Optimizing Investments in Kazakhstan's HIV Response

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CONTENTS

Appendixes

Figures

Tables

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The HIV allocative efficiency (AE) program, of which this study is part, is managed by the World Bank and supported by the Global Fund to Fight AIDS, Tuberculosis and Malaria (Global Fund), the United Nations Program on HIV/AIDS (UNAIDS), and the United Nations Development Programme (UNDP). The Steering Committee of the program—comprising Christoph Hamelmann (UNDP), Manoela Manova (UNAIDS), Emiko Masaki (World Bank), Shufang Zhang (Global Fund), and Feng Zhao (Chair and World Bank Task Team Leader),—provided overall guidance to the country studies. The four agencies and the United States Agency for International Development (USAID)/President's Emergency Plan for AIDS Relief (PEPFAR) cosponsored the various study activities.

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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 Report
GBD	global burden of disease
GDP	gross domestic product
GHHE	general government health expenditure
Global Fund	Global Fund to Fight AIDS, Tuberculosis and Malaria
HCV	hepatitis C virus
HIV	human immunodeficiency virus
HTC	HIV testing and counselling
IBBS	integrated bio-behavioral surveillance
IMF	International Monetary Fund
INSERM	l'Institut national de la santé et de la recherche médicale (French Institute of Health and Medical Research)
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	opioid substitution therapy
PEPFAR	President's Emergency Plan for AIDS Relief (U.S.)
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
UNGASS	United Nations General Assembly
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

Kazakhstan can further increase the impact of its already substantial HIV investment through a combination of multiple key measures:

- Optimized allocation of currently available resources to high-impact programs (US$38 million) would avert 6 percent of new infections and 22 percent of deaths over 2015–20 compared to business as usual.
- At current unit costs of programs, achieving national HIV prevention and treatment targets would require substantial additional investment. To achieve national targets (no increase in HIV incidence and deaths) would cost US$52 million per year and achieving more ambitious 2020 targets (reducing new infections and deaths by 50 percent) would cost US$80 million.
- The cost for achieving national targets could be reduced by 50 percent by reducing the currently high unit cost of antiretroviral therapy (ART) by 67 percent and management costs by 20 percent and reinvest funds into priority programs:
  - Scaling up antiretroviral therapy (ART) and HIV testing and counselling (HTC) as required to initiate PLHIV on ART
  - Sustaining and scaling up programs for people who inject drugs (PWID) including needle- syringe programs (NSP) and opioid substitution therapy (OST)
  - Substantially increasing coverage of programs for men who have sex with men (MSM)
  - Sustaining coverage of FSW and PMTCT programs.
- With optimized allocation of resources, reduced ART costs, and a 20 percent reduction of management cost, it will be possible to achieve a 50 percent reduction in both HIV incidence and deaths over 2015–20 with the level of funding currently available. Through such an annual investment of US$38 million, Kazakhstan could avert 5,300 new infections and 4,200 deaths by 2020.

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EXECUTIVE SUMMARY

As part of a Regional initiative, Kazakhstan conducted an HIV allocative efficiency analysis in 2014–15 to inform more strategic investment in HIV programs.

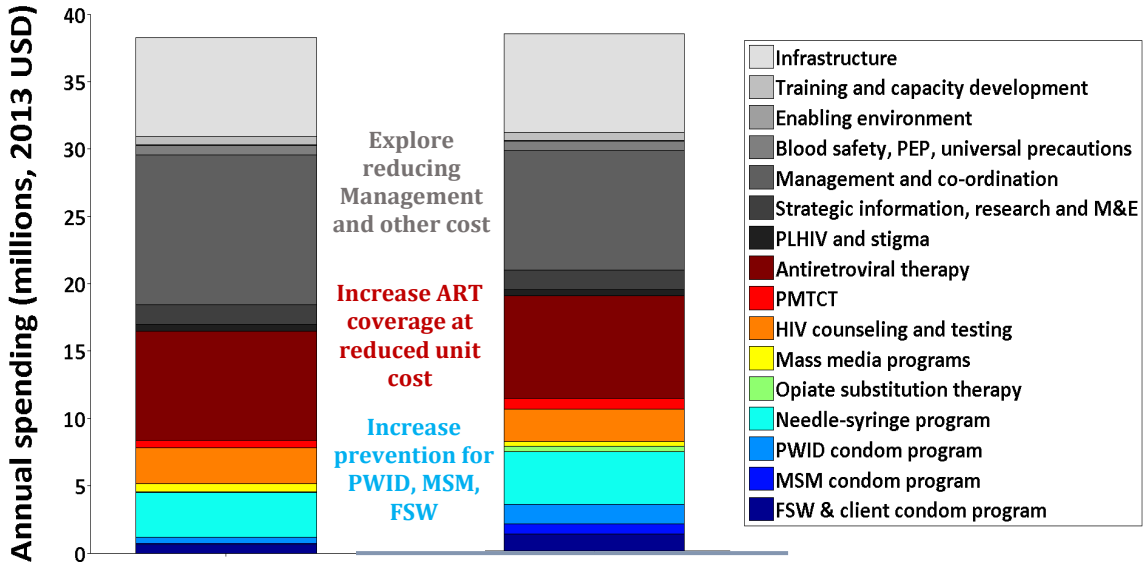
Kazakhstan continues to experience a concentrated HIV epidemic in which the majority of new infections occurred among key populations, particularly PWID, MSM, prison inmates, FSW, and their clients. Under current conditions (constant behaviors and program coverage), new HIV infections are projected to rise by 13 percent and deaths by 32 percent. The epidemics among PWID and MSM are projected to account for 67 percent of new HIV infections from 2015 to 2020 so need to be a core focus of programs.

With optimized allocations of 2013 spending levels, new HIV infections could be reduced by 6 percent and deaths by 22 percent. These efficiency gains could be increased substantially if Kazakhstan could reduce management cost by 20 percent. With optimized allocations of current funding plus a 20 percent reduction in management cost, Kazakhstan could reduce its new HIV infections by 18 percent and deaths by 32 percent. These reductions assume that savings on management and other costs would be reinvested in high-impact programs including ART and programs for PWID.

With optimized allocations, the cost to achieve national targets (no increase in incidence and deaths from 2015 to 2020) would be US$52 million per year. The cost to achieve more ambitious future HIV response targets (reduce HIV incidence and deaths by 50 percent cumulatively over 2015–20) was estimated at US$80 million.

The cost to achieve national targets could be reduced if the ART unit cost and management costs could be reduced. If Kazakhstan could reduce its ART cost to 33 percent of the 2013 cost, Kazakhstan could reach even the ambitious targets of reducing incidence and deaths by 50 percent by 2020 with current funding. With these cost reductions, the HIV response would remain within the range of unit costs of other countries of the region.

Figure 1.1 Actual and optimized allocations in Kazakhstan's HIV response with reduced unit cost of ART and reduced management costs, 2015–20



Note: Figure 1 is a condensed version of Figure 4.11 in the body of the report. The levels of investment and coverage described here also are detailed in Table 4.5.

Figure 1 summarizes the proposed reallocations arising out of this analysis for optimized allocation with reduced ART and management cost. The following programs would see particularly large changes in allocations (amounts should be seen as indicative of only the direction and dimension of change) over 2015–20:

- Increase coverage of ART from 47 percent among PLHIV with CD4 <500 to over 90 percent, but no increase in spending due to reduced unit cost
- Increase allocations for needle-syringe programs from US$3.3 million to US$3.9 million (to reach 55 percent coverage)
- Increase allocations for prevention among FSW from US$0.6 million to US$1.2 million (to achieve over 90 percent coverage)
- Increase allocations for prevention among MSM from US$0.1 million to US$0.7 million (to reach 20 percent coverage, thereby doubling the current national target)[1]
- Increase allocations for other prevention programs for PWID including condoms and HTC from US$0.5 million to US$1.5 million (47 percent coverage)
- Increase allocations for OST from US$0.1 to US$0.4 million, and consider mobilizing other health resources for OST to further increase coverage).

With optimized allocations and without technical efficiency gains, the cost for achieving ambitious national targets from 2015 to 2020 would be US$480 million; and with reduced ART and management cost, US$230 million. These 2 amounts are considerably below the amount derived through the preliminary costing of the national strategy (US$734 million), suggesting the potential for allocative and technical efficiency gains.

In conclusion, a combination of various efficiency gains in Kazakhstan's HIV response can halve new HIV infections and deaths, achieving ambitious national targets at no additional cost. As a first priority, ART will be essential for reducing deaths and new infections, but unit

[1] The coverage corresponding to the increased investment is derived from the cost-coverage curves in the model. The estimated coverage to be achieved is lower than for other groups because the difficulty in accessing MSM was considered in the cost-coverage curve for MSM programs.

costs need to be reviewed and reduced. A second consistent finding is the continued need to provide HIV services for PWID at scale. A third consistent finding is the need to scale up programs for MSM and at least double the current low coverage levels. Additional technical efficiency analysis is worth considering to explore the concrete pathways to achieve the proposed cost reductions for ART, OST, and management costs.

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1. INTRODUCTION

1.1 Necessity for allocative efficiency

Current HIV programs are faced with the necessity 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 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, HIV remains among the unfinished agenda items within the Millennium Development Goals (MDGs), which need to be transitioned and integrated into the post-2015 Sustainable Development Goals (SDGs).

Against this background, in 2014 UNAIDS defined a global Fast-Track strategy to achieve the goal of *Ending AIDS by 2030.* A core element of the Fast-Track approach is the 90-90-90 targets (UNAIDS 2014d). These targets set out to achieve that 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 need to focus on the geographic areas and communities most affected by HIV and recommends that resources be concentrated on the programs with the greatest impact.

In this context, a shift toward investment thinking in the design of HIV responses is being promoted by UNAIDS and cosponsors globally to maximize the impact of program investment and best realize the long-term health and economic benefits of HIV programs. Investment cases are being developed by a number of countries 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. In support of HIV investment cases, a group of countries in the ECA Region conducted allocative efficiency (AE) analyses. In 2014–15, AE analyses were carried out in Armenia, Belarus, Georgia, Kazakhstan, Republic of Kyrgyz, Moldova, Ukraine and a number of countries outside the ECA Region (Fraser and others 2014). This report summarizes the results of the analysis for policy makers, program leaders, and technical experts in Kazakhstan.

The concept of allocative efficiency refers to the maximization of health outcomes using the least costly mix of health interventions.[2] HIV allocative efficiency studies generally try toanswer the question “How can HIV funding be optimally allocated to the combination of HIV

[2] Technically, AE can be accomplished either within a fixed budget envelope (maximal impact with given amount of money) or within defined impact targets (minimal cost to achieve a given impact).

response interventions that will yield the highest impact?" This concept not only is critical for maximizing current and future impact but also is an integral element to transition to full domestic financing and a sustainable response. A response that is allocatively and technically efficient will be easier to sustain.

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

1.2 Objectives of the analysis

Kazakhstan has set out the priorities of its HIV response in its *Concept of Development Services for HIV Prevention for the Period 2016–2020* (Kazakhstan MOH 2015). This document sets out five key objectives:

- To increase public awareness on how to prevent HIV infection
- To implement HIV prevention programs among the general population and key populations group at higher risk, such as PWID, SW, MSM, and prison inmates
- To prevent HIV transmission from mother to child
- To provide access to treatment, care, and support in accordance with international standards
- To monitor and evaluate, project, and plan sustainable responses.

In its national HIV program, Kazakhstan proposes the following targets to be achieved by 2020:

a. Prevalence of HIV infection will be restricted to current levels so that the epidemic remains concentrated and overall prevalence in the population aged 15–49 years does not exceed 0.2 percent–0.6 percent.
b. The mortality rate among people living with HIV will be at 10 per 1,000 people living with HIV.
c. Transmission of HIV from mother to child will not exceed than 2 percent.
d. Awareness of general population and young people about HIV transmission and prevention measures will reach 36 percent by 2016; and 40 percent by 2020.
e. Annual coverage of HIV testing at the country level will be 10 percent.
f. Coverage of PWID reached with preventive measures will be not less than 60 percent; coverage of SW reached with preventive measures will be not less than 80 percent; and coverage of MSM reached with preventive measures will be not less than 10 percent.
g. Safe sexual behavior will be accepted by key populations at higher risk: at least 90 percent of SW, at least 70 percent of MSM, and at least 50 percent of PWID.
h. Safe injecting behavior will be accepted by a minimum of 50 percent of PWID.
i. ARV therapy (ART) will be provided to all individuals with HIV with CD4 count less than 500.
j. HIV-infected adults and children, who, according to available information, continue receiving ART 12 months after its initiation will reach 70 percent.

According to national estimates, the total tentative budget to reach these targets by 2020 is US$734 million.

The national HIV program sets a number of additional coverage targets. Given the limited resources, additional prioritization based on in-depth AE analysis is required to redefine

program coverage targets for maximum impact with different scenarios of resource availability, and to support additional operational planning and budgeting.

In this context, the government is developing HIV investment analyses, including the current allocative efficiency study, that attempt to increase the effectiveness of HIV investments and define corresponding priorities, strategies and impacts of the response. These analyses also attempt to determine the future sources of HIV financing and how to most effectively allocate the resources to be provided by the Global Fund. The analyses were conducted by a group of international partners in close collaboration with Government of Kazakhstan, particularly with the Republican AIDS Center and other governmental bodies.

