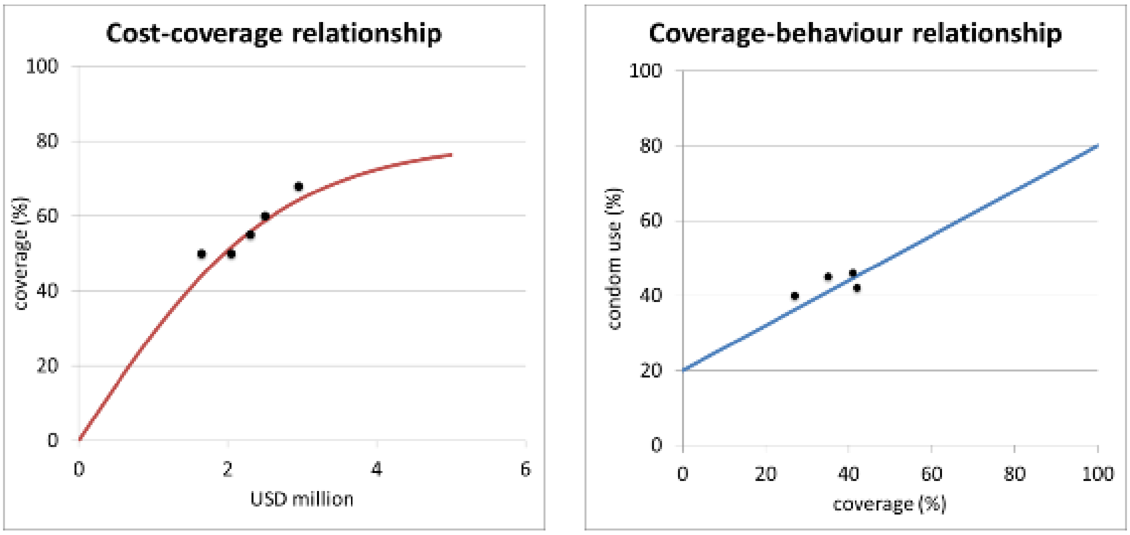
Once the Optima model is calibrated, it can describe future expected trends in the HIV epidemic as described in **Section 3**.

2.4 Cost-coverage-outcome relationships

The relationship between program spending and coverage is shown in the left panel of **Figure 2.1**. This relationship describes the level of output achieved with a specific level of financial input. In the context of these analyses, output is defined as the availability of a service to a specific proportion of the target population. Coverage refers to the number of the population reached. For example, this relationship would describe how many FSW can be provided with a standard package of services with an investment of 0 to 1,000,000 USD. The relationship between coverage levels and outcome is shown in the right panel. This relationship describes the proportion of people who will adopt a specific behavior, such as condom use or consistent use of ARVs leading to viral suppression. These analyses were produced in collaboration with Bulgarian experts and the full set of figures can be seen in **Annex 3**.

The cost-coverage-outcome relationships are utilized, together with the calibration projections, to run the optimization and scenario analyses described in **Sections 5, 6, 7 and 8**.

Figure 2.1 Logistic cost-outcome relationships for Bulgaria.27



Source: Authors.

27 The black dots represent available spending and coverage data, and associated behaviors. The solid curves are the best fitting or assumed relationships.

2.5 Allocative Efficiency Analysis

Efficiency analyses must be informed by local priorities. At the time of this study, Bulgaria was in the process of drafting a new national HIV strategy for 2016 to 2020. In-country experts highlighted that reducing new infections and deaths were likely to be key targets in the new HIV strategy.

To support these national priorities and assist Bulgaria within the context of sustainability planning, this report will answer the following five questions: 1) What is the trajectory of the epidemic under different scenarios, in comparison to the predicted epidemic trends under the current HIV response? 2) How can Bulgaria optimize the allocation of current HIV funding, and how close will the country get to minimizing new HIV infections and HIV-related deaths? 3) With changes to HIV budget allocation, how can Bulgaria optimize the allocation of HIV funding, and how close will the country get to minimizing new HIV infections and HIV-related deaths 4) What is the minimum spend required to achieve proposed National Strategic Plan targets if resources are allocated optimally? And; 5) What are the long-term financial commitments to the HIV response?

Each of these questions is the subject of an analytical module as described in more detail below.

Analysis 1: What is the trajectory of the epidemic under different scenarios, in comparison to the currently predicted epidemic trends under the current HIV response?

This analysis compares the trajectory of the epidemic and key outcomes under the current allocation of resources (**Section 3**) with different scenarios (**Section 5**). These include:

1. **Test and treat:** In this scenario it was assumed that by 2020, 90% of PLHIV will be aware of their status and 90% of PLHIV will be on ART.
2. **Attaining global targets for prevention and treatment:** In this scenario, the trajectory of the HIV epidemic is assessed if the country aims for reaching global goals for all key populations.
3. **Defunding all preventive programs:** In this scenario, possible impacts of defunding all prevention programs for the key populations (including HTS programs) will be explored.

The scenario analysis explores different levels of achievement of program outcomes. In this section we analyzed the epidemic impact if specific outcome levels or targets are achieved regardless of cost and coverage considerations. This approach is different from the other analyses which are based on optimization analysis considering these cost and coverage relationships.

Analysis 2: How can Bulgaria optimize the allocation of HIV funding, and how close will the country get to minimizing new HIV infections and HIV-related deaths?

This analysis compares the trajectory of the epidemic and key outcomes under the current allocation of resources, against an optimized allocation of resources. For the purposes of this analysis, the funding level remains the same as what is currently available and is not varied, only the way that funding is spent changes. The aim is to determine how Bulgaria can allocate available resources to achieve maximum impact (in terms of minimizing the number of new HIV infections and HIV-related deaths), and how close that maximum impact will be to National HIV Strategic Plan targets under consideration.

This analysis asks the following specific question:

- If funding is kept at the same level, but resources are allocated differently according to the optimization model, what then will be the expected annual levels of HIV incidence, HIV prevalence, and HIV-related deaths? The results of this analysis are described in **Section 6**.

Analysis 3: With changes to HIV budget allocation, how can Bulgaria optimize the allocation of HIV funding, and how close will the country get to minimizing new HIV infections and HIV-related deaths?

This analysis explores possible outcomes with potential decreases and increases in the available HIV response budget. The previous analysis assumed fixed amounts of available funding and explored an optimized allocation of those funds, to see what reductions in deaths and new infections could be achieved with the current budget. In contrast, this analysis aims for the maximum possible reduction of new deaths and infections under variable budget envelopes (80%, 120%, 140%, 160%, 180%, 200% of 2014 HIV budgets). The results of this analysis are presented in **Section 7**.

Analysis 4: What is the minimum spend required to achieve proposed National Strategic Plan targets if resources are allocated optimally?

This analysis identifies the minimum resource requirements to achieve proposed national strategy targets. As the new National HIV Strategic Plan targets had not yet been identified at the time when this report was being prepared, analyses were run to establish how much funding is required to a) maintain current outcomes and b) to reduce new infections and deaths by 50%? The results of this analysis are presented in **Section 8**.

Analysis 5: What are the long-term financial commitments to the HIV response?

This analysis reviews the impact of current investment choices on long-term financial commitments. Specifically, this analysis compares the commitments one would expect to result from the current allocation of the 2014 budget, against the optimized allocation of the 2014 budget described in **Section 6**. The findings from this analysis are presented in **Section 9**.

2.6 Limitations of the analysis

All mathematical models have their strengths and limitations. Results should therefore be interpreted in light of the assumptions made. In particular, it is important to note that:

- All model forecasts are subject to uncertainty. Therefore, point-estimates are indicative of trends rather than exact figures.
- The model calibration depends as much on the quality of input data as on the quality of the model itself. The country and study teams have done everything possible to ensure the best possible data quality but it is never possible to have a complete, or completely certain dataset. The best model calibration will rarely achieve an exact match of historical data, but will mirror as closely as possible the key trends of them.
- There were some data gaps in Bulgaria, in particular for the general population and for clients of sex workers. As in other models, estimates of HIV prevalence in the general population were derived from data in pregnant women as a proxy for prevalence in the female general population. There was no data available for clients. Therefore an assumed population size of 10% of the general adult male population (15-49 age group) was used.
- There is some uncertainty in the epidemic projections due to ambiguous trends in data sources. For PWID, the latest data from bio-behavioral surveys in 2012 indicated that

prevalence was higher for males and females in previous years but there has been a reduction in new diagnoses among PWID. This may be due to the fact that the sample sizes in the IBBS were smaller than previous years. It may also be due to under reporting of cause of transmission of HIV in the registered data. Local experts suggested that the population size of PWID is declining. For MSM, the latest data from IBBS suggest that the prevalence is lower than previous years. However the registered number of new diagnosis is proportionately high, and increasing among this group. This may be due to the sample size of the IBBS, or possible due to an increasing populations size of MSM.

- The modelling approach used to calculate relative cost-effectiveness between programs includes assumptions about the impact of increases or decreases in availability of funding for programs. These assumptions are based on unit costs and observed ecological relationships between outcomes of program coverage or risk behavior and the amount of money spent on programs in the past, assuming that there would be some saturation in the possible effect of programs with increases in spending.
- The analysis presented in this report does not determine the technical efficiency of programs as this was beyond the scope of the analysis. However, gains in technical efficiency would lead to lower unit costs and would therefore affect the optimized resource allocation described in this report.
- Modelling the optimization of allocative efficiencies depends critically on the availability of evidence-based parameter estimates of the effectiveness and cost-efficiency of individual interventions. Programs for which these parameter estimates do not exist, such as for many of the critical enablers, will be excluded for the analysis. However, this does not mean that these programs should not receive funding. In addition, there are uncertainties around parameter estimates of some of the critical clinical interventions (e.g. ART and the parameter estimates such as the preventive effect of ART), which may distort the results.
- Effects of the programs outside the HIV endpoints including, for example, the wider health and non-health benefits of OST (beyond those directly related to HIV) and the effects of needle exchange programs on Hepatitis, are not included in this model. Given that, in the case of OST, there are significant benefits beyond HIV outcomes, the optimized budget allocation was prevented from removing or reducing allocations to OST, by putting a limit on reduction in OST budget allocation.
- Testing among pregnant women is to be continued, and therefore a constraint was established by putting a limit of 27% reduction in HTS general population.
- No one who initiated ART is to stop receiving ART, except through natural attrition. Therefore a constraint was established by putting a limit of 0% reduction in ART.
- Along the same lines, the Optima modelling approach does not seek to quantify the human rights, stigma and discrimination, ethical, legal or psychosocial implications of providing or withdrawing care. The authors acknowledge that these are important aspects to consider.
- Other models may produce different projections than those produced by Optima. This is an underlying property when using theoretical mathematical frameworks. Different designs of the framework may generate different outcome projections. However, the projections presented in this report are not significantly different from the UNAIDS estimates based on the Spectrum model. In addition, the analyses presented in this report have made use of the best available country data, experience gained from applying the Optima model in over 20 countries, and comparisons within the ECA region for the validation and contextualization of inputs and findings wherever possible.

3. WHAT ARE THE EXPECTED TRENDS IN THE EPIDEMIC IF CURRENT SPENDING IS MAINTAINED?

3.1 The current epidemic

At the end of 2014, 2043 people had been diagnosed with HIV[28]. However, it is estimated that approximately one third of PLHIV remain undiagnosed and the Optima model estimates that there were 3,100 PLHIV at the end of 2014 (**Figure 3.1**), with 89% being from key populations.

There has been an increase in newly diagnosed PLHIV over the past 14 years, with 213 registered new diagnoses in 2014. **Table 3.1** shows the most recent data for population sizes and for HIV prevalence among key populations.

On the current trajectory, and with current levels of funding and current allocations to programs maintained - the total number of PLHIV is projected to increase from 3,100 in 2014 to 4,100 in 2020, and 5,300 by 2030 (**Figure 3.1**). This projection is based on an expected increase in HIV incidence and a projected decrease in the death rate among PLHIV due to the positive effect of ART. In 2014, an estimated 80% of PLHIV were either PWID or MSM. As **Figure 3.1** shows, the majority of new PLHIV will be among PWID and MSM, as the prevalence in this group is projected to continue to increase over the next 15 years.

Table 3.1 Population size and prevalence among key populations

Population	Population size	HIV prevalence
FSW	13500 (C.I. 12000 – 15000)[29]	1.88%[30]
Clients	160,000 (estimate)	0.01% (estimate)
MSM	58,000[31]	0.6%[32]

[28] HIV register data

[29] Republic of Bulgaria Council of Ministers. 2008. National Programme on Prevention and Control of HIV and Sexually Transmitted Infections in the Republic of Bulgaria 2008-2015. "Data is largely based on expert assessment and field worker observations under the Programme on Prevention and Control of HIV/AIDS financed by the Global Fund to Fight AIDS, Tuberculosis and Malaria."

[30] Results from the integrated biological and behavioral control of HIV among male and female sex workers within the period 2004–12, Bulgaria.

[31] Republic of Bulgaria Council of Ministers. 2008. National Programme on Prevention and Control of HIV and Sexually Transmitted Infections in the Republic of Bulgaria 2008–15. "3% of the male population, based on data from a number of surveys performed in Eastern Europe."

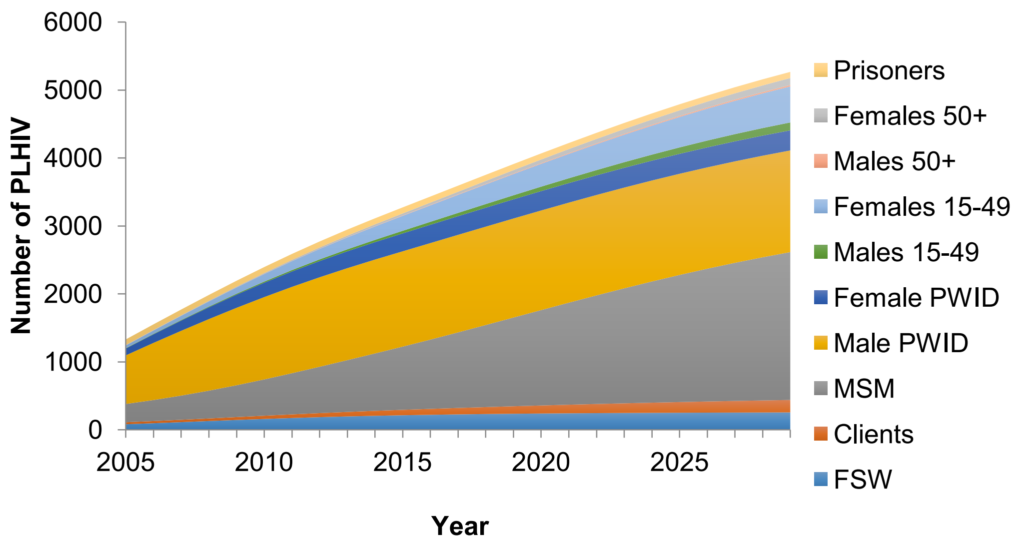
[32] Results from the integrated biological and behavioral control among men who have sex with men within the period 2006–12, Bulgaria

Table 3.1 Population size and prevalence among key populations (continued)

Population	Population size	HIV prevalence
Male PWID	15,000[33]	10.7%[34]
Female PWID	4,100[35]	10.1%[36]
Prisoners	8,500[37]	1.6%[38]

Source: Authors.

Figure 3.1 Calibration of PLHIV



Source: Authors

The remainder of this section describes these modelled projections based on the results of the calibration, which are shown in the Annex.

3.2 HIV prevalence is expected to increase

Overall HIV prevalence is projected to moderately increase from modelled estimates of 0.04% in 2014 to 0.06% in 2020 and 0.08% by 2030. HIV prevalence in the MSM population is predicted to increase substantially from an estimated 2.4% in 2014 to 4.0% in 2020, and 6.3% by 2030. The model estimates that HIV prevalence among PWID will also increase, but at a slower rate than in the past. HIV prevalence among PWID is relatively high compared with

33 2009 estimate based on capture-recapture study. http://www.emcdda.europa.eu/countries/bulgaria. Size estimation reduced slightly since 2009 based on expert opinion that the overall number of injecting drug users has decreased. Bio-Behavioural Surveillance Survey June - August 2012 provided gender disaggregation (77.9% Male, 22.1% Female).

34 Results from the integrated biological and behavioral control of HIV among injecting drug users within the period 2004–12, Bulgaria.

35 As per male PWID.

36 As per male PWID.

37 Prisoner population size obtained from Ministry of Justice.

38 Results from the integrated biological and behavioral control of HIV among imprisoned persons within the period 2006–11, Bulgaria.

other key populations, driven partly by needle sharing rates of 17% among female PWID and 19% among male PWID[39].

HIV prevalence is expected to virtually stabilize among FSWs, with only a small projected increase from 1.4% in 2014 to 1.6% in 2020 and 1.7% in 2030. HIV prevalence in the sex worker client population is similarly expected to increase only slowly and from a low base, from an estimated 0.04% in 2014 to 0.06% in 2020 and 0.09% in 2030. However, there is significant uncertainty around this finding due to the lack of primary data on this key population described in **Section 2**. HIV prevalence among prisoners is expected to remain stable at around 0.95%.

Whilst HIV prevalence in the general population is very low, the model projects that there will be a steeper increase among females aged 15–49 than among males aged 15–49. HIV prevalence among females 15–49 is projected to increase from 0.010% in 2014 to 0.017% in 2020, and 0.027% by 2030. In contrast, the model predicted prevalence for males aged 15–49 is approximately four times less than that of the females, increasing from 0.002% in 2014 to 0.004% by 2020, and 0.007% by 2030. This difference is mostly related to the downstream effect of females aged 15–49 having male partners who are MSM or males who inject drugs. HIV prevalence among males and females 50+ is expected to increase from a very low base due to the ageing transitions from key populations such as FSW and PWID as well as their sexual partners.

