Optimizing Investments in Belarus for the National HIV Response

МІНІСТЭРСТВА АХОВЫ ЗДАРОЎЯ РЭСПУБЛІКА БЕЛАРУСЬ

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[1] A mathematical model of HIV transmission and disease progression integrated with an economic and program analysis framework.

ABBREVIATIONS

AE	allocative efficiency
AIDS	acquired immune deficiency syndrome
ART	antiretroviral therapy
ARV	antiretroviral drug
BALLSD	Bayesian adaptive locally linear stochastic descent
BCC	behavior change communication
CD4 cell	T–lymphocyte cell bearing CD4 receptor
CRS	creditor reporting system (OECD)
DALY	disability-adjusted life year
ECA	Europe and Central Asia
FSW	female sex worker
GARPR	Global AIDS Response Progress Reporting
GBD	global burden of disease
GDP	gross domestic product
Global Fund, The	The Global Fund to Fight AIDS, Tuberculosis and Malaria
HIV	human immunodeficiency virus
HTC	HIV testing and counseling
IBBS	integrated bio-behavioral surveillance
IMF	International Monetary Fund
INSERM	Institut national de la santé et de la recherche médicale
M&E	monitoring and evaluation
MDG	Millennium Development Goal
MSM	men who have sex with men
MTCT	mother-to-child-transmission
NASA	national AIDS spending assessment
NHA	national health accounts
NSP	needle and syringe exchange program
OECD	Organisation for Economic Co-operation and Development
OST	opiate substitution therapy
OVC	orphans and other vulnerable children
PCR	polymerase chain reaction
PEP	pre-exposure prophylaxis (PrEP)
PLHIV	people living with HIV
PMTCT	prevention of mother-to-child transmission
PWID	people who inject drugs
SDG	Sustainable Development Goal
STI	sexually transmitted infections
THE	total health expenditure
UNAIDS	Joint United Nations Program on HIV/AIDS
UNDP	United Nations Development Programme
UNSW	University of New South Wales
USAID	United States Agency for International Development
US$	United States dollar
WEO	World Economic Outlook (IMF)
WHO	World Health Organization
YLL	years of life lost

KEY MESSAGES

The national HIV response in Belarus includes several priority prevention and treatment programs. However, the country could increase the impact of its investment through a combination of measures:

- Optimizing **allocations of the same amount of funding available that was in 2013 (US$20 million) over 2015–20 could reduce new HIV infections by 7 percent and deaths by 25 percent.**
- Doubling the investment in high-impact programs would require approximately US$29.5 million and would achieve a **remarkable reduction in new infections by 43 percent and in deaths by 51 percent over 2015–20 compared to 2013 allocations,** at a cost of US$4,700 for an infection averted and US$12,300 for a death averted.
- Further strengthening the focus on and **scaling up antiretroviral therapy (ART) are at the center of optimized allocations.** These allocations will increase ART coverage to 60 percent of people living with AIDS (PLHIV) and are predicted to achieve a 50 percent reduction in deaths and contribute to minimizing new infections.
- Scaling up **prevention for key populations**—particularly harm reduction for people who inject drugs (PWID) (including **needle and syringe exchange programs and Opiate Substitution Therapy** (OST)—is a core element of all optimized allocations.
- To finance the required scale-up of ART and prevention for key populations, a combination of increased domestic financing and **exploring technical efficiencies** is required. Reviewing unit costs for programs and the 52 percent of HIV funds that goes into management and other costs could contribute to achieve higher coverage with available resources.

EXECUTIVE SUMMARY

As part of a regional initiative, in 2014–15 Belarus conducted an HIV AE analysis to inform more strategic investment in HIV programs.

Nevertheless, **Belarus continues to experience a growing epidemic, which, however, is projected to remain concentrated in key populations. People who inject drugs (PWID) continue to account for approximately 50 percent of new infections. Moreover, although transmission is shifting toward sexual transmission**, even in 2030 (assuming constant program coverage and behaviors), over 33 percent of infections are projected to remain among PWID.

In Belarus in the early 2000s, the HIV epidemic among men who have sex with men (MSM) was relatively small. However, according to Optima estimates, MSM have become a rapidly growing segment of the epidemic and, by 2030, are projected to account for 1 in 7 new infections according to Optima. The epidemic among female sex workers (FSW) and clients accounts for approximately 1 in 10 new infections, and this share is projected to remain stable.

Large proportions of HIV acquisition in the general population in Belarus likely are due indirectly to transmission in three key populations: female sexual partners of men who inject drugs, MSM, and clients of sex workers.

Different **optimization and scenario analyses** were carried out in this allocative efficiency (AE) study.

The **first consistent finding of these analyses was the critical role of scaling up ART**, which will substantially impact both incidence and deaths. The Optima model suggests that ART can be scaled up through increased initiation of PLHIV already known to be HIV positive and increased HIV testing and counseling (HTC) for key populations. HIV testing for the general population was not found to be among the most cost-effective strategies for initiating treatment.

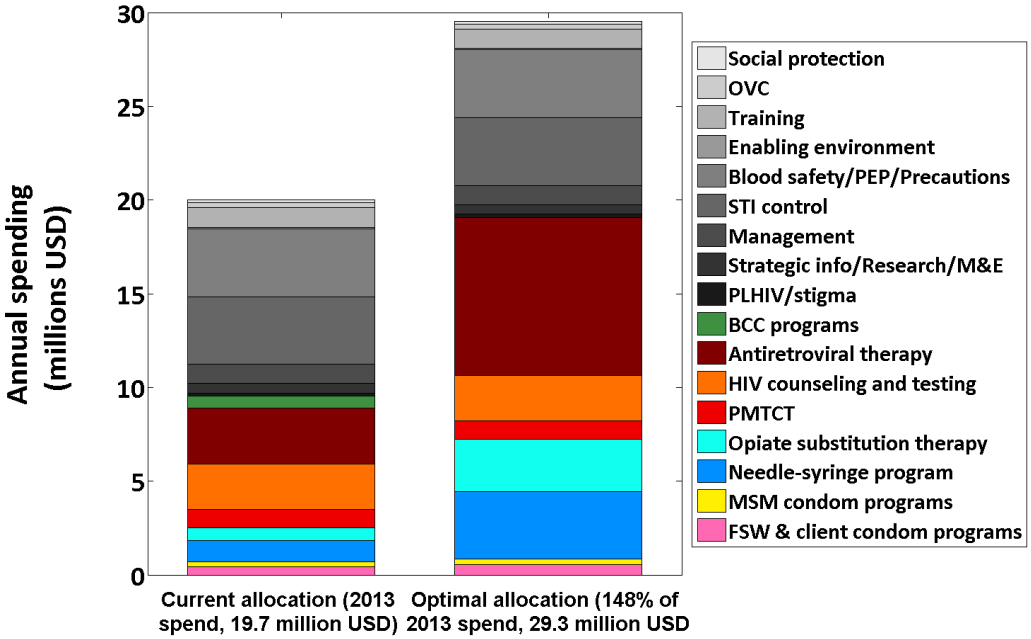
A **second consistent finding is the continued need for scaling up HIV services for people who inject drugs**. From an HIV prevention perspective, needle and syringe exchange programs will be the most cost-effective investment to further reduce rates of needle-sharing. However, beyond them, OST has critical benefits for HIV prevention, treatment adherence, and health in general so should be scaled up as well.

A **third consistent finding** is that Belarus could increase the impact of its HIV program by reallocating funds to high-impact programs. It could enhance this impact by increasing the total funding available to the HIV response so that high-impact programs could be scaled up further. **With optimized allocations of the same amount of funding available as in 2013 (US$19.7 million), over 2015–20, new HIV infections could be reduced by 7 percent and deaths by 25 percent.**

The analyses also established the optimized mix and cost of programs to **achieve national targets, which for the purpose of this exercise were defined as impact targets for HIV incidence and deaths: reducing incidence by 45 percent, reducing deaths by 65 percent, and reducing MTCT to below 1 percent**. The analyses suggest that, to fully achieve national targets, approximately US$58 million will be required, which is nearly 3 times current investment. The large funding requirement for fully achieving national targets is driven primarily by the very large necessity for HTC to achieve the specified ART coverage. Considering available funding and given unit costs, fully achieving current targets is ambitious.

Doubling the investment in high-impact programs would require 148 percent of total 2013 spending (US$29.5 million). However, **compared to 2013 allocations, over 2015–20, the 148 percent** would achieve a remarkable **reduction in new infections by 43 percent and in deaths by 51 percent.**

Figure 1.1 Comparison of current spending with optimized allocation of 200 percent of current prevention and treatment spending (equivalent to 148 percent of total current spending



Source: Populated Optima model for Belarus.

In this optimized allocation, there would be substantial increases in ART, NSP, and OST allocations in both amount and percentage. Allocations for MSM and FSW programs would increase in amounts, but would remain at approximately the same percentage levels as in 2013. Behavioral change and communication (BCC) programs would be defunded; HTC, PMTCT, and management cost would remain stable. This result is particularly relevant from a policy perspective because it would substantially impact both incidence and deaths. **By 2020, 10,000 new infections and 5,100 deaths could be averted as compared to business as usual (2013 levels of allocations).**

If unit costs and management cost in all program areas could be reduced by 32 percent[2] without a loss in service quality, the same results cited above (reduction in new infections by 43 percent and in deaths by 51 percent) could be achieved at the level of total 2013 spending. However, such a substantial reduction in unit cost may not be realistic, and additional technical efficiency analysis would be required to determine the extent of possible unit cost

[2] 32% is the reduction in cost required to offset a 48% increase in resource need (32% = 100%–100%/148%).

reductions. Therefore, other options including additional resource mobilization could be considered.

These options could include looking for other funding sources for programs such as STI control and blood safety that have major benefits beyond HIV. In practice, the most promising option for achieving these additional impacts would be a combination of measures: more focused allocations; increased investment; reduced unit costs in some programs; and identification of alternative and cofinancing from non-HIV budget lines for programs such as STI control, blood safety, and OST. Between 2010 and 2012, Belarus increased the proportion of government spending on health to over 13 percent, thereby allocating more to health than the 2012 global average of 11.7 percent. Despite increases in both its domestic and international funding for the HIV response, in a regional comparison, Belarus' overall levels of HIV funding are low relative to the size of its epidemic.[3]

[3] In 2013 Belarus spent US$800 per estimated number of PLHIV in a range of 490–2,201 in 6 countries of the Region. This figure was arrived at by dividing the total spending included in the country Optima spreadsheet by the total number of PLHIV according to global HIV estimates as per UNAIDS (2014).

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1. INTRODUCTION

1.1 Need for allocative efficiency

Globally, HIV programs are faced with the need to scale up prevention and provide treatment to a larger number of people living with HIV (PLHIV) than ever before. In the current environment of increasingly limited resources for HIV responses, focused design and efficiency in program delivery are essential to ensure that programs can do more with less.

In the 2011 United Nations Political Declaration on HIV and AIDS, countries agreed to reduce sexual and injection-related transmission by 50 percent, virtually eliminate mother-to-child-transmission (MTCT), initiate 80 percent of eligible people living with HIV (PLHIV) on treatment, and end HIV-related discrimination by 2015 (UNGASS 2011). The 2014 UNAIDS' Gap Report illustrated that substantial additional efforts will be required in most countries to achieve these targets. Despite the progress made since 2010, HIV remains among the unfinished agenda items in the 2000 Millennium Development Goals (MDGs) that was transitioned in the Sustainable Development Goal 3.3 (SDGs).[4]

Against this background, UNAIDS globally defined a *Fast-Track* strategy to achieve the goal of *Ending AIDS by 2030* (UNAIDS 2014b). A core element of the Fast-Track approach are the 90-90-90 targets (UNAIDS 2014d). Their goals are that, by 2030, 90 percent of all PLHIV are diagnosed; 90 percent of diagnosed PLHIV are on ART; and 90 percent of PLHIV on ART are virally suppressed. The Fast-Track approach also emphasizes the necessity to focus on the geographic areas and communities in the world that are most affected by HIV and recommends that resources be concentrated on the programs that have shown the greatest impact.

In this context, UNAIDS and cosponsors globally are promoting a shift toward investment thinking in the design of HIV responses to maximize the impact of program investment and best realize the long-term health and economic benefits of HIV programs. A number of countries are developing investment cases to understand HIV epidemics as well as to design, deliver, and sustain effective HIV responses. The investment cases are complemented with a human-rights-based approach to health care. To support HIV investment cases, a group of countries in the World Bank's ECA Region are conducting AE analyses. In 2014–15, these analyses were carried out in Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, and Ukraine as well as in a number of countries outside the ECA Region (Republic of Tajikistan 2014). This report summarizes the results of these analyses for policy makers, program leaders, and technical experts in Belarus.

[4] https://sustainabledevelopment.un.org/topics.

The concept of allocative efficiency (AE) refers to the maximization of health outcomes using the least costly mix of health interventions.[5] HIV allocative efficiency studies generally try to answer the question "*How can HIV funding be optimally allocated to the combination of HIV response interventions that will yield the highest impact?"* This concept is critical not only to maximize current and future impact. The concept also is an integral element of transitioning to full domestic financing and sustainability of the response because a response that is allocatively and technically efficient will be easier to sustain.

There is wide consensus that, in many settings, better outcomes could be achieved with a given amount of HIV funding, or that given outcomes could be achieved with less HIV funding if resources were distributed optimally or resources were used in the most efficient ways.

1.2 Objectives of the analysis

In its National Strategic Plan (NSP), Belarus has set the priorities for its HIV response by 2020. Key targets include:

- ART is being provided to 80 percent of the estimated number of PLHIV in need of ART in 2020
- HIV transmission from mother to child is less than 1 percent
- No cases of HIV transmission occur during blood transfusion and transplantation
- Thirty percent of the estimated number of PWID using opioids (estimated at 18,450) and 10 percent of the estimated number of PWID (of 75,000) are covered by the OST program
- 100 percent of key affected populations' representatives (PWID, MSM, FSW, MSW) receiving HIV prevention services are covered by TB screening and referred to TB institutions
- Coverage of key affected populations by HIV prevention programs is increased:
  - PWID – Up to 60 percent of estimated size
  - FSW – Up to 45 percent of estimated size
  - MSM – Up to 40 percent of estimated size
- Coverage of key affected populations by HIV testing and counseling is increased:
  - PWID – Up to 44 percent of estimated size
  - FSW – Up to 25 percent of estimated size
  - MSM – Up to 16 percent of estimated size
- 90 percent referral and linkage to care is provided to key affected populations (PWID, MSM, FSW, MSW) who visit HIV prevention services
- Morbidity of HIV associated TB is decreased
- 100 percent of health care workers doing invasive procedures are provided with modern individual protection
- 100 percent of donor blood is tested for HIV with ELISA and PCR using NUT technologies
- 80 percent of youth in school are covered by HIV prevention programs.

These output and outcome targets translate into the following impact targets:

[5] Technically, allocative efficiency can be achieved within a fixed budget envelope (maximize impact with given amount of money) or within defined impact targets (minimize cost to achieve a given impact).

- Incidence (2013) was 12 per 100,000 people per year (overall population), and the target is 7 per 100,000 per year by 2020:
- Equivalent to a 45% decrease in incidence by 2020.
- AIDS-related deaths (2013) were 2.8 per 100,000 per year (overall population) and the target is to keep AIDS-related deaths below 1.0 per 100,000 per year (overall population).
  - Equivalent to approximately 65 percent decrease in deaths.[6]

Given the limited resources available, additional prioritization based on in-depth AE analysis was conducted to redefine program coverage targets for maximum impact with different scenarios of resource availability, and to support additional operational planning and budgeting.

The findings of this study will assist the Government of Belarus to strengthen its HIV investment case, through which it attempts to increase effectiveness of HIV investments and define corresponding priorities, strategies, and impacts of the response. The national HIV allocative efficiency study was designed to answer the following main questions:

1. **How can Belarus optimize the allocation of its current HIV funding?**
2. **What might be gained from increased investment in HIV programming?**
3. **What is the minimum expenditure required to meet national targets and how should funds be allocated to achieve the targets?**
4. **What are the health and financial impacts of implementing different ART guidelines?**

[6] After the modelling was carried out, the targets were revised using 2014 data: HIV incidence (2014) is 20 per 100,000, and target by 2020 is 15 per 100,000.