The findings of the current study will assist the Government of Kazakhstan to further strengthen its HIV investment case, as explained in the paragraph above. The national HIV AE study was designed to answer three questions:

1. How can the country *optimize the allocation* of HIV funding for maximum health impacts?
2. How much will it *cost to achieve the targets* of the National HIV Strategy and long-term international commitments toward HIV goals?
3. What is the *cost-effectiveness* of optimized allocations for HIV??

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2. KAZAKHSTAN'S HEALTH AND HIV FINANCING CONTEXT

This chapter summarizes the trends in health and HIV financing in Kazakhstan as background to the economic component of the allocative efficiency analysis. Table 2.1 provides an overview of health financing in Kazakhstan.

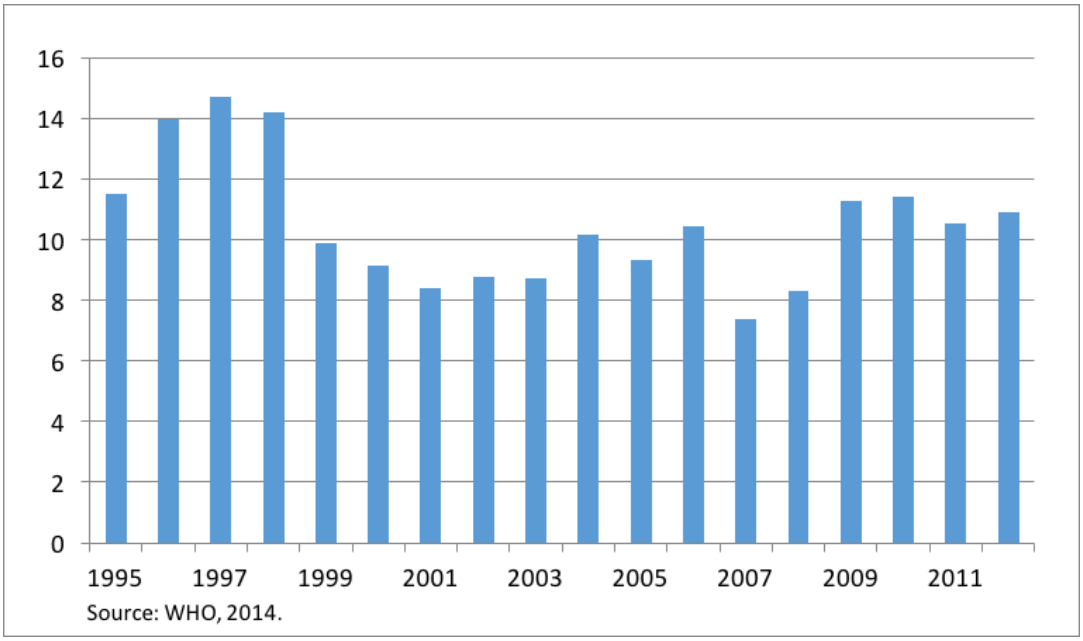
Table 2.1 Overview on health expenditure in Kazakhstan, 2000IV

Indicator		2000	2005	2010	2011	2012	2013
Total health spending							
Gross domestic product (GDP)	US$ current million	18,268	56,952	148,039	188,007	203,340	224,075
Total expenditure on health	US$ current million	760	2,318	6,544	7,624	8,775	9,537
Total health expenditure (THE) % GDP	%	4	4	4	4	4	4
Total expenditure on health/capita at exchange rate	Per capita	52	154	411	474	539	580
Government health spending							
General government expenditure	US$ current million	4,230	15,395	32,752	40,500	44,916	46,490
General government expenditure on health (GGHE)	US$ current million	387	1,436	3,741	4,271	4,897	5,069
GGHE as % of general government expenditure	%	9	9	11	11	11	11
General government expenditure on health as % of THE	%	51	62	57	56	56	53
Private health spending							
Private expenditure on health	US$ current million	373	882	2,803	3,353	3,878	4,468
Private expenditure on health as % of THE	%	49	38	43	44	44	47
Out-of-pocket expenditure as % of THE	%	49	37	42	43	44	46
Out-of-pocket expenditure as % private health expenditure	%	99	99	99	99	99	99
External funding							
Rest of the world (ROW) funds/ External resources	US$ current million	56	11	43	52	35	41
External resources on health as % of THE	%	7	<1	1	1	<1	<1

Source: WHO 2014a.

Over the past two decades, Kazakhstan's health investment has fluctuated. The share of government spending on health ranged from 14.7 percent in 1997 to 7.4 percent in 2005 (Figure 2.1). In 2012 government health expenditure was at 10.9 percent, just below the global average of 11.7 percent.

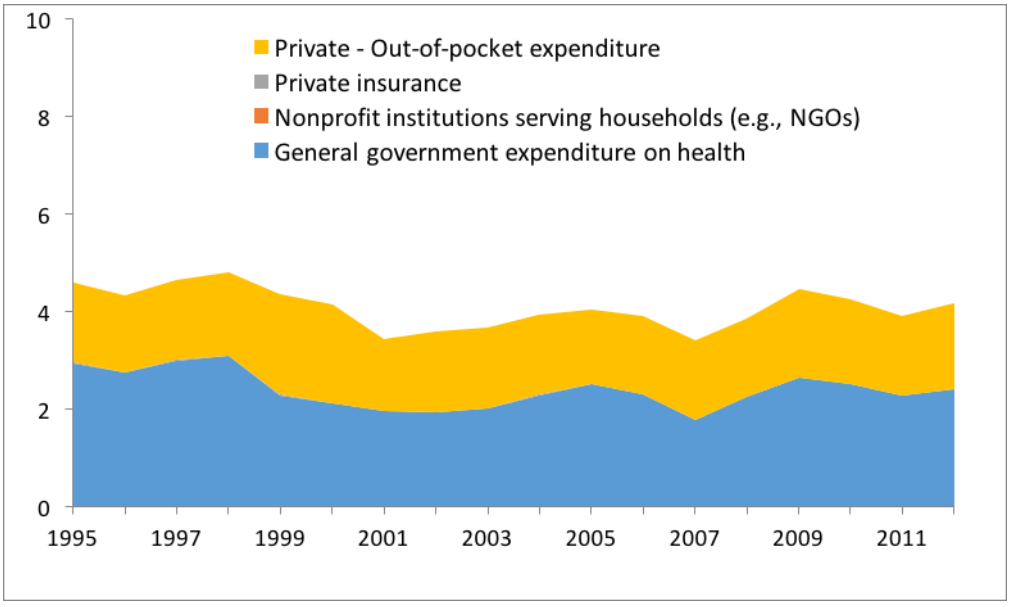
Figure 2.1 Kazakhstan: General Government Expenditure on Health (GGHE) as share of general government expenditure, 1995n health



Source: WHO 2014b.

In absolute numbers, Kazakhstan's health expenditure increased sharply from US$0.77 billion in 1997 to US$8.48 billion in 2012 (WHO 2014b). However, this increase corresponds to a large increase in GDP. In contrast, health spending remained relatively stable at approximately 4 percent of GDP (Figure 2.2). In 2012, 58 percent of health spending was government expenditure. Forty-two percent was funded out of pocket, and nonprofit and private insurance funding remained below 1 percent of total health spending.

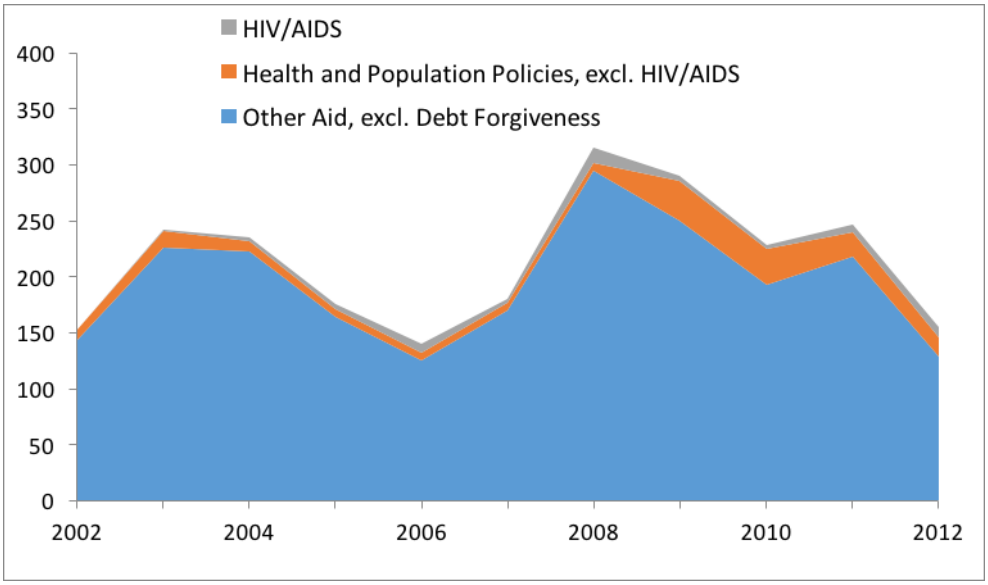
Figure 2.2 Kazakhstan: Health spending by source of financing, 1995n GDP. In con



Source: WHO 2014b.

International assistance to Kazakhstan fluctuated over the past decade. It peaked in 2008 and declined since then. In 2012, support for health and population (US$17.1 million) and HIV (US$8.7 million) combined accounted for 16.7 percent of external support.

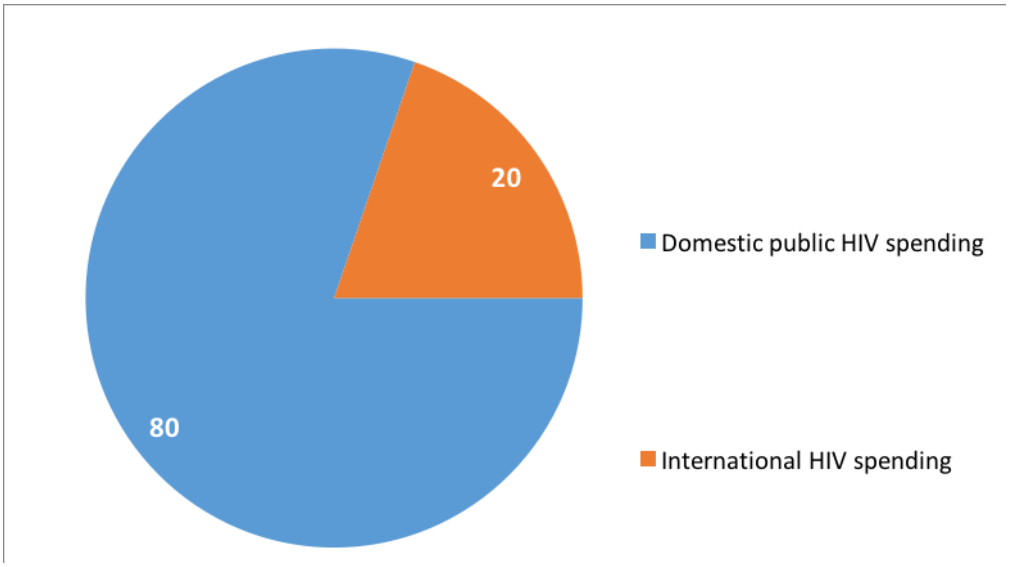
Figure 2.3 Kazakhstan: Aid disbursements, 2002tan fluctuated ov



Source: OECD and CRS 2014.

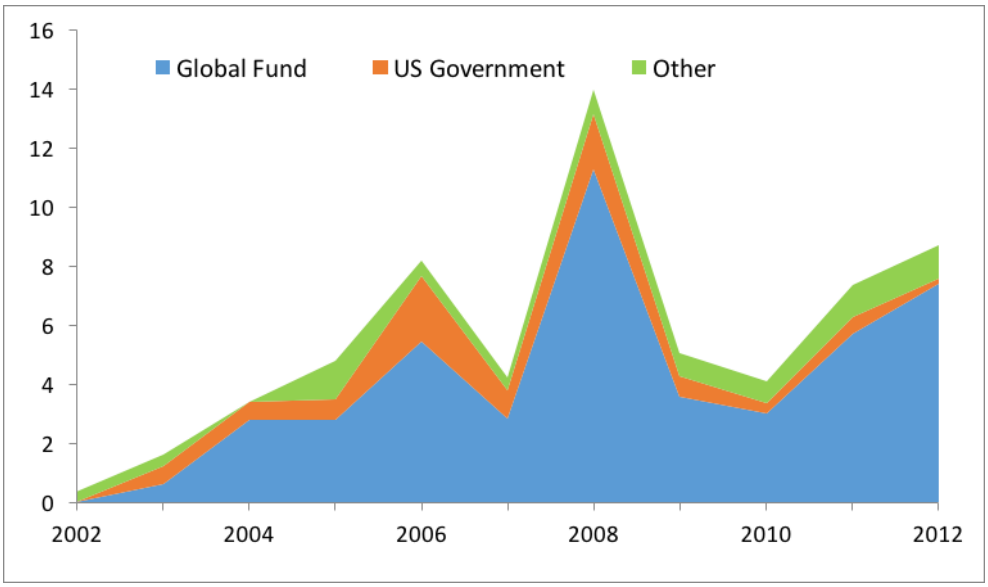
Kazakhstan's HIV response is funded predominantly domestically, with over 80 percent of HIV funding being provided by government. Another 20 percent of the HIV response is funded by international partners (Figure 2.4). Within the international funding support provided to Kazakhstan HIV response, the largest share (85.3 percent in 2012) was provided by the Global Fund for HIV, Tuberculosis and Malaria. The United States Government and other partners provided additional complementary support.