3.3 HIV Incidence is increasing

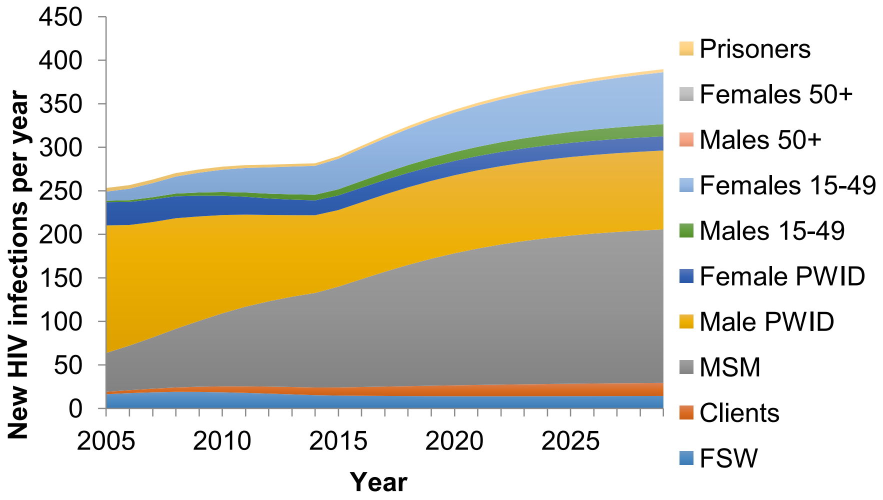
One of the main factors underpinning the increase in HIV prevalence described above is an expected increase in HIV incidence. Since 2000, overall HIV incidence rates have increased and the model predicts that —assuming constant behaviours and service coverage—incidence will increase further between 2016–30, with an estimated 280 new infections per year in 2014, to 340 new infections per year in 2020, and 390 per year by 2030 (**Figure 3.2**). The highest number of new infections is expected to be among MSM and male PWID. The expected increase in HIV incidence is mostly driven by the increasing transmission due to unprotected sex between MSM and their male and female partners. Relatively low condom use (75%) among MSM in paid sexual relationships is therefore a particular cause for concern[40]. Among MSM, the high probability of sex with female partners also implies that HIV incidence among females 15–49 is projected to increase[41].

39 Results from the integrated biological and behavioral control of HIV among injecting drug users within the period 2004-2012, Bulgaria.

40 Results from the integrated biological and behavioral control among men who have sex with men within the period 2006-2012, Bulgaria.

41 Results from the integrated biological and behavioral control among men who have sex with men within the period 2006–12, Bulgaria indicated that 1 in 4 MSM had sex with a female partner in 2008 in the preivious year and in 2010, and 1 in 10 had a female partner.

Figure 3.2 Calibrated number of new HIV infections per year



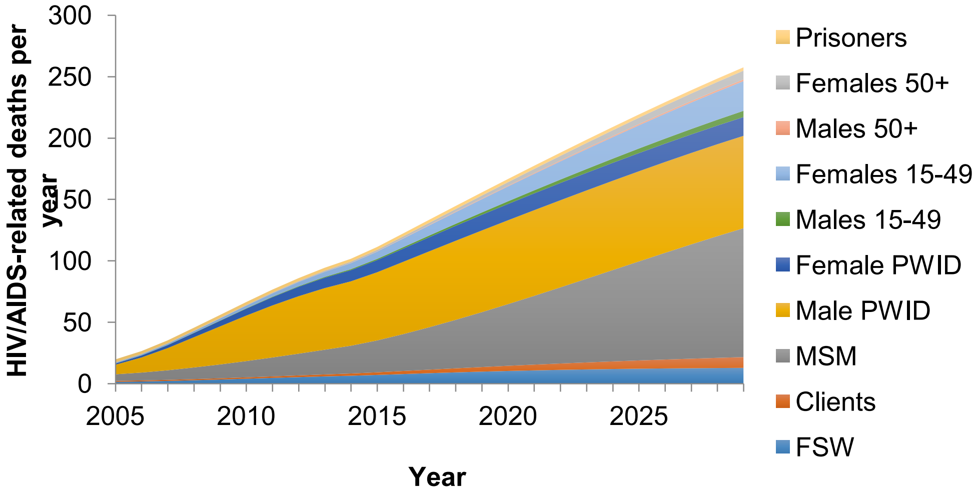
Source: Authors.

3.4 AIDS-related deaths are low but increasing in number

Until 2010, the number of AIDS-related deaths was estimated to be low and stable, reflecting the low-level epidemic of the 1990s. However, the number of deaths is projected to increase with the expanding key population epidemics of the past decade.

ART has slowed the increase in AIDS-related mortality. Overall however, the number of deaths attributable to HIV is predicted to increase from 100 per year in 2014, to 170 in 2020, and 260 by 2030 (**Figure 3.3**) with current levels of ART coverage.

Figure 3.3 Calibration predicted number of deaths due to HIV in Bulgaria, assuming stable coverage of programs



Source: Authors.

3.5 The number of people requiring HIV treatment will increase

Table 3.2 below shows ART coverage in Bulgaria from 2011 to 2014 in relation to the total population of PLHIV. The large difference between the size of the population on treatment and the estimated population in need, suggests that ART coverage has been increasing moderately over time, but considering WHO recommendations to initiate ART for all PLHIV, there is a sizeable treatment gap. Furthermore, 19% of people tested in 2014 had CD4 counts <200, which indicates late presentation for testing and treatment.

Table 3.2 ART coverage in Bulgaria, 2011–14[42]

Year	Number of PLHIV on ART	Total estimated number of PLHIV (Optima derived estimates)	Percent ART coverage from estimated PLHIV (Optima derived estimates)
2011	452	2587	17%
2012	539	2770	19%
2013	626	2945	21%
2014	741	3111	24%

Source: Authors.

42 From the Bulgarian Final Draft National HIV Strategic Plan, page 11.

4. WHAT IS THE IMPACT OF PAST AND CURRENT SPENDING?

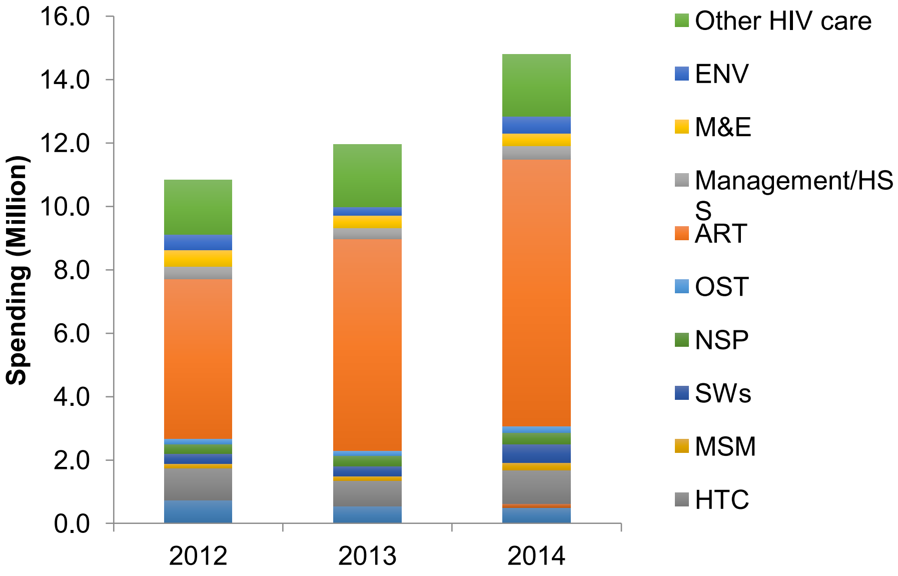
4.1 Treatment receives the majority of current funding

Treatment, including ART and HIV care, is the largest component of HIV spending in the context of Bulgaria, at approximately 70% of spending in 2014 **(Figure 4.1)**. In 2014, approximately 81% of treatment spending was allocated to ART. Spending on ART, which has grown substantially since 2012, is funded entirely by domestic sources.

By comparison, spending on preventive programs constituted around 20% of total HIV spending in 2014. In 2014, HTS and SW programs were the largest components of spending in this category, with 35% and 19% of the budget respectively. However, in the same year, MSM, NSP and OST programs were allocated only 8%, 12% and 7% of spending respectively.

The proportion of spending allocated to indirect costs such as management, enabling environment and M&E has decreased slightly since 2012. In 2014, these costs comprised approximately 9% of total HIV spending.[43].

Figure 4.1 HIV expenditure in Bulgaria by type of spending[44]



Source: Authors.

[43] Source: National HIV/AIDS Spending report 2012-2014.

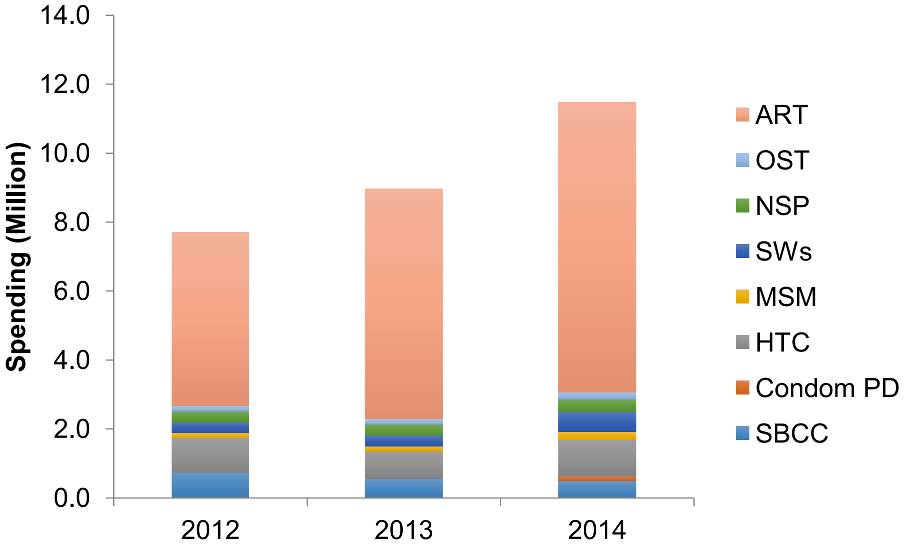
[44] Source: National HIV/AIDS Spending report 2012-2014..

4.2 Prevention could be better targeted within and between key populations

Current spending on HIV prevention and treatment may not be benefiting those most in need (**Figure 4.2**). Model-based estimates suggest that HIV incidence and prevalence are increasing among key high-risk populations, in particular MSM.

Although the increase in prevalence among male and female PWID is expected to be small, Optima analyses suggest that there remains a need to invest in programs for PWID, including needle-syringe programs (NSP) and opiate substitution therapy (OST).

Figure 4.2 Trends in spending across key priority prevention and treatment programs[45].



Source: Authors.

Using the cost-coverage relationships described in **Section 2**, the unit costs for the current level of spending (2014) were derived. The derived unit costs for ART are particularly high when compared with cost data for other countries in the region (**Table 4.1**).

This finding suggests that a more detailed review of these unit costs and a technical efficiency analysis may be beneficial in this context. If high unit costs are reduced without compromising the quality of programs, then a clear efficiency gain may be achieved and 'saved' resources can be more effectively used to combat the epidemic through reallocation to other programs or expansion of current programs.

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45 HTS and ART are programs for the whole population and as such, include people from key population groups.

Table 4.1 Comparing Costs of Programs in the ECA Region

Cost per person reached	Bulgaria, 2014[46]	Regional comparison[47]			
		Lowest	Highest	Average	Median
FSW programs	$73.16	$41.66	$203.39	$111.78	$105.35
MSM programs	$34.72	$23.67	$449.13	$121.29	$48.38
PWID-NSP programs	$52.74	$40.90	$174.51	$93.30	$84.11
ART	$11,259	$576.48	$11,258.94	$2,592.78	$1,264.12
HTS	$8.31	$0.55	$182.23	$33.64	$3.89

Source: Authors.

While the data in **Table 4.1** may identify potential areas for technical efficiency gains, a number of cautions in interpreting these data should be noted. In particular:

1. Although all expenditure data has been extracted from NASA/GARPR reports, which follow a standard methodology, individual countries may not have classified all costs in the same way.
2. Coverage definitions and packages for each program may differ between countries.

Consequently, this table does not provide substantive information about which countries deliver services more efficiently. Instead, this analysis seeks only to highlight, which programmes incur relatively high costs per person reached and may benefit from a more robust review of the potential for technical efficiency gains.

4.3 Investing in an HIV response averts infections and deaths

Model–based projections of the epidemic indicate that current spending on HIV prevention and treatment programs will continue to avert new infections and deaths. In the absence of any spending on the HIV epidemic, the model estimates that 554 (17%) more deaths would occur and 982 (15%) more people would be infected (**Figure 4.3A and B**). Furthermore, as noted above, the total number of PLHIV is projected to increase to 4395 by 2020 and 6034 by 2030 (8% more PLHIV than the current spending) (**Figure 3.1**). This highlights the need to continue investing in the HIV response

[46] Data extracted from the "Global AIDS Response Progress Report of Bulgaria 2014 (GARPR)".

[47] Source: Completed Optima data matrixes for 7 ECA countries, compiled by the study team from a range of country specific data sources during 2014–15.

Figure 4.3A Model-estimated impact of current spending compared to no spending on the HIV response, 2015–30[48].

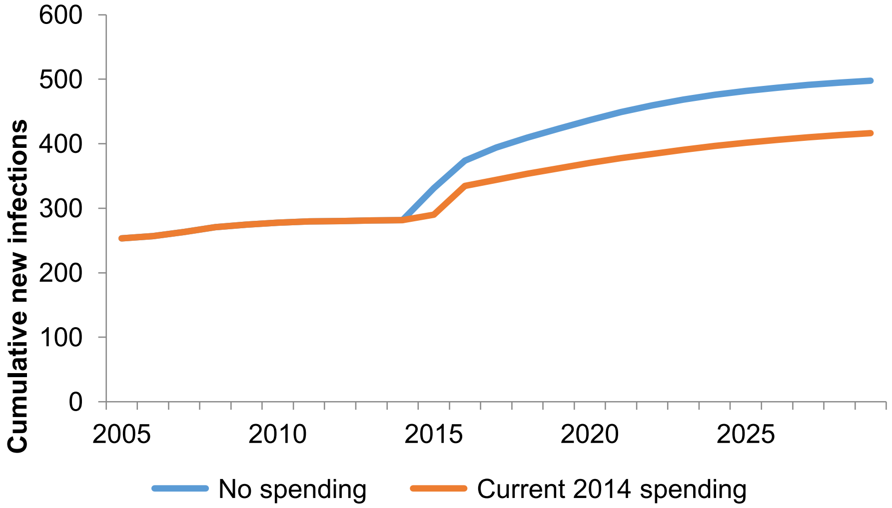
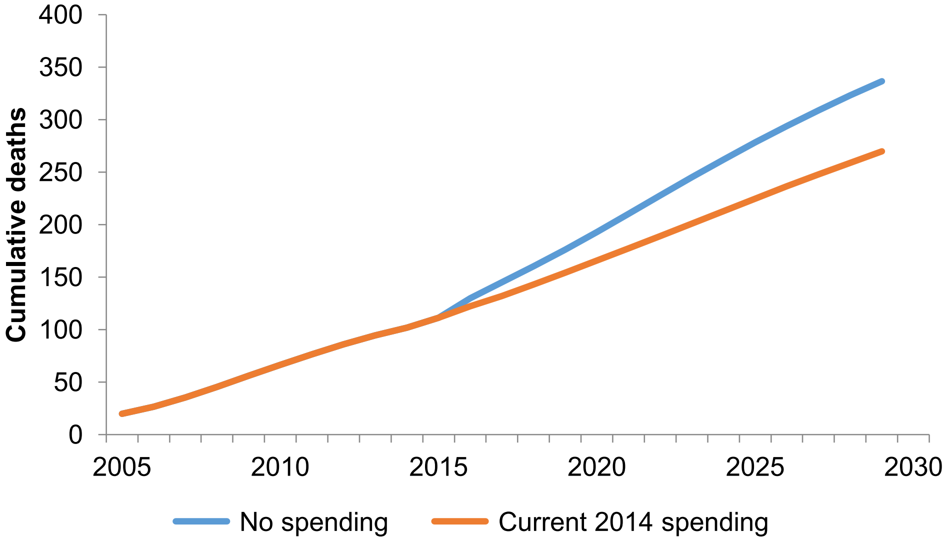


Figure 4.3B Model-estimated impact of current spending compared to no spending on the HIV response, 2015–30



Source: Authors

[48] 'No spending' assumes that there is no spending on the HIV response and 'current spending' assumes that current funding conditions remain stable.

5. PREDICTING THE TRAJECTORY OF THE HIV EPIDEMIC: COMPARING HIV RESPONSE SCENARIOS

In the previous section, we compared current spending levels and allocations against a 'no spending' scenario. **Figure 4.3** demonstrated that the current response to the epidemic is significantly reducing HIV prevalence, HIV incidence and HIV-related mortality compared to the levels projected in a scenario with no programs. The Optima model predicts that this positive impact is likely to persist, and even grow, in the time period to 2030. In this section, we ask whether an alternative HIV response – determined by the need to reach pre-specified targets, could potentially reduce HIV prevalence, incidence and mortality further.

Here we compare the trajectory of the HIV epidemic by 2030 in Bulgaria under the current HIV response against three alternative HIV response scenarios that are not constrained by a budget but are determined solely by targets. These scenarios were identified through consultation with local stakeholders. In this section, the epidemic trajectory is predicted for each of these scenarios and compared with the trajectory under current programmes. The three response scenarios used for comparison were:

1. ***Test and treat:*** In this scenario it was assumed that by 2020, 90% of PLHIV will be aware of their status and 90% of the diagnosed PLHIV will be on ART.
2. ***Attaining combined targets for prevention and treatment:*** In this scenario, the trajectory of the HIV epidemic is assessed if the country aims for reaching global goals for all key populations.
3. ***Defunding all preventive programs:*** In this scenario, possible impacts of defunding all prevention programs for the key populations (including HTS programs) will be explored.

Table 5.1 presents detailed information on parameters and targets specified in the alternative scenarios.