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2. BELARUS' HEALTH AND HEALTH FINANCING CONTEXT

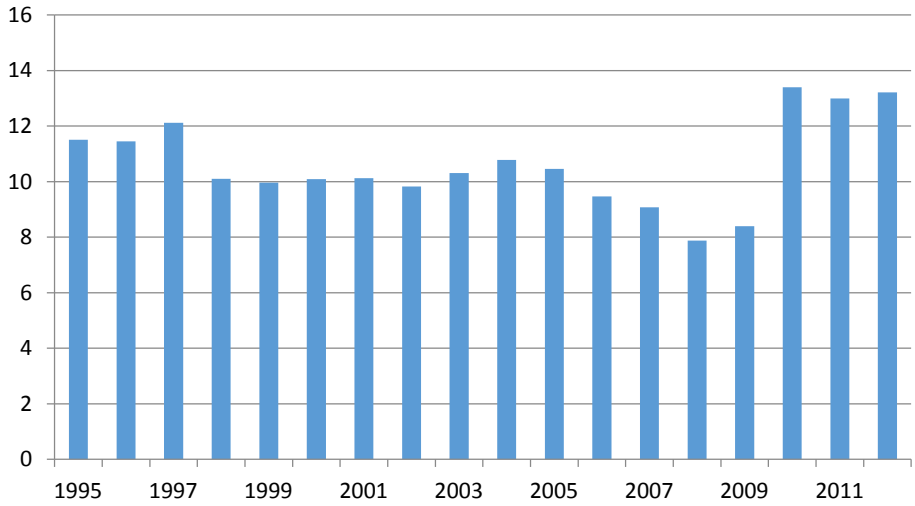
To put the epidemiological analysis of HIV in Belarus in context, section 2 summarizes Belarus' overall burden of disease. The section also summarizes [trends in health and HIV financing in Belarus as background to the economic component of the allocative efficiency analysis (Table 2.1).

Table 2.1 Belarus: Breakdown of health spending by funding source, 2000–13

Indicator		2000	2005	2010	2011	2012	2013
Total health spending							
Gross domestic product	Current US$ million	12,173	30,222	55,122	56,482	63,668	71,375
Total expenditure on health	Current US$ million	746	2,081	3,062	2,781	3,189	4,331
Total health expenditure (THE) % GDP	%	6	7	6	5	5	6
Total expenditure on health per capita at exchange rate	Per capita	75	215	323	294	339	463
Government health spending							
General government expenditure	Current US$ million	5,584	14,518	17,756	15,097	18,628	21,044
General government expenditure on health (GGHE)	Current US$ million	563	1,518	2,378	1,961	2,461	2,831
GGHE as % of general government expenditure	%	10	10	13	13	13	13
GGHE as % THE	%	75	73	78	71	77	65
Private health spending							
Private expenditure on health	Current US$ million	183	563	683	820	727	1,500
Private expenditure on health as % THE	%	25	27	22	29	23	35
Out-of-pocket expenditure as % THE	%	14	20	20	27	19	32
Out-of-pocket expenditure as % private health expenditure	%	57	73	89	90	85	92
External funding							
Rest of the world funds/External resources	Current US$ million	1	2	16	9	21	20
External resources on health as % THE	%	<	<	1	<	1	<

From 1995 to 2012, the level of health spending in Belarus fluctuated. It declined from 1995 to 2009, reaching its lowest point in 2008 at 7.9 percent. The level peaked in 2010 with 13.4 percent (Figure 2.1) and remained consistently above 13.0 percent between 2010 and 2012. The proportion of government health expenditure in 2012 was also above the global average of 11.7 percent.

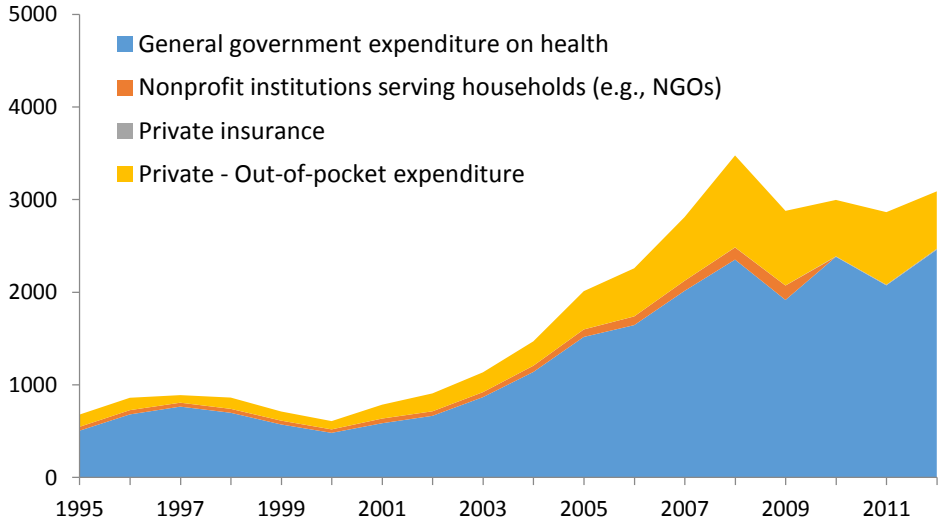
Figure 2.1 Belarus: General government expenditure on health as share of general government expenditure, 1995–2012 (%)



Source: WHO 2014.

In Belarus, 80 percent of health expenditure is incurred by government (Figure 2.2). Twenty percent of expenses is private and out-of-pocket. In the late 1990's and early 2000's, the contribution of nonprofit organizations exceeded 5.0 percent of total health spending, but, after 2009, their share declined. In 2012 nonprofit organizations and private insurance accounted for less than 1.0 percent of health expenditure.

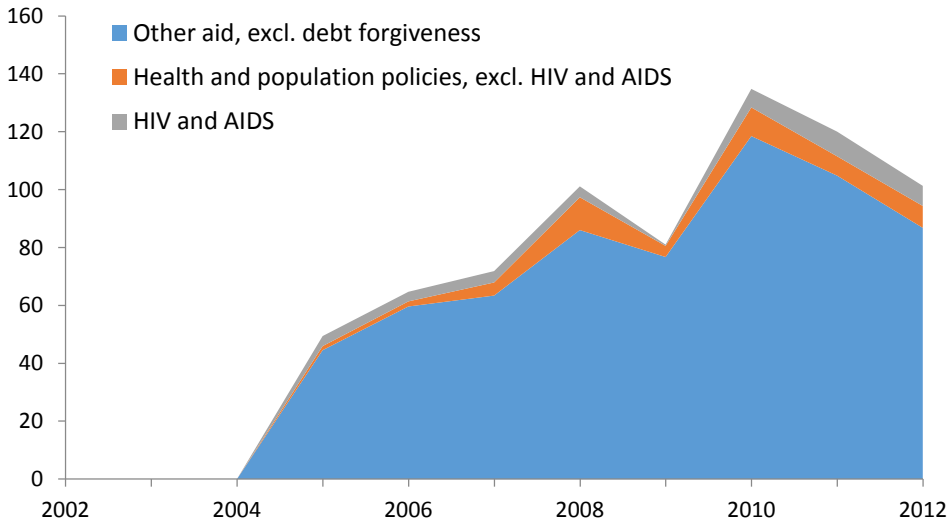
Figure 2.2 Belarus: Health spending by source of financing, 1995–2012 (US$ million)



Source: WHO 2014.

Since the mid-2000's, external assistance to Belarus increased, peaking in 2010 at US$134.8 million (Figure 2.3). Health, population policies, and HIV/AIDS accounted for 5.3 percent–14.9 percent of all external assistance. HIV/AIDS has been a key focus of external assistance to the health sector and, in some years, exceeded all other support to health and population policies. In 2012 external support to Belarus for HIV/AIDS was US$6.9 million and all other support to health US$7.6 million.

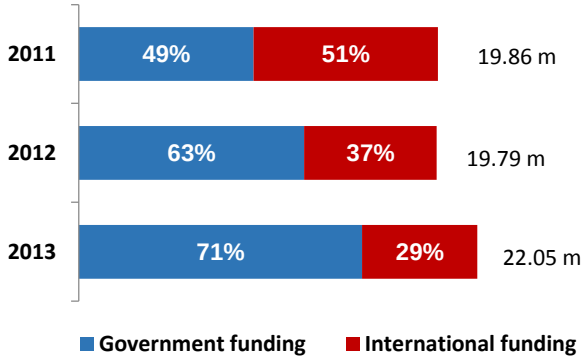
Figure 2.3 Aid disbursements, 2002–12 (US$ million)



Source: OECD and CRS 2014.

The majority of HIV funding is through the public sector, which accounted for 63 percent of expenditure on HIV in 2012 (Figure 2.4). International partners financed 37 percent of all HIV spending. Compared to overall health spending, a larger proportion of HIV expenditure is externally funded. Unlike for general health spending, private spending on HIV/AIDS does not play a significant role. It is assumed that there are out-of-pocket expenses for items including condoms and needles in pharmacies, which are not recorded here. The Global Fund is the major external funding partner for Belarus' HIV response, providing 95 percent of HIV funding in 2012 (Figure 2.5).

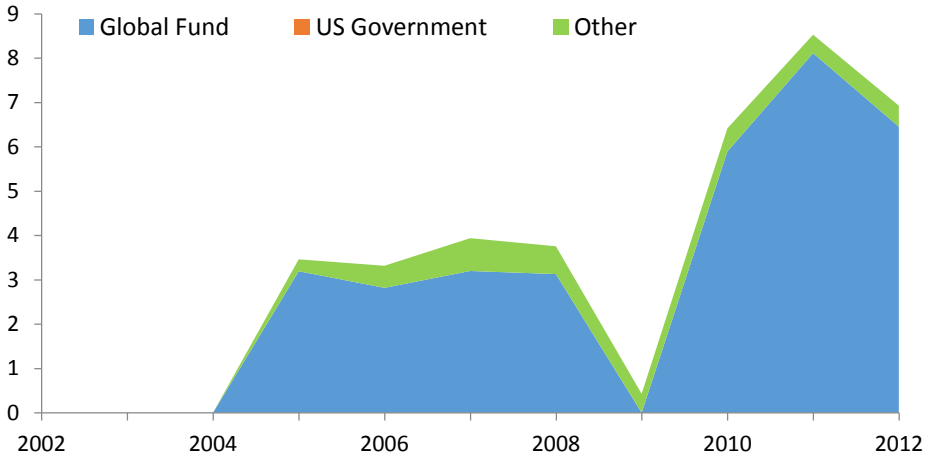
Figure 2.4 Belarus: Total annual expenditure on HIV programs, 2011–13 (%)



The total funding envelope available in Belarus for HIV programs increased gradually from 2011 to 2013. This increase occurred despite a 37 percent decline in international funding over the same period and was due mainly to a 62 percent increase in government funding in 2013 (Figure 2.4).

Of the overall budget allocated to fight the HIV epidemic in 2013, 24 percent was used to fund treatment and care programs for PLHIV. Although 61 percent of ARV treatment costs were borne by the government, no government funds were utilized for ARV drug costs.

Figure 2.5 Belarus: HIV/AIDS-related aid disbursements by donor, 2002–12 (US$ million)



Source: OECD and CRS 2014.

3. METHODOLOGY

This section outlines the main steps taken and tools applied to carry out the analyses presented in this report. Additional details are available in the appendixes.

3.1 Optima Model

To carry out the analyses, the partners used Optima, a mathematical model of HIV transmission and disease progression integrated with an economic and program analysis framework. Optima uses HIV epidemic modeling techniques and incorporates evidence on biological transmission probabilities, detailed infection progression, sexual-mixing patterns and drug-injection behaviors. In consultation with in-country experts, Optima was calibrated to HIV prevalence data points available from the different subpopulations (such as female sex workers, injecting drug users, and men who have sex with men), and to data points on the number of people on ART.

To assess how incremental changes in spending affect HIV epidemics and determine an optimized funding allocation, the model parameterizes relationships among 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 prevention program being considered.

Using the relationships among cost, coverage, and outcome in combination with Optima's epidemic module, it is possible to calculate how incremental changes in the funding level allocated to each program will impact on overall epidemic outcomes. Furthermore, by using a mathematical optimization algorithm, Optima is able to determine an optimized allocation of funding across different HIV programs (appendix A).

3.2 Analytical framework

The study was conceptualized by a regional steering group involving The Global Fund, UNAIDS, UNDP, and convened by the World Bank. A national technical group convened by UNAIDS in collaboration with government was formed. Country-specific objectives of the analysis and parameters were outlined in a Scope of Work document. Epidemiological, program, and cost data were collected by in-country experts with technical support from international partners using an adapted MS-Excel-based Optima data entry spreadsheet. In November 2014, a regional mathematical modelling workshop was conducted in Yerevan, Armenia. In this workshop, national experts and specialists from international partners including the Global Fund, UNAIDS, UNDP and the World Bank worked together with mathematical modelers from UNSW to carry out modelling analyses using the Matlab software package. This regional process also aimed at data comparison, exchange, quality assurance, and development of capacities in HIV epidemic and response analysis using mathematical modelling techniques. Preliminary results then consulted on with government experts and other in-country partners and summarized in this report.

Optima is a flexible model that enables the user to decide which populations, programs, time frames, and funding levels to consider in a country analysis. Table 3.1 summarizes the main parameters, which were identified based on contextual, epidemiological, national strategy, program, and funding information; and agreed with in-country stakeholders.

Table 3.1 describes the populations and programs included in the analysis and relevant time frames.

Table 3.1 Modelling parametrization

Category	Parametrization in Optima	Description/Assumptions
Populations defined in model	Female sex workers	Females, aged 15–49
	Clients of sex workers	Males, aged 15–49
	Men who have sex with men	Males, aged 15–49
	Men who inject drugs	Males, aged 15–49
	Women who inject drugs	Females, aged 15–49
	Boys	Males, aged 0–14
	Girls	Females, aged 0–14
	Male youth	Males, aged 15–24
	Female youth	Females, aged 15–24
	Male adults	Males, aged 25–49
	Female adults	Females, aged 25–49
	Older men	Males, aged 50+
	Older females	Females, aged 50+
Expenditure areas defined in model and included in optimization analysis	Female sex worker & clients condom program	Condom distribution, HIV testing and counseling, community outreach
	MSM condom program	Condom distribution, HIV testing and counseling, community outreach
	Needle and syringe exchange and related prevention for PWID	Needle and syringe exchange, condom distribution, HIV testing and counseling, community outreach
	Opiate substitution therapy	Provision of medication and related counseling
	HIV testing and counseling	HIV test kits and pre- and post-testing counseling
	Antiretroviral therapy	Antiretroviral drugs, related laboratory monitoring, clinical visits
	Prevention of mother to child transmission	HIV testing of pregnant women, counseling, provision of antiretroviral prophylaxis for women living with HIV*
	Behavior change communication (BCC)	HIV-related education, interpersonal and media communications
Expenditure areas not included in optimization	Management and other costs	PLHIV/stigma, strategic information, research, M&E, management, STI control, blood safety, PEP, precautions, enabling environment, training, social protection
Time frames	2014 (baseline) 2015–20 period for optimization	Available data from 2000–14 was used. Projections started with year 2015. Optimizations were performed up to 2020 (main body of report) and 2030 (see appendix B)
Baseline scenario funding	Program spending: US$9,527,000 Management and other cost: 10,275,000 Total spending: $20,002,000	2013 spending as per Optima spreadsheet in line with GARPR financial tables

Note: * = A comprehensive four-pronged approach to PMTCT includes additional elements such as provision of contraception. For the vast majority of women in this concentrated epidemic setting, the primary purpose of contraception is not PMTCT but pregnancy prevention. Thus, it was decided not to include cost in relation to contraception in this analysis (apart from the cost for condom promotion for key populations covered in FSW, MSM, and PWID programs). The same logic applies to other related services.