Figure 2.4 Kazakhstan: HIV/AIDS spending by source of financing, 2012 (%)



Source: aidsinfo online.

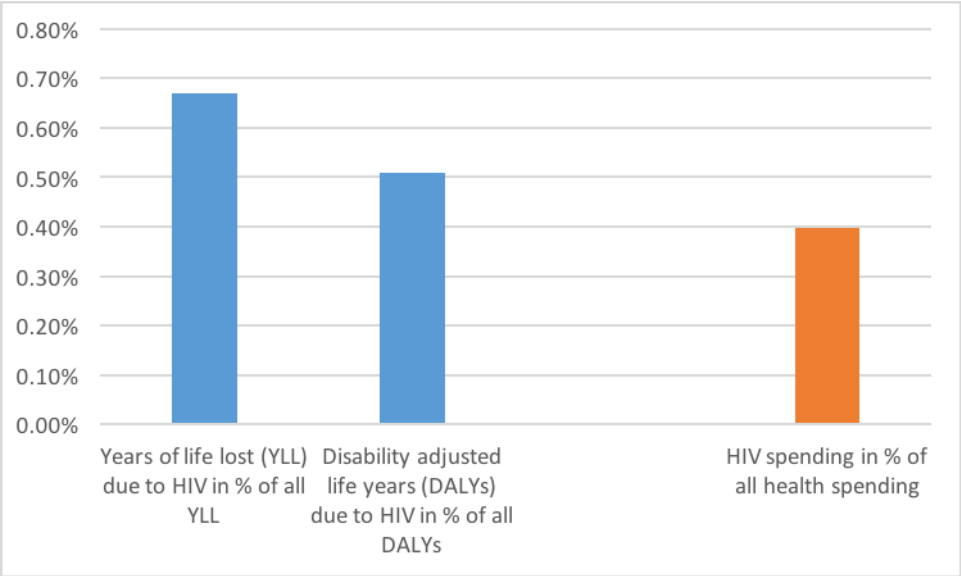
Figure 2.5 Kazakhstan: HIV/AIDS-related aid disbursements by donor, 2002) with over 80 p



Source: OECD and CRS 2014.

HIV accounts for 0.7 percent of years of life lost (YLLs) in Kazakhstan; and 0.5 percent of disability-adjusted life years (DALYs) and HIV spending for 0.4 percent of total health expenditure (THE) in Kazakhstan (Figure 2.6). The latter suggests that, in the population overall, HIV accounts for only a small proportion of disease burden, but, as this study demonstrates (chapter 4), the burden is concentrated in key populations. Levels of HIV investment are in a similar range, but slightly below the proportion of disease burden attributable to HIV. Therefore, Kazakhstan's overall level of HIV spending is in a range similar to that of other countries in the Region.

Figure 2.6 Levels of HIV disease burden compared to levels of HIV spending (%)



Source: WHO 2014a; UNAIDS 2014a; University of Washington 2014.

3. METHODOLOGY: HOW WILL THIS REPORT ANSWER KEY QUESTIONS?

Chapter 3 outlines the main steps taken and tools applied to carry out the analyses presented in this report. Additional detail is available in appendixes A, B, and C.

3.1 Optima Model

To carry out the analyses, the team 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 FSW, PWID, and MSM), 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 the 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 level of funding 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. Additional details about Optima are contained in appendix A.

3.2 Analytical framework

The study was conceptualized by a Regional steering group comprising the Global Fund, UNAIDS, UNDP, and convened by the World Bank. A national technical group convened by UNAIDS in collaboration with the 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 modeling workshop was conducted in Yerevan, Armenia. National experts and specialists from international partners worked together with mathematical modelers from UNSW to perform modeling 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

modeling techniques. Preliminary results were consulted 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 strategic, program, and funding information and agreed with in-country stakeholders.

Table 3.1 Modeling parameterization

Category	Parameterization in Optima model	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
	Men of reproductive age	Males, aged 15–49
	Women of reproductive age	Females, aged 15–49
	Older men	Males, aged 50+
	Older females	Females, aged 50+
	Prison inmates	Males aged, 15–49
Expenditure areas defined in model and included in optimization analysis	Female sex worker and client condom program	Condom distribution, HIV testing and counselling, community outreach
	MSM condom program	Condom distribution, HIV testing and counselling, community outreach
	Needle and syringe program	Needle and syringe distribution
	PWID condom program	Condom distribution, HIV testing and counselling, community outreach
	Opioid substitution therapy	Provision of medication and related counselling
	HIV testing and counselling	HIV test kits and pre- and post-testing counselling
	Antiretroviral therapy	Antiretroviral drugs, related laboratory monitoring, and clinical visits
	Prevention of mother-to-child Transmission	HIV testing of pregnant women, counselling, and provision of antiretroviral prophylaxis for women living with HIV
Expenditure areas not included in optimization (effectiveness in reducing HIV incidence, morbidity/mortality not known or indirect effects)	Management and other costs	Management, coordination, advocacy and support for PLHIV, infrastructure, monitoring, evaluation, surveillance, research, enabling environment, human resources (see detailed breakdown below)
Time frames	2014 (baseline)	Available data from 2000–14 was used. Projections started with 2015.
	2015–20 period for optimization	Optimizations were performed up to 2020 (main body of report) and 2030 (appendix D).
Baseline scenario funding	US$37.8 million (2013)	2013 spending as per Optima spreadsheet prepared based on GARPR, financial report tables

Note: A comprehensive four-pronged approach to PMTCT includes additional elements such as provision of contraception. For the vast majority of women, the primary purpose of contraception in this concentrated epidemic setting is not PMTCT but pregnancy prevention. Therefore, it was decided not to include contraception costs 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 comprise *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 into *direct programs* and *indirect programs.* Direct programs have a direct effect on HIV incidence or deaths so could be included in the mathematical optimization analysis. Within direct programs, some service packages target specific key populations (FSW, MSM, PWID); others (HTC, ART, PMTCT) cut across all populations, including key populations. Indirect programs are cross-cutting expenses or have indirect or unclear effects on health outcomes so were not included in the mathematical optimization.

Costs per person reached––derived from coverage information and total spending on programs––are presented in Table 3.2. These are not unit costs, and definitions of program coverage vary among countries. In addition, Kazakhstan used a different approach than did other ECA countries to account for the human resource expenses and management cost of specific programs. In Kazakhstan, these costs were included in the general management cost. Therefore, management costs were higher than in other countries, while program costs were lower. For these reasons of different accounting (among others), in Kazakhstan, indirect programs (management, enablers, synergies, other costs) accounted for 56 percent of HIV expenditure reported. Kazakhstan's cost for antiretroviral therapy (ART) was particularly high in Regional comparison. As a result, specific analyses were conducted to assess the effect of reducing ART cost.

Table 3.2 Costs per person reached (US$)

		Other countries in the Region (program management cost and human resources included in the program cost)			
Cost per person reached	Kazakhstan[a]	**Lowest**	**Highest**	**Average**	**Median**
FSW programs	34.13	41.66	166.24	102.94	105.35
MSM programs	13.46	23.67	449.13	159.45	71.25
PWID-NSP programs	56.43	40.90	129.25	109.73	84.11
OST[b]	378.17	431.41	1,645.24	747.36	790.23
ART[c]	2,278.52	576.48	2,278.52	1,203.26	1,127.29

Source: Populated Optima data entry spreadsheets from 7 countries.
Note: Table 3.2 reflects how costs were categorized by countries for this analysis. It is not based on detailed matching of classification of inputs, but on how countries classified expenses using the detailed available guidance for NASA and GARPR reports. Although this guidance is detailed and specific, differences cannot be ruled out, particularly when it comes to cross-cutting costs such as HR costs. Moreover, even if costs are classified consistently, the comprehensiveness of service packages may differ; a=Program management cost and human resources *not included* in the program cost; b=Cost differs from the unit cost established in a separate study, which included comprehensive service cost and which was US$2,492 per person per year, that is, substantially higher (INSERM and UNAIDS 2015). However, this higher cost could not be used here because, for optimization, the same approach should be used for different programs within the same country. The differences among countries suggest the need for additional technical efficiency analysis; c=Average cost per person reached (including first and subsequent lines of treatment).

3.3 Limitations of analysis

For this modeling analysis, as for any, understanding key assumptions and the related limitations is important.

- Some gaps in data existed for both key populations and the general population. As in other models, estimates of HIV prevalence in the general population were derived from data of HIV in pregnant women as a proxy. Some of the available data (from IBBS and service delivery data from HTC sites) were limited by nonrandom sampling.

- For this analysis, standard classification of cost data in line with National AIDS Spending Assessments (NASA) was used. However, differences in program packages among countries limited the comparability of findings.
- The analysis used past ratios of expenditure to coverage as a basis for determining program cost 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, using past cost and results also has the disadvantage that 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 includes assumptions concerning the impact of increases or decreases in funding for programs. These assumptions are 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. These assumptions also anticipate some saturation in the possible effects of programs caused by increases in spending.[3]
- The analysis did not determine the technical efficiency of programs. Gains in technical efficiency would lead to different unit costs so would affect resource allocation.
- Modeling the optimization of allocative efficiencies critically depends on the availability of evidence-based estimated parameters of the effectiveness of individual interventions. Although these estimates were derived from a systematic global literature review,[4] 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. However, because they have important functions in the HIV response, they have been treated as fixed costs and, in certain scenarios, adjusted with specific justifications.
- Effects outside the HIV endpoints (such as non-health benefits of OST, effects of needle exchange on hepatitis, effects of condoms on contraception and STIs) are complex to consider. Given that the majority of OST benefits go beyond HIV outcomes, specific consideration was given to consider the non-HIV benefits of OST (appendix A). However, given the complexity of interactions among interventions and their non-HIV benefits, this approach was applied only for OST. Along the same lines, the model does not seek to quantify human rights; stigma and discrimination; or ethical, legal, or psychosocial implications. Nevertheless, the model acknowledges that these aspects are important to be considered.
- Different models may not always produce exactly the same projections as those produced by Optima. The analysts 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.

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[3] Saturation of a program occurs when most persons who were easy to reach––for example, all PWID who were prepared to participate in needle syringe programs––have been reached. To reach the remaining persons not yet covered with a program was assumed to become increasingly more expensive because additional mobilization and support are required to reach and maintain hard-to-reach subpopulations.

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

4. RESULTS AND THEIR INTERPRETATIONS

This chapter presents the findings of the analyses carried out, beginning with epidemic analysis, then moves into optimization analysis and related cost-effectiveness analysis.

4.1 What is the status of the HIV epidemic in Kazakhstan?

Table 4.1 summarizes the key national data on the HIV epidemic. Table 4.1 illustrates the rapid growth of the epidemic from 2000 to 2010, then the stabilizing of deaths and slowing of the number of new diagnoses around 2010. HIV prevalence remains highest among PWID and prison inmates.

Table 4.2 shows key estimates in Kazakhstan for 2014 from Optima. According to Optima projections, the country had an estimated 18,000 PLHIV, 1,500 new infections, and 900 deaths. In relation to national data, the number of new infections was lower than the number of new diagnoses. This finding can be explained by the projected epidemic trend, which, based on the available prevalence data, was estimated to have declined between 2007 and 2014. The higher number of new diagnoses between 2010 and 2013 in the registered data plausibly reflects the new infections during the mid-2000s, when the estimated annual new infections exceeded 2,000 per year. The model-estimated number of AIDS-related deaths exceeds the number of registered deaths. This pattern is similar to those found in other countries in the ECA Region (and in Spectrum estimates in the Region) and likely is due to the fact that a proportion of AIDS deaths are not recorded as such.[5]

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

The following Optima projections assumed that current trends in transmission-related behaviors will continue. As mentioned above, appendixes A and B describe the process and some of the data used to generate these estimations and projections. Table 4.3 summarizes HIV epidemic estimates for 2014 and 2020, and assumes that current conditions (behaviors and service coverage as per latest available data) will be sustained over 2015–20.

[5] The issue of differences in registered versus model-estimated mortality would warrant a separate epidemiological review in countries of the Region.