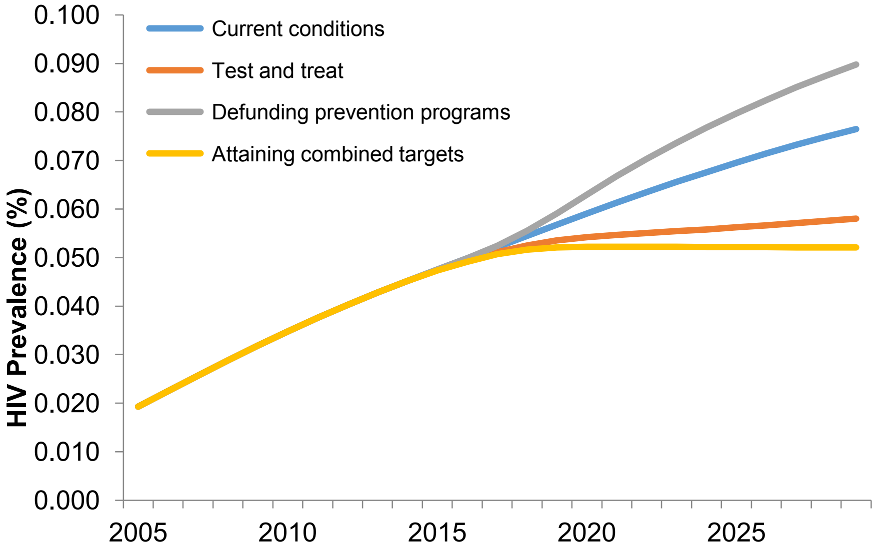
Table 5.1 Parameters and target values used in the alternative scenarios

		Alternative response scenarios*		
Target population	**Parameters**	**Test and Treat (Baseline-2020)**	**Attaining global targets (Baseline-2020)**	**Defunding all preventive programs (Baseline-2020)**
FSWs	Proportion of sexual acts in which condoms are used with commercial partners	No change (99%)	99%–99%	96%–85%
	Proportion of people who are tested for HIV each year	N/A	N/A	76%–48%
MSM	Proportion of sexual acts in which condoms are used with casual partners	No change (76 %)	76%–90%	76%–55%
	Proportion of sexual acts in which condoms are used with commercial partners	No change (75%)	75%–99%	75%–50%
	Proportion of people who are tested for HIV each year	N/A	N/A	54%–38%
Males who inject drugs	Proportion of sexual acts in which condoms are used with casual partners	No change (56 %)	56%–90%	56%–40%
	Proportion of injections using receptively shared needle syringes	No change (19%)	19%–2%	19% –30%
	Proportion of people who are tested for HIV each year	N/A	N/A	62%–40%
Females who inject drugs	Proportion of sexual acts in which condoms are used with commercial partners	No change (91%)	91%–99%	96%–80%
	Proportion of sexual acts in which condoms are used with casual partners	No change (57%)	57%–90%	85%–60%
	Proportion of people who are tested for HIV each year	N/A	N/A	67%–45%
	Proportion of injections using receptively shared needle syringes	No change (17%)	17%–2%	17%–30%
Prisoners	Proportion of sexual acts in which condoms are used with casual partners	No change (44%)	44%–90%	44%–35%
	Proportion of people who are tested for HIV each year	N/A	N/A	37%–1%
Number of PLHIV on ART (all populations)		741–3,294 (2014–20)	741–3,294 (2014–20)	N/A
Proportion of people who are tested for HIV in each year (all populations)		62%–90% (2016–20)	62%–90% (2016–20)	N/A

Source: Authors.
Note: * Baseline data in each scenario are from different years when the latest data was available.

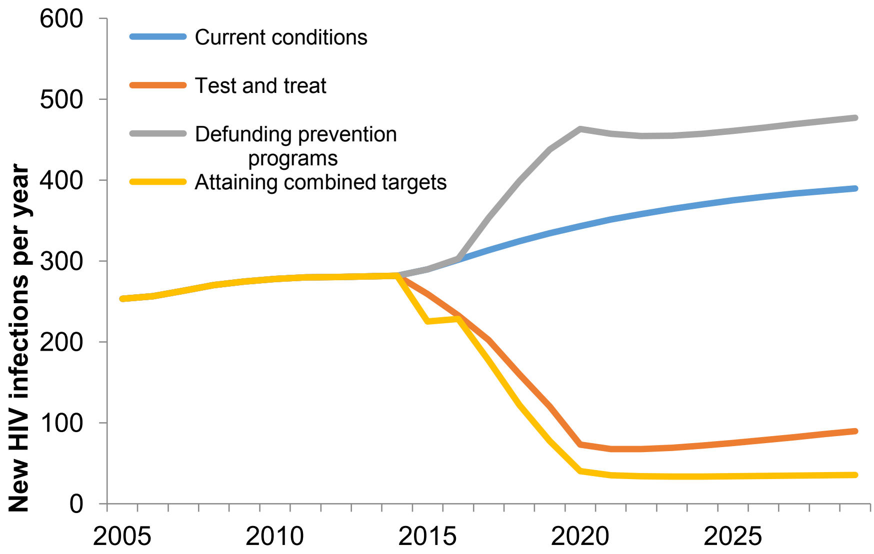
The model-predicted evolution of annual HIV prevalence, new infections and deaths (2000–30) under these scenarios are shown in **Figures 5.1, 5.2** and **5.3. Figures 5.4 and 5.5** show the expected incidence among MSM and male PWID respectively, for the same period and for each scenario[49].

Figure 5.1 Model-predicted evolution of annual HIV prevalence under different scenarios (2000–30)



Source: Authors

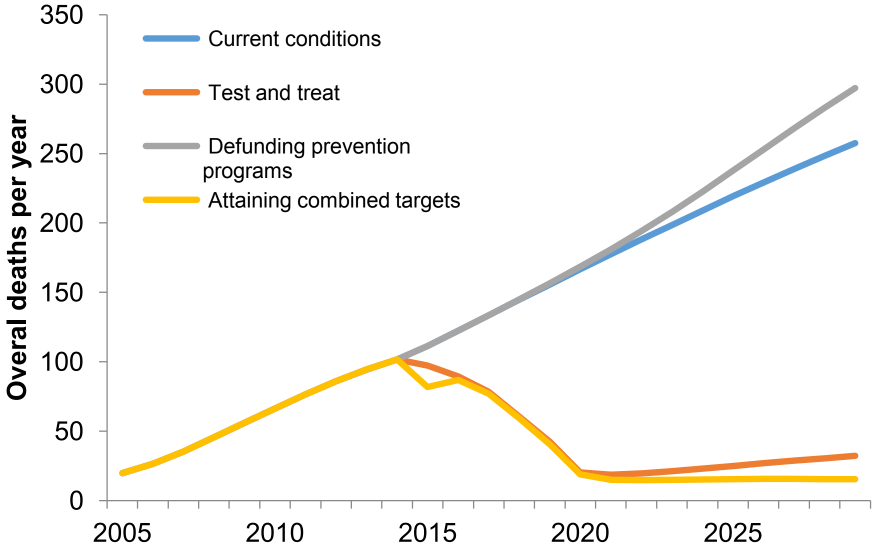
Figure 5.2 Model-predicted evolution of annual new HIV infections under different scenarios (2000–30)



Source: Authors

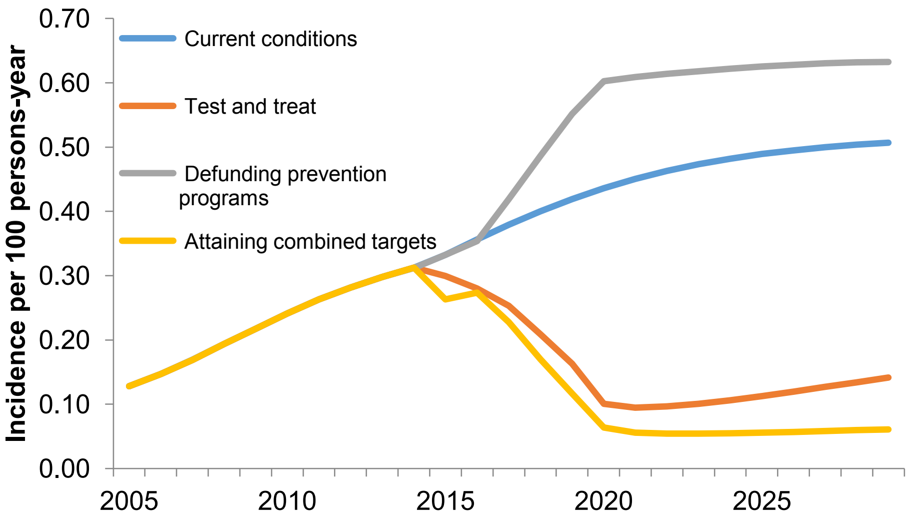
49 It should be considered that whether the curve covering the historical period until 2015 in all scenarios is a calibration output.

Figure 5.3 Model-predicted evolution of annual HIV-related deaths under different scenarios (2000–30)



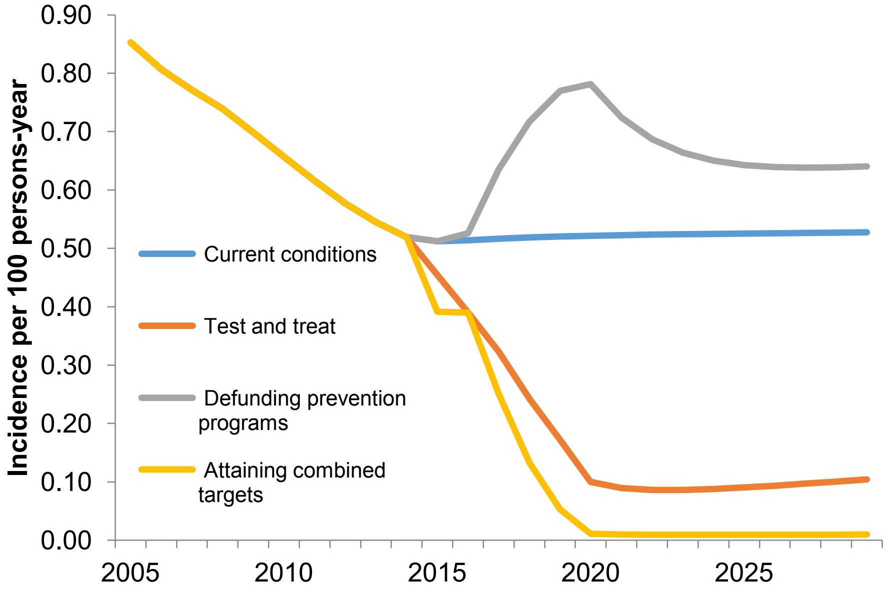
Source: Authors

Figure 5.4 Model-predicted incidence for MSM under different scenarios (2000–30)



Source: Authors

Figure 5.5 Model-predicted incidence for Male PWID under different scenarios (2000–30)



Source: Authors

With 2014 levels and allocations of funding[50] maintained, HIV prevalence, incidence and the number of deaths are expected to increase. This is mainly driven by rising incidence among MSM, as described earlier.

Findings from the analysis shows that defunding all prevention programs for key populations (*Option 3* above) is expected to increase overall HIV prevalence, the number of new HIV infections and deaths, cumulatively by 10%, 19% and 6% respectively, compared to the current HIV response.

The findings demonstrate that 'Attaining combined targets for prevention and treatment' (*Scenario 2* above), is more effective in reducing overall HIV incidence, new infections and deaths than *Scenario 1* ie. Test and Treat. *Scenario 2* and is projected to achieve an estimated 81% reduction in new infections (4,000 fewer infections), and 84% reduction in deaths (2,300 fewer deaths), by 2030. The analysis predicts that the 'Test and Treat' scenario will reduce new infections by 70% (3,500 fewer infections), and deaths by 81% (2,200 fewer deaths) by 2030 compared to current conditions. The analysis shows that 'Attaining global targets for prevention and treatment' (*Option 2*) is also the most effective in reducing incidence among MSM and male PWID population at 79% and 87%, respectively (**Figure 5.4 and Figure 5.5)**. In reducing the number of deaths and new infections over time, *Scenarios 1 and 2* are both significantly more effective than the spending allocation of the current HIV response.

It should be noted that this scenario analysis explores different levels of achievement of program outcomes. In this section we analyze the epidemic impact if specific outcome levels or targets are achieved regardless of cost and coverage considerations. This approach is different from the optimization analysis in the next section, which is based on the Cost-Coverage Outcome Curves (CCOCs). In the optimization analysis presented next, we consider the effect of different levels of spending on programs, which then translate into coverage and outcomes according to the CCOCs.

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50 An annual budget of $14,796,161.

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6. WHAT CAN BE IMPROVED BY OPTIMIZING EFFICIENCIES UNDER THE CURRENT LEVEL OF FUNDING?

A mathematical optimization analysis[51] was conducted by comparing the allocation of the 2014 expenditure of US$14.8 million , with an optimized allocation of the same amount for the time period 2016-2030.

Overall, HIV prevalence among the low-risk, general population in Bulgaria is still very low. As such the Bulgarian epidemic is clearly categorized as a concentrated epidemic. In 2014, HIV spending in Bulgaria was distributed across a wide range of HIV programs. According to model-based analyses, using 2014 as the baseline year, the current distribution of funding is different from an optimized allocation that minimizes both new infections and deaths (Figure 6.1 and Table 6.1). Optimization of 2014 spending to reduce HIV incidence and deaths, averts an estimated 1,100 (21%) additional HIV infections, mainly among PWID, and 197 (7%) additional deaths from 2016 to 2030. To achieve these gains, the following key changes are proposed:

- **Investment in PWID programs, including both NSP and OST, should be increased.**

  The model suggests that investment in PWID programs should be substantially increased, from 2.5% to 11% of the annual HIV budget (Figure 6.1 and Table 6.1). The model also suggests doubling the annual investment in OST, from 1.4% to 3.3% of annual HIV spending. This shift in spending reflects the fact that PWID are the single largest group of PLHIV in the Bulgarian context, followed by MSM. In addition, these programs are highly cost-effective in this context, compared with other countries in the region. Increased investment in OST is particularly important as it has significant wider public health benefits.

- **Investment in MSM programs should be increased.**

  The analysis suggests an approximate 20% increase in annual investment in MSM programs (Figure 6.1 and Table 6.1). MSM constitute the second largest number of PLHIV in Bulgaria. As described earlier, targeting key populations has benefits for both high- and low-risk populations but constitutes a more efficient financial investment. Since the epidemic in the low-risk, general population is too small to be self-sustaining without the increased risk from 'bridging' individuals in key, higher-risk populations, the most effective strategy is likely to focus on reducing new infections among key populations such as MSM and PWID.

- **Programs for prisoners should be expanded**

[51] In this analysis, constraints were placed on OST, ART and HTS spending.

The model suggests doubling the annual investment in the prisoner programs, from 0.15% to 0.31%. This program is highly cost-effective in the Bulgarian context.

- **Investment in ART provision should be maintained**

  Investment in ART provision should be maintained as both treatment and prevention. This intervention will reduce HIV incidence and prevalence across all key population groups. However, given the very high cost of ART provision in the Bulgarian context when compared with other countries in the region, increases in coverage may require further technical efficiency analyses to identify ways of reducing the unit cost of ART provision.

- **Spending on low-risk populations could be more effectively diverted to comprehensive HIV programs**

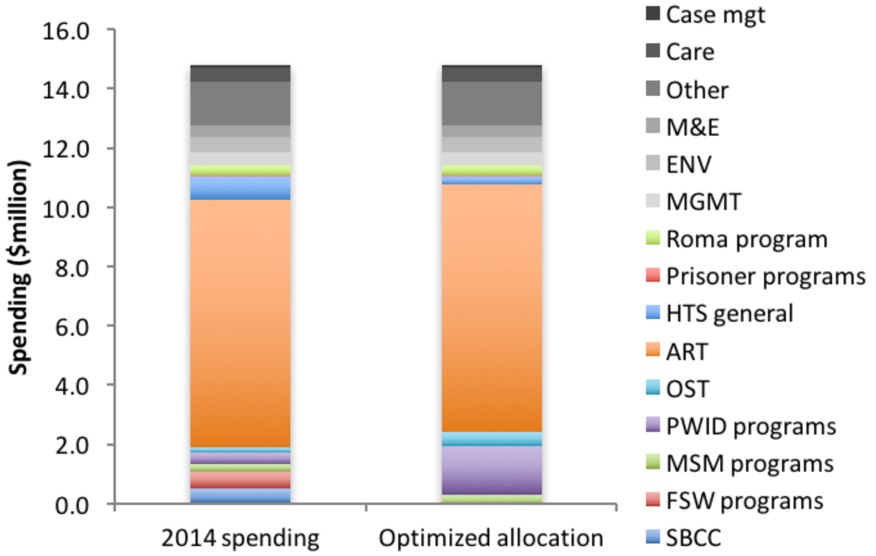
  In Bulgaria, low-risk populations are large and their individual risk of contracting HIV is low. It is therefore more efficient in contexts such as this, to prioritize key populations such as PWID and MSM, which tend to be smaller, more concentrated and with a higher individual risk of infection. This would not, and should not, remove the provision of testing and treatment for low risk individuals actively seeking care.

- **Investment into FSW programs could be maintained, but the proportion of total spending reduced from current levels**.

  Programs to reduce HIV among FSW in the Bulgarian context were estimated to be less cost-effective than programs targeted at PWID or MSM in the current epidemic context. HIV prevalence and incidence among FSW are relatively low. The optimization analysis therefore suggests that the annual investment to FSW programs from HIV funding should be reduced as a proportion of the total budget. However, the wider public health benefits (beyond HIV) of programs targeting FSWs are not accounted for in this model and there is likely to be a strong public health argument for the continued provision of FSW services from other health funds.

The model suggests that allocating current funding differently, could further reduce the spread of the epidemic when compared with the current budget allocation. However, with a larger budget envelope it may be possible to avert additional new infections and deaths. The potential gains of increased investment in HIV programs are described further in the following section.

Figure 6.1 Comparison of current and optimized budget allocation to minimize both new infections and deaths for the period of 2015–30



Source: Authors

Table 6.1 Current and optimized budget allocations (2014 level of HIV spending)

	Current allocation	%	Optimized allocation
SBCC	$ 499,820	3.38%	$ 2,559
FSW programs	$ 590,398	3.99%	$ 2,518
MSM programs	$ 250,276	1.69%	$ 304,336
PWID programs	$ 368,083	2.49%	$ 1,623,076
OST	$ 204,550	1.38%	$ 492,679
ART	$ 8,342,875	56.39%	$ 8,342,875
HTS general	$ 777,354	5.25%	$ 240,978
Prisoner programs	$ 21,473	0.15%	$ 45,808
Roma program	$ 350,821	2.37%	$ 350,821
MGMT	$ 433,876	2.93%	$ 433,876
ENV	$ 545,190	3.68%	$ 545,190
M&E	$ 390,047	2.64%	$ 390,047
Other	$ 1,433,741	9.69%	$ 1,433,741
Care	$ 516,386	3.49%	$ 516,386
Case mgt	$ 71,270	0.48%	$ 71,270
Total	**$ 14,796,161**	**100.00%**	**$ 14,796,161**

Source: Authors

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7. WHAT MIGHT BE GAINED OR LOST FROM CHANGES IN HIV SPENDING AND ALLOCATION?