Populations include *key populations,* which are defined around the dominant factor influencing HIV acquisition; and *general populations*, which are disaggregated by age and sex. **Programs** were divided in two categories:

1. **Direct programs**, which directly affect HIV incidence or deaths and which therefore could be included in the mathematical optimization analysis
2. **Indirect programs**, which are cross-cutting expenses or have indirect or unclear effects on health outcomes and were not included in the mathematical optimization.

Within ***direct programs,*** some service packages target specific key populations (FSW, MSM, and PWID). Others (HTC, ART, PMTCT) cut across all populations including key populations.

Based on program spending per person reached, cost-coverage outcome relations were developed. Calibrations and cost-coverage outcome relations were produced in collaboration with experts from Belarus (appendixes B and C).

The costs per person reached were derived from 2013 program spending and coverage data (Table 3.2). These costs are not strictly comparable among countries, particularly for prevention programs, whose packages differ. In other words, higher unit cost may not necessarily mean lower technical efficiency but also could mean a more comprehensive package. Costs per person reached in Belarus are below regional average and median costs for most programs except PWID-NSP programs. Additional analysis would be required to determine in which areas technical efficiencies could be realized.

Table 3.2 Costs per person reached established in the analysis, 2013 (US$)

Cost per person reached	Belarus	Regional comparison (6 countries incl. Belarus)			
	2013	Lowest	Highest	Average	Median
FSW programs	88.62	41.66	166.24	102.94	105.35
MSM programs	39.03	23.67	449.13	159.45	71.25
PWID-NSP programs	101.36	40.90	129.25	109.73	84.11
OST	645.31	431.41	1,645.24	747.36	790.23
PMTCT*	4,068.39	738.08	8,905.27	4,616.80	4,267.59
ART**	576.48	576.48	2,278.52	1,203.26	1,127.29

Source: Populated Optima data entry spreadsheets from 7 countries.
Note: * = Total program cost divided by the number of HIV-positive pregnant women receiving ARV prophylaxis/ART; ** = Average cost per person on ART (including first and subsequent lines of treatment).

3.3 Limitations of analysis

- There are some gaps in data, particularly for the general population. 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 general population.
- For this analysis, standard classification of cost data in line with National AIDS Spending Assessments (NASA) was used. However, there are differences in program packages among countries, which limit comparability of findings.
- As the basis for determining program cost, the analysis used past ratios of expenditure to coverage, rather than unit costs from a costing of future programs. Using past cost and results has a number of advantages over using projected costs from plans and budgets, which ultimately, are predictions of future cost. However, the method applied also has a

disadvantage because there may be future increases or decreases in cost in relation to new approaches, implementation arrangements, or technologies.

- The modeling approach used to calculate relative cost effectiveness among programs included assumptions around the impact of increases or decreases in funding for programs. These assumptions were based on unit costs and observed ecological relationships among outcomes of program coverage or risk behavior and the amount of money spent on programs in the past. This model also assumed that increased spending would result in some saturation.
- The analysis did not determine the technical efficiency of programs. Gains in technical efficiency would lead to different unit costs and therefore affect resource allocation.
- Modelling the optimization of allocative efficiencies depends critically on the availability of evidence-based parametric estimates of the effectiveness of individual interventions. Although these estimates were derived from a global systematic literature review,[7] they may vary in specific countries and populations depending on various factors, particularly the levels of adherence to interventions. All programs and spending categories for which such parameters cannot be obtained, such as enablers and synergies, could not be included in the mathematical optimization. Nevertheless, because they still have important functions in the HIV response, they have been treated as fixed costs and, in specific scenarios, adjusted with specific justifications.
- Effects outside the HIV endpoints are complex to consider (including non-health benefits of OST, effects of needle exchange on hepatitis, and effects of condoms on contraception and STIs). Given that, for OST, the majority of benefits exceed HIV outcomes, specific consideration was given to consider the non-HIV benefits of OST (appendix A). However, given the complexity of interactions between interventions and their non-HIV benefits, this approach was applied only for OST. Similarly, the model does not seek to quantify human rights; stigma and discrimination; or ethical, legal, or psychosocial implications, but acknowledges that these are important aspects to be considered.
- Different models may not always produce exactly the same projections as those produced by Optima. The partners used the best possible data, the combined experience from model application in over 20 countries, and regional comparison and validation of inputs through comparison among different sources including data from clinical records, surveillance, and research.

[7] The full literature review is available at www.optimamodel.com.

4. RESULTS AND THEIR INTERPRETATION

This section presents the findings of the analyses carried out in the Optima model, beginning with epidemic analysis and then moving into optimization analysis as well as related cost-effectiveness analysis.

4.1 What is the current status of the HIV epidemic in Belarus?

A summary of key national data on the HIV epidemic is provided in Table 4.1 illustrating the rapid growth of the epidemic between 2000 and 2014.

Table 4.1 Belarus: Summary of key national data on HIV

	2000	2005	2010	2011	2012	2013	2014	Source
HIV diagnoses								
Cumulative number of people diagnosed with HIV, total	N/A	7,014	11,759	12,955	14,178	15,711	17,522	MOH database
Cumulative registered number of people diagnosed with HIV and alive, total	N/A	6,811	10,587	11,498	12,453	12,213	13,527	
New diagnoses								
Number of people newly diagnosed with HIV, total	527	751	1,069	1,196	1,223	1,533	1,811	
Number of people newly diagnosed with HIV (ages 15 and older)	N/A	716	1,045	1,173	1,207	1,516	1,793	
Number of people newly diagnosed with HIV (ages 0–14)	N/A	35	24	23	16	17	18	MOH database
Number of people newly diagnosed with HIV, females	N/A	352	496	574	N/A	731	759	
Number of people newly diagnosed with HIV, males	N/A	399	573	622	N/A	802	1,052	
Registered HIV related deaths								
Annual registered number of deaths due to AIDS, total	N/A	71	235	285	391	416	497	MOH database
Cumulative registered number of deaths due to AIDS, total	N/A	203	1,172	1,457	1,725	1,991	2,264	
HIV prevalence among key population								
HIV prevalence among sex workers (%)	N/A	N/A	N/A	2.4	N/A	5.8	N/A	National surveillance data
HIV prevalence among MSM (%)	N/A	N/A	N/A	2.8	N/A	6.2	N/A	
HIV prevalence among PWID (%)	N/A	16.7	N/A	13.3	N/A	14.2	N/A	

Table 4.1 Belarus: Summary of key national data on HIV *(Continued)*

	2000	2005	2010	2011	2012	2013	2014	Source
Service coverage and utilization								
Number of people receiving ART	8	149	2,614	3,223	4,274	5,095	6,062	
Coverage of ART (receiving ART as a % of registered people living with HIV)	N/A	N/A	52%	40%	49%	40%	40%	
Coverage of ART (receiving ART as a % of estimated people living with HIV	N/A	2%	25%	28%	34%	42%	N/A	MOH database
Number of syringes distributed per estimated PWID	N/A	N/A	47	48	21	36	46	
Percent of estimated number of PWID receiving OST	0.0	0.0	2.0	3.0	5.0	6.0	7.0	
Self-reported modes of HIV transmission (% of newly diagnosed with HIV)								
Heterosexual HIV transmission	N/A	57.0%	73.8%	73.7%	75.1%	82.4%	74.5%	
Homosexual HIV transmission	N/A	0.3%	1.3%	2.4%	2.5%	2.8%	2.9%	MOH
HIV transmission through IDU	N/A	36.8%	20.9%	21.2%	20.2%	13.0%	20.8%	database
Vertical HIV transmission	N/A	N/A	2.1%	1.9%	0.1%	2.0%	2.0%	

Source: indicated within the Table.

Based on the available data, the model was calibrated as described in appendix B and produced the HIV epidemic estimates summarized in Table 4.2 and Figure 4.1. The estimates suggest that, in 2014, there were 22,600 PLHIV in Belarus, a number that was consistent with the registered number of PLHIV, and moderately lower than the estimated number of PLHIV in the Global HIV Estimates based on Spectrum (25,000). The estimated number of new infections in 2014 was 2,900 (2,700 in Spectrum) and AIDS-related deaths approximately 1,000 (<1000 in Spectrum, 1,200 as upper bound). Both figures are within the confidence bounds of Spectrum estimates.

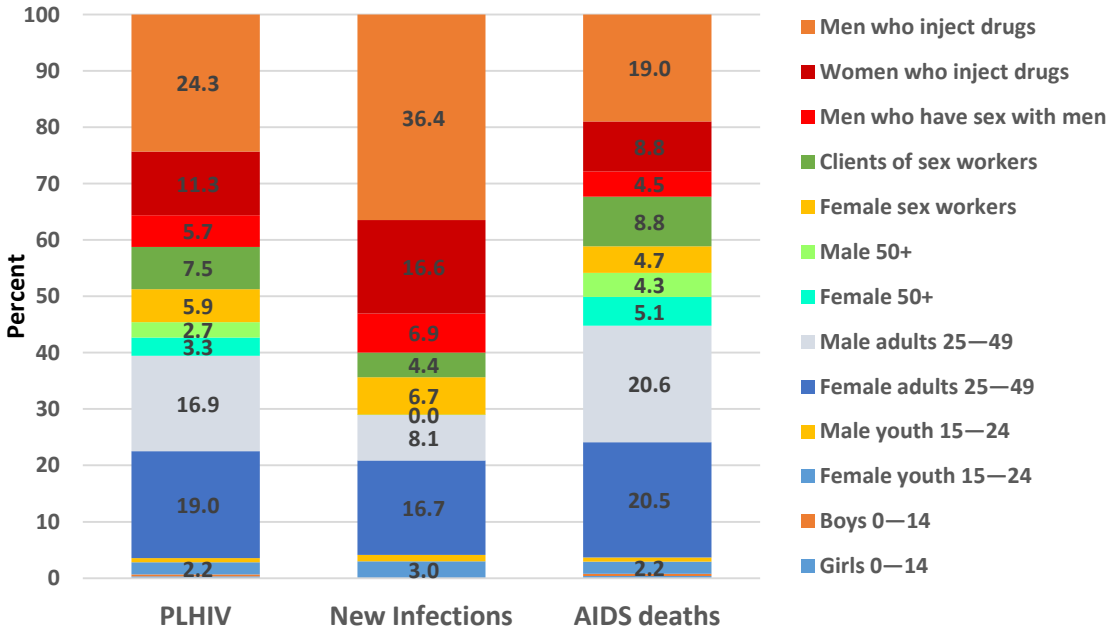
Table 4.2 Belarus: Summary of HIV epidemic estimates, 2014

Epidemiology 2014	PLHIV	Prevalence (%)	New infections	AIDS deaths	Number on ART
Girls 0–14	100	<0.1	<100	<100	<100
Boys 0–14	100	<0.1	<100	<100	<100
Female youth 15–24	500	0.1	100	<100	100
Male youth 15–24	200	<0.1	<100	<100	<100
Female adults 25–49	4,300	0.3	500	200	1,100
Male adults 25–49	3,800	0.3	200	200	1,100
Female 50+	700	<0.1	<100	<100	200
Male 50+	600	0.1	<100	<100	200
Female sex workers	1,300	3.9	200	<100	400
Clients of sex workers	1,700	0.9	100	100	500
Men who have sex with men	1,300	2.9	200	<100	400
Women who inject drugs	2,600	16.1	500	<100	600
Men who inject drugs	5,500	14.0	1,100	200	1,200
Overall	**22,600**	**0.3**	**2,900**	**1,000**	**5,700**

Source: Populated Optima model for Belarus.

Understanding HIV transmission dynamics and modes of transmission is a critical foundation for developing HIV responses. Figure 4.1 describes the breakdown of PLHIV, new infections, and deaths in Belarus among different sub-populations. PWID account for approximately 50 percent of new infections. However, only just over 33 percent of PLHIV are PWID, and fewer than 33 percent of AIDS-related deaths are among PWID, which is explained by the higher background mortality among PWID from non-AIDS-related causes.

Figure 4.1 Distribution of estimated PLHIV, estimated new infections, and estimated AIDS-related deaths by population group in Belarus, 2014 (%)



4.2 What are the expected trends in the epidemic if current conditions are maintained?

The analysis carried out in Optima assumed the maintenance of current conditions, defined as stable behaviors and stable coverage of programs.

The model estimated the evolution of annual new HIV infections (2000–30) in each subpopulation. With current coverage of programs, Belarus' HIV epidemic is predicted to grow from an estimated 2,900 new infections per year in 2014 to approximately 4,500 in 2030 (Table 4.3). People who inject drugs continue to account for the single largest segment of new HIV infections. The number of new infections among PWID is projected to continue growing. However, their share of new infections is projected to decline over time from approximately 67 percent of all new infections in 2000 to approximately 50 percent of all new infections in 2015 to approximately one third in 2030. The epidemic among female sex workers and their clients contributes just over 10 percent of all new infections, and the FSW epidemic's relative importance in the epidemic overall is projected to be stable.

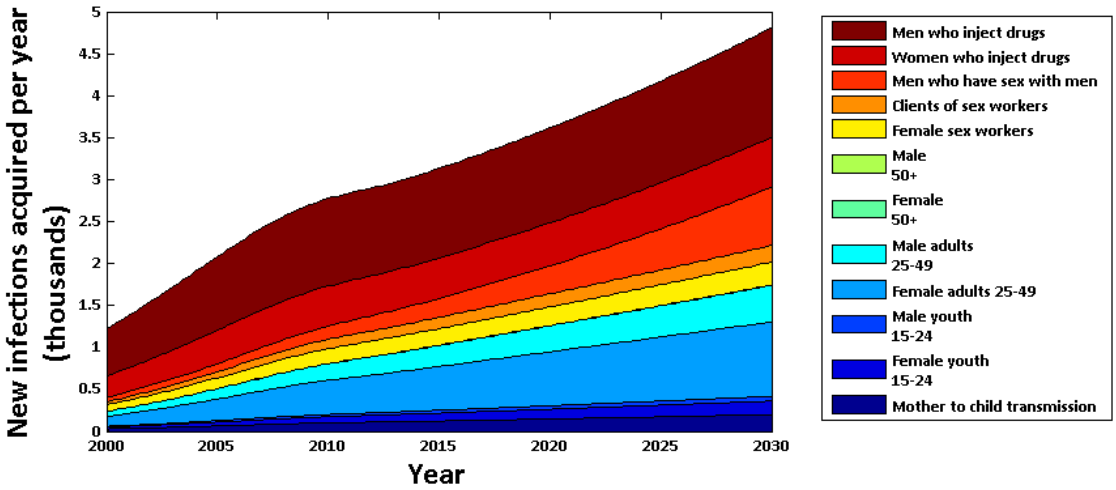
Table 4.3 Projected change in key HIV estimates under current conditions, 2014–20

	2014	2020
New infections	2,900	3,500
AIDS-related deaths	1,000	1,200
Number of PLHIV	22,600	34,300

Source: Populated Optima model for Belarus.

The epidemic among MSM contributed only a relatively small fraction of new infections between 2000 and 2010, but in 2013 contributed approximately 7.0 percent of new infections. The available HIV prevalence data suggested an increase in HIV prevalence among MSM from 3.1 percent in 2008 to 6.2 percent in 2013. Considering the level of risk behavior and current service coverage, the model projects that the MSM epidemic will be the fastest growing component of the HIV epidemic. After 2025, the number of new infections in MSM is predicted to exceed the number in sex work settings. Female adults account for the second largest share of new infections received after PWID. However, this group is less involved in transmitting HIV, but acquires HIV infections from male sexual partners including PWID, former PWID, clients of FSW, and bisexual MSM (Figure 4.2).