Table 4.1 Kazakhstan: Summary of key national HIV data, 2000–14

	2000	2005	2010	2011	2012	2013	2014	Source
HIV diagnoses								
Cumulative number of people diagnosed with HIV, total	1,344	5,629	15,717	17,716	19,727	21,867	22,408	
Cumulative registered number of people diagnosed with HIV and alive, total	1,181	4,511	11,832	13,107	14,213	15,386	18,126	National AIDS Center database
Cumulative registered number of people diagnosed with HIV and alive (Kazakhstan citizenship), total	1,132	4,236	11,251	12,447	13,561	14,778	16,199	
New diagnoses								
Number of people newly diagnosed with HIV, total	347	958	1,987	1,999	2,011	2,140	2,350	
Number of people newly diagnosed with HIV (ages 15+)	345	945	1,963	1,979	1,977	2,098	2,320	
Number of people newly diagnosed with HIV (ages 0–14)	2	13	24	20	34	42	30	National AIDS Center database
Number of people newly diagnosed with HIV, females	77	266	733	791	842	936	1013	
Number of people newly diagnosed with HIV, males	270	692	1,254	1,208	1,169	1,204	1337	
Registered HIV related deaths								
Annual registered number of deaths due to AIDS, total	5	98	185	183	168	170	134	National AIDS Center database
Cumulative registered number of deaths due to AIDS, total	28	288	952	1,133	1,302	1,467	1,675	
HIV prevalence among key population								
HIV prevalence among sex workers (%)	2.1	2.1	1.5	1.5	1.3	1.5	1,5	
HIV prevalence among MSM (%)	-	0.3	1.0	1.0	0.6	1.2	1,2	National surveillance
HIV prevalence among PWID (%)	3.0	3.0	5.4	5.1	6.5	6.8	8,4	
HIV prevalence among prison inmates (%)	0.5	1.3	3.7	3.6	3.3	3.3	3,9	
Service coverage and utilization								
Number of people receiving ART	1	196	1,336	1,830	2,634	3,571	4639	
Coverage of ART (receiving ART as % of registered PLHIV)	0	4.6	11.8	14.6	19.4	21.2	28.6	
Estimated number of people living with HIV, who need ART (CD4 - 350), Spectrum	0	1,239	4,690	5,210	5,830	7,018	8,302	National AIDS Center database
Estimated number of people living with HIV, Spectrum			16,585	17,795	18,935	20,046	21,047	Spectrum
Coverage of ART (receiving ART as % of estimated PLHIV)	0	0	8	10.3	13.9	17.8	22.0	National program records
Number of syringes distributed per estimated PWID	0	70	184	163	201	224	178	
Estimated number of PWID receiving OST (%)	0.0	0.0	0.1	0.1	0.2	0.3	0,3	
Self-reported modes of HIV transmission (% of newly diagnosed with HIV)								
Heterosexual HIV transmission (%)	10.1	25.8	41.2	50.5	56.7	59.5	59.8	
Homosexual HIV transmission (%)	0.6	0.3	1.1	1.4	1.2	1.9	1.8	National AIDS Center database
HIV transmission through IDU[a] (%)	85.9	69.3	54.1	5.0	38.3	33.6	31.7	
HIV transmission through unsafe blood/blood products (%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Vertical HIV transmission (%)	0.3	0.9	1.1	0.9	1.5	1.7	1	

Note: IDU = injection drug use.

Table 4.2 Kazakhstan: Estimates of key indicators from Optima projections for 2014

	2014 (rounded)	2014 HIV registration data	Comments
Number of PLHIV/ Number of registered PLHIV	18,000	16,199	A proportion of PLHIV is assumed to be undiagnosed.
Number of new infections Number of registered new diagnoses	1,500	2,350 (of which 2,208 are citizens of Kazakhstan)	New diagnoses reflect past numbers of new infections rather than current ones.
Number of AIDS-related deaths Number of registered HIV deaths	900	718	A proportion of HIV deaths is expected to be unregistered.

Source: Populated Optima model for Kazakhstan.

Table 4.3 Kazakhstan: Overview of HIV epidemic estimates for 2014 and 2020 under current conditions

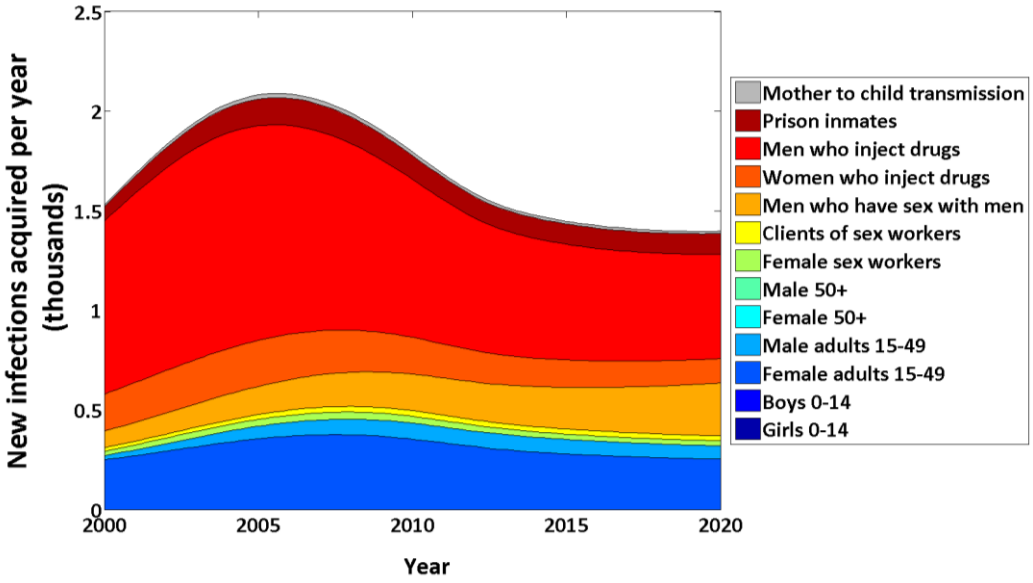
	PLHIV		Prevalence (%)		New infections		AIDS deaths	
	2014	2020	2014	2020	2014	2020	2014	2020
Girls 0–14	<100	<100	<0.1	<0.1	<10	<10	<10	<10
Boys 0–14	<100	<100	<0.1	<0.1	<10	<10	<10	<10
Women of reproductive age 15–49	2,900	3,000	0.07	0.07	290	300	160	200
Men of reproductive age 15–49	700	800	0.02	0.02	70	80	40	50
Female 50+	<100	<100	<0.1	<0.1	<10	<10	10	10
Male 50+	<100	<100	<0.1	<0.1	<10	<10	<10	<10
Female sex workers	300	300	1.88	1.84	30	30	10	20
Clients of sex workers	600	700	0.12	0.14	30	30	30	50
Men who have sex with men	1,600	2,300	1.23	1.65	200	320	60	130
Women who inject drugs	1,900	2,000	9.07	8.46	140	150	90	120
Men who inject drugs	8,500	8,300	5.94	5.34	600	620	410	500
Prison inmates	1,200	1,300	3.20	3.33	100	120	50	80
Total	18,000	19,000	0.15	0.14	1,460	1,650	880	1,160

Source: Populated Optima model for Kazakhstan.
Note: These are modelled HIV estimates from Optima, and the numbers are not exactly the same as those produced in Spectrum. All model estimates differ from service statistics, which include only new diagnoses (reflecting past new infections) and registered AIDS-related deaths (which are a subset of all AIDS-related deaths).

The projections suggest that, while overall HIV prevalence will stabilize as a percentage, PLHIV numbers will grow proportionately with population growth. New infections and deaths are projected to increase by 13 percent and 32 percent, respectively.

The model-predicted evolution of annual HIV incidence (2000–20) in each subpopulations is shown in Figure 4.1. Figure 4.1 suggests that HIV transmission among PWID, who are predominantly males, remains the single largest segment of transmission. Notably, the annual number of new infections in this group peaked in the early 2000; declined thereafter; and, according to Optima projections, will account for fewer than 50 percent of new infections from 2015 to 2020. The model also projected that, by 2020, transmission among MSM will account for 20 percent of new infections. Another approximately 20 percent of new infections will occur through sexual transmission to females of reproductive age (15–49)—commonly female partners of men from key populations. Transmission among female sex workers and their clients accounts for less than 5 percent of new infections and is projected to stay near the same level up to 2020.

Figure 4.1 Kazakhstan: Model-predicted evolution of annual HIV incidence, 2000–20



Source: Populated Optima model for Kazakhstan.

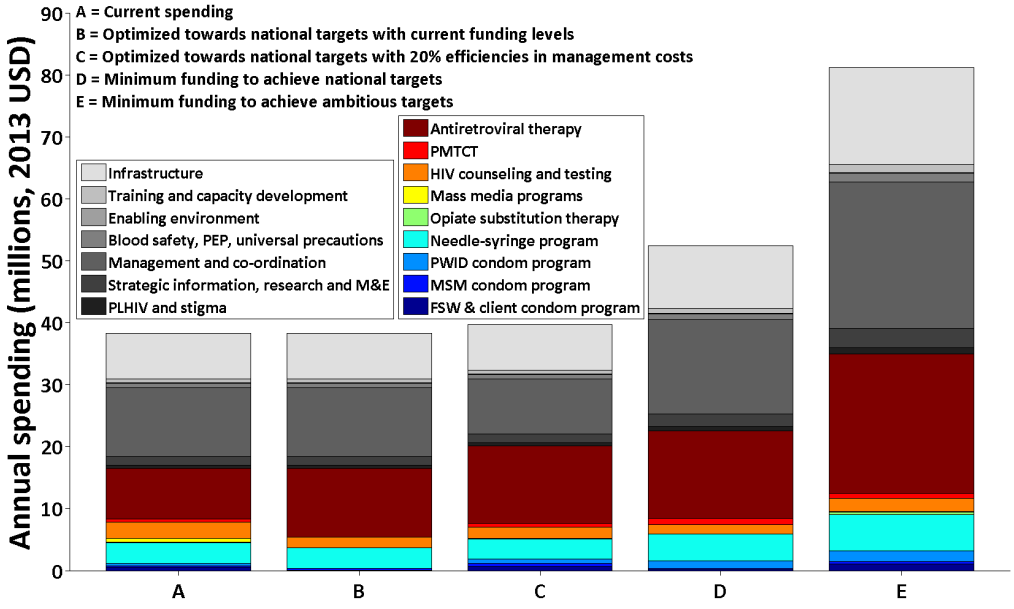
4.3 Optimizing resources toward moderate targets and national strategy targets using current unit costs by 2020

This chapter summarizes results of optimization analysis using current unit costs. To provide nuanced results, this analysis was conducted for moderate and ambitious targets to understand differences in resource needs.

4.3.1. What is the effect of maintaining current spending up to 2020?

In Figure 4.2, Allocation A shows the actual 2013 spending on the range of HIV programs.

Figure 4.2 Kazakhstan: Optimizing spending toward national ambitious targets to reduce HIV incidence and AIDS-related deaths to 50 percent of their 2014 levels by 2020 (Allocations A–E)



Source: Populated Optima model for Kazakhstan.

Compared to zero spending, current HIV spending in Kazakhstan is very substantially impacting the HIV epidemic (Figure 4.3 to Figure 4.9, and Table 4.4). With no programs in place, the HIV epidemic is projected to grow dramatically, and a projected 54,000 new infections and 11,100 deaths would occur in 2015–20. If current spending and allocations were sustained, the epidemic would grow only slowly so that, over the same period, 9,500 new infections and 6,500 deaths would occur. Nevertheless, current allocations and spending would be insufficient to fully stabilize or reduce new infections and deaths in Kazakhstan.

4.3.2. What is the effect of optimized spending at the current level of funding?

If only the current level of funding is available, Allocation B represents the optimized spending allocation from 2015 to 2020 that would get as close as possible to the same national targets. Figure 4.3 illustrates the health outcomes of implementing such an allocation, and therefore shows how close this scenario comes to achieving the national targets.

Optimized allocation of 2013 spending would imply increasing coverage of ART from 47 percent to 61 percent (CD4<500) and MSM programs from 8 percent to 15 percent. Simultaneously, the current high levels of coverage of NSP for PWID and current (low) coverage of OST would be sustained, and savings would be made on the other programs. The model prioritized ART over HTC for two reasons: a large number of already diagnosed PLHIV are not yet on ART, and HTC for key populations would continue to be provided within the programs for these groups. MSM programs are prioritized because of the growing number of new infections in this group. This choice does not mean that programs with reduced allocations are not important. Prioritizing MSM programs simply suggests that, at current levels of spending and current unit cost, more emphasis on ART and MSM would increase the impact of the overall response. Compared to business as usual (current allocations maintained over the same period), over 2015–20, the optimized allocation would avert 6 percent of new infections and 22 percent of deaths.

Allocation C is very similar to Allocation B. However, Allocation C reduces resources to "management and coordination" by 20 percent and redirects them to the direct HIV programs considered in the optimization analysis. Saving 20 percent of management costs at current levels of funding would enable both increasing ART and MSM program coverage; and sustaining coverage of critical programs including NSP, HTC, FSW, and PMTCT (Table 4.4). Saving 20 percent of management costs at current levels of funding and optimally allocating the resources would avert 18 percent of new infections and 32 percent of deaths compared to current allocations.

4.3.3. What is the amount needed and the optimized allocation to achieve moderate and ambitious national targets at current unit costs?