In this analysis, optimized allocations to programs and the corresponding impact are compared for different levels of funding. Specifically, this analysis considers what could be gained by increasing the HIV budget from the 2014 budget levels. Conversely, the analysis also considers which programs would have the largest impact on the epidemic if less funding was available and the response needed to be further rationalised.

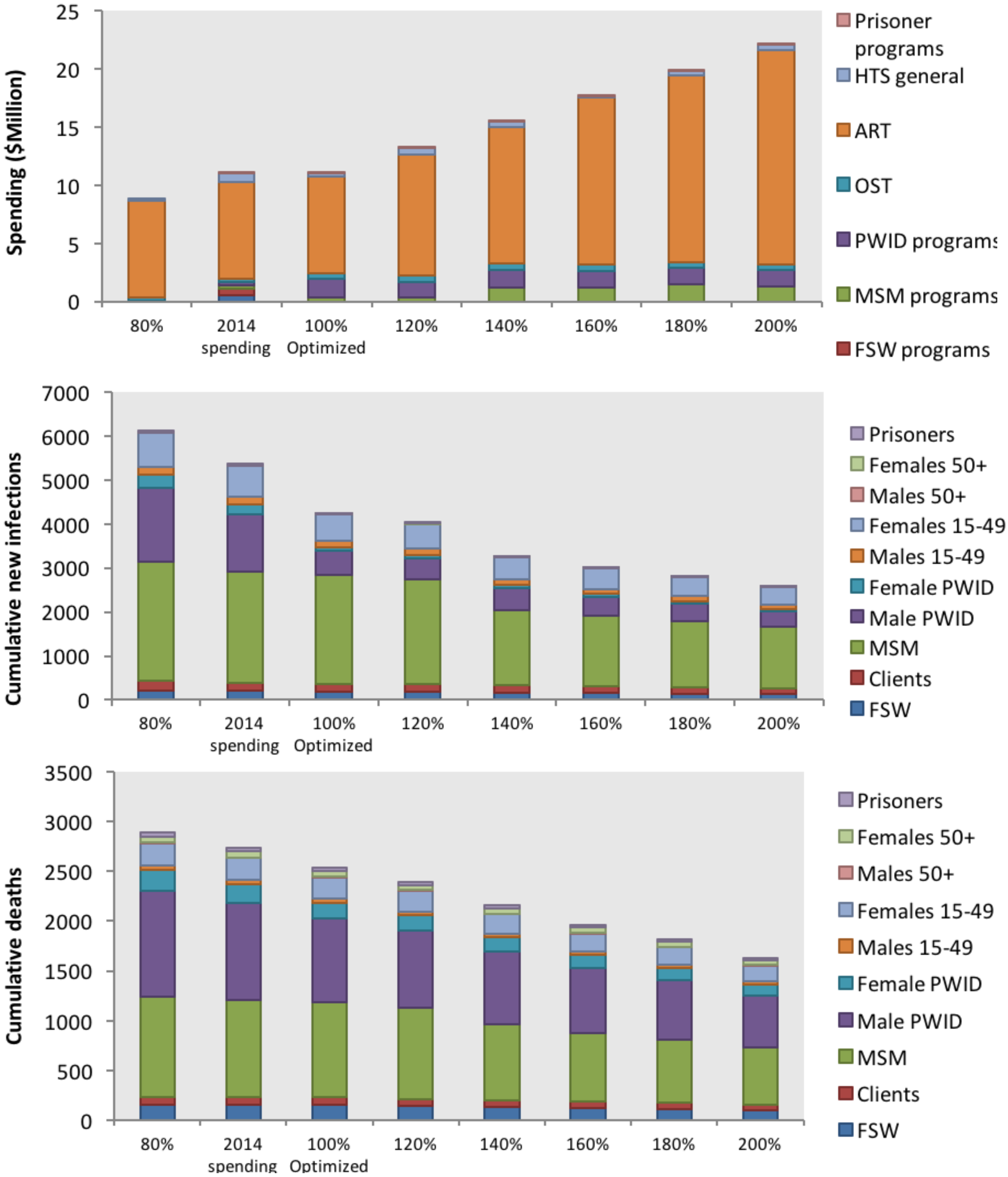
If future funding is below the 2014 funding level, optimization suggests that ART, OST and MSM programs should be given first priority. This finding is the result of a combination of factors. ART is essential to minimize AIDS related deaths and contributes to reducing HIV incidence. For prevention, increasing condom use among MSM and PWID are epidemiologically important factors given the key role of these two populations in HIV transmission. These results are also partially due to the fact that the model construct protects funding for ART and OST services. This is based on the rationale that nobody on ART or OST should be taken off treatment.

With budgets between 100% and 200% of 2014 program spending, optimization suggests that investment should continue to be focused on ART, OST and programs for key, high-risk populations such as MSM and PWID. Spending on key populations with lower HIV incidence (such as FSWs) and programs for the low-risk general population (such as, SBCC and HTS), are only recommended at higher multiples of the current budget i.e. when optimized spending is approximately 200% of the 2014 program budget. These two spending options are compared in more detail in **Figure 7.1** below. By increasing investment into direct programs from US$11 million to US$22 million, and optimally allocating these funds, Bulgaria could avert 2,800 new infections (-52%) and 1,100 deaths (-40%) by 2030, compared with the current allocation of resources.

This analysis clearly shows that increased and optimally allocated spending on HIV programs will continue to yield incremental gains in terms of new infections and deaths averted (see **Figure 7.1**). However, considering that ART provision in the context of Bulgaria is both relatively expensive and constitutes a substantial proportion of the HIV response, technical efficiency gains need to be explored for this intervention.

It should be noted that the following figures present increases in spending for the program budgets to 120 %, 150 % and 200%, not increases in the total HIV response budgets. It was assumed that the indirect cost for management and enablers will be stable and these were therefore fixed as US$ amounts.

Figure 7.1 Optimized allocations to minimize HIV incidence and deaths by 2030 at different budget levels (2014 budget)



Source: Authors
Note: Only optimized costs are scaled whereas non-optimized spending remains at current levels.

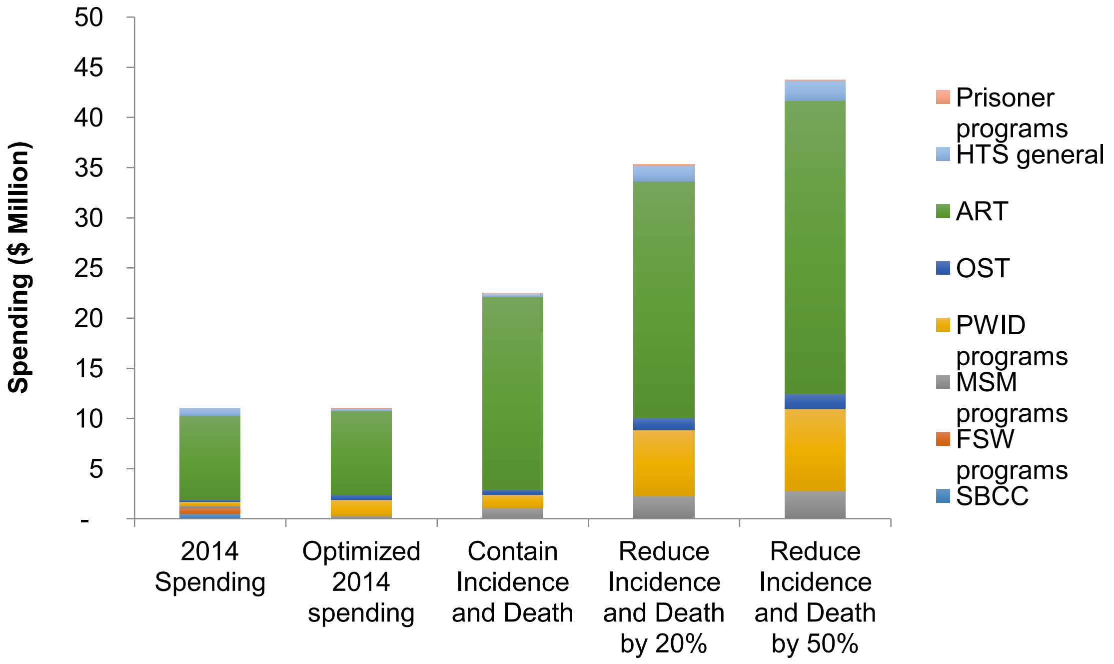
8. HOW MUCH WILL IT COST TO ACHIEVE THE PROPOSED TARGETS OF THE NATIONAL HIV STRATEGIC PLAN?

This analysis identifies the minimum resource requirements to achieve the proposed national strategy targets and other long-term programme commitments, described in **Section 2**. The analyses in **Section 6** assumed fixed amounts of available funding and explored an optimized allocation of those funds, to minimize new infections and deaths with the current budget. In **Section 7**, the analyses explored the likely gains from increased investment in the HIV response. In contrast, the analysis in this section aims for the full achievement of the possible National HIV Strategic Plan targets, and determines minimum budget required to achieve those goals under an optimized allocation. As the final National HIV Strategic Plan targets have not yet been confirmed in Bulgaria at the time of this study, this analysis was run to establish how much funding would be required to a) contain the current incidence and death values, b) reduce new infections and deaths by 20% and c) reduce new infections and deaths by 50%.

Figure 8.1 below, shows 2014 spending, the optimized allocation of 2014 spending and the minimum spending required with an optimal allocation to achieve the three targets described above. The model results in this section suggest that maintaining the current incidence and death values could be achieved with an annual spend of $26.2 million, nearly double the current 2014 spend. In order to achieve the second target i.e. reducing new infections and deaths by 20%, the model estimates that an estimated annual spend of around $39 million is required. Similarly, reducing new infections and deaths by 50% could be achieved with annual spending of around $47.5 million.

In order to achieve these targets, the model findings recommend increased investments in ART, OST, MSM, PWID, prisoner, and HTS programs. In particular, the analysis recommends a substantial increase in investment in PWID and MSM programs in order to achieve the proposed targets. For example, the model suggests increasing investment in MSM four-fold to stabilize outcomes, and eight-fold to reduce incidence and deaths by 20%. A ten-fold increase is required to reduce incidence and deaths by 50%.

Figure 8.1 Minimum annual programmatic spending required to meet proposed National Strategy targets



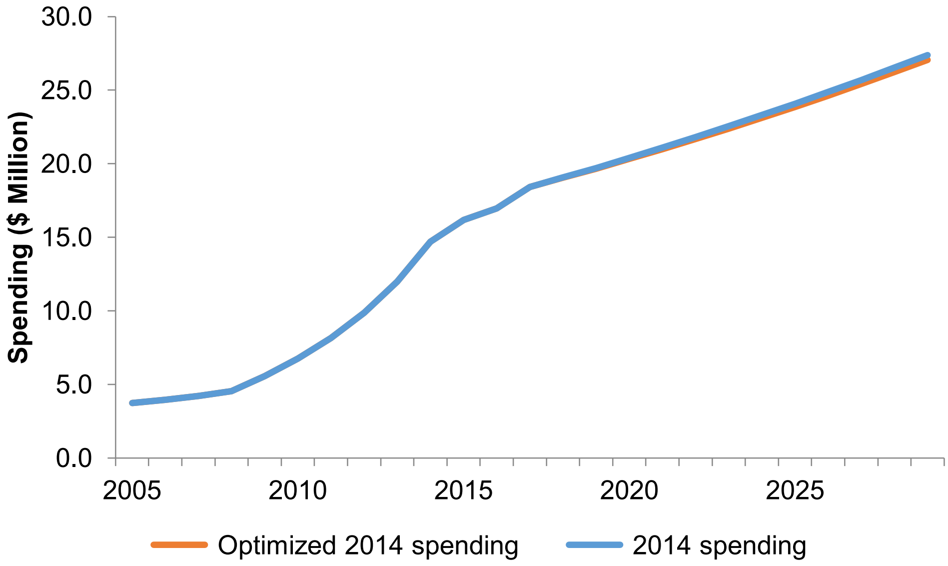
Source: Authors

9. WHAT IS THE LONG-TERM FINANCIAL COMMITMENT TO HIV SERVICES FOR PLHIV?

This analysis reviews the long-term impact of current and optimized investment choices, assuming that an annual spend of USD$14.8 million is maintained. In other words, it estimates long-term financial commitments as liabilities arising from the commitment to provide HIV and related health services to PLHIV in the future. In monetary terms, a financial commitment is the discounted cost of providing HIV services for PLHIV in a particular year. It includes HIV treatment costs, HIV related health care costs and social mitigation costs.

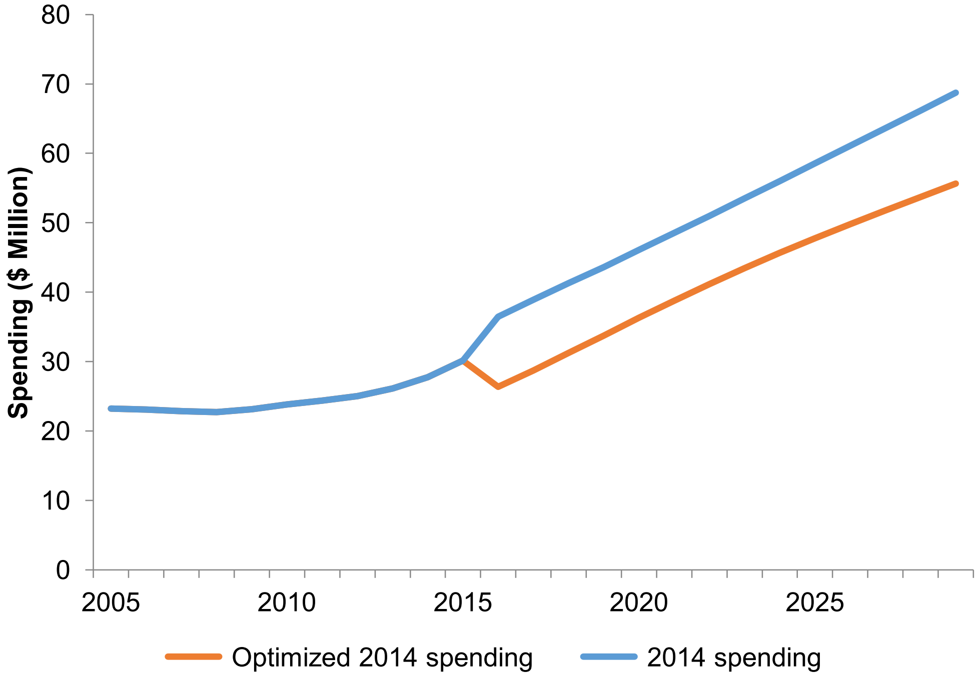
Figure 9.1 describes the annual costs for HIV treatment and HIV related care derived from the expected number of PLHIV between 2016 and 2030, comparing the current allocation of 2014 spending against the optimized allocation described in **Section 6**. The model predicts that the costs of the national response will rise under both allocations, driven by the increases in the total number of PLHIV. The analysis estimates that optimizing current allocations could save around $2.2 million (around 1%) compared to the current, non-optimized allocation (**Figure 9.1**). This suggests that although the optimized allocation will keep more PLHIV alive, the total long-term cost for the response is lower due to reduced new infections and reduced HIV related health care through reduced opportunistic infections. The analysis also suggests that financial commitments caused by new infections i.e. life-time HIV care costs for newly diagnosed PLHIV under the optimized allocation of current spending (cumulatively around $584 million) will be approximately US$149 million or 26% lower than under the current allocation at an estimated US$734 million (**Figure 9.2**).

Figure 9.1 Annual HIV related spending for all (new and old) HIV infections up to 2030



Source: Authors

Figure 9.2 Annual HIV related spending for all new HIV infections up to 2030



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10. CONCLUSIONS

1 **The Bulgarian government has implemented an effective HIV response to date, managing a concentrated HIV epidemic. At the Bulgarian government may be able to better allocate HIV spending to further minimize HIV incidence, prevalence and HIV-related deaths.**

2 To assess HIV epidemic trends, we used Optima's epidemic module, calibrated to HIV prevalence data points available for different sub-populations in Bulgaria, including key populations. The model was also calibrated to data points on the number of people on ART from available data sources and in consultation with Bulgarian experts. **Analyses using this model highlight a strong risk that prevalence and incidence will continue to increase overall in Bulgaria, in spite of current efforts to contain the epidemic.**

3 **The expected overall increase in the epidemic appears to be driven by incidence and prevalence among PWID and MSM, key populations that currently only receive a small portion of prevention funding.** While improvements have been made regarding condom use, interventions targeting these key populations need to be strengthened. Prevention programs targeting these populations are most at risk during the transition out of Global Fund support, as these programs have been funded with donor funds in the past.

4 **An optimized allocation of current funding may reduce long-term financial commitments to the HIV response by containing HIV incidence and prevalence.** Most importantly, the analysis suggests that optimized allocations – despite increasing treatment coverage – will not increase long-term cost due to the reductions in new HIV infections achieved through optimized allocations compared to business as usual.

5 These analyses suggested that diverting **funding away from HIV testing in the general population, towards prevention among MSM and PWID, would improve the efficiency of current spending levels.** This could reduce new infections, deaths and future costs.

6 **The FSW epidemic is relatively contained in Bulgaria due to significant and prolonged efforts to target this population.** However, wider experience with the epidemic and knowledge of the limitations of the Optima model as described in Section 2, suggest that this strategy should be followed with caution as; i) the gains from past spending on this population may be eroded over time and ii) wider public health benefits of investment in programs for this population, for example in relation to other sexually transmitted infections, may be underestimated by Optima-HIV.

7 While these analyses advocate for the increased targeting of MSM and PWID, this alone will not be sufficient to contain the epidemic, even at increased funding levels. As such, **key populations should be reached as far as possible with strong preventive efforts, complemented by comprehensive test-and-treat programs.**

8 **Additional domestic resources will be needed to sustain the HIV response after the withdrawal of Global Fund support.** Funding for HIV in Bulgaria has increased since 2007. However, apart from ART, preventive programs and programs focused on key populations are primarily funded by international donors. As such, the withdrawal of international funding without a concurrent increase in domestic resources, will have a significant negative impact on the HIV epidemic in Bulgaria.