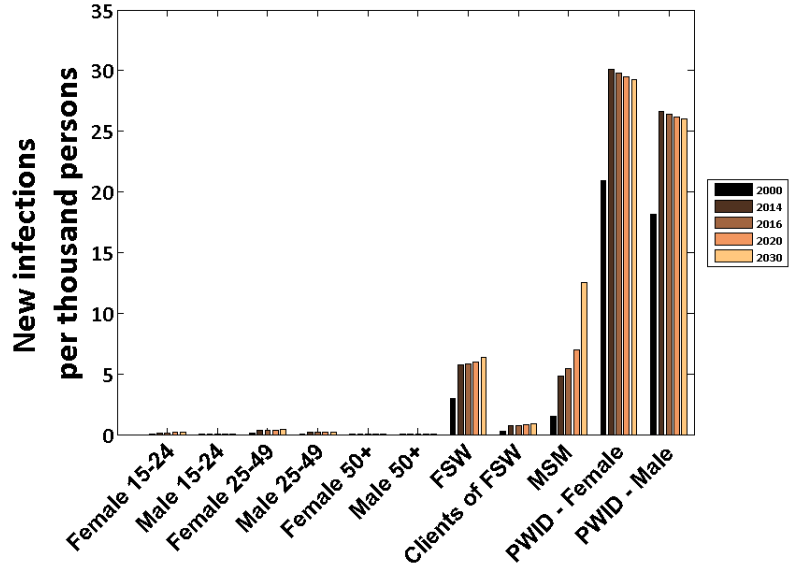
Figure 4.2 Belarus: Annual estimated new infections, 2000–30



Source: Populated Optima model for Belarus.

HIV incidence rates in 1,000 person years are shown in Figure 4.3. Throughout 2000–30, HIV incidence will remain highest among people who inject drugs (PWID). This result suggests that, based on current projections, drug-injecting behavior is likely to remain a dominant risk factor. HIV incidence rates among FSW and their clients will grow only moderately. In contrast, based on projections of current trends, HIV incidence rates among MSM are expected to grow rapidly.

Figure 4.3 Belarus: Estimated HIV incidence rates in specific populations, 2000–30



Source: Populated Optima model for Belarus.

4.3 How will outcomes improve by optimizing allocations under the current funding level?

Optimization analyses were carried out for different funding levels and different policy questions in line with the agreed Scope of Work document. Results show some differences in nuances for different policy questions but also indicate some overarching trends. When interpreting the results, one should note that all management cost and other cost for related health services were kept stable and were not included in the mathematical optimization (appendix A). All optimization analyses suggest that there is room for substantial improvement of current allocations among the program areas as detailed below.

The first optimization presented here describes optimized allocations with constant funding at the 2013 HIV spending level available up to 2020.

4.3.1. Optimized allocations at the current level of spending

The optimization analysis in Figure 4.4 shows results for current funding volume (2013 expenditure) allocated optimally to minimize both HIV incidence and HIV-related deaths. In line with country guidance, a weighting of 40–60 was applied for new HIV infections averted versus HIV-related deaths averted.

This analysis suggests that, if current funding and current unit costs are maintained, the highest impact programs in Belarus would be ART and prevention programs for PWID including needle-syringe and OST programs. The effect of these reallocations on deaths would be substantial: they would achieve a 25 percent reduction as compared to current allocations. However, the effect on new infections would only be 7 percent as compared to current allocations and therefore too small to stabilize the growing epidemic.

KEY MESSAGE

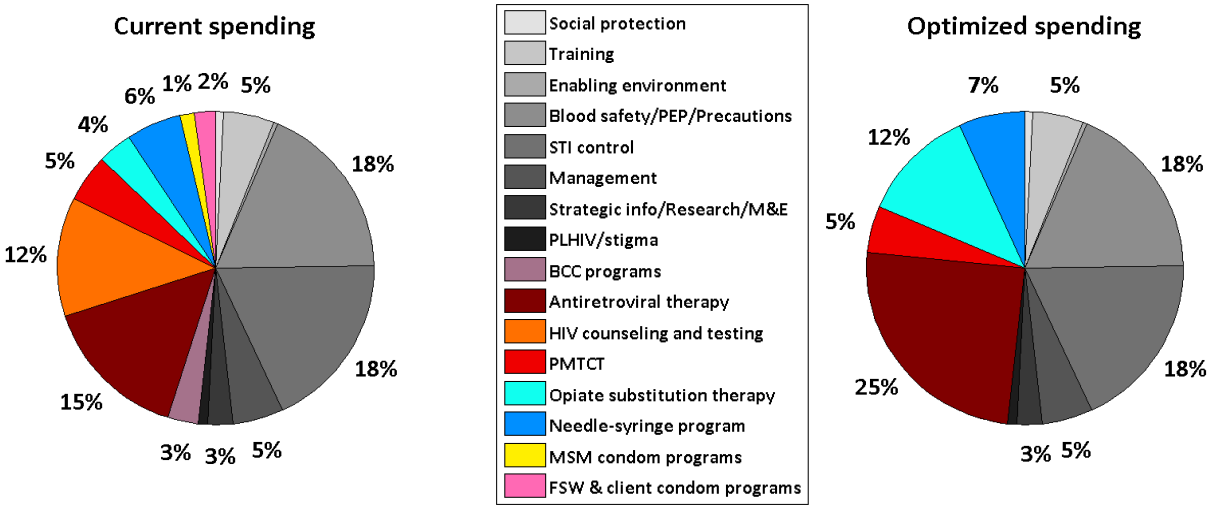
With current funding, unit cost, and assumptions of fixed costs, the effect on averting deaths and new infections would be highest if **ART and prevention for PWID were prioritized. Compared to current allocations, optimized allocations would avert 25 percent of deaths and 7 percent of new infections.** Thus, optimized allocations would slow the projected increase in new infections but not stop it. Thus, at the current funding level, and with 56 percent of funding going into management and other fixed programs, the HIV epidemic will continue to grow.

In the optimized allocation, behavior change communication (BCC) for the general population would be defunded. The reason is the large cost associated with reaching the general population and the limited epidemiological impact due to low prevalence in this group. General population HTC would not be part of the optimized mix because, from a modelling perspective, either initiating already diagnosed PLHIV on ART or providing HTC within programs for key populations would be more cost effective. In practical terms, HTC certainly still would be required. However, what the model suggests is that, as long as the resources remain insufficient to initiate more people on ART after HTC , scaling up HTC to the general population would not be as cost effective as scaling up ART and programs for PWID (which include HTC).

Similarly, at current funding levels, prevention programs for MSM and FSW would not be part of optimized allocations. However, given the epidemiological role of these groups these programs remain important to sustain. What happens in the mathematical optimization is that, the limited funding would be absorbed by ART and programs for PWID, which, with the given assumptions, would be more cost effective in averting deaths and new infections. If the total

level of funding cannot be increased, this would imply that unit costs of programs would need to be reduced to cover essential programs. The analysis treated a large proportion of HIV-related cost as fixed cost (see Figure 4.6, pie segments shaded in grey and red for PMTCT) in the mathematical optimization and savings could also be identified within these programs.

Figure 4.4 Comparison of current (2013) and optimized HIV program spending to minimize new infections and HIV-related deaths, 2015–20 (%)



Source: Populated Optima model for Belarus.
Note: 2013 total spending = US$20 million. *A*llocations with < 1% of overall budget not labelled.

4.3.2. Program coverage with optimized allocations at current levels of spending

The allocations in Figure 4.5 correspond to the coverage levels expressed in Table 4.3 for the priority programs. Table 4.43 illustrates that, due to the larger weight on averting deaths and the dual effect of ART on incidence and deaths, coverage of ART would increase most substantially. PMTCT coverage would remain high because the cost was treated as fixed. Coverage of NSP programs would more than double, while OST programs would increase six-fold. As mentioned above, with these increases, given unit costs and the high fixed cost, there would not be any funding left for other programs.

Table 4.4 Comparison of current (2013) and optimized HIV prevention and treatment program spending and corresponding coverage required to minimize new infections and HIV-related deaths, 2015–20

Program	2013 spending (US$)	2013 coverage (%)	Optimized allocation of same 2013 budget (US$)	Coverage for optimized allocation (%)
Direct programs				
FSW and client condom programs	430,000	10.0	0	0.0*
MSM condom programs	285,000	13.0	0	0.0
Needle-syringe program	1,117,000	14.0	1,343,000	30.0
Opiate substitution therapy	695,000	1.4	2,319,000	9.3
PMTCT (fixed amount)	960,000	97	960,000	97
HIV counseling and testing	2,433,000	24	0	0**)
Antiretroviral therapy	2,987,000	5,200 on ART	4,905,000	10,800 ART
BCC programs	620,000	–	0	0
Sub-total: Direct programs	9,527,000	–	9,527,000	–
Indirect programs	10,475,000	–	10,475,000	–

Table 4.4 Comparison of current (2013) and optimized HIV prevention and treatment program spending and corresponding coverage required to minimize new infections and HIV-related deaths, 2015–20 *(Continued)*

Program	2013 spending (US$)	2013 coverage (%)	Optimized allocation of same 2013 budget (US$)	Coverage for optimized allocation (%)
Total costs	20,002,000		20,002,000	–
Corresponding impacts	–	–	–	–
Cumulative new infections	23,300	–	21,700	–
Cumulative HIV-related deaths	10,000	–	7,500	–
Reduction in cumulative new infections compared to current allocations	0	–	7	–
Reduction in cumulative deaths compared to current allocations	0	–	25	–

Source: Populated Optima model and data spreadsheet for Belarus.
Note: * = As explained in the narrative these programs remain important from an epidemiological point of view and should continue to be provided. Therefore there is need to increase overall funding for the HIV response or reduce unit costs; ** = HIV testing and counselling would continue to be provided as part of programs for key populations. Also, other persons requesting to be tested for HIV should continue to receive the service, even if they are not part of key populations. What the model suggests is that from a cost-effectiveness perspective expanded testing for the general population is not among the most cost-effective programs if no additional resources are available.

In this analysis, cost amounts for ***indirect programs*** and PMTCT were kept fixed. Table 4.5 breaks down the cost of programs that were not included in the optimization and that account for US$10.5 million, or 52 percent, of all HIV spending. Management costs account for only 10 percent of these costs, or 5 percent of total HIV response costs. The largest proportion of these other costs go to STI control and blood safety as well as training and management.

Table 4.5 Breakdown of indirect programs: Management and other costs, 2013 (US$)

Indirect programs	2013 spending (treated as fixed cost)
PLHIV/Stigma	180,000
Strategic info/Research/M&E	515,000
Management	1,025,000
STI control	3,600,000
Blood safety/PEP/Precautions	3,623,000
Enabling environment	80,000
Training	1,027,000
Social protection	163,000
Orphans and vulnerable children	262,000
Total: Indirect programs	**10,475,000**

Source: Financial reporting tables, GARPR 2013.

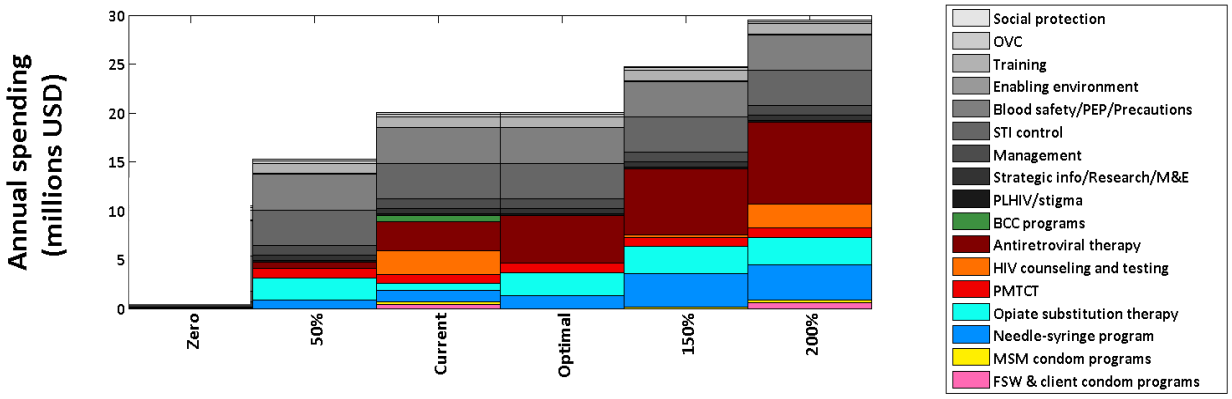
4.4 What might be gained from increased funding and how should reduced funding be prioritized?

The optimization of current funding (**Error! Reference source not found.**4.4) shows that reallocating current funding would improve outcomes but would be insufficient to achieve high coverage levels and impact for all key segments of the epidemic. The optimization results (in Figure 4.5 show optimized allocations at different budget levels. Total HIV spending per

PLHIV was US$800 in 2013 in Belarus, which was below average compared to other countries in the region, in which allocative efficiency analyses were conducted.[8] Therefore, it is relevant to explore how larger amounts of funding could be allocated optimally.

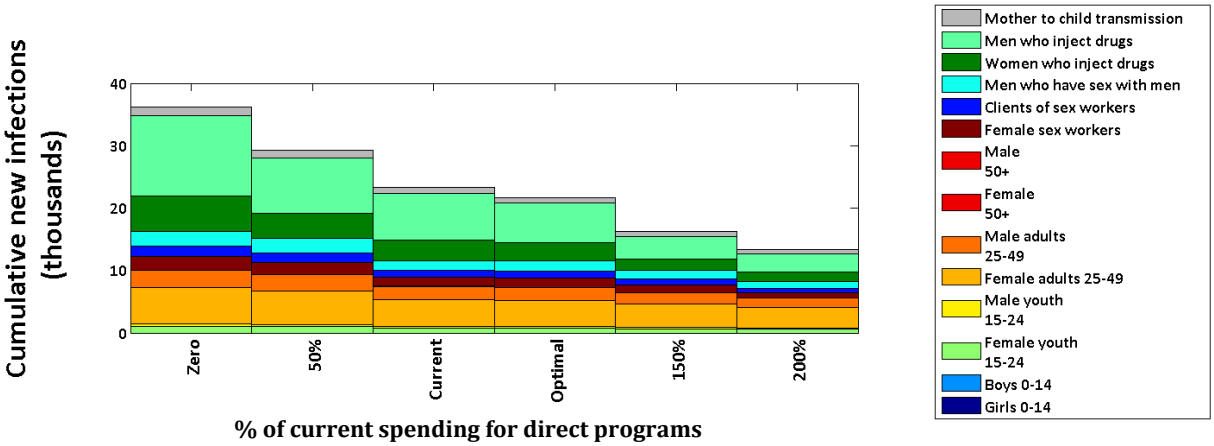
Figure 4.5 Optimized allocations to minimize HIV infections and HIV-attributable deaths at different budget levels, 2015–20

A. Optimized allocations

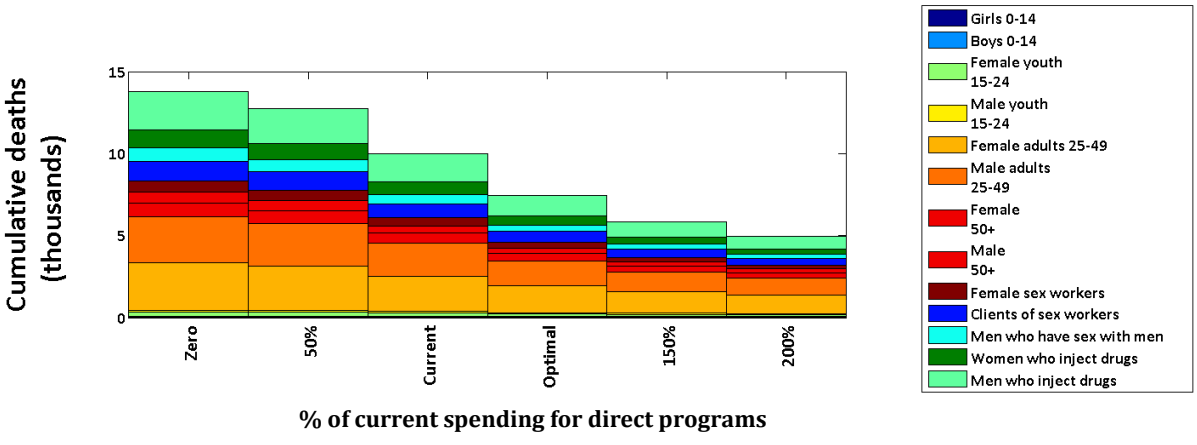


Source: Populated Optima model for all subfigures in this figure.
Note: Only optimized costs are scaled. Nonoptimized spending remains at current levels. Part A, B and C should be read together, as part B and C show the outcomes corresponding to the allocations proposed in Part A.