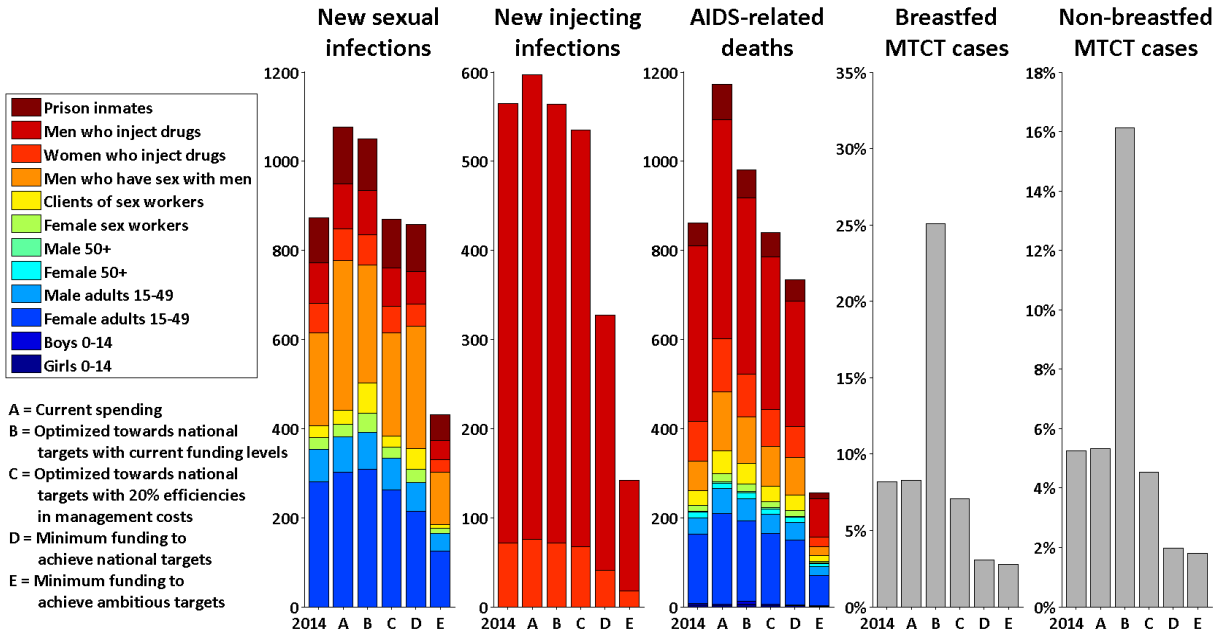
Allocation D represents the minimal annual spending required to achieve national strategy targets. These targets were defined as *no increase in new HIV infections; no increase in AIDS-related deaths* from 2014 levels by 2020; and the virtual elimination of MTCT. The estimated minimal total annual spending to satisfy these targets is a 37 percent increase ($52.5 million per year) above what was spent on HIV programs in Kazakhstan in 2014 ($37.8 million). The team's analyses suggest that, to fully achieve the national targets, increases in funding to PWID condom programs and NSP, PMTCT, and ART programs are required.

Allocation E represents the minimal amount of annual spending required to completely achieve a set of ambitious targets. For this analysis, these ambitious targets were defined to

reduce both new HIV infections and AIDS-related deaths by 50 percent from 2014 levels by 2020, and to eliminate MTCT. The estimated minimal total annual spending to satisfy these ambitious targets would be a 112 percent increase ($81.2 million per year) above what was spent on HIV programs in 2014 in Kazakhstan ($37.8 million). To achieve the ambitious targets, the team's analysis suggests that additional spending increases to FSW and clients, MSM and PWID condom programs, NSP, OST, PMTCT, and ART programs are required.

Figure 4.3 should be viewed in tandem with Figure 4.2. The bars presented in Figure 4.3 show the projected national health outcomes in 2020 under each scenario in Figure 4.2. The first bar in each subfigure (2014) shows the estimated 2014 values of the respective health outcome indicator. The second bar (current spending) shows the effect of maintaining 2013 levels of spending and the same allocations over 2015–20. This outcome differs from 2014 values because of the upward trajectory of the epidemic. The bars that represent Allocation D––the minimal amount of money required to completely achieve national targets––illustrate that the allocation described in Figure 4.2 is estimated to lead to no increase in either new infections (sexual or injecting) or deaths from 2014 levels by 2020. Allocation B and Allocation C show that optimally redistributing current resources would reduce infections and deaths by 2020 compared to the projection of the scenario of Allocation A by 2020, but not compared to 2014 levels. The bars that represent Allocation E show that the ambitious targets of reducing incidence and deaths by 50 percent from 2014 levels and eliminating MTCT are expected to be achieved by 2020. In line with global targets to eliminate MTCT, "Breastfed MTCT cases" and "Non-breastfed MTCT cases" are defined here as the proportion of HIV positive women who transmit HIV to their babies, disaggregated by their breastfeeding status.

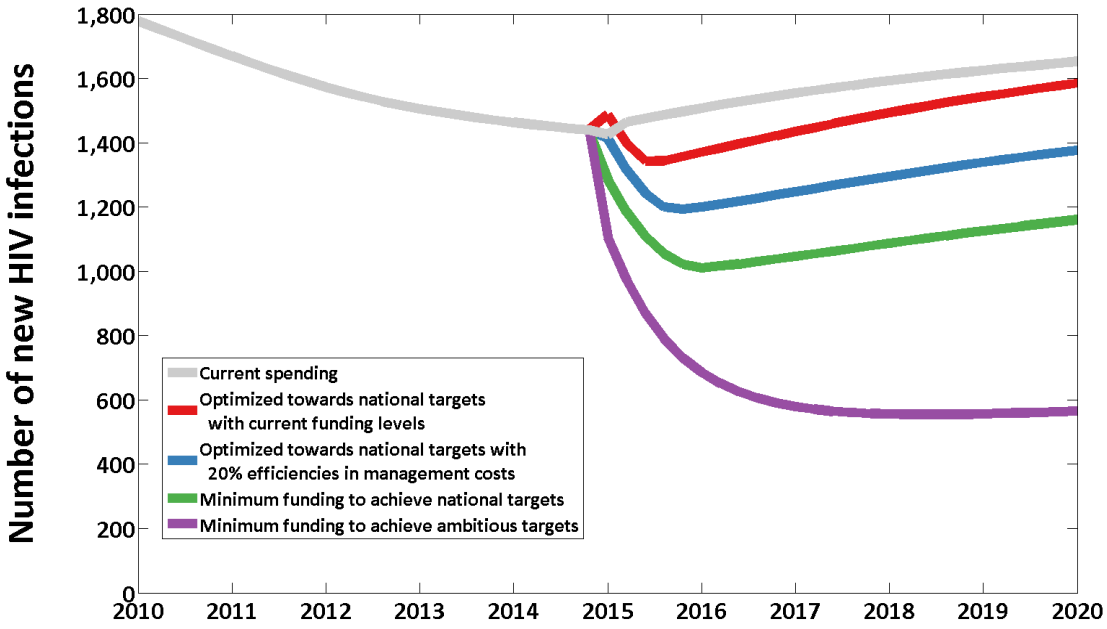
Figure 4.3 Kazakhstan: Comparison of epidemic outcomes key to the national targets, 2014 (Allocations A–E)



Source: Populated Optima model for Kazakhstan.

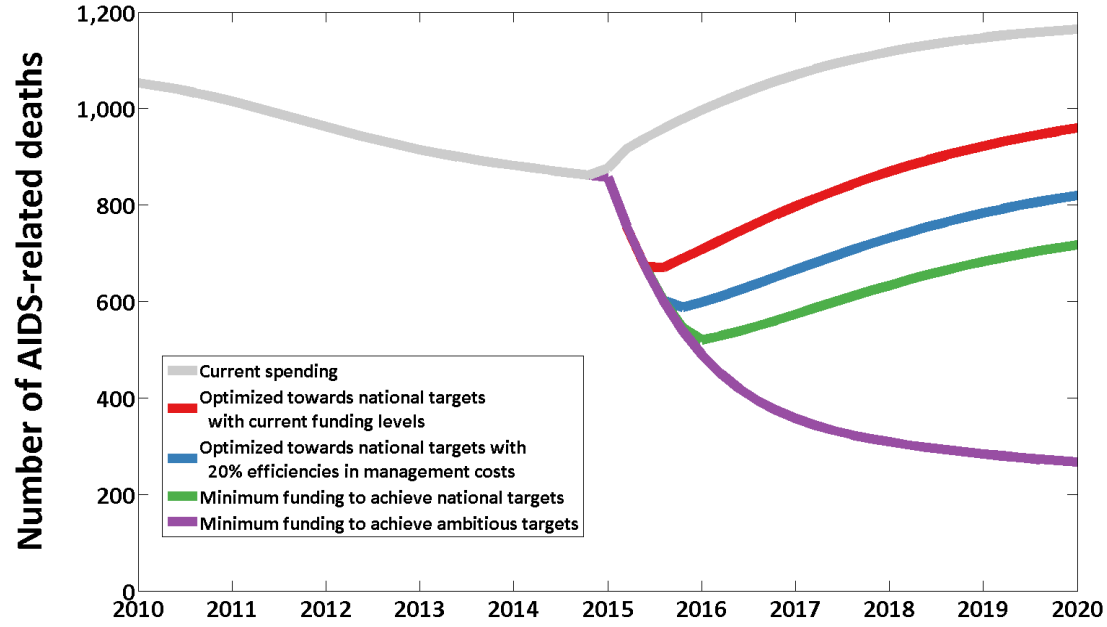
Figure 4.4 and Figure 4.5 show the key epidemiological outcomes over time under each of the spending scenarios described in chapter 3.

Figure 4.4 Kazakhstan: Total number of new HIV infections over time, 2010–20 (Allocations A–E)



Source: Populated Optima model for Kazakhstan.

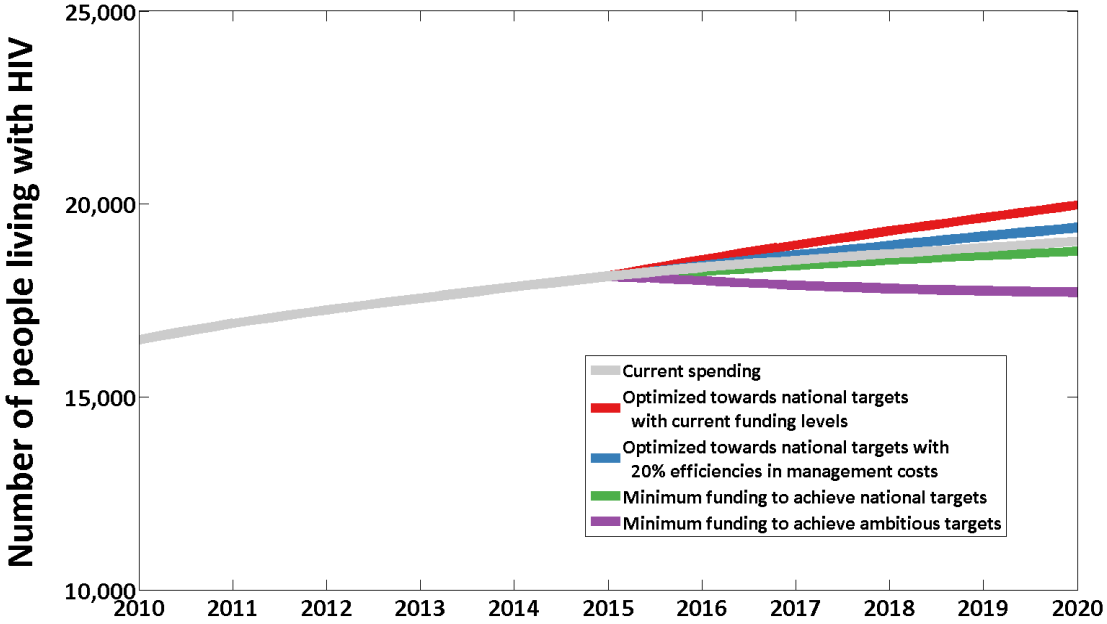
Figure 4.5 Kazakhstan: Total number of AIDS-related deaths over time, 2010–20 (Allocations A–E)



Source: Populated Optima model for Kazakhstan.

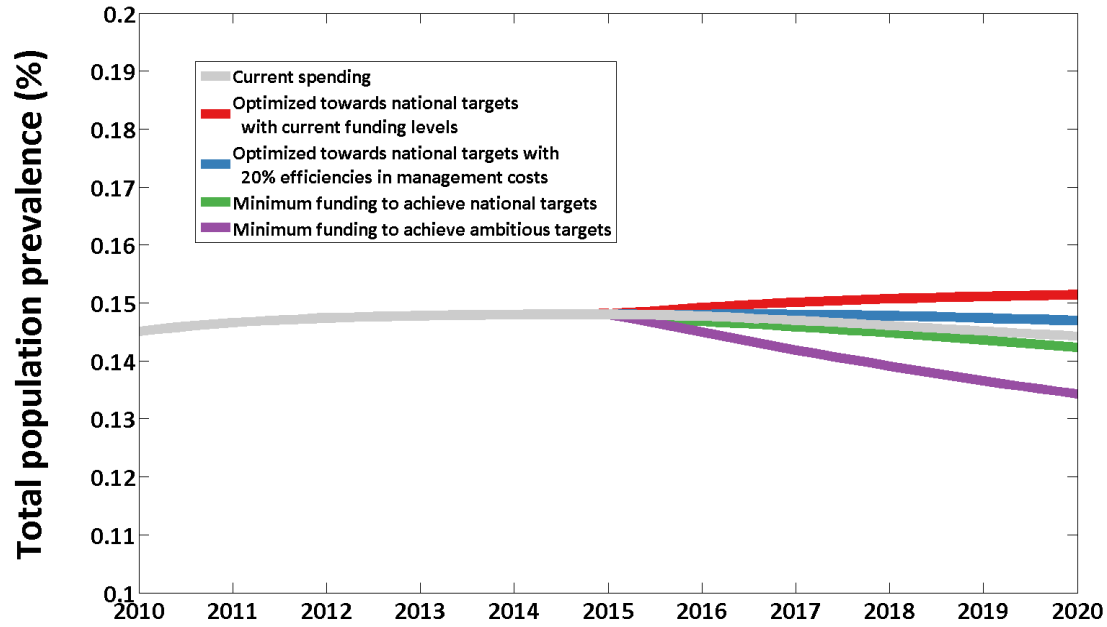
Figure 4.6 and 4.7 show the effect of different allocation options on the total number of PLHIV and total HIV prevalence. The total number of new HIV infections by population is shown in Figure 4.8. Figure 4.9 illustrates the effect of different allocation options on the coverage of ART.