9 Transitional funding mechanisms need to be explored with the aim of raising domestic funding to at least the level of the current total budget for the HIV response. **International donor funding must be replaced with alternate funding, and all funding should be spent on an optimal mix of programs targeted at key populations and the scale-up of ART delivery.**

10 **Effective ART scale-up is needed, with a strong focus on HIV diagnosis in key populations.** Coverage must be increased if global targets are to be met: In 2014, 23% of Bulgaria's estimated 3,100 people living with HIV received treatment, compared with a global target of 81% by 2020.

11 **Comparing the unit costs of care in Bulgaria, with data from other countries in the region, suggests that greater technical efficiency in spending might be achieved through strategies to reduce the average spend per person reached.** This is particularly relevant for ART programs. Care should be taken however, that these strategies do not compromise the quality of prevention or treatment and further analyses of technical efficiency are needed before more robust conclusions can be reached.

By describing the likely trajectories of the HIV epidemic under different conditions, highlighting areas of particular risk in the short- to medium-term, and suggesting ways to incrementally improve the efficiency of current spending, these suggestions should assist Bulgaria with their response to the HIV epidemic. Modelling the epidemic highlighted the significant gains already achieved with current spending in the form of new infections and deaths averted. However, analyses of what may be needed to achieve the proposed targets of the National Strategic Plan have identified a need for increased investment in an optimized HIV response in Bulgaria, unless costs for ART can be substantially reduced.

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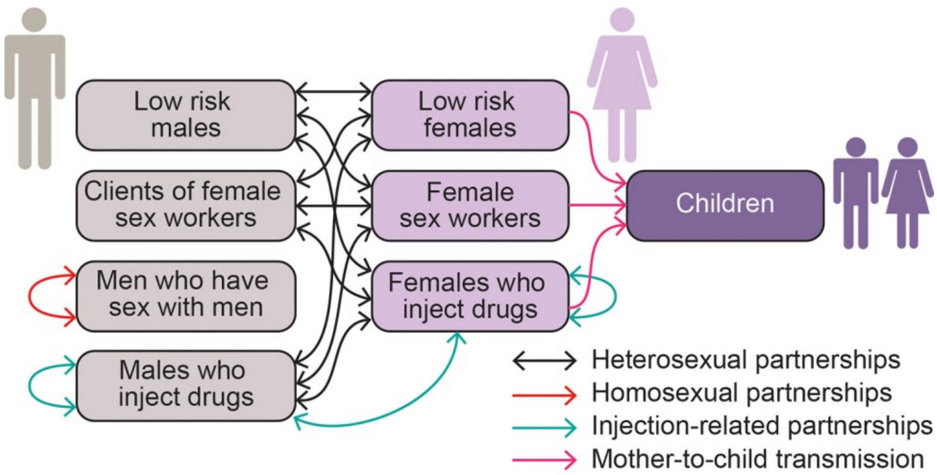
11. APPENDIXES

APPENDIX A TECHNICAL SUMMARY OF OPTIMA

Appendix A provides a brief technical overview of Optima. A more detailed summary of the model and methods is provided elsewhere (Kerr and others 2015). Optima is based on a dynamic, population-based HIV model. **Figure A.1A** summarizes the populations and mixing patterns used in Optima. **Figure A.1B** shows the disease progression implemented in the model. Optima tracks the entire population of people living with HIV (PLHIV) across 5 stages of CD4 count. These CD4 count stages are aligned with the progression of the World Health Organization (WHO) treatment guidelines, namely, acute HIV infection, >500, 350–500, 200–350, 50–200, and 50 cells per microliter. Key aspects of the antiretroviral therapy (ART) service delivery cascade are included: from infection to diagnosis, ART initiation on first-line therapy, treatment failure, subsequent lines of therapy, and HIV/AIDS-related or other death.

Figure A.1A Example population groups and HIV transmission-related interactions in Optima



Source: Graphic prepared by UNSW study team.

The model uses a linked system of ordinary differential equations to track the movement of PLHIV among HIV health states. The full set of equations is provided in the supplementary material to a summary paper on the Optima model. The overall population is partitioned in two ways: by population group and by HIV health state. Individuals are assigned to a given population group based on their dominant risk.[52] HIV infections occur through the interactions among different populations by regular, casual, or commercial (including transactional) sexual partnerships; through sharing of injecting equipment; or through mother-to-child transmission. The force-of-infection is the rate at which uninfected individuals become infected. The rate depends on the number and type of risk events to which individuals are

52 However, to capture important cross-modal types of transmission, relevant behavioral parameters can be set to non-zero values (for example, males who inject drugs may engage in commercial sex; some MSM may have female sexual partners).

exposed in a given period (either within their population groups or through interaction with other population groups) and the infection probability of each event. Mathematically, the force of- infection has the general form:

$$\lambda = 1 - (1 - \beta)^{n},$$

where λ is the force-of-infection, β is the transmission probability of each event, and n is the effective number of at-risk events (that is, n gives the average number of interaction events with HIV-infected people through which HIV transmission may occur). The value of the transmission probability β varies across CD4 count compartments (indirectly reflecting the high viral load at early and late stages of infection); differs for different modes of transmission (intravenous drug injection with a contaminated needle-syringe, penile-vaginal or penile-anal intercourse, and mother-to-child); and may be reduced by behavioral interventions (for example, condom use), biological interventions (for example, male circumcision), or ART. There is one force-of-infection term for each type of interaction, for example, casual sexual relationships between male sex workers and female sex workers (FSW). The force-of-infection for a given population will be the sum of all interaction types.[53] In addition to the force-of-infection rate, which is the number of individuals who become infected with HIV per year, there are seven other ways by which individuals can change health states.[54] The change in the number of people in each compartment is determined by the sum over the relevant rates described above multiplied by the population size of the compartments on which they act.[55]

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53 For sexual transmission, the force-of-infection is determined by:

- HIV prevalence (weighted by viral load) in partner populations
- Average number of casual, regular, and commercial homosexual and heterosexual acts per person per year
- Proportion of these acts in which condoms are used
- Proportion of men who are circumcised
- Prevalence of sexually transmissible infections (which can increase HIV transmission probability)
- Proportion of acts that are covered by pre-exposure prophylaxis and post-exposure prophylaxis
- Proportion of partners on antiretroviral treatment (art)
- Efficacies of condoms, male circumcision, post-exposure prophylaxis, pre-exposure prophylaxis, and art at preventing HIV transmission.

For injecting-related transmission, the force-of-infection is determined by:

- HIV prevalence (weighted by viral load) in populations of people who use a syringe and then share it
- Number of injections per person per year
- Proportion of injections made with shared equipment
- Fraction of people who inject drugs on opioid substitution therapy and its efficacy in reducing injecting behavior.

For mother-to-child transmission, the number of-infections is determined by:

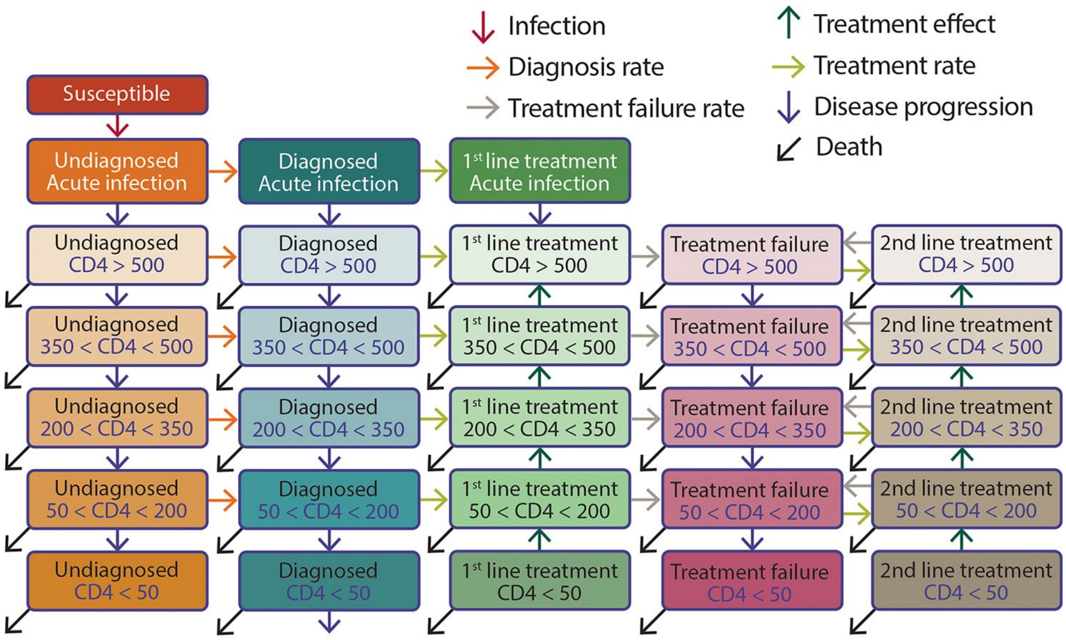
- Birth rate among women living with HIV
- Proportion of women with HIV who breastfeed
- Probability of perinatal HIV transmission in the absence of intervention
- Proportion of women receiving prevention of mother-to-child transmission (PMTCT), including ART.

54 First, individuals may die, either because of an average background death rate for that population (which is greater for older populations or for people who inject drugs) or because of HIV/AIDS (which depends on CD4 count). Second, in the absence of treatment, individuals progress from higher to lower CD4 counts. Third, individuals can move from undiagnosed to diagnosed states based on their HIV testing rate, which depends on CD4 count (for example, people with AIDS symptoms or primary HIV infection may have a higher testing rate) and population type (for example, FSW may test more frequently than males in the general population). Fourth, diagnosed individuals may commence ART at a rate depending on CD4 count. Fifth, individuals may experience treatment failure due to lack of adherence to therapy or development of drug resistance. Sixth, people may initiate second and subsequent lines of treatment after treatment failure. Finally, while on successful first- or second-line treatment (that is, effective viral suppressive therapy), individuals may progress from lower to higher CD4 counts.

55 For example, the change in the number of undiagnosed HIV-positive FSW with a CD4 count between 200–350 cells per microliter is:

$$\frac{dU_{\mathrm{FSW}_{200-350}}}{dt} = U_{\mathrm{FSW}_{350-500}} \tau_{350-500} - U_{\mathrm{FSW}_{200-350}} \left(\mu_{200-350} + \tau_{200-350} + \eta_{\mathrm{FSW}_{350-500}}\right),$$

Figure A.1B Schematic diagram of the health state structure of the model



Source: Figure prepared by UNSW study team.

Note: Each compartment represents a single population group with the specified health state. Each arrow represents the movement of numbers of individuals among health states. All compartments except for "susceptible" represent individuals living with HIV. Death includes all causes of death.

Each compartment (Figure A.1b, boxes) corresponds to a single differential equation in the model, and each rate (Figure A.1b, arrows) corresponds to a single term in that equation. Table A.1 lists the parameters used in Optima; most of these are used to calculate the force of infection. The analysts interpret empirical estimates for model parameter values in Bayesian terms as previous distributions. The model then must be calibrated: finding posterior distributions of the model parameter values so+ that the model generates accurate estimates of HIV prevalence, the number of people on treatment, and any other epidemiological data that are available (such as HIV-related deaths). The calibration can be performed automatically, manually, or a combination. Model calibration and validation normally should be performed in consultation with governments in the countries in which the model is being applied.

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where UFSW2002350 is the current number of undiagnosed HIV-positive FSW with a CD4 count between 200–350 cells per microliter; UFSW3502500 is the same population but with higher CD4 count (350–500 cells/mL); t is the disease progression rate for the given CD4 count (where 1/t is the average time to lose 150 CD4 cells/mL); m is the death rate; and h is the HIV testing rate. (Note: This example does not consider movement among populations, such as FSW returning to the general female population and vice versa—something which is included in Optima.)

Table A.1 Input parameters of the model

	Biological parameters	Behavioral parameters	Epidemiological/Other parameters
Population parameters	Background death rate		Population sizes (T, P)
HIV-related parameters	Sexual HIV transmission probabilities* STI-related transmissibility increase* Condom efficacy* Circumcision efficacy* HIV health state progression rates (H) HIV-related death rates (H)	Number of sexual partners* (T, P, S) Number of acts per partner* (S) Condom usage probability* (T, P) Circumcision probability* (T)	HIV prevalence (T, P) STI prevalence (T, P)
MTCT parameters	Mother-to-child transmission probability*	Birth rate* PMTCT access rate* (T)	
	Injecting HIV transmissibility* Syringe cleaning efficacy* Drug-related death rate	Number of injections* (T) Syringe sharing probability* (T) Syringe cleaning probability* Methadone treatment probability (T)	
Treatment parameters	ART efficacy in reducing infectiousness* ART failure rates	HIV testing rates (T, P, H)	Number of people on ART
Economic parameters	Health utilities		Costs of all prevention, care and treatment programs, enablers and management (T, I) Discounting and inflation rates (T) Health care costs

Source: UNSW study team.
Note: *=Parameter is used to calculate the force of infection; H=Parameter depends on health state; I=Parameter depends on intervention type; P=Parameter depends on population group; S=Parameter depends on sexual partnership type; T=Parameter value changes over time.

HIV Resource Optimization and Program Coverage Targets

A novel component of Optima is its ability to calculate allocations of resources that optimally address one or more HIV-related objectives (for example, impact-level targets in a country's HIV national strategic plan). Because this model also calculates the coverage levels required to achieve these targets, Optima can be used to inform HIV strategic planning and the determination of program coverage levels. The key assumptions of resource optimization are the relationships among (1) the cost of HIV programs for specific target populations, (2) the resulting coverage levels of targeted populations with these HIV programs, and (3) how these coverage levels of HIV programs for targeted populations influence behavioral and clinical outcomes. Such relationships are required to understand how incremental changes in spending (marginal costs) affect HIV epidemics.[56] Logistic functions can incorporate initial

[56] A traditional approach is to apply unit cost values to inform a linear relationship between money spent and coverage attained. This assumption is reasonable for programs such as an established ART program that no longer incurs start-up or initiation costs. However, the assumption is less appropriate for condom promotion and behavior change communication programs. Most HIV programs typically have initial setup costs, followed by a more effective scale-up with increased funding. However, very high coverage levels have saturation effects because these high levels require increased incremental costs due to generating demand and related activities for the most difficult-to-reach groups. Optima uses a logistic function fitted to available input data to model cost–coverage curves (Appendix 2).

start-up costs and enable changes in behavior to saturate at high spending levels, thus better reflecting program reality. The logistic function has the form:

$$L(x) = A + \frac{B - A}{1 + e^{-(x-C)/D}},$$

where L(x) relates spending to coverage; x is the amount of funding for the program; A is the lower asymptote value (adjusted to match the value of L when there is no spending on a program); B is the upper asymptote value (for very high spending); C is the midpoint; and D is the steepness of the transition from A to B. For its fits, the team typically chose saturation values of the coverage to match behavioral data in countries with heavily funded HIV responses.[57] To perform the optimization, Optima uses a global parameter search algorithm called Bayesian adaptive locally linear stochastic descent (BALLSD). BALLSD is similar to simulated annealing in that it makes stochastic downhill steps in parameter space from an initial starting point. However, unlike simulated annealing, BALLSD chooses future step sizes and directions based on the outcome of previous steps. For certain classes of optimization problems, the team has shown that BALLSD can determine optimized solutions with fewer function evaluations than traditional optimization methods, including gradient descent and simulated annealing.

While all HIV interventions have some direct or indirect non-HIV benefits, some programs including opiate substitution therapy (OST) or conditional cash transfers, have multiple substantial proven benefits across different sectors. Such additional benefits were reflected by using the approach of a cross-sectoral financing model to effectively distribute the costs in accordance with the benefits. By adapting standard techniques from welfare economics to attribute the benefits of OST programs across the benefiting sectors, it was estimated that average HIV-related benefits are approximately only 10 percent of the overall health and social benefits of OST. Therefore, only 10 percent of the OST cost was included in the optimization analysis.