B. Cumulative new infections



C. Cumulative deaths



[8] Authors' calculations comparing total spending as reported in NASA ([add year]) for six countries in the ECA Region.

Although the likelihood is small that the country will move immediately to either 0 percent or 200 percent of funding, this analysis is helpful in understanding an epidemic's dynamics in relationship to the level of programmatic investments. (1) The analysis shows which services are the most essential in case of reduced funding. (2) It shows to what extent the same impact could be achieved with less funding. (3) The analysis illustrates whether additional investment would lead to saturation of impact or whether additional large gains could be made with additional investment. (4) Scenarios in which higher coverage and impact are achieved with more funding also are useful as starting points from which to discuss implementation efficiency: how to achieve the same coverage and impact with lower funding.

The analysis of allocations and impact at different funding levels also has four important implications. (1) It suggests that current allocations are making a significant impact compared to zero spending. (2) At current levels of spending, a substantial impact on averting deaths could be achieved with a better focus on ART, but the effect on HIV incidence would be limited. (3) At 150 percent of current spending on direct programs, optimization suggests an additional increase of ART as well as a substantial increase of funding for PWID. (4) At 200 percent of current spending on direct programs, allocations for ART would increase further and, in addition to funding for PWID programs, allocations for FSW and MSM programs would be part of the optimized mix.

Table 4.6 summarizes the different allocation amounts and corresponding programmatic impacts. Increasing allocations to 150 percent of spending on direct programs (124 percent of total 2013 spending) would reduce deaths by 42 percent and reduce incidence by 30 percent, mainly by increasing allocations to programs for PWID and ART. Since management and other costs already account for over 50 percent of HIV response costs, it was assumed that these programs and PMTCT would continue at their current funding levels. In practice, this assumption would require additional, more nuanced analysis because some management costs are expected to grow with scale, while other areas will develop technical efficiencies.

Table 4.6 Distribution of HIV prevention and treatment spending to reduce new infections and HIV-related deaths, 2015–20

Program/Indicator	Current allocations	Optimized 50% program budget	Optimized 100% program budget	Optimized 150% program budget	Optimized 200% program budget
FSW and client programs	$430,000	0*)	0*)	0*)	$549,000
MSM programs	$285,000	0*)	0*)	$99,000	$309,000
Needle-syringe program	$1,117,000	$819,000	$1,343,000	$3,483,000	$3,568,000
Opiate substitution therapy	$695,000	$2,294,000	$2,319,000	$2,752,000	$2,828,000
PMTCT	$960,000	$960,000	$960,000	$960,000	$960,000
HIV counseling and testing	$2,433,000	0**)	0**)	$192,000	$2,426,000
Antiretroviral therapy	$2,987,000	$690,000	$4,905,000	$6,804,000	$8,415,000
BCC programs	$620,000	0	0	0	0
Sub-total program spending	9,527,000	4,763,000	9,527,000	14,290,000	19,055,000
Management and other cost	10,475,000	10,475,000	10,475,000	10,475,000	10,475,000
Total spending	20,002,000	15,238,000	20,002,000.00	24,765,000	29,530,000
% of 2013 total spending	100%	76%	100%	124%	148%

Table 4.6 Distribution of HIV prevention and treatment spending to reduce new infections and HIV-related deaths, 2015–20 *(Continued)*

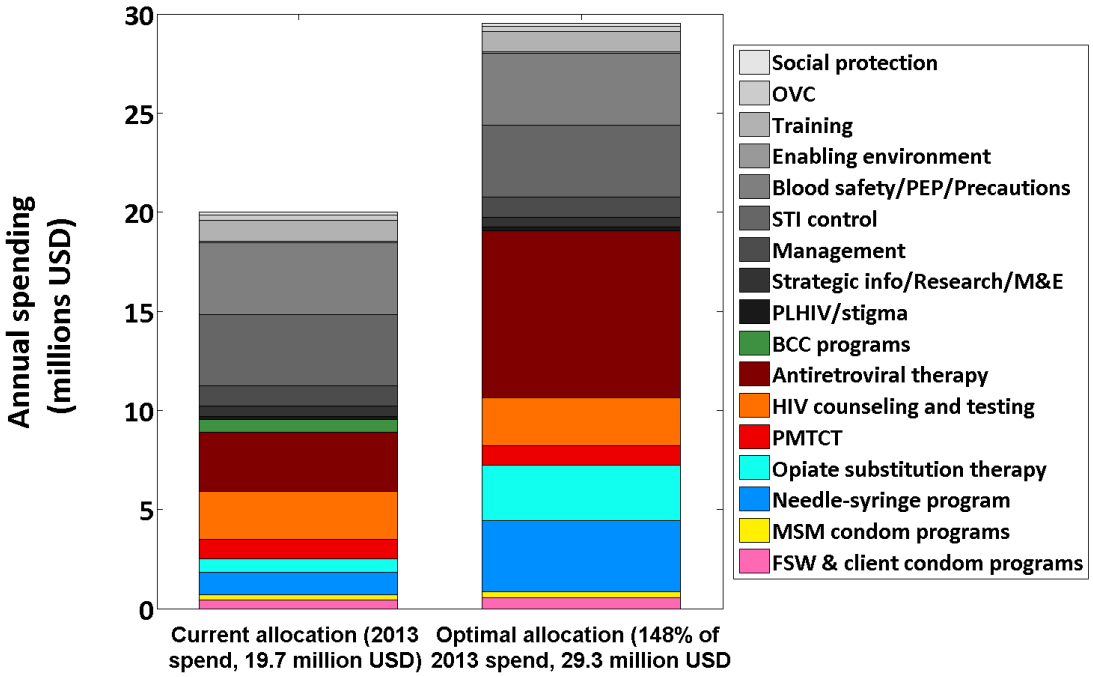
Program/Indicator	Current allocations	Optimized 50% program budget	Optimized 100% program budget	Optimized 150% program budget	Optimized 200% program budget
Corresponding program coverage					
FSW and client programs	13%	0%*)	0%*)	0%*)	16%
MSM programs	16%	0%*)	0%*)	6%*)	18%
Needle-syringe program	25%	19%	29%	59%	60%
Opiate substitution therapy	4%	9%	9%	10%	10%
PMTCT	97%	97%	97%	97%	97%
HIV counseling and testing	32%	0%**)	0%	3%	32%
Antiretroviral therapy	6600 (19% of all PLHIV)	1500 (4% of all PLHIV)	10800 (31% of all PLHIV)	15000 (47% of all PLHIV)	18500 (62% of all PLHIV)
Epidemic impacts					
Cumulative new Infections	23,300	29,200	21,700	16,200	13,300
Cumulative HIV-related deaths	10,000	12,700	7,500	5,800	4,900
Reduction in cumulative new infections compared to current allocations	0%	-25%	7%	30%	43%
Reduction in cumulative deaths compared to current allocations	0%	-27%	25%	42%	51%

Source: Populated Optima model for Belarus.
Note: Amounts rounded to the nearest US$1,000; *) = As explained in the narrative these programs remain important from an epidemiological point of view and should continue to be provided. Therefore there is need to increase overall funding for the HIV response or reduce unit costs; **) = HIV testing and counselling would continue to be provided as part of programs for key populations. Also, other persons requesting to be tested for HIV should continue to receive the service, even if they are not part of key populations. What the model suggests is that from a cost-effectiveness perspective expanded testing for the general population is not among the most cost-effective programs if no additional resources are available.

Table 4.6 demonstrates that higher investment (150 percent and 200 percent of current program spending) would produce substantial additional impacts. The effects of such increased allocations is elaborated in Figure 4.6. It illustrates the optimized allocations if the amount invested in direct programs is doubled while management and other fixed cost (including PMTCT) remain stable. This optimized and increased allocation equals 148 percent of 2013 spending (far right column in Table 4.5).

This optimized allocation would enable substantial increases in ART, NSP, and OST allocations in both amount and percentage. Allocations for MSM and FSW programs would increase in amounts but remain at approximately the same percentage levels as in 2013. HTC would remain stable at US$2.4 million. **This optimized allocation would achieve a remarkable reduction in new infections of 43 percent, and in deaths of 51 percent compared to 2013 allocations.**

Figure 4.6 Comparison of current spending with optimized allocation of 200% of current prevention and treatment spending (equivalent to 148 percent of total current spending)



Source: Populated Optima model for Belarus.

In this optimized allocation, the annual cost for direct programs is US$19.1 million. The total annual cost for the HIV response US$29.5 million, which is 48 percent more than was spent in 2013. One way to achieve the same results at lower cost would be to reduce unit costs of programs. If unit costs and management cost in all program areas could be reduced by 32 percent[9] without a loss in service quality, equal results could be achieved at the level of total 2013 spending. However, although examples for lower unit costs for specific programs do exist in the region, such a substantial reduction may not be realistic. Regional comparison of program costs has great limitations because coverage and cost definitions vary among countries. However, available data suggests that, in many program areas, cost is already below both the regional average and median costs in Belarus. Additional technical efficiency analysis would be required to determine the extent of possible additional unit cost reductions. Therefore, other options, including additional resource mobilization, could be considered. Another option would be to look for other funding sources for programs, such as STI control, that have major benefits beyond HIV. In practice, the most promising option for achieving these additional impacts would be a combination of measures: improved allocation mix, increased allocations, reduced unit costs, and identification of alternative and cofinancing from non-HIV budget lines for programs such as STI control and OST.

4.5 How much does it cost to achieve national targets?

The optimizations presented so far in this report are seeking optimized spending at different funding levels. In other words, they are seeking the best health impact on new infections and deaths with different given amounts of money. The following optimization results are based on a different approach. They explore the optimized mix to achieve a given impact target in line with national targets at the lowest possible cost. Based on a discussion with experts from

[9] The reduction in cost required to set off a 48% increase in resource need is 32% (32% = 100%–100%/148%).

Belarus, two different sets of targets were modelled: one moderate set of targets and one more ambitious set of targets aligned to national targets and international commitments.

For the purpose of optimization analysis, it is not useful to include the full set of coverage targets as outlined in section 1. Coverage targets constrain the optimization analysis, which would be forced to meet the spending requirements for all programs to meet coverage targets rather than to identify the optimized mix and minimum amount required to meet national targets. Therefore, impact targets were used in this analysis and formulated as described in Table 4.7.

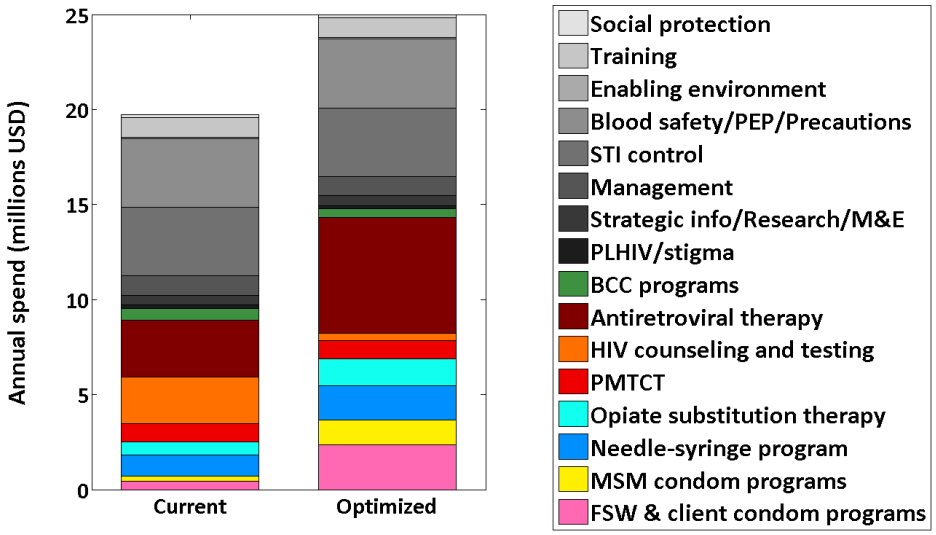
Table 4.7 National targets as applied in the optimization

	AIDS-related deaths	HIV infections	Mother-to-child-transmission
Moderate targets (stabilize epidemic)	No separate target	No increase in annual new infections in 2020 compared to 2014 levels (2,900 new infections per year)	No separate target—maintain 2014 coverage
National targets	Reduce AIDS deaths by 65% (equivalent to reducing AIDS deaths from 2.8 per 100,000 per year to 1 per 100,000 per year);	Reduce annual incidence by approximately 45% (equivalent to reducing incidence from 12 per 100,000 per year to 7 per 100,000 per year	HIV transmission from mother-to-child is virtually eliminated (less than 1%

4.5.1. Optimized allocations and cost to achieve moderate targets: stabilize the epidemic

The results in this section show the minimal spending required to achieve moderate targets by 2020, which was a main result requested by the Belarus country team. Achieving moderate targets would require an increase in programmatic spending from US$9.5 million–$14.8 million (Table 4.7, Figure 4.7). The increased investment would go primarily to ART, prevention programs for female sex workers and MSM, NSP, and OST. In addition, a large proportion of funds for general-population HTC and BCC programs would need to be reallocated toward them. In this analysis, management and other costs as well as PMTCT were assumed to remain stable for the same reasons as outlined above. As a result of this allocation, new HIV infections would remain below the baseline value of 2,900 new infections in 2014 over 2015–20.

Figure 4.7 Comparison of current (2013) and the minimal HIV prevention and treatment program spending to achieve stable HIV incidence, 2015–20



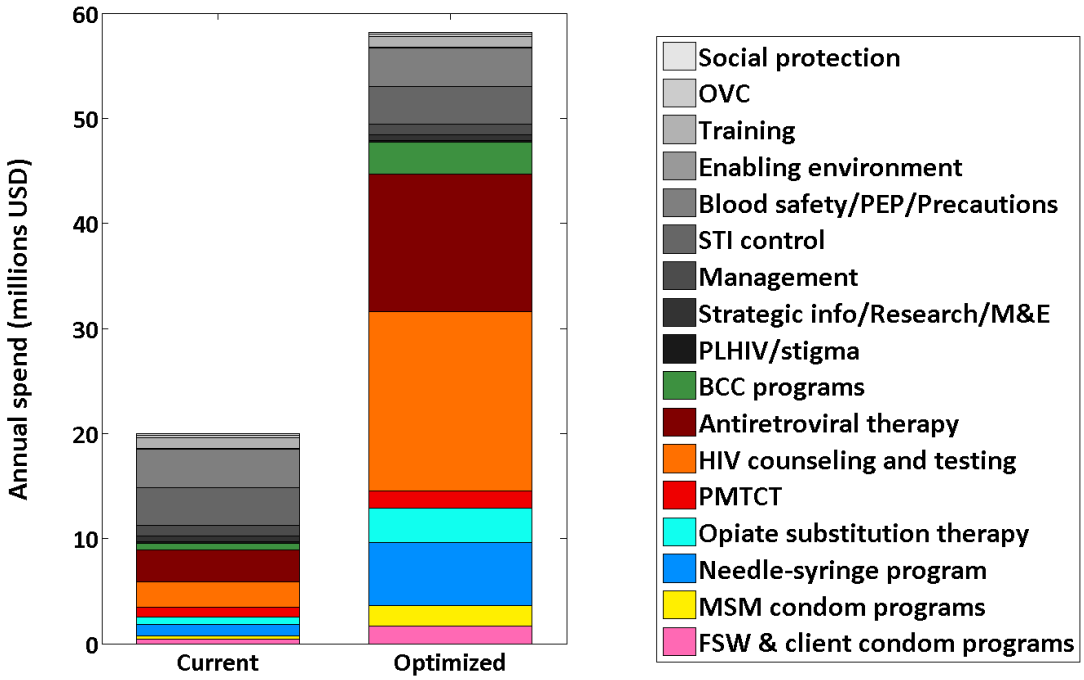
Source: Populated Optima model and data spreadsheet for Belarus.
Note: Only optimized costs are scaled. Nonoptimized spending remains at current levels.