Figure 4.6 Kazakhstan: Total number of people living with HIV over time, 2010–20 (Allocations A–E)



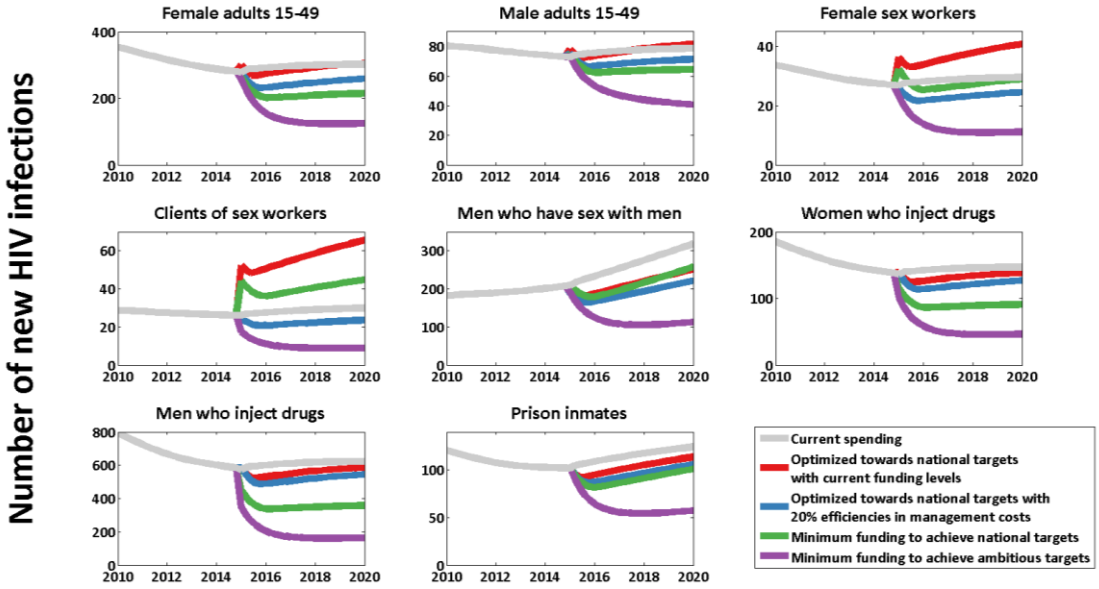
Source: Populated Optima model for Kazakhstan.

Figure 4.7 Kazakhstan: Total population prevalence over time, 2010–20 (Allocations A–E)



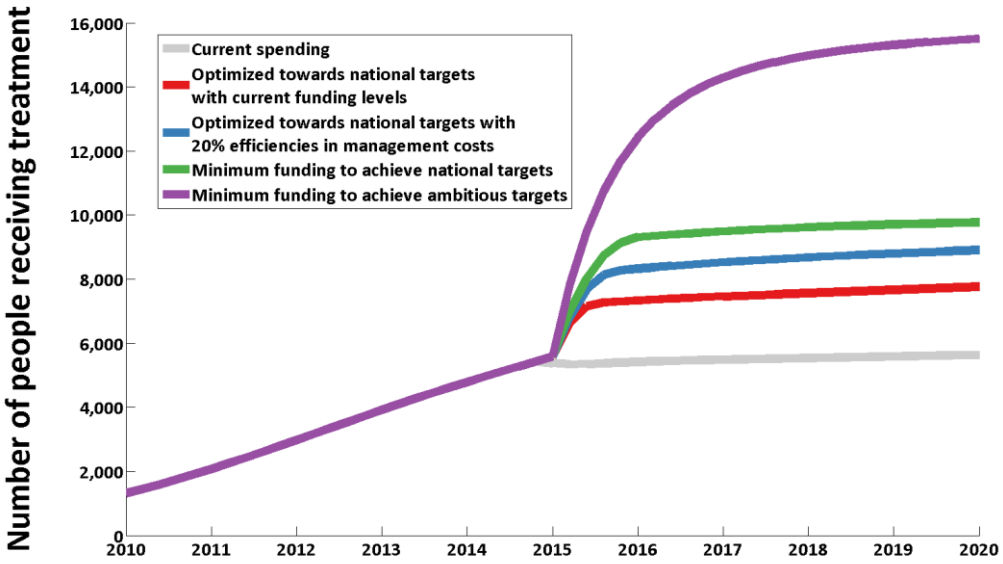
Source: Populated Optima model for Kazakhstan.

Figure 4.8 Kazakhstan: Number of new HIV infections by population, 2010–20 (Allocations A–E



Source: Populated Optima model for Kazakhstan.

Figure 4.9 Kazakhstan: Number of people receiving treatment, 2010–20 (Allocations A–E



Source: Populated Optima model for Kazakhstan.

Table 4.4 describes the associated coverages expected with such funding.

Table 4.4 Program coverage levels, epidemiological outcomes, and cost-effectiveness calculation*s* relating the spending scenarios described, 2015–20

Analysis to end-2020	Zero spending	Current (2013) spending maintained 2015–20	Optimized toward national targets with current funding levels	Optimized toward national targets with 20% efficiencies in management costs	Minimum spending to achieve national targets	Minimum spending to achieve ambitious targets
(US$)						
Allocation to FSW and client condom program in 2015	0	604,000	55,000	665,000	194,000	1,050,000
Allocation to MSM condom program in 2015	0	128,000	324,000	504,000	124,000	400,000
Allocation to PWID condom program in 2015	0	456,000	0a	718,000	1,269,000	1,690,000
Allocation to needle-syringe program in 2015	0	3,307,000	3,264,000	3,223,000	4,289,000	5,937,000
Allocation to opiate substitution therapy in 2015	0	74,000	74,000	74,000	74,000	327,000
Allocation to mass media programs in 2015	0	592,000	0	0	0	107,000
Allocation to HIV counselling and testing in 2015	0	2,647,000	1,686,000	1,844,000	1,452,000	2,160,000
Allocation to PMTCT in 2015	0	552,000	0b	556,000	1,016,000	836,000
Allocation to antiretroviral therapy in 2015	0	8,137,000	11,094,000	12,536,000	14,183,000	22,467,000
Total annual cost for direct programs (average)	0	16,497,000	16,497,000	20,121,000	22,600,000	34,973,000
Total annual cost for indirect programs (average)	0	21,307,000	21,307,000	18,711,000	29,189,000	45,170,000
Total annual HIV response costs (average)	0	37,804,000	37,804,000	37,167,000	51,789,000	80,143,000
Percentage						
FSW and client condom program coverage	0	78	9	81	32	>90
MSM condom program coverage	0	8	15	18	7	17
PWID condom program coverage	0	19	0	29	44	51
Needle-syringe program coverage	0	51	51	51	56	59
Opioid substitution therapy program coverage	0	0.2	0.2	0.2	0.2	1
Mass media programs program coverage	0	14	0.0	0	0.0	3
People living with HIV who know their status	14	82	79	83	83	>90
PMTCT program coverage	0	75	0.0	75	>90	89
Antiretroviral therapy coverage (eligibility: <500 dx)	0	47	61	67	73	>90
Antiretroviral therapy coverage (eligibility: <350 dx)	0	58	71	76	81	>90
Those on treatment who are virally suppressed	N/A	87	87	87	87	87

Table 4.4 Program coverage levels, epidemiological outcomes, and cost-effectiveness calculations relating the spending scenarios described, 2015–20 *(Continued)*

Analysis to end-2020	Zero spending	Current (2013) spending maintained 2015–20	Optimized toward national targets with current funding levels	Optimized toward national targets with 20% efficiencies in management costs	Minimum spending to achieve national targets	Minimum spending to achieve ambitious targets
Number on 1st-line treatment	–	5,100	7,200	8,300	9,100	14,600
Number on 2d-line treatment	–	600	700	700	800	1,100
Number eligible for treatment (eligibility: <500 dx)	6,500	12,000	12,900	13,400	13,400	15,800
Number eligible for treatment (eligibility: <350 dx)	5,500	9,900	11,200	11,800	12,100	15,800
Cumulative new infections	53,500	9,500	8,900	7,800	6,600	3,800
Cumulative AIDS-related deaths	11,100	6,500	5,100	4,400	3,900	2,300
Cumulative DALYs (%)	315,100	289,900	285,300	281,400	279,300	260,800
Overall prevalence	0.42	0.14	0.15	0.15	0.14	0.13
Number of people living with HIV	55,900	19,200	20,200	19,600	18,900	17,700
New infections averted	Baseline	44,100	44,600	45,700	46,900	49,800
AIDS-related deaths averted	Baseline	4,600	6,000	6,700	7,200	8,800
DALYs averted	Baseline	25,100	29,800	33,700	35,800	54,300
(US$)						
Cost per new infection averted	Baseline	$2,300	$2,300	$2,700	$2,900	$4,100
Cost per AIDS-related death averted	Baseline	$22,100	$16,900	$18,500	$19,000	$23,000
Cost per DALY averted	Baseline	$4,000	$3,400	$3,700	$3,800	$3,700

Source: Populated Optima model for Kazakhstan.

Note: Table 4.4 details the allocations described in the previous chapters, and describes the associated coverages expected with such funding. Program coverages associated with the described allocations are derived from the appropriate cost-coverage outcome curves. The analysis period for calculating cumulative program spending and cumulative new HIV infections, AIDS-related deaths, and DALYs is from the beginning of 2015 to the end of 2020. The overall HIV prevalence and number of people living with HIV estimates are taken from the end point of the analysis period (end-2020). The number of averted new infections, AIDS-related deaths, and DALYs for each scenario are calculated by comparing against a baseline of zero spending. The cost per infection, death, or DALY averted then is simply the total program costs over the 2015–20 analysis period divided by the number of infections, deaths, or DALYs averted, respectively; a=The fact that, for this level of spending, the model suggests 0 coverage of condom programs for PWID should not be interpreted to mean that condom distribution to PWID should be stopped. The 0 coverage simply suggests that, given current unit costs and limited resources, this program is not as cost effective as other programs. In practice, continued condom distribution to PWID using a cost-efficient approach would reflect the requirements of this HIV epidemic characterized by substantial levels of sexual transmission of HIV from PWID to their partners; b=Pregnant women should continue to be covered with ART as part of the increased ART budget. In practice, ART coverage also would require continued HIV testing and counselling for pregnant women.

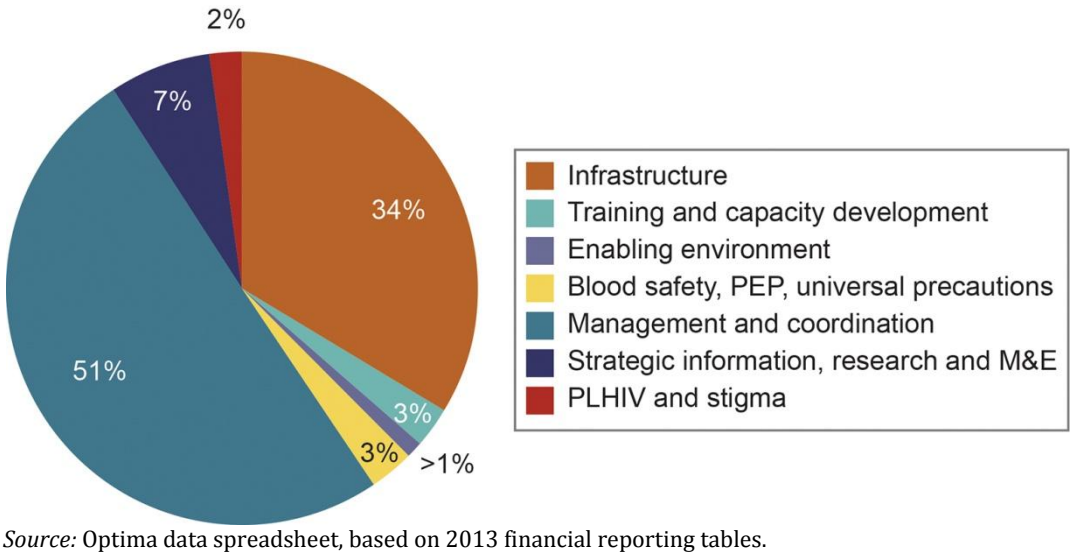
Achieving moderate targets at current program unit cost would cost US$51.8 million. Achieving ambitious targets would cost US$80.1 million, and therefore would require substantial increases in investment (Table 4.4).

In each of these scenarios—except Allocation C—the *proportion* of annual spending to "management and other costs" is kept fixed. The breakdown in management cost is shown in Figure 4.10. Because 56 percent of 2013 HIV spending was allocated to indirect programs, including management and other costs, it also is important to explore in more depth the actual breakdown of these costs. The two single largest subcategories of management and other costs were actual administration, management, and coordination (including human resources); and infrastructure. Infrastructure costs relate primarily to AIDS centers, Trust Points, and Friendly Clinics, through which HIV services and counselling are provided. As mentioned, costs for indirect programs are not included in the mathematical optimization because their effects on HIV incidence, deaths, or DALYs is either indirect, cross-cutting, or not quantifiable. The fact that these costs were not part of mathematical optimization does not mean that they are less important, but it also does not mean that there is no potential for improving efficiency. Because 56 percent of HIV funding is not spent inside programs that directly affect incidence, deaths, or DALYs, it is plausible that additional efficiency gains could be found in that 56 percent. Analyzing technical efficiency was beyond the scope of this study, but doing so would be important to determine any potential areas for savings. For this study, in line with similar analyses in other countries, the team tested an assumption that management costs (within these indirect programs) could be reduced by 20 percent in specific analyses (Allocation C).