Uncertainty Analyses

Optima uses a Markov chain Monte Carlo (MCMC) algorithm for performing automatic calibration and for computing uncertainties in the model fit to epidemiological data. With this algorithm, the model is run many times (typically, 1,000–10,000) to generate a range of epidemic projections. Their differences represent uncertainty in the expected epidemiological trajectories. The most important assumptions in the optimization analysis are associated with the cost-coverage and coverage-outcome curves. To incorporate uncertainty in these curves, users define upper and lower limits for both coverage and behavior for no spending and for very high spending.[58]

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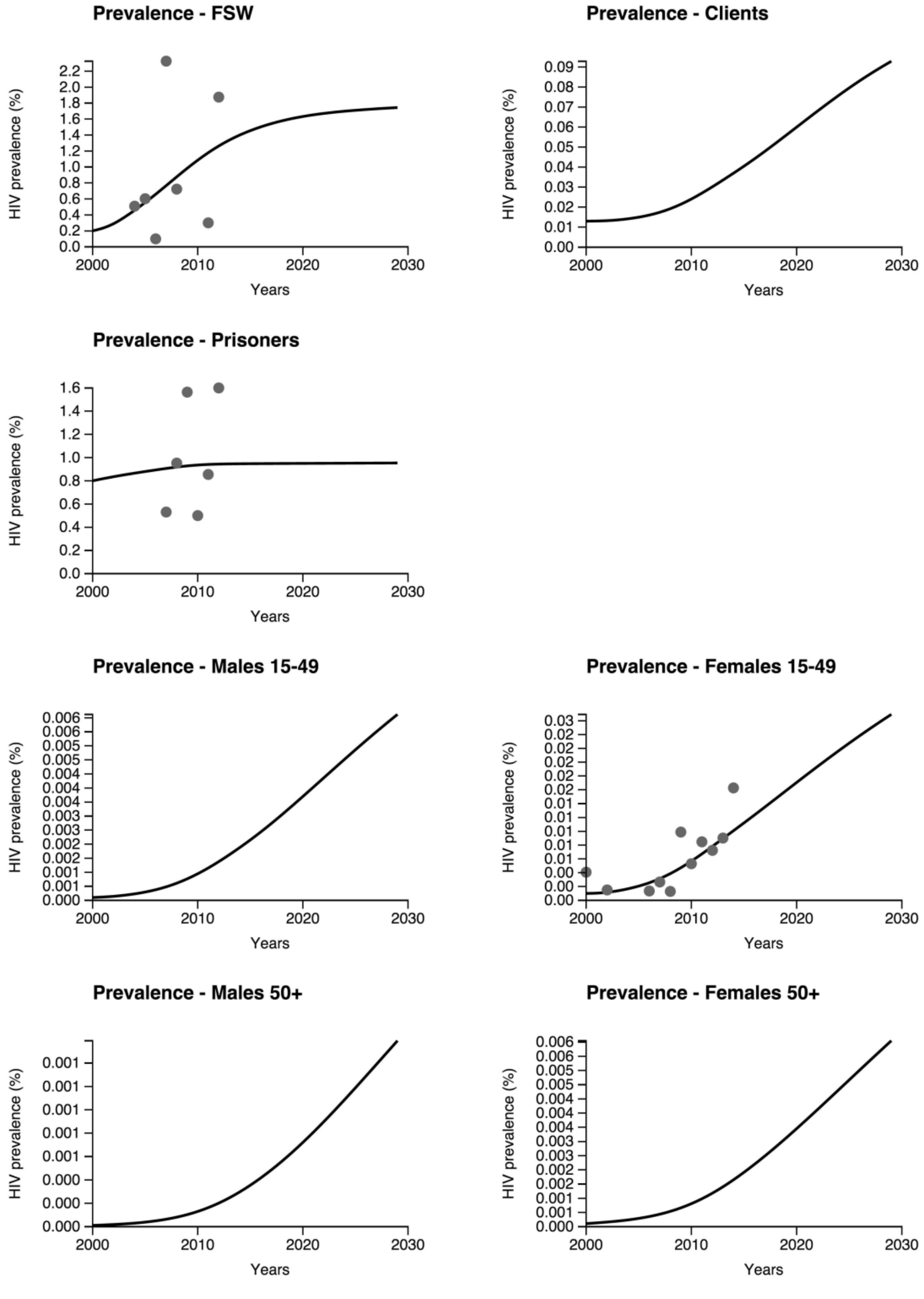
57 Program coverage for zero spending, or behavioral outcomes for zero coverage of formal programs, is inferred using data from early on in the epidemic or just before significant investment in HIV programs. Practically, the team also discussed the zero and high spending cases with local experts, who could advise on private sector HIV service delivery outside the governments' expenditure tracking systems. For each HIV program, the team derived one set of logistic curves that related funding to program coverage levels and another set of curves (generally, linear relationships) that related coverage levels to clinical or behavioral outcomes (the impacts that HIV strategies aim to achieve).

58 All available historical spending data and achieved outcomes of spending, data from comparable settings, experience, and extensive discussion with stakeholders in the country of application can be used to inform these ranges. All logistic curves within these ranges then are allowable and are incorporated in Optima uncertainty analyses. These cost-coverage and coverage-outcome curves thus are reconciled with the epidemiological, behavioral, and biological data in a Bayesian optimal way, thereby enabling the calculation of unified uncertainty estimates.

APPENDIX B CALIBRATION FIGURES

Figure B1 Calibration of HIV prevalence among key populations[59]



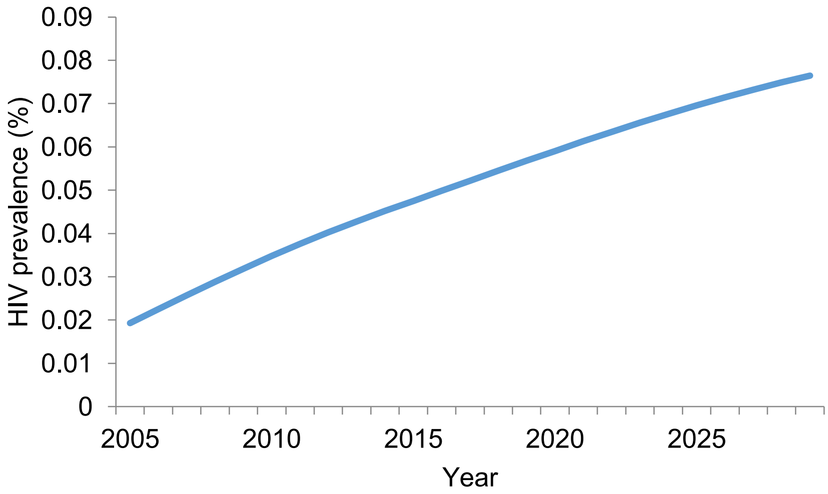
Source: Authors.

Relatively late diagnosis of PLHIV suggests that there may be a higher number of PLHIV than currently diagnosed. The stabilization of the curve for PWID is driven by the trends in the number of newly registered PLHIV among PWID as well as behavioral data and risk reduction such as reduced needle sharing. The data points for FSW are fairly variable but suggest a stabilizing trend, also supported by behavioral data and high reported condom use. The

[59] Black dots represent available data for the number of people on ART. Lines attached to these discs represent uncertainty bounds. The solid curve is the best fitting simulation of total ART patient numbers.

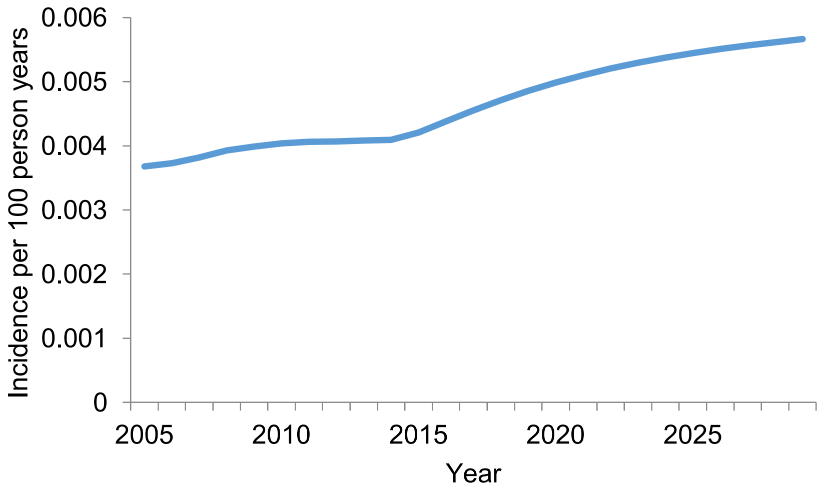
increase in prevalence among MSM was established based on the trend indicated by the number of newly registered PLHIV among this population.

Figure B2 Calibrated overall Incidence of HIV



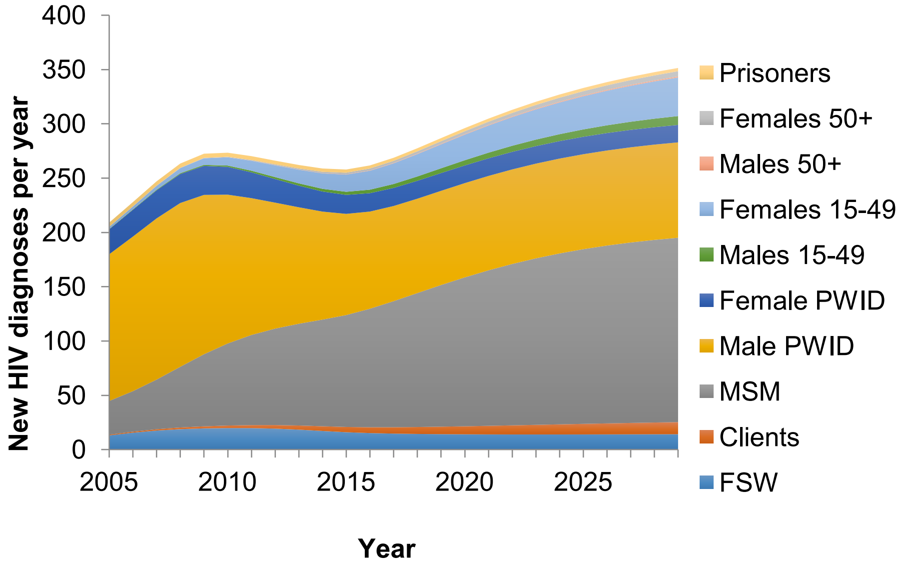
Source: UNSW study team.

Figure B3 Calibration of model to overall HIV prevalence



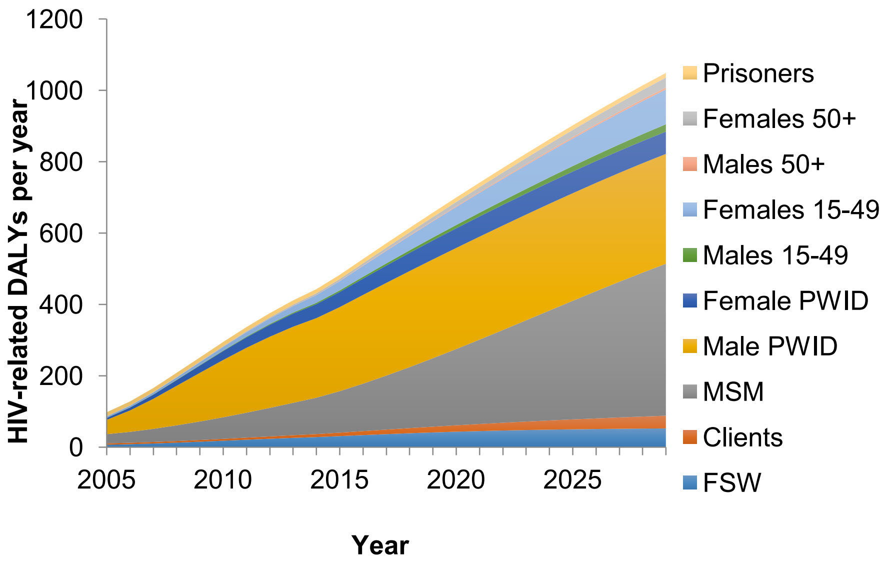
Source: UNSW study team.

Figure B4 Calibrated number of new HIV diagnoses



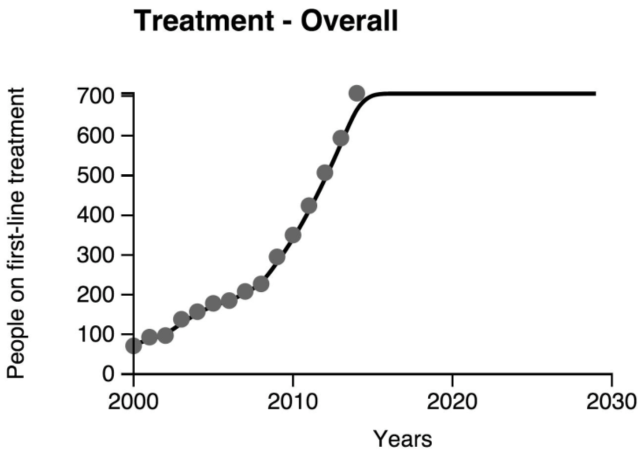
Source: UNSW study team.

Figure B5 Calibrated number of HIV-related DALYs



Source: UNSW study team.

Figure B6 Calibrated overall number of people on treatment



Source: UNSW study team.

APPENDIX C COST COVERAGE OUTCOME CURVES

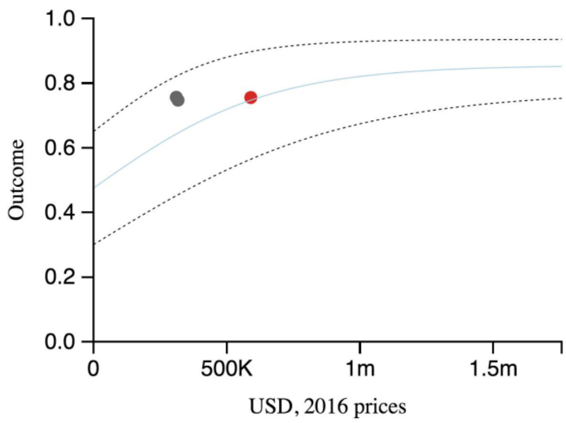
Table C1 Selected behaviors affected by HIV programs

HIV Program	Targeted Behavior
Programs for female sex workers and clients (package)	▪ Proportion of FSW who are tested for HIV each year ▪ Proportion of sexual acts in which condoms are used with commercial partners – FSW
Programs for men who have sex with men (package)	▪ Proportion of sexual acts in which condoms are used with casual partners by MSM ▪ Proportion of sexual acts in which condoms are used with commercial partners by MSM ▪ Proportion of MSM who are tested for HIV each year
Social and behavior change communication	▪ Proportion of sexual acts in which condoms are used with casual partners by males 15-49 ▪ Proportion of sexual acts in which condoms are used with casual partners by females 15-49
Opiate substitution therapy	▪ Number of people on OST
Needle-syringe program (NSP) and other prevention for PWID (package)	▪ Proportion of injections using receptively shared needle-syringes by male and female PWID ▪ Proportion of male and female PWID who are tested for HIV each year ▪ Proportion of sexual acts in which condoms are used with commercial partners by female PWID ▪ Proportion of sexual acts in which condoms are used with casual partners by male and female PWID
Programs prisoners (package)	▪ Proportion of prisoners who are tested for HIV each year ▪ Proportion of sexual acts in which condoms are used with casual partners by prisoners
HIV testing services	▪ Proportion of males 15 - 49 who are tested for HIV each year ▪ Proportion of females (15-49) who are tested for HIV each year - Females 15-49 ▪ Proportion of males (50+) who are tested for HIV each year] ▪ Proportion of females (50+) who are tested for HIV each year
Antiretroviral therapy	▪ Number of people on ART

Source: UNSW study team.

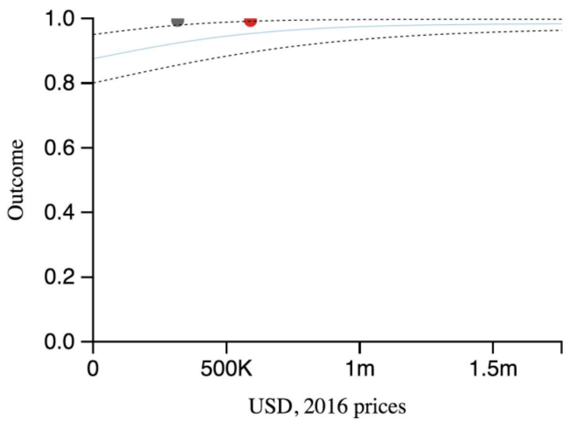
Cost-coverage outcome curves for FSW programs

Figure C1 FSW – proportion of people who are tested for HIV each year



Source: UNSW study team.

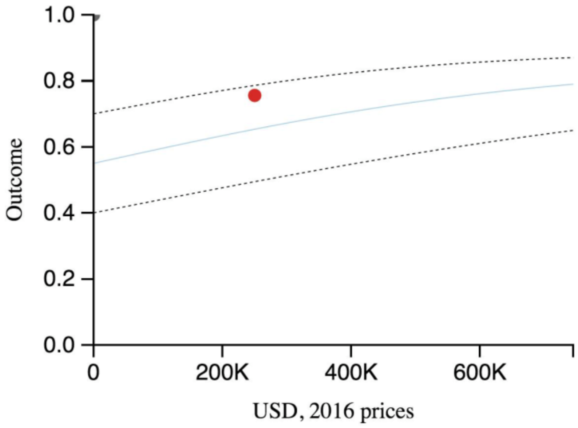
Figure C2 FSW – Proportion of sexual acts in which condoms are used with commercial partners (FSW)



Source: UNSW study team.

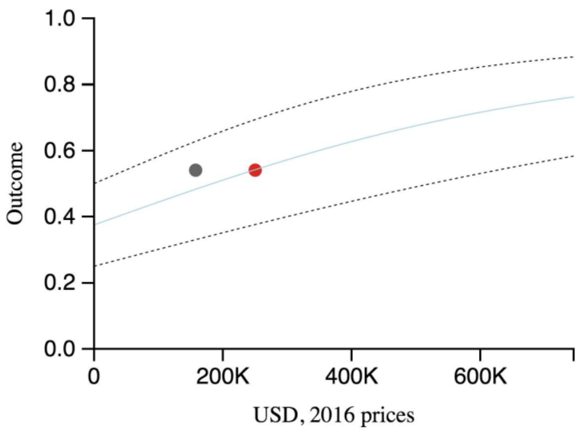
Cost-coverage outcome curves for MSM programs

Figure C3 MSM – proportion of sexual acts in which condoms are used with casual partners



Source: UNSW study team.

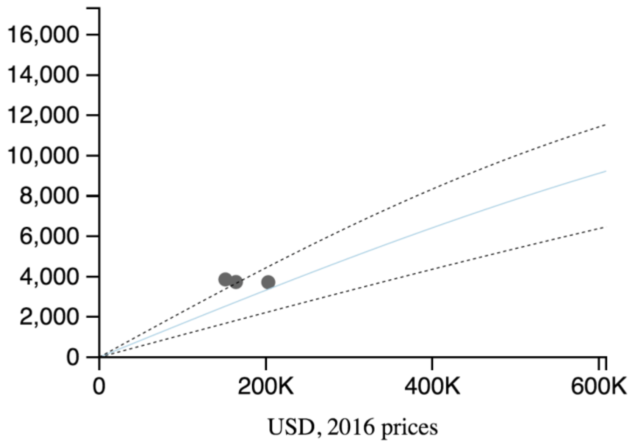
Figure C4 MSM – proportion of people who are tested for HIV each year



Source: UNSW study team.

Cost-coverage outcome curve for OST program

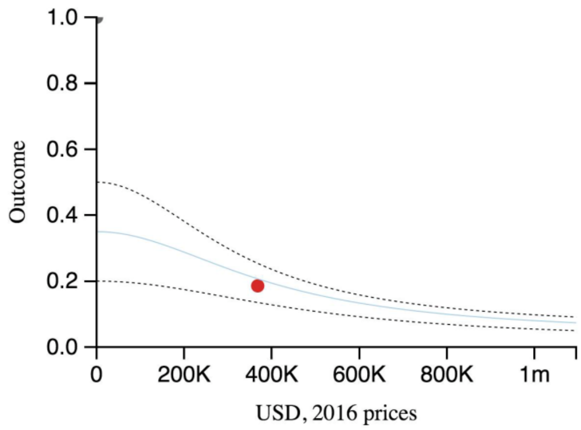
Figure C5 Opiate substitution therapy – number of people covered



Source: UNSW study team.