4.5.2. Optimized allocations and cost to achieve national targets

The optimized mix of programs to achieve national targets (reduce incidence by 45 percent, reduce deaths by 65 percent, reduce MTCT to below 1 percent) is presented in Figure 4.8. The analysis suggests that, to fully achieve national targets, approximately US$58 million will be required. This large funding requirement is driven primarily by the very large need for HTC (US$17.1 million), which, together with the allocation to treatment (US$13.1 million), would absorb 51 percent of all HIV spending. Programs for PWID would absorb another 16 percent of resources (NSP US$5.9 million and OST US$3.2 million). These allocations will reduce cumulative deaths by 62 percent and new infections by 64 percent. These results also imply that, due to the dual effects of ART on survival and averting new infections, achieving a large mortality reduction will over-achieve the target to reduce HIV incidence.

The analysis suggests that full achievement of national targets requires over 230 percent more funding than do moderate targets (US$25.2 million). The allocation for doubling spending on direct programs (US$29.5 million) described in section 4.3 (Figure 4.6) reduced incidence by 43 percent and deaths by 51 percent. For this reason, and it could be argued that the national targets may be overly ambitious within the given ti.me frame, unless unit costs can be reduced or budgets increased substantially.

Figure 4.8 Optimized allocations to achieve national targets



Source: Populated Optima model for Belarus.

Table 4.8 HIV prevention and treatment spending allocation to achieve moderate targets and national targets. 2015–20

Program	2013 allocations		Optimized allocation to achieve moderate targets		Optimized allocation to achieve national targets	
	Spending (%)	Coverage (%)	Spending ($)	Coverage (%)	Spending ($)	Coverage (%)
FSW and client condom programs	430,000	13	2,371,000	60	1,703,000	46
MSM condom programs	285,000	16	1,285,000	62	1,920,000	76

Table 4.8 HIV prevention and treatment spending allocation to achieve moderate targets and national targets. 2015–20 *(Continued)*

2013 allocations	Optimized allocation to achieve moderate targets	Optimized allocation to achieve national targets	2013 allocations	Optimized allocation to achieve moderate targets	Optimized allocation to achieve national targets	2013 allocations
Needle-syringe program	1,117,000	25	1,810,000	38	5,988,000	71
Opiate substitution therapy	695,000	4	1,410,000	7	3,292,000	10
PMTCT	960,000	>95	960,000	>95	1,653,000	>95
HIV counseling and testing	2,433,000	32	407,000	6	17,061,000	89
Antiretroviral therapy	2,987,000	6,600 (19% of all PLHIV)	6,080,000	13,400 (39% of all PLHIV)	13,106,000	28,900 (84% of all PLHIV)
BCC programs	620,000	–	444,000	–	3,008,000	–
Total	**9,527,000**	**–**	**14,767,000**	**–**	**47,731,000**	**–**
Management and other cost	10,475,000	–	10,475,000	–	10,475,000	–
Total spending	**20,002,000**	**–**	**25,242,000**	**–**	**58,206,000**	**–**

Source: Populated Optima model for Belarus.
Note: Amounts rounded to the nearest US$1,000.

4.6 Efficiency gains from optimized allocations

This section explores the financial implications and gains from different allocations as developed in previous sections.

As summarized in Table 4.6 “business as usual” using 2013 allocations would mean an estimated 23,300 new infections and 10,000 HIV-related deaths between 2015 and 2020. Optimally allocating the same amount of funding (without any cost increases or technical efficiency gains) would imply 21,700 new infections and 7,500 deaths, that is, a reduction in deaths by 25 percent and in new infections by 7 percent. Table 4.9 shows the costs per additional infection and death averted for 3 different allocations. The lowest cost per infection and death averted can be achieved by doubling spending on direct programs (to? approximately US$29.5 million). Aiming for very high coverage and more ambitious impact targets makes programs more costly again. The reason is that increasing coverage becomes more expensive when approaching saturation-coverage levels and the increasing cost to achieve the HTC coverage needed to achieve high ART coverage.

Table 4.9 Total program costs per infection averted and HIV-related deaths averted (US$)

Allocation scenario	Program cost per infection averted (2015–20, 3 percent discounting) ($)	Program cost per HIV-related death averted (2015–20, 3 percent discounting) ($)
Current level of spending, optimized	7,500	17,200
200% of current spending on direct programs	4,700	12,300
Allocation to achieve national targets	11,400	31,600

Source: Populated Optima model for Belarus.
Note: Amounts rounded to the nearest US$1,000. Program costs include optimized spending and treatment costs as well as nonoptimized costs.

4.7 Health and financial impacts of implementing different ART guidelines

A specific analysis was carried out to establish the impact of scaling up ART. The impact of scaling up Belarus' ART program so that all PLHIV are eligible to begin treatment regardless of their CD4 count is compared to the baseline scenario of current ART coverage.

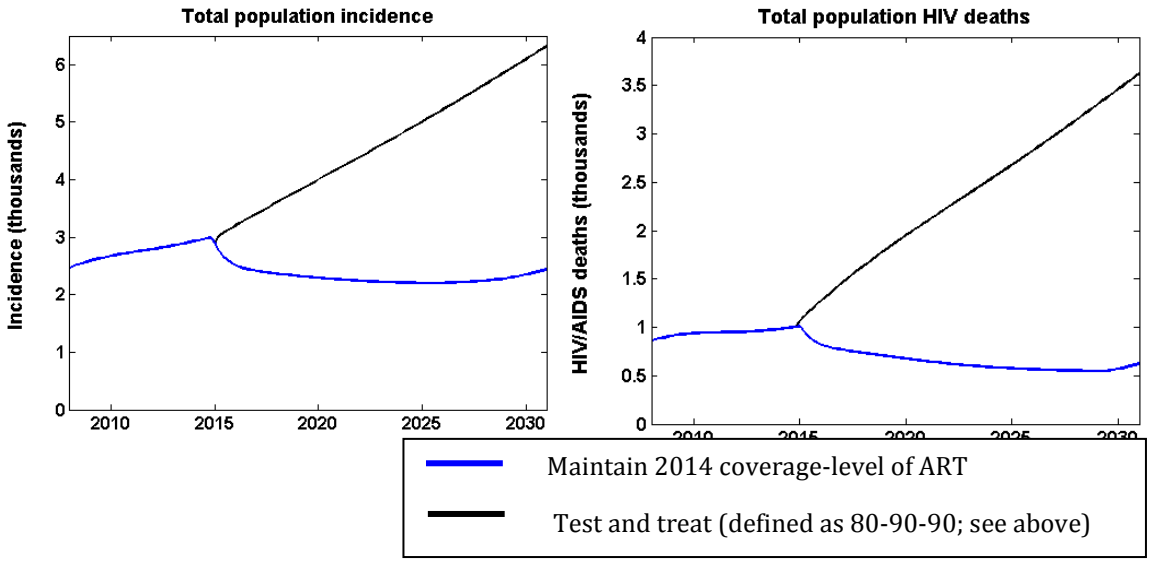
The results presented below are for the following level of testing and treatment coverage:

- 80 of all PLHIV diagnosed by 2020
- 90 of those diagnosed on ART by 2020
- 90 of those on ART with viral suppression by 2020.

The full achievement of 90-90-90 targets by 2020 for the entire population of PLHIV was considered unrealistic. Consequently, as a proxy for 90-90-90 among key populations, an 80 percent diagnosis of all PLHIV was used––still considered a highly ambitious target. This target translates to 72 percent of all PLHIV being on ART and 65 percent of all PLHIV being virally suppressed by 2020. Figure 4.9 and Table 4.10 show the additional impact of such a test and treat scenario as compared to current allocations and current ART coverage. This analysis shows that if such high levels of coverage and adherence can be achieved, a substantial reduction in new infections and deaths could be achieved by 2030. A test and treat scenario could reduce HIV incidence by 61 percent.

It needs to be emphasized that such high levels of ART coverage and adherence will be very difficult to achieve, particularly in key populations such as PWID. It is plausible that adherence support would need to include substantial scale-up of other prevention programs for PWID and OST. Moreover, to achieve such high rates of HTC among FSW and MSM would require reduction in stigma and high coverage of prevention and HTC outreach, which might require additional investment. Thus, the additional annual estimated cost of US$12.4 million could be an underestimate of the comprehensive HIV response cost to achieve high ART coverage and adherence, particularly for PWID.

Figure 4.9 Projected new HIV infections and AIDS-related deaths with current ART coverage and a test and treat approach in Belarus, 2010–30



Source: Populated Optima model for Belarus.

Table 4.10 Comparing the effect of different ART eligibility criteria for PLHIV

	Effect of test and treat (defined as 80-90-90*) compared to maintaining 2014 coverage of ART)	
Impact measures	**By 2020**	**By 2030**
HIV incidence (compared to baseline scenario) reduction	46	61
Number of new HIV infections averted	7,400	37,000
Number of AIDS-related deaths averted	5,300	28,000
Additional cost per year ($)	12,416,000	12,416,000

Source: Populated Optima model for Belarus.
Note: *See preceding text.

The following figures show the effect of the test and treat approach compared to current conditions (including current ART coverage). The projections show that applying a test and treat approach would have the potential to both stabilize HIV incidence and reduce HIV-related deaths by 2030. However, the additional annual cost of US$12.4 million would take the total annual HIV response cost to US$32.2 million. Therefore, the cost of the test and treat scenario would exceed the cost of optimized allocations to stabilize incidence (US$25.0 million), as well as optimized allocations to minimize both incidence and deaths (US$29.5 million).

It is useful to compare the impact and cost of the "test and treat only" scenario to the "double spend on direct programs" optimization to minimize both HIV incidence and deaths. Although the exclusive focus on scaling up test and treat would avert slightly more deaths (5,300 vs. 5,100), the optimization to "double spend on direct programs" would avert substantially more new infections (10,000 vs. 7,400). The "double spend on direct programs" also would require a lower level of investment (US$29.5 million vs. US$32.2 million). Overall, this comparison suggests that a combination of programs established through optimization with a strong, but not exclusive, focus on scaling up ART would have the strongest impact on Belarus' epidemic.

5. CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the 10 main implications of the epidemic and optimization analyses carried out as part of the Belarus HIV allocative efficiency study.

1 **The epidemics among PWID, MSM, and FSW including clients account for approximately two-thirds of new HIV infections in Belarus and need to remain the core focus of HIV programs.** Prevention, HIV testing, and treatment need to be targeted primarily at these key groups. At the same time, programmatic efforts to also reach their sexual partners need to be enhanced. Belarus is progressing from an early concentrated epidemic among PWID to an advanced concentrated epidemic in which sexual transmission from key populations to their sexual partners, most commonly women aged 15–49, will continue to grow. In this context, HIV transmission in key populations remains the "engine" of the epidemic, while transmission also will reach other groups. Therefore, there is continued need to focus the generation of strategic information, analysis, and planning on key populations, particularly PWID, MSM, FSW, their clients, and their sexual partners. If the focus is kept on them, new trends such as growing incidence among MSM can be understood and addressed early.

2 **It is critical for Belarus to continue to prioritize the ongoing ART scale-up and substantially increase the allocation to ART.** If the same funding level is available as in 2013 (US$20 million), ART allocations should be increased from US$3.0 million in 2013 to US$4.9 million, which would increase the proportion of PLHIV on ART from 19 percent to 31 percent. This increase in allocations would be the main contributor to reduce deaths by 25 percent with 2013-level funding. With an additional 50 percent of total funding available, the allocation to ART should increase to US$8.5 million, achieving coverage of 62 percent of all PLHIV and reducing deaths by 51 percent compared to 2013 allocations. Rather than aiming for widespread HTC for the general population to initiate ART, it will be important to focus on identifying PLHIV from key populations, particularly PWID, MSM, FSW, and their clients and their sexual partners.

3 **Addressing the HIV service and wider health needs of people who inject drugs remains a critical priority for Belarus.** Needle and syringe programs should be further scaled up as part of a program package for PWID that includes HTC and condom promotion. Opioid substitution therapy has important effects on HIV prevention and ART adherence and should be doubled in coverage from 4 percent to 10 percent. However, since health and social benefits of OST go far beyond HIV, additional funding from outside the HIV response would reflect the wide range of benefits and contribute to the increased scale and sustainability of OST programs.

4 **To address the growing MSM epidemic, MSM programs need to increase in coverage.** These programs will require pragmatic outreach approaches through informal networks while continuing efforts to reduce the stigma and discrimination of MSM. With current funding levels, MSM programs would not be part of the optimized mix.

With a 50 percent increase in total funding for HIV, MSM programs would increase moderately in coverage from 16 percent to 18 percent. This result suggests that unit costs should be reviewed and that strategies to achieve higher coverage with given or, if available, increased resources could be explored.

5 **Focused programs for FSW should be sustained and reach the FSW at the highest risk of HIV.** There is a need to provide clinical services and outreach to FSW with strong geographic prioritization. With current funding levels, FSW programs would not be part of the optimized mix; yet, with a 50 percent increase in resources for the HIV response, it could reach 16 percent of all FSW. Just as for MSM programs, unit costs should be reviewed and strategies to achieve higher coverage with given or, if available, increased resources could be explored.

6 **Programs for the general population are much less cost effective compared to programs for key populations and should receive reduced allocations.** HTC should remain available as the entry point for ART and other services but be focused on key populations, particularly if the current total funding envelope for the HIV response cannot be increased. In the analysis, PMTCT was considered a fixed cost, but it should be provided as cost efficiently as possible, particularly in low-volume sites. Funds allocated to BCC programs for the general population should be reallocated to the specified high-impact programs including ART and prevention for key populations.

7 Belarus funds several other programs through its HIV response including blood safety and STI control, although the primary benefit of these programs goes beyond the HIV response. **If alternative funding for blood safety and STI programs could be identified, while advocating for the continued need to sustain the full HIV budget of US$19.7 million, the alternative funding would free up US$7.2 million.** That amount then could contribute a large portion of the funding required to achieve higher impact on HIV incidence and deaths. Similar effects could also be achieved by reducing training costs, which accounted for US$1.0 million in 2013.

8 This analysis was not focused on identifying technical efficiencies; therefore, no specific technical recommendations can be made. Big-picture comparison to other countries––which has a number of limitations––showed that the cost range per person reached in Belarus is similar to ranges in other countries. However, given limited resources in Belarus, **it is worth conducting additional technical efficiency analysis focused on the programs that absorb the largest proportion of funding** (ART, OST, and PWID/NSP programs; management; and other costs).

Apart from the growing needs of the HIV epidemic, a number of complementary health priorities require continued attention and should be allocated additional funding outside HIV budgets. Such funding would include harm-reduction programs for people who inject drugs (PWID), particularly, opiate substitution therapy. OST has important impacts not only on reduced needle-sharing and increased HIV treatment adherence but, more broadly, also on health and wellbeing and reduced rates of drug-related crime.

9 "Business as usual" would imply additional growth of Belarus' HIV epidemic and an estimated increase in the annual new infections by 50 percent by 2030. Solely changing the mix of programs would not be sufficient to reverse the increase in the epidemic. **Therefore, domestic and international resource mobilization for HIV programs remains a priority. Increases in funding by 10 percent to 50 percent compared to 2013 may be required to reduce HIV incidence and deaths by 40 percent–50 percent.** Very ambitious medium-term targets such as reducing deaths and/or incidence by over 60 percent by 2020

would require even larger increases in funding. The team's analyses suggest that very high value for money can be obtained with approximately a 50 percent increase in funding (or less if technical efficiencies and savings can be achieved). .