KEY MESSAGE

If the current ART unit cost and the proportion of cost going into indirect programs were maintained, 86 percent–90 percent of HIV funding would be locked in HTC/ART (including PMTCT) and indirect programs, leaving little room to invest in other key programs.

Figure 4.10 Breakdown of "management and other costs," 2013 (%)



Source: Optima data spreadsheet, based on 2013 financial reporting tables.

4.4 How much would it cost to achieve moderate and ambitious national targets with reduced ART cost?

Achieving national targets would require large increases in resources (section 4.3). Regional cost comparison in seven countries suggests that Kazakhstan had the highest cost per person reached with ART in the Region. Therefore, it was considered relevant to explore how the analysis would change if ART cost could be reduced. Regional comparison of procurement costs suggests that more competitive or international procurement of antiretrovirals (ARVs) and diagnostics such as viral load tests could lower costs by two-thirds. A 67 percent reduction in ART unit cost would imply a reduction from US$2,279 to US$760 per person reached by ART per year. Even with such a substantial reduction, ART cost would remain within the range of costs reported by other countries. The reduced cost would range from the lowest cost reported in 7 countries (US$576 per person year of ART) to the median cost (US$1,127).

An analysis was conducted to determine the minimal annual spending required to achieve the national and ambitious targets previously described in these scenarios should the future unit cost of ART be reduced by a factor of 3. Twenty percent efficiencies in "management and coordination" activities were also simulated.

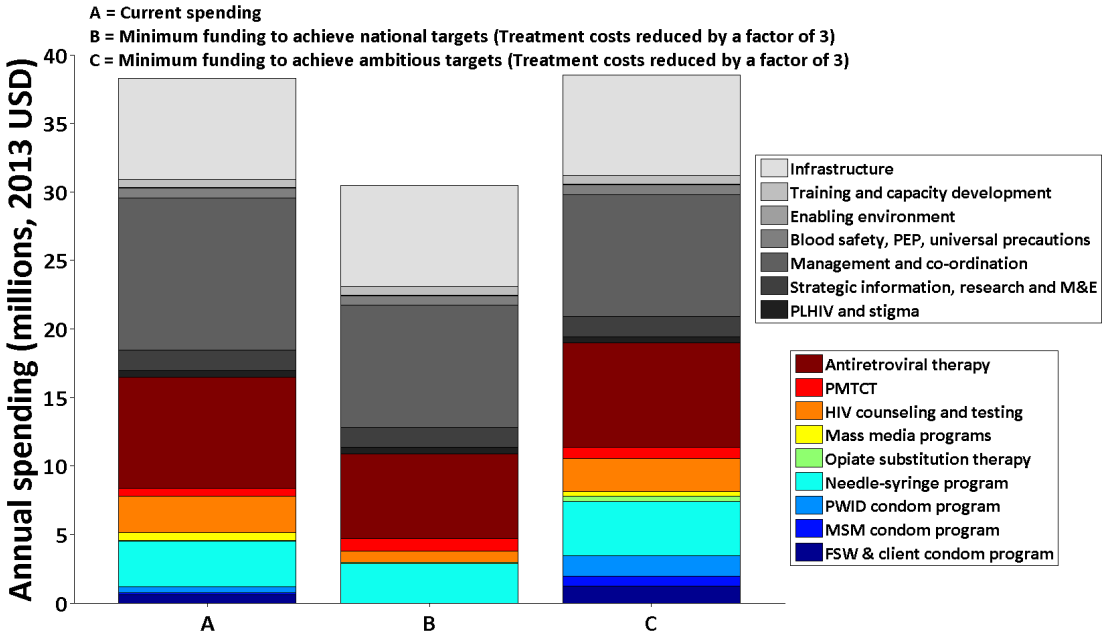
KEY MESSAGE

By reducing ART cost to 30 percent of current cost and reducing management cost by 20 percent, Kazakhstan could achieve ambitious targets or reduce HIV incidence and deaths by 50 percent by 2020.

Should the unit cost of ART be reduced by a factor of 3, the minimal annual spending required to achieve the moderate national targets was estimated at just below US$30 million, that is, lower than the 2013 spending (US$37.8 million). In line with targets set, this allocation would only stabilize HIV incidence and moderately reduce deaths. Interestingly, as shown in Figure 4.11, *if the cost of ART were reduced by a factor of 3 and funding were distributed optimally, nearly the same amount that was available in 2013 (US$37.7 million) would be sufficient to achieve the ambitious targets of a 50 percent reduction in incidence and deaths by 2020 compared to 2014 levels.* In this allocation (Allocation C), ART coverage (CD4<500) increases from 47 percent to over 90 percent. Savings on ART and management costs enable prioritizing FSW, MSM, and PWID condom programs as well as OST and PMTCT programs. Under this scenario, funding to ART, NSP, and HTC programs is similar to current levels. The estimated impact of such a scenario (Figure 4.12) provides a strong argument to advocate for cheaper ART procurement, efficiency gains in "management and coordination" activities, and the optimized distribution of funding. *Optimally allocating resources accompanied by an ART cost reduced by two-thirds would achieve the targets of reducing new infections and deaths by 50 percent compared to 2014. Compared to maintaining current allocations up to 2020, this optimized allocation with reduced ART cost would avert 5,300 new infections and 4,200 deaths, or 56 percent of new infections and 65 percent of deaths.*[6]

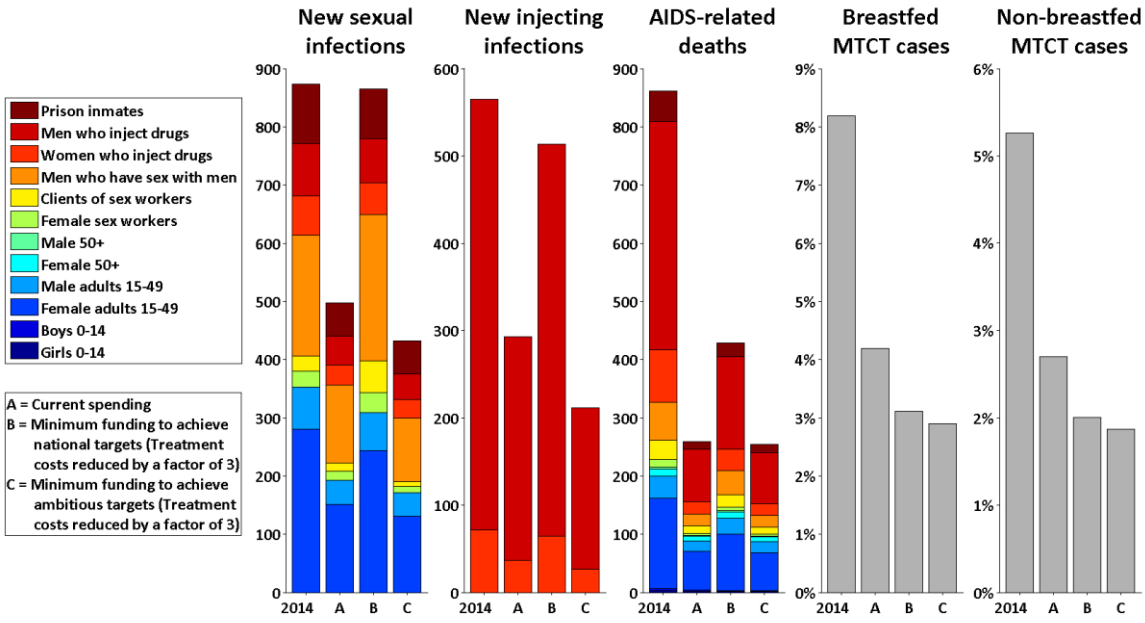
[6] Reductions compared to 2014 levels differ slightly from reductions compared to current allocations maintained from 2015 to 2020. The latter include the moderate increases in new infections and deaths that are estimated to occur over 2015–20. This is the reason that these reductions are slightly higher than reductions compared to 2014 levels.

Figure 4.11 Minimal spending to achieve national and ambitious targets with reduced ART cost (Allocations A-C)



Source: Populated Optima model for Kazakhstan.
Note: In addition to reduced ART cost, an assumption was made that management cost could be reduced by 20 percent.

Figure 4.12 Epidemic outcomes associated with allocations with reduced ART cost, 2014–20 (Allocations A–C)



Source: Populated Optima model for Kazakhstan.

Table 4.5 details the allocations described in this section and describes the associated coverages expected with such funding (following the same approach as outlined above for Table 4.4).

Table 4.5 Epidemiological outcomes and cost-effectiveness relating to the ART scenarios, 2015–20

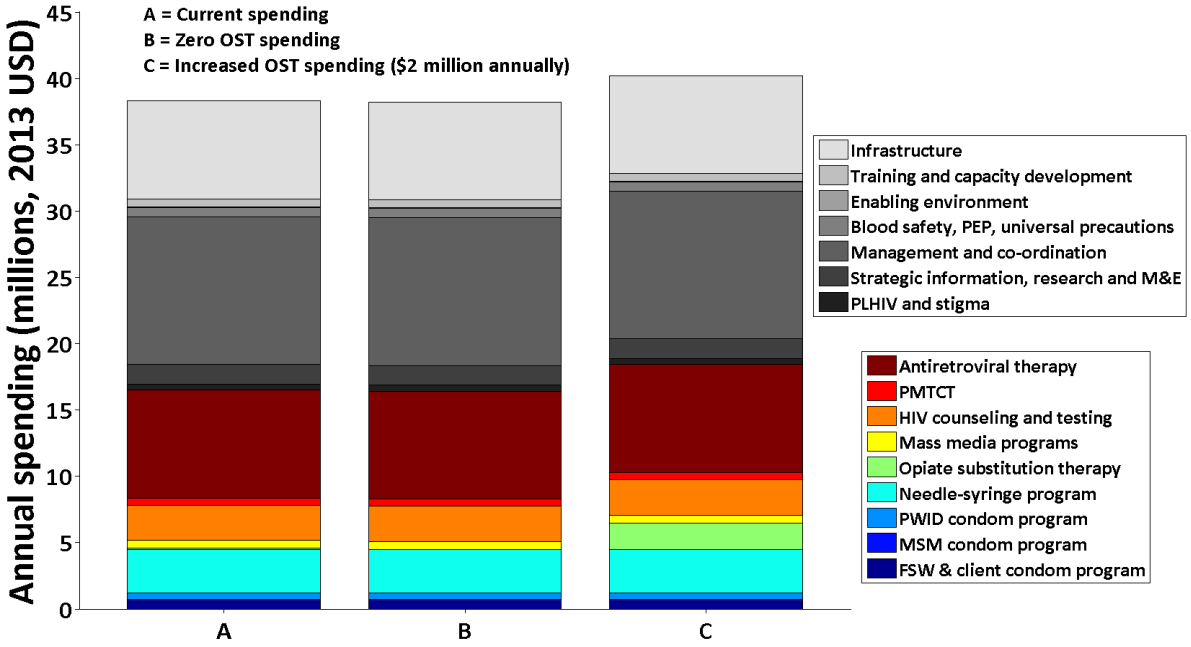
Analysis to end-2020	Current (2013) spending maintained 2015–20 (current unit costs)	Current (2013) spending maintained 2015–20 (treatment costs reduced by 2/3)	Minimum spending to achieve national targets (treatment costs reduced by 2/3)	Minimum spending to achieve ambitious targets (treatment costs reduced by 2/3)
(US$)				
Allocation to FSW and client condom program in 2015	604,000	604,000	0	1,243,000
Allocation to MSM condom program in 2015	128,000	128,000	0	722,000
Allocation to PWID condom program in 2015	456,000	456,000	0	1,467,000
Allocation to Needle-syringe program in 2015	3,307,000	3,307,000	2,880,000	3,955,000
Allocation to opioid substitution therapy in 2015	74,000	74,000	74,000	408,000
Allocation to mass media programs in 2015	592,000	592,000	0	314,000
Allocation to HIV counselling and testing in 2015	2,647,000	2,647,000	814,000	2,438,000
Allocation to PMTCT in 2015	552,000	552,000	933,000	799,000
Allocation to antiretroviral therapy in 2015	8,137,000	8,137,000	6,188,000	7,626,000
Total annual spending direct programs (average, 2015–20)	16,497,000	16,497,000	10,888,000	18,971,000
Total annual spending indirect programs (average, 2015–20)	21,307,000	21,307,000	18,711,000	18,711,000
Total HIV annual HIV spending (average, 2015–20)	37,804,000	37,804,000	29,599,000	37,682,000
Percentage				
FSW and client condom program coverage	78	78	0	>90
MSM condom program coverage	8	8	0	20
PWID condom program coverage	19	19	0	47
Needle-syringe program coverage	51	51	48	55
Opioid substitution therapy program coverage	0.2	0	0	1
Mass media programs program coverage	14	14	0	8
People living with HIV who know their status	82	90	78	>90
PMTCT program coverage	75	75	>90	88
Antiretroviral therapy coverage (eligibility: <500 dx)	47	>90	>90	>90
Antiretroviral therapy coverage (eligibility: <350 dx)	58	>90	>90	>90
Those on treatment who are virally suppressed	87	88	88	87
Number on 1st-line treatment (2020)	5,100	15,400	12,400	14,900
Number on 2d-line treatment (2020)	600	1,100	900	1,100
Number eligible for treatment (2020) (20*((eligibility: <500 dx)	12,000	16,700	14,900	16,200
Number eligible for treatment (2020) (20((**(eligibility: <350 dx)	9,900	16,600	14,100	16,100
Cumulative new infections, 2015–20	9,500	5,000	7,600	4,200
Cumulative AIDS deaths, 2015–20	6,500	2,300	2,800	2,300
Cumulative DALYs, 2015–20	289,900	273,000	275,500	258,300
Overall prevalence, 2020 (%)	0.14	0.14	0.16	0.14
Number of PLHIV, 2020	19,200	18,900	20,800	18,100
New infections averted, 2015–20	44,100	48,500	46,000	49,300
AIDS deaths averted, 2015–20	4,600	8,800	8,300	8,800
DALYs averted, 2015–20	25,100	42,100	39,600	56,800
(US$)				
Cost per new infection averted (US$)	N.a.	3,700	3,000	4,000
Cost per AIDS-related death averted (US$)	N.a.	20,600	16,500	22,400
Cost per DALY averted (US$)	N.a.	4,300	3,500	3,500

Source: Populated Optima model for Kazakhstan.