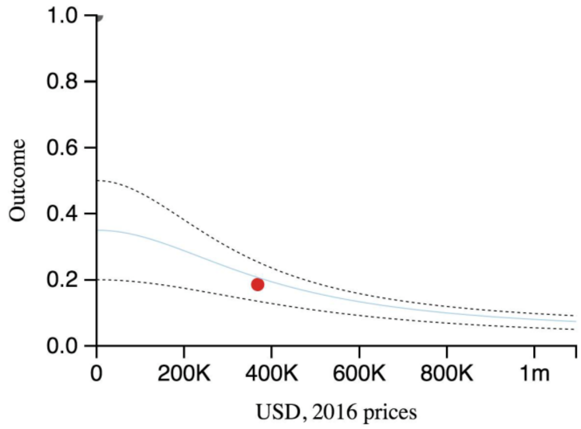
Cost-coverage outcome curve for needle-syringe program and other prevention for PWID

Figure C6 Male PWID – proportion of injections using receptively shared needle-syringes



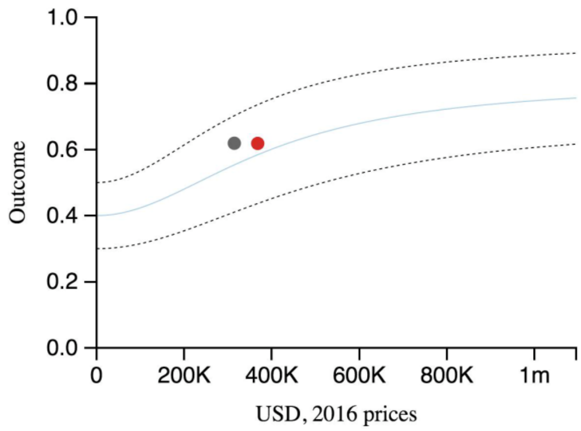
Source: UNSW study team.

Figure C7 Female PWID – proportion of injections using receptively shared needle-syringes



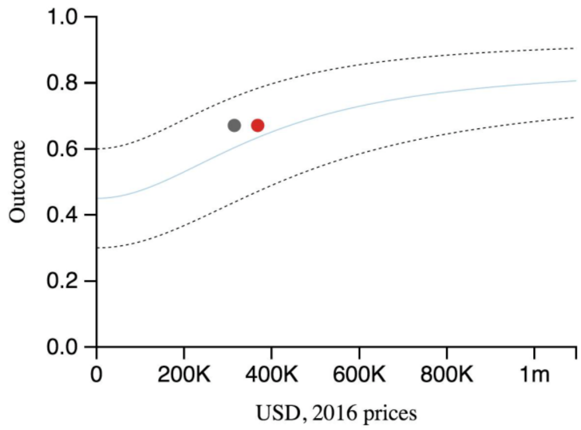
Source: UNSW study team.

Figure C8 Male PWID – proportion of people who are tested for HIV each year



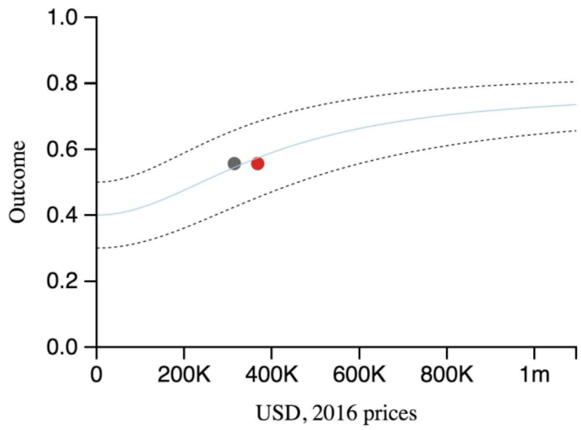
Source: UNSW study team.

Figure C9 Female PWID – proportion of people who are tested for HIV each year



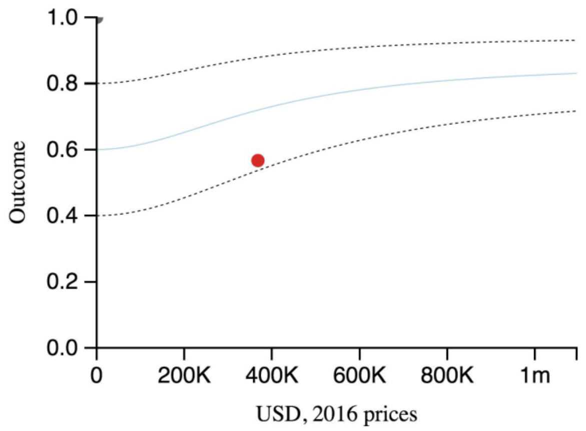
Source: UNSW study team.

Figure C10 Male PWID – proportion of sexual acts in which condoms are used with casual partners



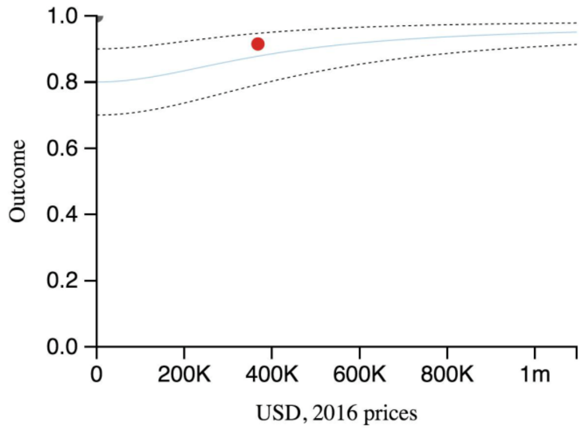
Source: UNSW study team.

Figure C11 Female PWID – proportion of sexual acts in which condoms are used with casual partners



Source: UNSW study team.

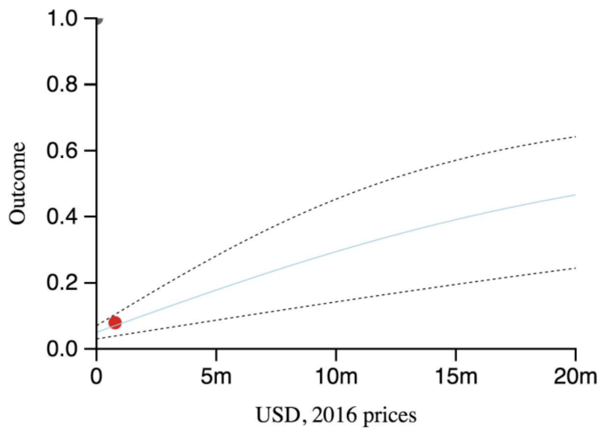
Figure C12 Female PWID – proportion of sexual acts in which condoms are used with commercial partners



Source: UNSW study team.

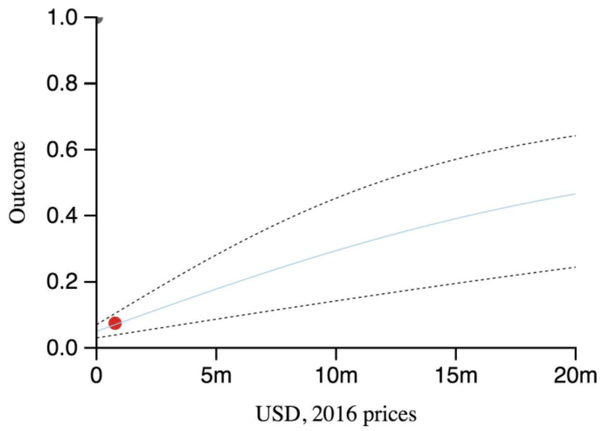
Cost-coverage outcome curves for HIV testing services program - general population

Figure C14 Males 15–49 population – proportion of people who are tested for HIV each year



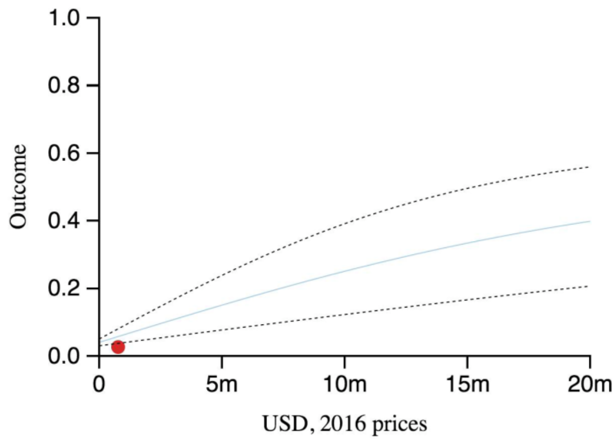
Source: UNSW study team.

Figure C15: Females 15–49 population – proportion of people who are tested for HIV each year



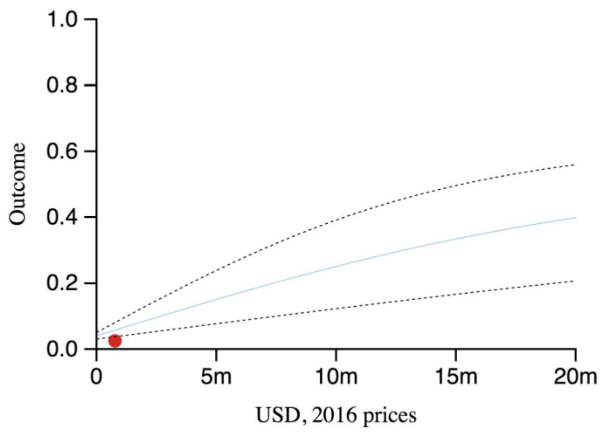
Source: UNSW study team.

Figure C16 Males 50+ population – proportion of people who are tested for HIV each year



Source: UNSW study team.

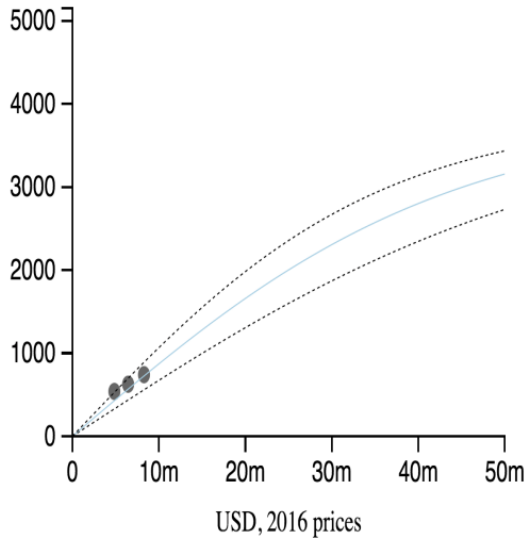
Figure C17 Females 50+ population - proportion of people who are tested for HIV each year



Source: UNSW study team.

Cost-coverage outcome curve for ART

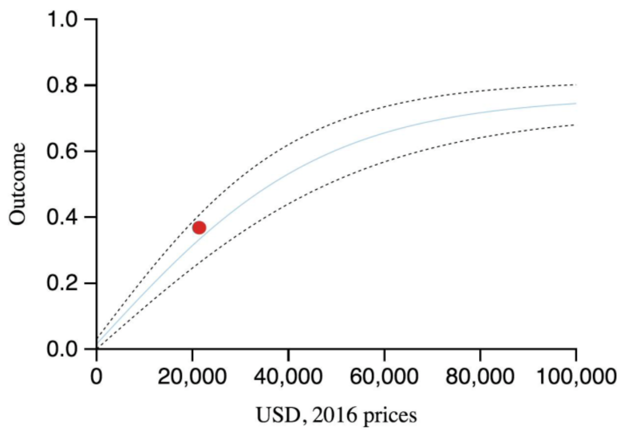
Figure C18 Antiretroviral therapy – number of people covered



Source: UNSW study team.

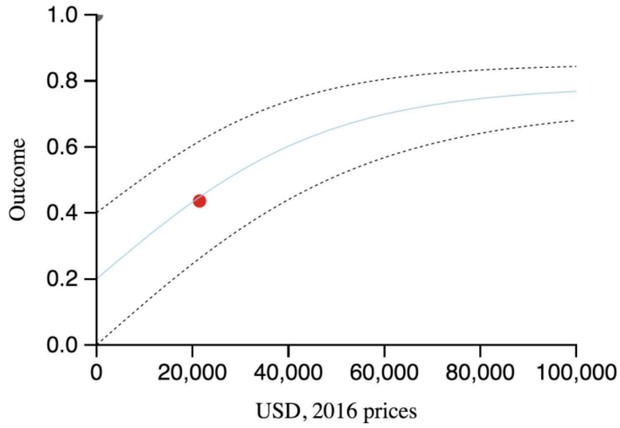
Cost-coverage outcome curve for prisoner programs

Figure C19 Prisoner population - proportion of people who are tested for HIV each year



Source: UNSW study team.

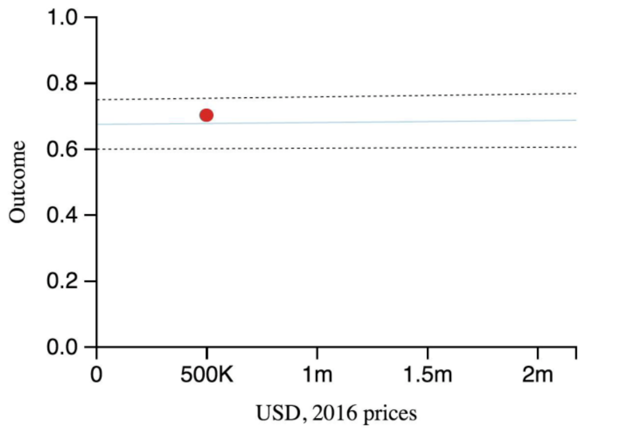
Figure C20 Prisoner population – proportion of sexual acts in which condoms are used with casual partners



Source: UNSW study team.

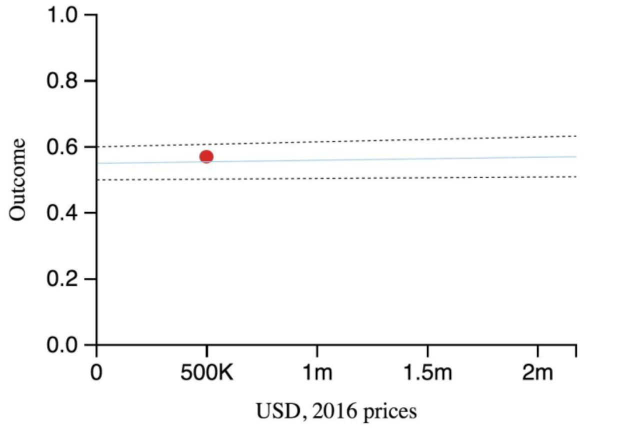
Figure C21 Males 15–49 – proportion of sexual acts in which condoms are used with casual partners

Cost-coverage outcome curve for SBCC program,



Source: UNSW study team.

Figure C22 Females 15–49 – proportion of sexual acts in which condoms are used with casual partners



Source: UNSW study team.

Appendix D Datatables

Table D1 Population size (Thousands)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Assumption
FSW	High	16	16	16	15	15	15	15	15	15	15	14	13	13	13	13	OR
	Best	15	14	14	14	14	14	14	14	13	13	13	12	12	12	12	OR
	Low	13	12	12	12	12	12	12	12	12	12	11	11	11	10	10	OR
Clients	High	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
	Best	197	189	188	187	186	185	183	182	180	177	174	167	165	163	161	OR
	Low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
MSM	High	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
	Best	35	37	67	66	66	66	65	65	64	63	62	60	59	59	58	OR
	Low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
Male PWID	High	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
	Best	17	17	16	16	16	16	16	16	16	15	15	15	15	14	14	OR
	Low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
Female PWID	High	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
	Best	5	5	5	5	5	5	5	5	5	4	4	4	4	4	4	OR
	Low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR
Males 15-49	Best	1,774	1,704	1,695	1,686	1,677	1,665	1,649	1,635	1,619	1,597	1,567	1,507	1,485	1,466	1,447	*OR*
Females 15-49	Best	1,979	1,890	1,881	1,872	1,863	1,850	1,834	1,817	1,798	1,772	1,740	1,633	1,608	1,584	1,563	OR
Males [50+]	Best	1,286	1,279	1,279	1,280	1,280	1,279	1,278	1,276	1,275	1,273	1,271	1,303	1,302	1,302	1,301	OR
Females [50+]	Best	1,568	1,567	1,575	1,583	1,591	1,598	1,604	1,608	1,612	1,615	1,616	1,634	1,633	1,635	1,635	OR
Prisoners	High	–	–	–	–	–	–	–	11	11	12	12	12	12	12		OR
	Best	9	9	10	10	11	11	11	11	10	9	9	10	10	9	9	OR
	Low	–	–	–	–	–	–	–	10	–	–	–	–	–	–	–	OR

Source: UNSW study team.

60

Table D2 HIV prevalence (Percent)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
FSW	Best	–	–	–	–	0.51	0.60	0.10	2.33	0.72	–	–	0.30	1.88	–	–	OR	–
Clients	Best	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.0001
MSM	High	–	–	–	–	–	–	–	2.65	–	–	–	–	–	–	–	OR	–
	Best	–	–	–	–	–	–	–	2.27	3.32	0.58		0.60	–	–	–	OR	–
	Low	–	–	–	–	–		–	0.99	–	–	–	–	–	–	–	OR	–
Male PWID	Best	0.64	0.59	3.26	6.31	7.45	7.1		7.42	10.71	0.64	0.59	3.26	6.31	7.45	7.1	OR	–
Female PWID	Low	–	–	–	–	0.00	0.00	4.23	2.50	3.97	4.0	–	3.64	10.13	–	–	OR	–
Males 15-49	Best	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.0001
Females 15-49	Best	0.004	0.000	0.002	0.000	0.000	0.000	0.001	0.003	0.001	0.010	0.005	0.01	0.01	0.01	0.02	OR	–
Males [50+]	Best	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.0001
Females [50+]	Best	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.0001
Prisoners	Best	0.00	0.53	0.95	1.56	0.5	0.85	1.6	0.00	0.53	0.95	1.56	0.5	0.85	1.6	0.00	OR	–

Source: UNSW study team.