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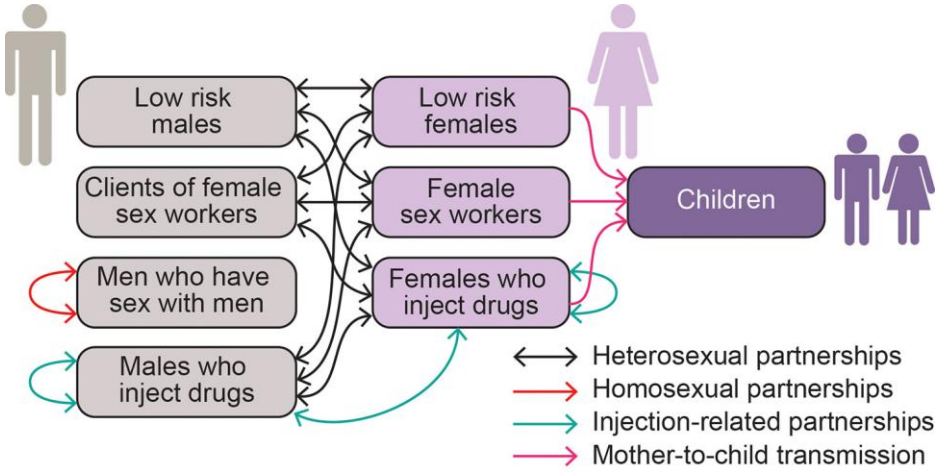
APPENDIXES

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.[10] 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 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

[10] 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).

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.[11] 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.[12] 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.[13]

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[11] 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.

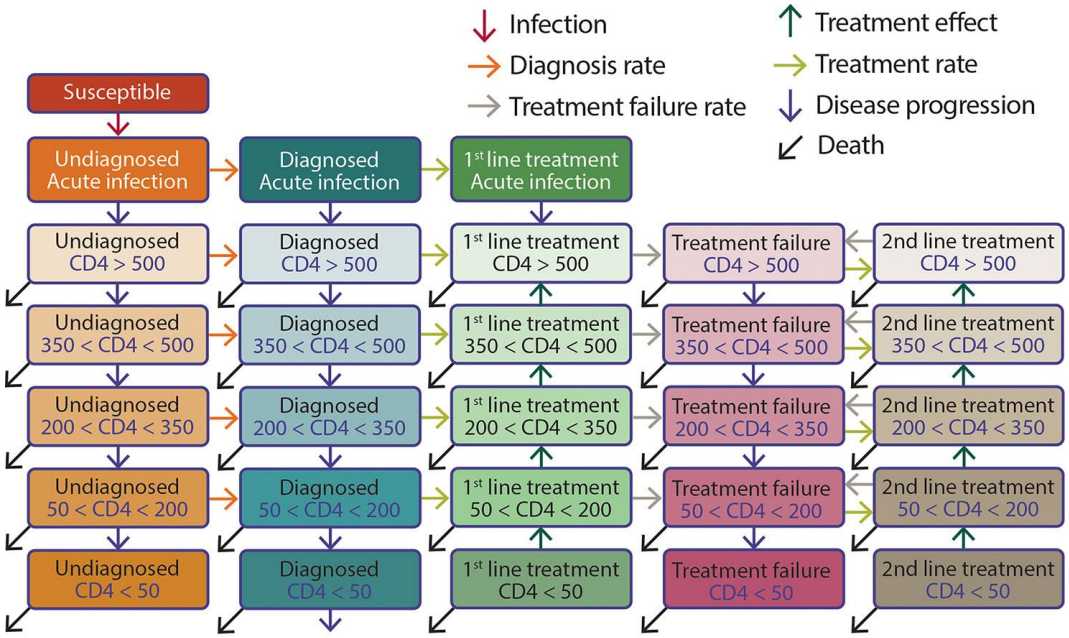
[12] First, individuals may die, either because of an average background death rate for that population (which is greater for older populations or for people who inject drugs) or because of HIV/AIDS (which depends on CD4 count). Second, in the absence of treatment, individuals progress from higher to 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.

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

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

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.)

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.

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)

Table A.1 Input parameters of the model *(Continued)*

	Biological parameters	Behavioral parameters	Epidemiological/Other parameters
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.[14] Logistic functions can incorporate initial 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

[14] 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).

responses.[15] 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.[16]

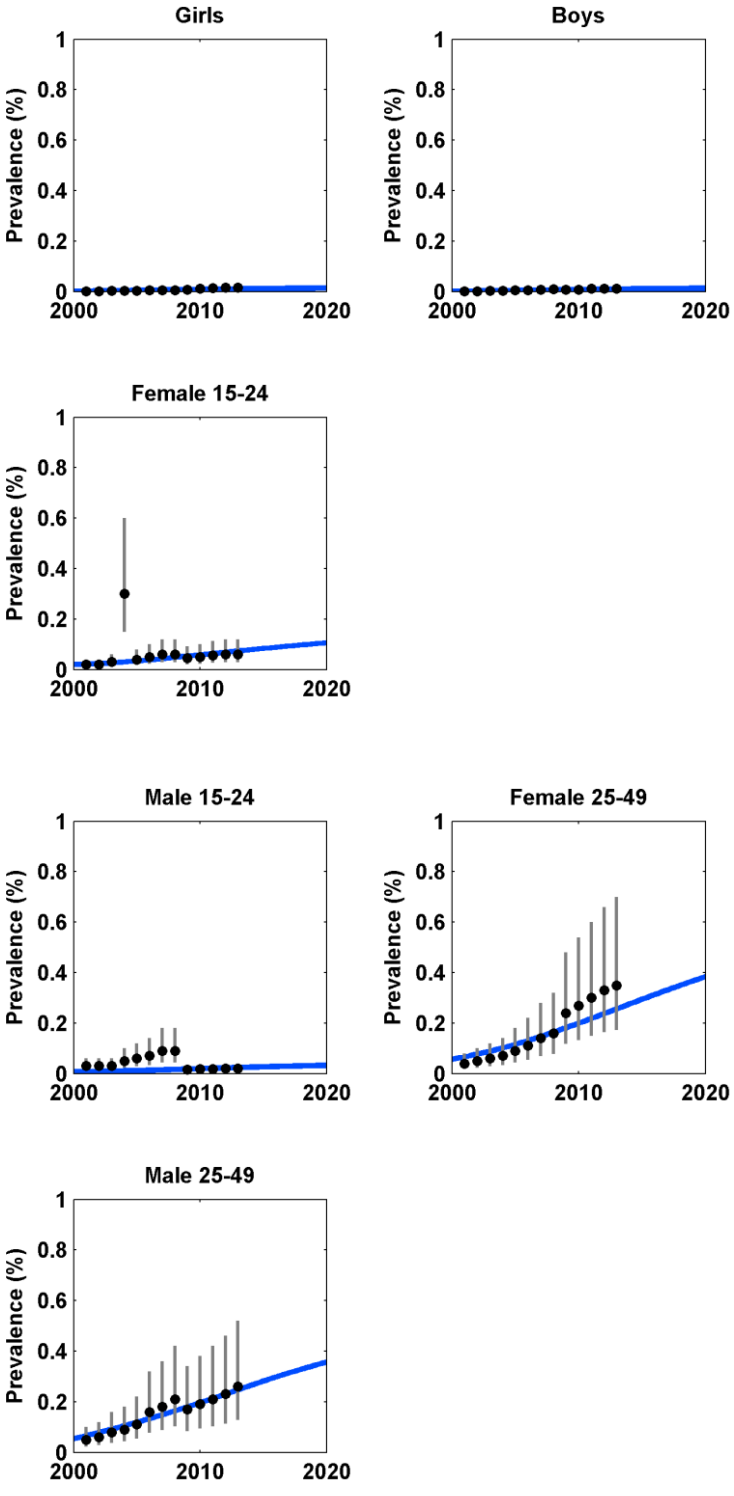
[15] Program coverage for zero spending, or behavioral outcomes for zero coverage of formal programs, is inferred using data from early on in the epidemic or just before significant investment in HIV programs. Practically, the team also discussed the zero and high spending cases with local experts, who 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).

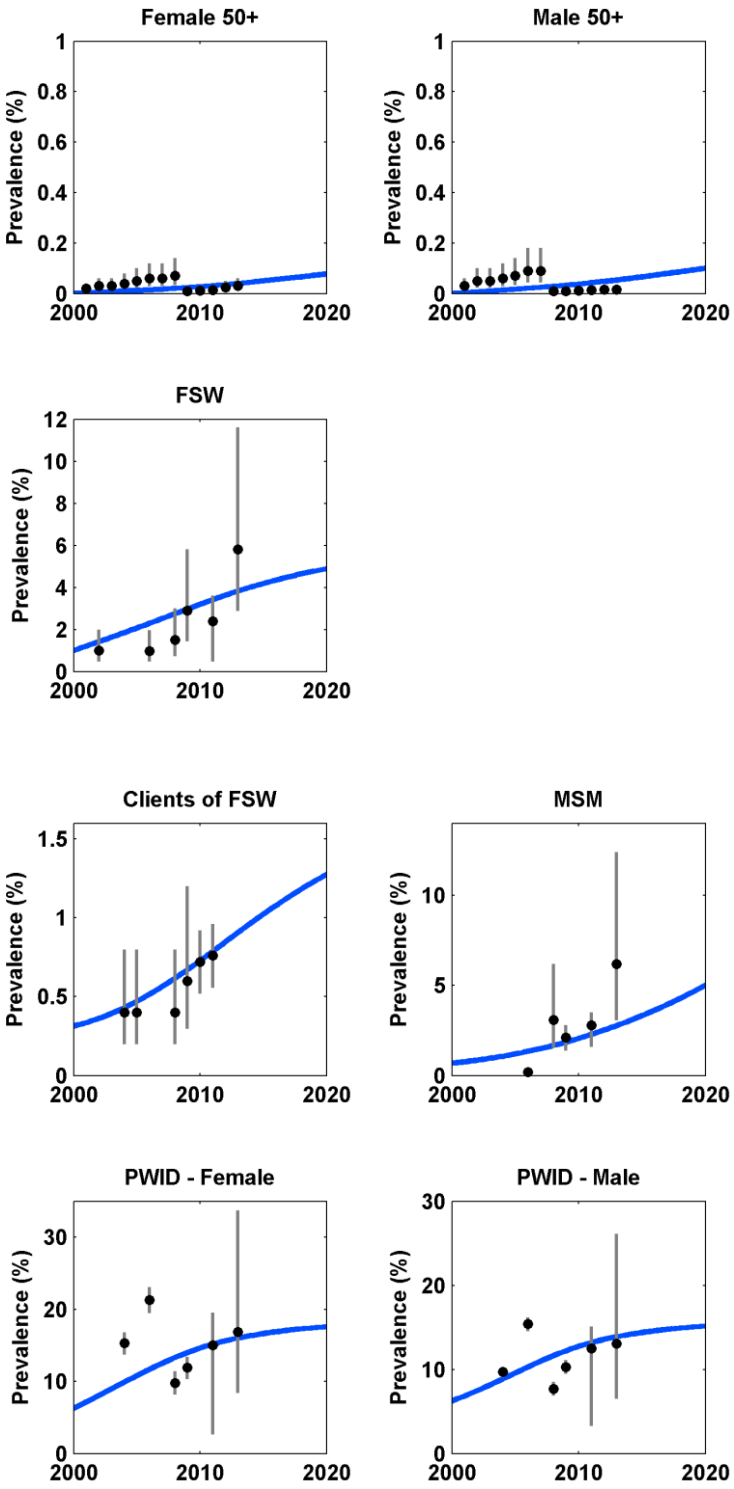
[16] All available historical spending data and achieved outcomes of spending, data from comparable settings, experience, and extensive discussion with stakeholders in the country of application can be used to inform these ranges. All logistic curves within these ranges then are allowable and are incorporated 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 OF THE MODEL TO EPIDEMIC DATA

The calibration to HIV prevalence data points is shown in Figure B.1, and the calibration to data points on the number of people on ART is shown in B2.

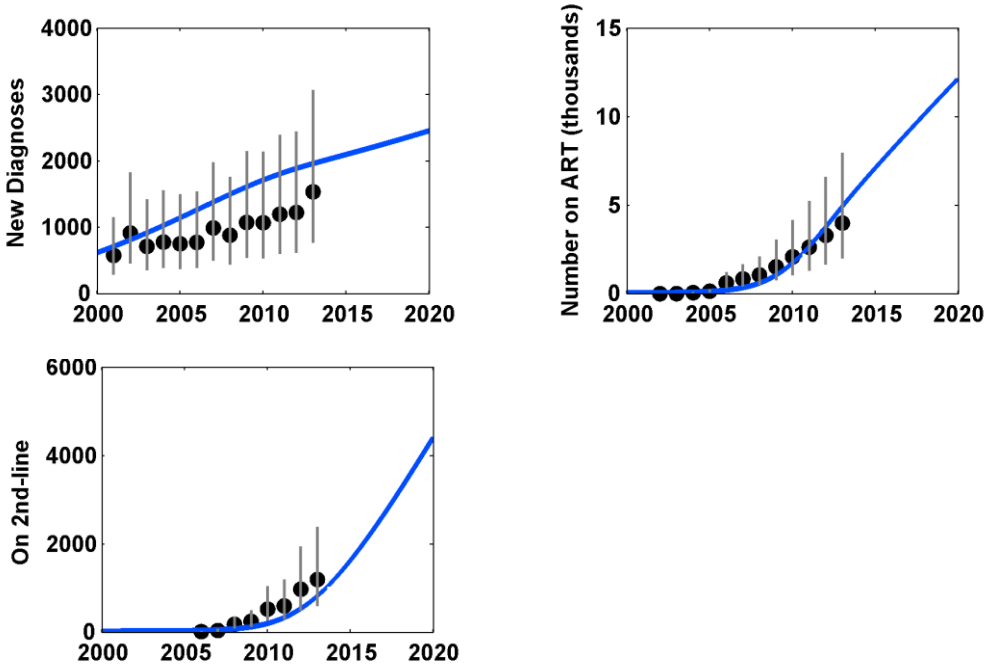
Figure B.1 Calibration of Optima to the HIV epidemic in Belarus, 2000–20 (%)





Source: Populated Optima model for Belarus.
Note: Black discs represent available data for HIV prevalence. Lines attached to these discs represent uncertainty bounds. The solid curve is the best fitting simulation used to produce the main findings.

Figure B.2 Calibration of model to diagnoses and ART scale-up data in Belarus, 2000–20



Source: Populated Optima model for Belarus.
Note: These calibrations were produced in collaboration with Belarus experts. Black discs represent available data for number of new diagnoses and the number of people on first- and second-line antiretroviral treatment (ART). Lines attached to these discs represent uncertainty bounds. The solid curve is the best fitting simulation. The note number on ART includes those on first-line ART and those who are experiencing treatment failure.

APPENDIX C. COST-COVERAGE OUTCOME CURVES

Table C.1 shows the cost-coverage outcome curves used to generate the allocative efficiency (AE) in Belarus results. The relationship between program spending and coverage is shown in the left subfigure. This relationship describes the level of output (availability of a service to a specific proportion of the target population) achieved with a specific level of financial input (cost in US$). For example, this relationship would describe how many female sex workers could be provided with a standard package of services with an investment of US$0–US$1 million. The relationship between coverage levels and outcome is shown in the middle subfigure. 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). The subfigure on the right shows the cost-outcome relation, which combines the left and middle subfigures and shows the direct relationship between cost and outcome. These relationships were produced in collaboration with Belarus experts.

Table C.1 Cost-coverage outcome curves for Belarus

1. FSW Programs

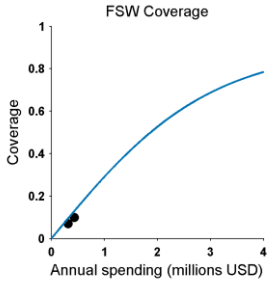
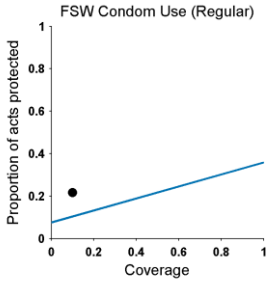
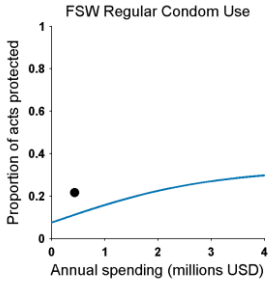
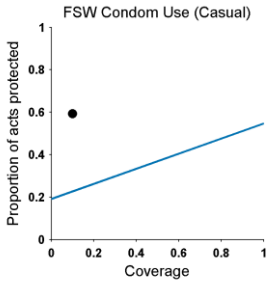
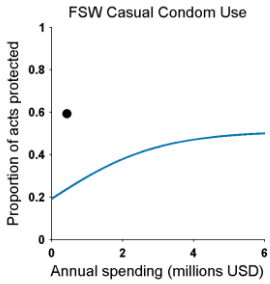
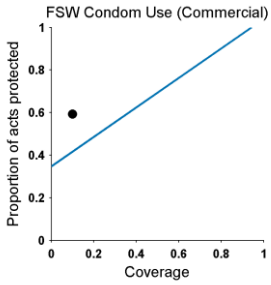
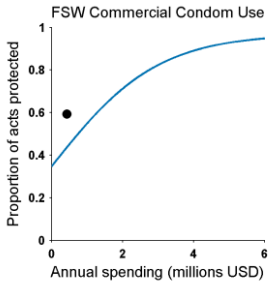
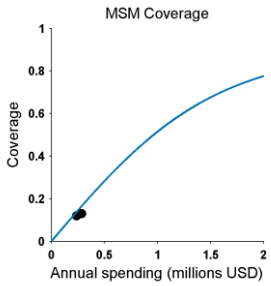
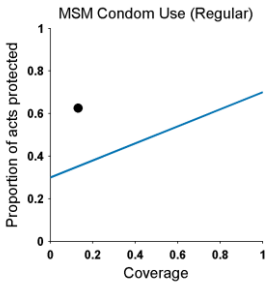
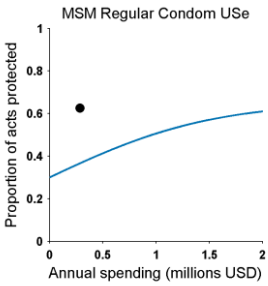
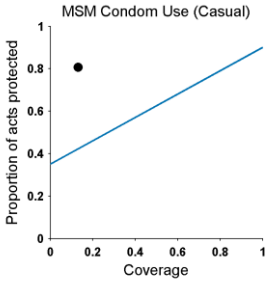
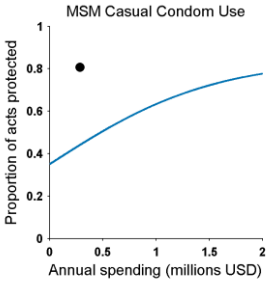
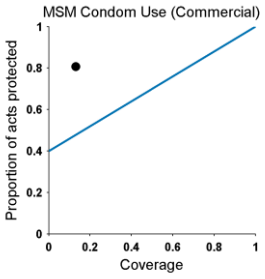
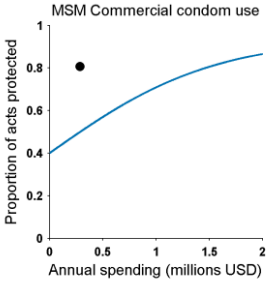
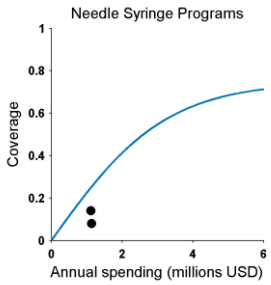
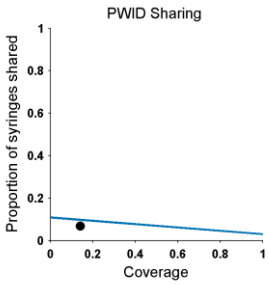
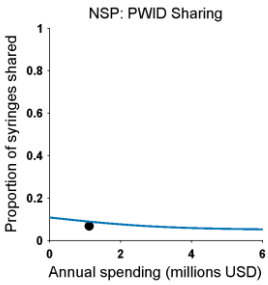
Cost-Coverage	Coverage-Outcome	Cost-Outcome
		
		
		

Table C.1 Cost-coverage outcome curves for Belarus *(Continued)*

2. MSM

Cost-Coverage	Coverage-Outcome	Cost-Outcome
		
		
		

3. NSP

4. OST

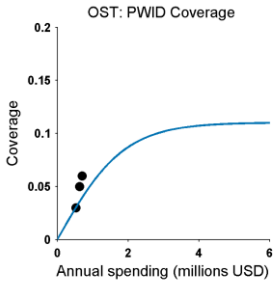
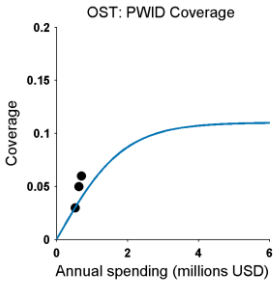
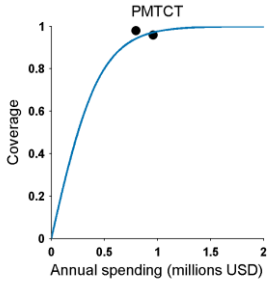
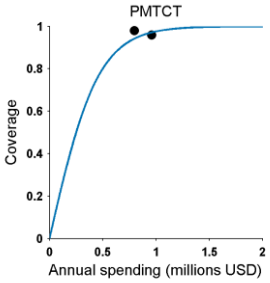
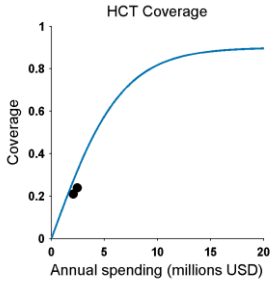
	Not applicable OST coverage is defined as the number of people receiving OST, which is equivalent to the outcome (number of people utilizing OST services). Therefore, the cost-coverage relation is the same as the cost-outcome relation).	

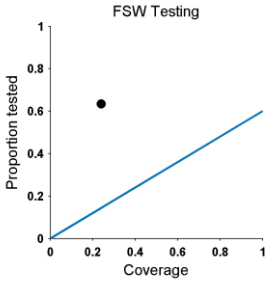
Table C.1 Cost-coverage outcome curves for Belarus *(Continued)*

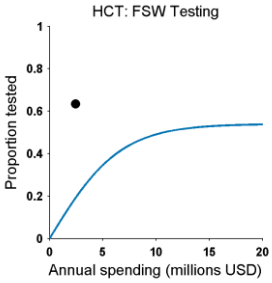
C.5 PMTCT

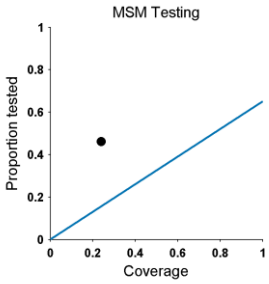
Cost-Coverage	Cost-Coverage	Cost-Coverage
	Not applicable PMTCT coverage is defined as the number of pregnant women receiving ARV prophylaxis, which is equivalent to the outcome. Therefore, the cost-coverage relation is the same as the cost-outcome relation).	

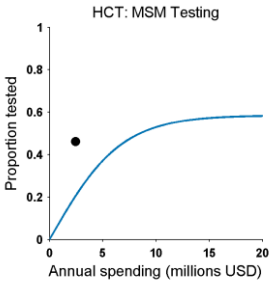
C.6. HTC

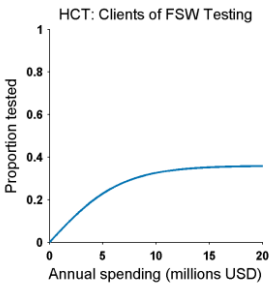


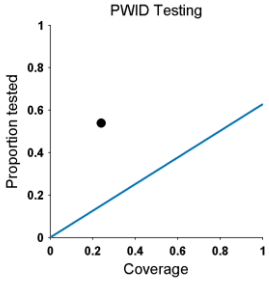












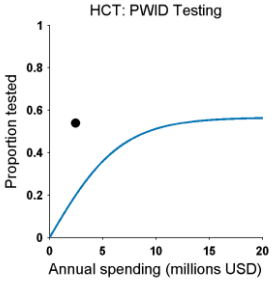


Table C.1 Cost-coverage outcome curves for Belarus *(Continued)*

C.5 PMTCT

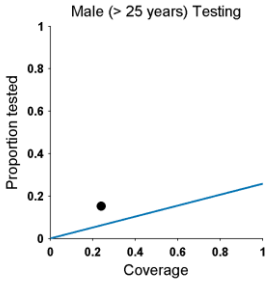
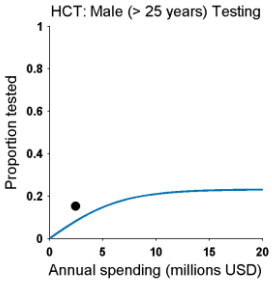
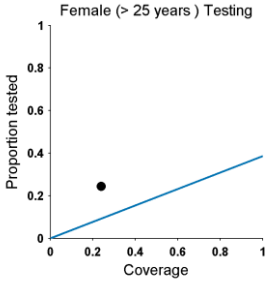
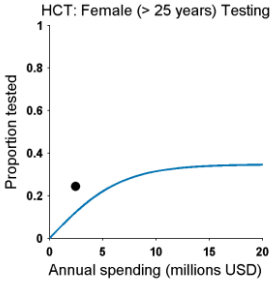
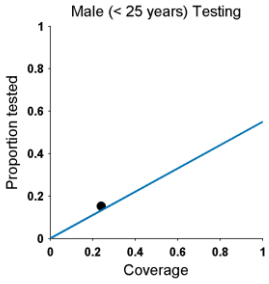
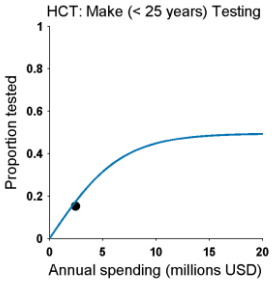
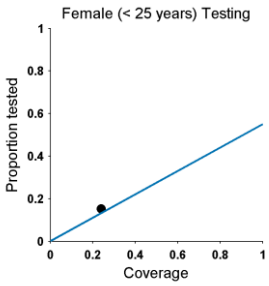
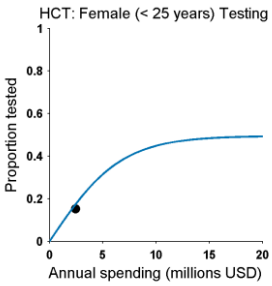
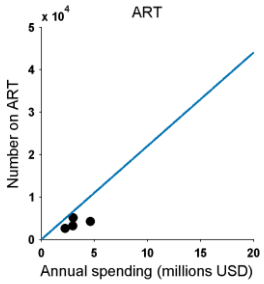
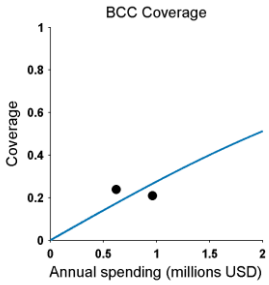
Cost-Coverage	Cost-Coverage	Cost-Coverage
		
		
		
		

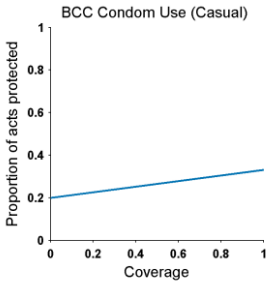
Table C.1 Cost-coverage outcome curves for Belarus *(Continued)*

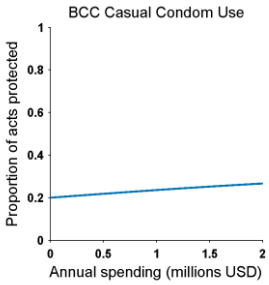
C.7 ART

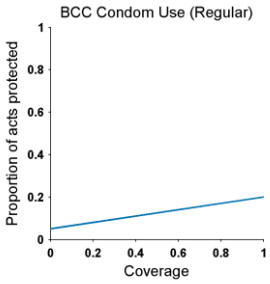
Cost-Coverage	Cost-Coverage	Cost-Coverage
Not applicable	Not applicable ART coverage is defined as the number of people receiving ART, which is equivalent to the outcome (number of people utilizing ART services). Therefore, the cost-coverage relation is the same as the cost-outcome relation).	

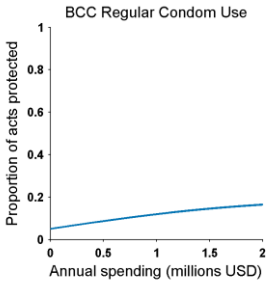
8. BCC









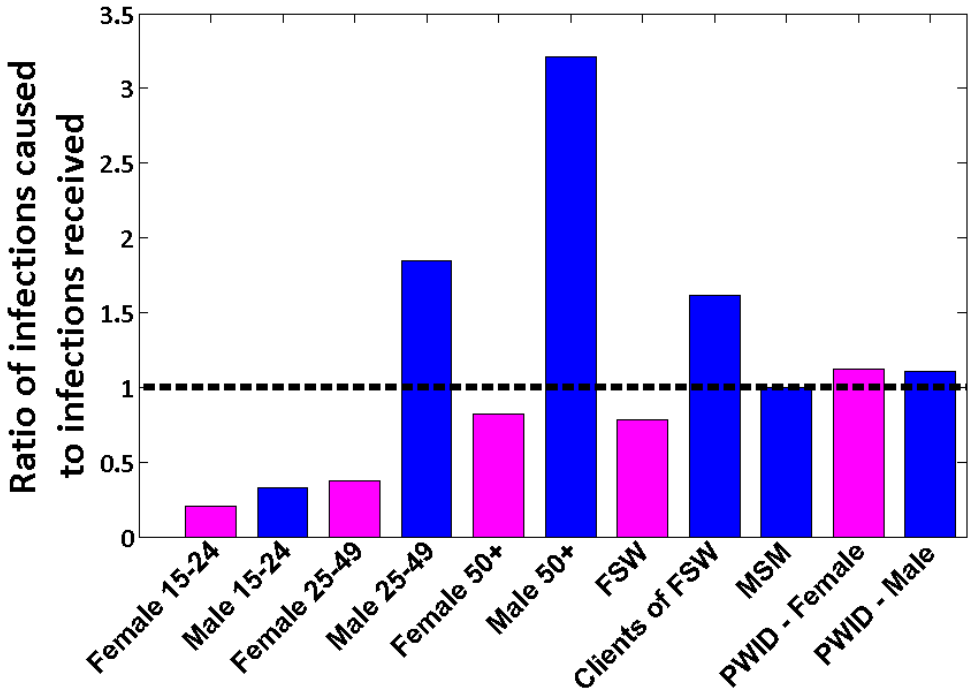


Source: Populated Optima model for Belarus.

APPENDIX D. ADDITIONAL RESULTS: INFECTIONS RECEIVED VS. INFECTIONS TRANSMITTED

The ratios of HIV transmission (infections caused) versus HIV acquisition (infections received) among populations in 2013 are shown in Figure D.1. The populations with a value below 1 receive more HIV infections than they cause. Although men 50+ cause many more new infections than they receive, their contribution to new infections is not very large due to the relatively small number of new infections and PLHIV in this group. The "Male 50+" group also includes former PWID and clients of FSW who were infected earlier and aged into this group but who still may pass on HIV. Their presence also explains the high ratio of infections transmitted versus received. However, what Figure D.1 demonstrates is that ***clients of sex workers, male PWID, and males 25–49 (who include former FSW clients and PWID) transmit more infections than they receive.*** This fact can be explained by the high levels of transmission from these groups to female youth and adults.

Figure D.1 Belarus: Ratios of HIV transmission (infections caused) versus HIV acquisition (infections received) among populations, 2013



Source: Populated Optima model for Belarus.
Note: **Pink** = female populations. **Blue** = male populations.

APPENDIX E. COST-COVERAGE-OUTCOME CURVES

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	Saturation here refers to the maximum level of coverage that a program can achieve. When approaching very high levels of coverage—which for different programs may be 70 to 90 percent —it becomes increasingly difficult and expensive to reach more beneficiaries, as the remaining beneficiaries are hard-to-reach due to location, low motivation, or other social factors. These effects of increasing cost to reach saturation are also referred to as saturation effects.
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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