Table D3 Testing and treatment

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Testing rate per year (%)	FSW	35.18%	42.30%	52.64%	53.00%	58.34%	58.00%		59.85%	74.71%	75.60%	35.18%	42.30%	52.64%	53.00%	58.34%	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	8%
	MSM	–	–	28.64%	29.55%	41.87%	47.18%	–	56.22%	54.04%	–	–	–	28.64%	29.55%	41.87%	OR	–
	Male PWID	–	–	–	36.00%	47.20%	63.86%	–	47.69%	61.90%	–	–	–		36.00%	47.20%	OR	–
	Female PWID	–	–	–	52.00%	49.27%	68.82%	–	67.27%	67.09%	–	–	–		52.00%	49.27%	OR	–
	Males 15–49	–	–	–	–	–	7.90%	–	7.90%	–	–	–	–	–	–	–	OR	–
	Females 15–49	–	–	–	–	–	7.45%	–	7.45%	–	–	–	–	–	–	–	OR	3%
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	2%
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	37%
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	8%
Probability being tested with CD4 <200 per year	High	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Average	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	0.8	OR	–
	Low	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
No. on first-line treatment		71	93	97	138	157	178	185	208	227	295	350	424	507	594	707	OR	–
No. on subsequent lines treatment								15	16	22	36	37	28	32	32	34	OR	–
Treatment eligibility criterion		250	250	250	250	250	250	250	250	250	250	350	350	350	350	350	OR	–

Table D3 Testing and treatment (continued)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
% covered by pre-exposure prophylaxis	FSW	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	MSM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	PWID	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	Females 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
Number of women on PMTCT (Option B/B+)		–	–	–	–	–	–	–	–	–	–	9	6	9	11	12	OR	–
Birth rate	FSW	0.037	0.036	0.035	0.036	0.037	0.038	0.040	0.041	0.043	0.045	0.043	0.043	0.042	0.042	0.037	–	–
	Female PWID	0.037	0.036	0.035	0.036	0.037	0.038	0.040	0.041	0.043	0.045	0.043	0.043	0.042	0.042	0.037	–	–
	Females 15-49	0.037	0.036	0.035	0.036	0.037	0.038	0.040	0.041	0.043	0.045	0.043	0.043	0.042	0.042	0.037	–	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0%
% HIV-positive women who breastfeed		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	5%

Source: UNSW study team.

Table D4 Optional indicators

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Number of HIV tests per year (thousands)	–	–	–	–	–	–	–	–	–	84	317	369	405	388	374
Number of HIV diagnoses per year	49	40	43	63	50	83	91	126	123	171	163	201	157	200	213
Modelled estimate of new HIV infections per year	186	211	242	279	315	354	392	427	452	467	467	459	440	418	405
Modelled estimate of HIV prevalence	–	–	–	–	0.05	0.05	0.06	0.07	0.08	0.09	0.10	0.11	0.11	0.12	0.13
Number of HIV-related deaths	–	–	–	–	–	–	3	8	7	4	9	17	20	32	33
Number of people initiating ART each year	–	22	4	41	19	21	23	20	26	80	56	69	87	87	115

Source: UNSW study team.

Table D5 Sexual acts per person per year

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Average no. regular sexual acts	FSW	–	–	–	–	–	–	–	–	–	–	–	76	–	–	–	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	54
	MSM	–	–	–	–	–	–	–	–	–	–	–	54	–	–	–	OR	–
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	92	–	–	–	OR	–
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	85	–	–	–	OR	–
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	54
	Females 15-49	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	54
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	27
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	27
	Prisoners	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	0
Average no. casual sexual acts	FSW	–	–	–	–	–	–	–	–	–	–	–	25	–	–	–	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	7
	MSM	–	–	–	–	–	–	–	–	–	–	–	52	–	–	–	OR	–
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	39	–	–	–	OR	–
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	9	–	–	–	OR	–
	Males 15-49	–	–	–	–	–	–	9	–	–	7	–	–	–	–	–	OR	–
	Females 15-49	–	–	–	–	–	–	9	–	–	7	–	–	–	–	–	OR	–
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	3
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	1
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–

Table D5 Sexual acts per person per year (continued)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Average no. commercial sexual acts	FSW	–	–	–	–	–	–	–	–	–	–	–	356	–	–	–	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	23
	MSM	–	–	–	–	–	–	–	–	–	–	–	20	–	–	–	OR	–
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	OR	–
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	165	–	–	–	OR	–
	Males 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Females 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0

Source: UNSW study team.

Table D6 Condom use, and circumcision probability

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Condom use % for regular acts	FSW	–	–	–	–	–	–	–	–	–	–	–	18%	18%			OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	MSM	–	–	–	–	–	–	–	–	–	–	–	45%	49%	–	–	OR	–
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	14%	22%	–	–	OR	–
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	19%	20%	–	–	OR	–
	Males 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Females 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
Condom use % for casual acts	FSW	–	–	–	–	–	–	–	–	–	–	–	68%	71%	–	–	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–		–	–	–	OR	57%
	MSM	–	–	–	–	–	–	–	–	–	–	–	76%	–	–	–	OR	–
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	54%	56%	–	–	OR	–
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	57%	–	–	–	OR	–
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	70%
	Females 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	57%
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Prisoners	–	–	–	–	–	–	–	–	8%	20%		44%	–	–	–	OR	–
Condom use % for commercial acts	FSW	–	–	–	–	96%	96%	95%	100%	92%	–	–	92%	99%	96%	96%	OR	–
	Clients	–	–	–	–	96%	96%	95%	100%	92%	–	–	92%	99%	96%	96%	OR	–
	MSM	–	–	–	–	–	–	–	–	–	–	–	75%	–	–	–	OR	–
	PWID	–	–	–	–	–	–	–	–	–	–	–	79%	–	–	–	OR	–
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–	91%	–	–	–	OR	–
	Females 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	–

Table D6 Condom use, and circumcision probability (continued)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Circumcision probability	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	MSM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	PWID	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	10%

Source: UNSW study team.

Table D7 Non HIV deaths, STIs and TB prevalence (percentage)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
% People die from non-HIV-related causes per year	FSW	0.22	0.24	0.24	0.24	0.24	0.22	0.20	0.22	0.22	0.22	0.20	0.22	0.22	0.22	0.22	OR	–
	Clients	0.26	0.27	0.27	0.27	0.27	0.25	0.25	0.25	0.26	0.26	0.23	0.23	0.23	0.24	0.24	OR	–
	MSM	0.26	0.27	0.27	0.27	0.27	0.25	0.25	0.25	0.26	0.26	0.23	0.23	0.23	0.24	0.24	OR	–
	Male PWID	1.04	1.08	1.08	1.08	1.08	1.00	1.00	1.00	1.04	1.0	0.92	0.92	0.92	0.96	0.96	OR	–
	Female PWID	0.22	0.24	0.24	0.24	0.24	0.22	0.20	0.22	0.22	0.22	0.20	0.22	0.22	0.22	0.22	OR	–
	Males 15–49	0.26	0.27	0.27	0.27	0.27	0.25	0.25	0.2	0.26	0.26	0.23	0.23	0.23	0.24	0.24	OR	–
	Females 15-49	0.11	0.12	0.12	0.12	0.12	0.11	0.10	0.11	0.11	0.11	0.10	0.11	0.11	0.11	0.11	OR	–
	Males [50+]	4.28	4.26	4.24	4.23	4.22	4.22	4.21	4.20	4.20	4.20	4.00	4.01	4.02	4.03	4.04	OR	–
	Females [50+]	3.22	3.20	3.18	3.16	3.14	3.16	3.15	3.14	3.13	3.12	3.14	3.15	3.15	3.16	3.16	OR	–
	Prisoners	0.52	0.54	0.54	0.54	0.54	0.50	0.50	0.50	0.52	0.52	0.46	0.46	0.46	0.48	0.48	OR	–
Prevalence of ulcerative STIs (%)	FSW	–	–	–	–	6.4	11.1	9.1	10.5	9.2	–	–	11.8	15.0	–	–	OR	–
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	5.0
	MSM	–	–	–	–	–	–	–	4.9	2.4	4.3	–	4.9	3.0	–	–	OR	–
	Male PWID	–	–	–	–	2.7	4.1	3.3	3.1	1.8	2.2	–	2.0	4.1	–	–	OR	–
	Female PWID	–	–	–	–	7.8	10.6	12.7	4.	5.4		–	7.3	10.1	–	–	OR	–
	Males 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.2
	Females 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.2
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.1
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0.1
	Prisoners	–	–	–	–	–	–	5.5	4.8	6.6	4.1	–	6.4	–	–	–	OR	–

Table D7 Non HIV deaths, STIs and TB prevalence (percentage) (continued)

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Prevalence of discharging STIs (%)	FSW	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	15
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	5
	MSM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	2
	Male PWID	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	5
	Female PWID	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	5
	Males 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	2
	Females 15-49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	4
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	1
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	1
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	5
Tuberculosis prevalence%	FSW	–	–	–	–	–	–	–	0.07	0.07	0.07	0.06	0.05	0.05	0.05	0.04	OR	–
	Clients	–	–	–	–	–	–	–	0.05	0.06	0.05	0.05	0.05	0.04	0.04	0.04	OR	–
	MSM	–	–	–	–	–	–	–	0.05	0.06	0.05	0.05	0.05	0.04	0.04	0.04	OR	–
	Male PWID	–	–	–	–	–	–	–	0.05	0.06	0.05	0.05	0.05	0.04	0.04	0.04	OR	–
	Female PWID	–	–	–	–	–	–	–	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	OR	–
	Males 15-49	–	–	–	–	–	–	–	0.05	0.06	0.05	0.05	0.05	0.04	0.04	0.04	OR	–
	Females 15-49	–	–	–	–	–	–	–	0.03	0.03	0.03	0.03	0.02	0.02	0.02	0.02	OR	–
	Males [50+]	–	–	–	–	–	–	–	0.07	0.07	0.07	0.06	0.05	0.05	0.05	0.04	OR	–
	Females [50+]	–	–	–	–	–	–	–	0.02	0.03	0.03	0.02	0.02	0.02	0.01	0.02	OR	–
	Prisoners	–	–	–	–	–	–	–	0.61	0.84	0.87	0.63	0.67	0.77	0.51	0.63	OR	–

Source: UNSW study team.

Table D8 Injecting drug use parameters

		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014		Assumption
Average no. injections/ person/yr	FSW	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Clients	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	MSM	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Male PWID	–	–	–	–	–	–	–	–	–	–	212	210	191	189		OR	
	Female PWID	–	–	–	–	–	–	–	–	–	–	212	210	161	189		OR	
	Males 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Females 15–49	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Males [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Females [50+]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	OR	0
	Prisoners	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	OR	0
Drug use parameters	% shared injections – Male PWID	–	–	–	–	–	–	–	–	–	–	–	19%	–	–	–	OR	–
	% shared injections – Female PWID	–	–	–	–	–	–	–	–	–	–	–	17%	–	–	–		–
	PWID on OST	–	–	–	–	–	–	–	–	–	–	–		3731	3858	3720	OR	–

Source: UNSW study team.

Table D9 Transitions

		FSW	Clients	MSM	Malee PWID	Female PWID	Males 15-49	Females 15-49	Males [50+]	Females [50+]	Prisoners
Age-related transitions	FSW	–	–	–	–	–	–	–	–	–	–
	Clients	–	–	–	–	–	–	–	–	–	–
	MSM	–	–	–	–	–	–	–	–	–	–
	Male PWID	–	–	–	–	–	–	–	–	–	–
	Female PWID	–	–	–	–	–	–	–	–	–	–
	Males 15–49	–	–	–	–	–	–	–	35	–	–
	Females 15–49	–	–	–	–	–	–	–	–	35	
	Males [50+]	–	–	–	–	–	–	–	–	–	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–	–	–	–	–	–

Table D9 Transitions (continued)

		FSW	Clients	MSM	Male PWID	Female PWID	Males 15-49	Females 15-49	Males [50+]	Females [50+]	Prisoners
Risk-related transitions	FSW	–	–	–	–	–	–	12	–	–	–
	Clients	–	–	–	–	–	10	–	–	–	–
	MSM	–	–	–	–	–	–	–	–	–	–
	Male PWID	–	–	–	–	–	20	–	–	–	16
	Female PWID	–	–	–	–	–	20	–	–	–	–
	Males 15–49	–	–	–	–	–	–	–	–	–	–
	Females 15–49	–	–	–	–	–	–	–	–	–	–
	Males [50+]	–	–	–	–	–	–	–	–	–	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–	–	–	–	–	–

Source: UNSW study team.

Table D10 Partnerships

		FSW	Clients	MSM	Male PWID	Female PWID	Males 15-49	Females 15-49	Males [50+]	Females [50+]	Prisoners
Regular sexual interactions	FSW	–	–	–	–	–	–	–	–	–	–
	Clients	1	–	–	–	–	–	5	–	–	–
	MSM	–	–	2	–		–	1	–	–	–
	Male PWID	1	–		–	3	–	1	–	–	–
	Female PWID	–	–	–	–	–	–	–	–	–	–
	Males 15–49	–	–	–	–	1		10	–	–	–
	Females 15–49	–	–	–	–	–	–	–	–	–	–
	Males [50+]	–	–	–	–	–	–	1		5	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–	–	–	–	–	–

Table D10 Partnerships (continued)

		FSW	Clients	MSM	Male PWID	Female PWID	Males 15-49	Females 15-49	Males [50+]	Females [50+]	Prisoners
Casual sexual interactions	FSW	–	–	–	–	–	–	–	–	–	–
	Clients	1	–	–	–	–	–	5	–	–	–
	MSM	–	–	1	–	–	–	–	–	–	–
	Male PWID	1	–	–	–	5	–	1	–	–	–
	Female PWID	–	–	–	–	–	–		–	–	–
	Males 15–49	1	–	–	–	1	–	5	–	–	–
	Females 15–49	–	–	–	–	–	–		–	–	–
	Males [50+]	–	–	–	–	–	–	1		2	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–		–	–	–	1
Commercial sexual interactions	FSW	–	–	–	–	–	–	–	–	–	–
	Clients	4	–	–	–	1	–	–	–	–	–
	MSM	–	–	1	–	–	–	–	–	–	–
	Male PWID	0.5	–	–	–	–	–	–	–	–	–
	Female PWID	–	–	–	–	–	–	–	–	–	–
	Males 15-49	–	–	–	–	–	–	–	–	–	–
	Females 15-49	–	–	–	–	–	–	–	–	–	–
	Males [50+]	–	–	–	–	–	–	–	–	–	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–	–	–	–	–	–
Injecting interactions	FSW	–	–	–	–	–	–	–	–	–	–
	Clients	–	–	–	–	–	–	–	–	–	–
	MSM	–	–	–	–	–	–	–	–	–	–
	Male PWID	–	–	–	1	1	–	–	–	–	–
	Female PWID	–	–	–	–	1	–	–	–	–	–
	Males 15–49	–	–	–	–	–	–	–	–	–	–
	Females 15–49	–	–	–	–	–	–	–	–	–	–
	Males [50+]	–	–	–	–	–	–	–	–	–	–
	Females [50+]	–	–	–	–	–	–	–	–	–	–
	Prisoners	–	–	–	–	–	–	–	–	–	1

APPENDIX E GLOSSARY

Allocative efficiency (AE)	Within a defined resource envelope, AE of health or HIV-specific interventions provides the right intervention to the right people at the right place in the correct way to maximize targeted health outcomes.
Behavioral intervention	Discourages risky behaviors and reinforces protective ones, typically by addressing knowledge, attitudes, norms, and skills.
Biomedical intervention	Biomedical HIV intervention strategies use medical and public health approaches to block infection, decrease infectiousness, and reduce susceptibility.
Bottom-up costing	Costing method that identifies all of the resources that are used to provide a service and assigns a value to each of them. These values then are summed and linked to a unit of activity to derive a total unit cost.
Cost-effectiveness analysis (CEA)	Form of economic analysis that compares the relative costs and outcomes (effects) of two or more courses of action.
Effectiveness	Degree of achievement of a (health) outcome in a real-world implementation setting.
Efficiency	Achievement of an output with the lowest possible input without compromising quality.
Financial sustainability	Ability of government and its partners to continue spending on a health or HIV outcome for the required duration and to meet any cost of borrowing without compromising the government's, household's, or other funding partner's financial position.
HIV incidence	Estimated total number (or rate) of new (total number of diagnosed and undiagnosed) HIV infections in a given period.
HIV prevalence	Percentage of people who are infected with HIV at a given point in time.
Implementation efficiency	Set of measures to ensure that programs are implemented in a way that achieves outputs with the lowest input of resources. In practical terms, improving implementation efficiency means identifying better delivery solutions. Doing so requires improving planning, designing service delivery models, and assessing and addressing service delivery "roadblocks." Implementation efficiency will improve the scale, coverage, and quality of programs.
Incremental cost-effectiveness ratio (ICER)	Equation commonly used in health economics to provide a practical approach to decision making regarding health interventions. ICER is the ratio of the change in costs to incremental benefits of a therapeutic intervention or treatment.
Model	Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.
Opioid substitution therapy (OST)	Medical procedure of replacing an illegal opioid, such as heroin, with a longer acting but less euphoric opioid. Methadone or buprenorphine typically are used, and the drug is taken under medical supervision.

Opportunistic infection under medical (OI prophylaxis)	Treatment given to PLHIV to prevent either a first episode of an OI (primary prophylaxis) or the recurrence of infection (secondary prophylaxis).
Pre-exposure prophylaxis (PrEP)	Method for people who do not have HIV but are at substantial risk of acquiring it to prevent HIV infection by taking an antiretroviral drug.
Program effectiveness	Program effectiveness incorporates evaluations to establish what works and impacts disease and/or transmission intensity, disseminating proven practice, and improving the public health results of programs.
Program sustainability	Ability to maintain the institutions, management, human resources, service delivery, and demand generation components of a national response until impact goals have been achieved and maintained over time as intended by the strategy.
Return on investments (ROI)	Performance measure used to evaluate the efficiency of an investment or to compare the efficiency of a number of different investments. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment; the result is expressed as a percentage or a ratio.
Saturation	Maximum level of coverage that a program can achieve.
Technical efficiency	Delivery of a (health) service in a way that produces maximum output at the lowest possible unit cost while according with operational quality standards.
Top-down costing	Costing method that divides total expenditure (quantum of funding available) for a given area or policy by total units of activity (such as patients served) to derive a unit cost.
Universal health coverage (UC)	Universal health coverage (UC), is defined as ensuring that all people have access to the promotive, preventive, curative, rehabilitative, and palliative health services that they need, of sufficient quality to be effective, while ensuring that the use of these services does not expose the user to financial hardship.

APPENDIX F REFERENCES

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