4.5 Impact of funding to opioid substitution therapy programs

The potential impacts of scaling down and scaling up OST programs also were simulated (Figure 4.13). In one scenario, OST programs were defunded. In another scenario, funding to OST programs was increased to US$2 million a year.

Figure 4.13 Spending scenarios simulated to assess the impact of OST programs, 2015–30 (Allocations A–C)



Source: Populated Optima model for Kazakhstan.

The health and economic outcomes of such allocations are summarized in Table 4.6, which details the allocations described in this section and describes the associated effects.

An additional investment of US$2 million would take OST coverage from 0.2 percent to 4 percent. Although a 20-fold increase, this coverage is low compared to high coverage levels achieved in other regions of the world. This level of investment in OST would avert 700 new infections, 100 deaths, and 32,400 DALYs cumulatively by 2030. The costs per death, new infection, and DALY averted are calculated as compared to current level of spending, not to zero spending. Therefore, these costs are higher and not comparable to the costs calculated in other parts of the report, which all compare to zero spending.

Table 4.6 Epidemiological outcomes and cost-effectiveness relating to OST scenarios, 2015–30

Analysis to end-2030	Zero OST spending	Increased OST spending
Annual allocation to OST (US$)	0	2,000,000
Total direct program spending 2015–30 (US$)	373,274,000	404,187,000
OST program coverage (%)	0.00	4.00
Cumulative new infections	23,200	22,500
Cumulative AIDS-related deaths	12,000	11,900
Cumulative DALYs	885,400	853,000
Overall prevalence (%)	0.15	0.15
Number of people living with HIV	23,600	23,100
New infections averted	Baseline	700

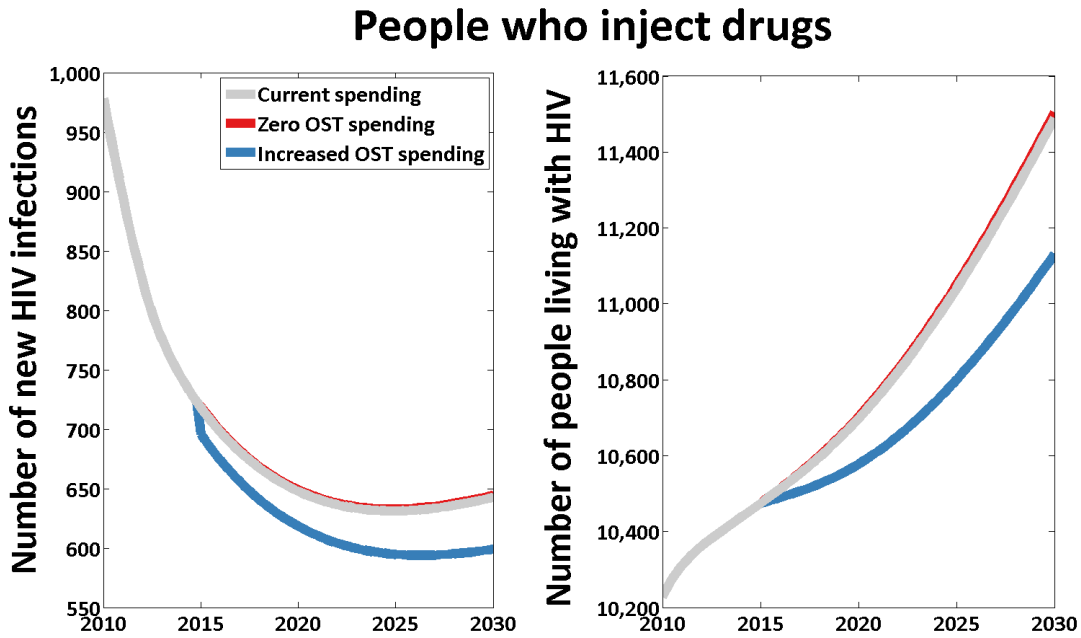
Table 4.6 Epidemiological outcomes and cost-effectiveness relating to OST scenarios, 2015–30 *(Continued)*

Analysis to end-2030	Zero OST spending	Increased OST spending
AIDS-related deaths averted	Baseline	100
DALYs averted	Baseline	32,400
Cost per new infection averted (US$)	Baseline	46,000
Cost per AIDS-related death averted (US$)	Baseline	258,000
Cost per DALY averted (US$)	Baseline	953

Source: Populated Optima model for Kazakhstan.

Figure 4.14 illustrates the changing number of annual new infections and PLHIV over time among PWID under the two scenarios of decreased and increased funding to OST programs.

Figure 4.14 Incidence among PWID and the number of PWID living with HIV in the 3 OST scenarios, 2010–30



Source: Populated Optima model for Kazakhstan.

4.6 Efficiency gains from optimized allocations

The cost effectiveness calculations discussed in this section compare to a baseline of *zero spending* from 2015 and build on data presented in sections 4.3 and 4.4.

In the zero spending scenario, an estimated 53,500 cumulative new HIV infections and 11,100 cumulative AIDS-related deaths would occur over 2015–20 in Kazakhstan (Table 4.7). Under this scenario, the epidemic is projected to explode so that an estimated 305,000 cumulative new HIV infections and 89,600 cumulative AIDS-related deaths would occur from 2015 to 2030.

Under a scenario of maintaining current spending and distribution to programs, an estimated 44,100 of the 53,500 new infections could be averted by 2020; and 4,600 of the 11,100 AIDS-related deaths could be averted. By 2030, maintaining current spending could avert 277,600 of the 305,200 new infections and 70,900 of the 89,600 AIDS-related deaths. If current funding is maintained, program costs over 2015–20 would total US$277 million. This total implies that the cost per infection averted in the maintaining current spending scenario would be US$2,300, and the cost per death averted would be US$22,100. When the longer

2015–30 time frame is considered, compared to the baseline scenario of zero spending (a counterfactual that assumes that there is no public spending on HIV programs), the cost per infection averted would be $1,000 and the cost per AIDS-related death averted would be $3,900.

By increasing the national budget by 37 percent to $52.5 million per year and spending optimally to achieve national strategic targets (Allocation D, Figure 4.2), 46,900 new infections and 7,200 AIDS-related deaths could be averted by 2020 compared to the zero-spend baseline. These epidemiological outcomes of Allocation D equate to an additional 2,800 new infections and, significantly, 2,600 AIDS-related deaths averted by 2020 compared to the maintaining current spending projection. By 2030, optimally redistributing current funding levels toward the national strategic targets can avert an estimated 288,500 new infections and 79,200 deaths, which equal 11,000 infections and 8,300 deaths fewer than the maintaining current spending scenario.

The cost per infection averted by 2020 by optimally allocating toward national targets is $2,900, and the cost per death averted is $19,000. The cost per AIDS-related death averted in this scenario is $3,100 less than in the scenario of maintaining current spending.

Under the scenario in which the cost of ART procurement is reduced by a factor of 3, the minimal spending required to achieve the same national strategic targets would be less than the current budget (section 4.4). Furthermore, should 20 percent efficiencies in "management and costs" activities be achieved and funds be distributed in an optimized way, the total spending required to achieve a set of ambitious targets also would be possible within the current budget. By optimally allocating funds to achieve these ambitious targets under the described assumptions of ART procurement (Allocation C, Figure 4.11), the cost per infection averted by 2020 would be $4,000 and the cost per AIDS-related death averted would be $22,400. When coupled with the estimate that this allocation would achieve 50 percent reductions in infections and deaths by 2020 relative to 2014 levels (Figure 4.12), the implication is that HIV investments remain highly cost effective compared to zero spending. Table 4.7 also illustrates that, compared to zero spending, current spending is already cost effective.

Table 4.7 Impact and cost-effectiveness of Kazakhstan's HIV programs by 2020

Impact measures	Maintain 2013 spending	Minimum funding to achieve national targets	Minimum funding to achieve ambitious targets (treatment costs reduced by 2/3)
Number of new HIV infections averted	44,000	46,900	49,300
Cost per infection averted (US$)	2,300	2,900	4,000
Number of AIDS-related deaths averted	4,600	7,200	8,800
Cost per death averted (US$)	22,100	19,000	22,400

Source: Populated Optima model for Kazakhstan.
Note: The number of infections/deaths averted is calculated by comparing to a baseline of zero spending.

5. CONCLUSIONS AND RECOMMENDATIONS

The following are key recommendations from this study to policy makers and planners in Kazakhstan.

1 **In Kazakhstan's concentrated HIV epidemic, there is continued need to focus analysis, planning, and implementation on key populations, particularly people who inject drugs, men who have sex with men, prison inmates, female sex workers, and their clients.** Under current conditions (constant behaviors and program coverage), new HIV infections are projected to rise by 13 percent and deaths by 32 percent between 2014 and 2020. The epidemics among PWID and MSM are projected to account for two-thirds of new HIV infections and must be core foci of programs. Prevention, HTC, and treatment need to be targeted primarily toward these two groups while continuing to provide services to other key populations.

2 **Kazakhstan's current investments already are making a great difference in slowing the spread of the HIV epidemic, and the level of investment needs to be sustained**. With no programs in place, the HIV epidemic would grow dramatically and a projected 54,000 new infections and 11,100 deaths would occur from 2015 to 2020. Given current spending and allocations, the epidemic would grow slowly, and 9,500 new infections and 6,500 deaths would occur over 2015–20. Nevertheless, at current unit cost and with current allocations, the current level of HIV spending would not be sufficient to stabilize and reduce new infections and deaths in Kazakhstan.

3 **By optimizing current allocations to HIV programs, Kazakhstan could reduce new infections and deaths.** Optimized allocation of US$37.8 million (2013 spending) **would avert 6 percent of new infections and 22 percent of deaths** over 2015–20 compared to business as usual (current allocations maintained during same period). Optimized allocation of 2013 spending would imply increasing coverage of ART from 47 percent to 61 percent (CD4<500) and of MSM programs from 8 percent to 15 percent. Simultaneously, the current high levels of coverage of NSP for PWID and current coverage of OST would be sustained, and savings in the other programs would be made.

4 **With additional savings on management costs, Kazakhstan could substantially further increase the impact of the national HIV response.** With the same amount of money available as in 2013, saving 20 percent of management costs at current levels of funding and allocating the resources optimally would avert 18 percent of new infections and 32 percent of deaths, compared to current allocations.

5 **At current unit costs of programs, achieving the national HIV prevention and treatment targets would require substantial additional investment.** To achieve the national targets (no increase in HIV incidence and deaths) would cost US$51.8 million

per year—33 percent more than current spending. Achieving the more ambitious targets (reducing new infections and deaths by 50 percent) would cost US$80.1 million, thus requiring substantially increased investment.

6 **Reducing the unit cost of ART while scaling up ART to high coverage levels are the key elements required to achieve the national targets at current spending levels.** Unit cost for ART in Kazakhstan has been high compared to other countries in the region and the effect of a reduction of unit costs by 67 percent (from US$2,280 to US$760 per person reached per year) was explored. Even with such a substantial reduction, ART cost still would be within the range of costs reported by other countries in the Region. When combined with a 20 percent reduction of management cost and optimized allocation of funds, it would be possible to achieve a 50 percent in both HIV incidence and deaths with an annual investment of US$37.7 million––approximately the 2013 funding levels. This optimized allocation with reduced ART cost would avert 5,300 new infections and 4,200 deaths. Optimization also would enable almost doubling ART coverage from 47 percent of PLHIV (CD4<500) to over 90 percent of PLHIV (CD4<500).

7 **Addressing the HIV epidemic and wider health needs of people who inject drugs remains a critical priority for Kazakhstan.** Needle and syringe exchange programs should be sustained with at least 50 percent coverage and further scaled up in the context of comprehensive harm-reduction programs. Opioid substitution therapy has important effects on HIV prevention and ART adherence and should be provided at substantially larger scale. Increasing the proportion of PWID on OST from 0.2 percent to 4 percent would avert 700 new infections, 100 deaths, and over 32,000 DALYs from 2015 to 2030. These findings are in line with a recent analysis of cost-effectiveness of HIV and HCV programs in Kazakhstan. The analysis showed that reductions in HIV and HCV epidemics over the next 15 years would not be feasible without raising the coverage of NSP, OST, access to ART, and HIV diagnosis (INSERM and UNAIDS 2015). Because the health and social benefits of OST extend far beyond HIV, substantial additional funding from outside the HIV response should be provided for OST. In addition, a technical efficiency analysis could be conducted how to make OST programs more cost effective.

8 **To address the growing MSM epidemic, MSM programs need to increase coverage.** By 2020, MSM are projected to account for approximately 20 percent of new HIV infections. Under current allocations, program coverage would remain low at 8 percent, but it should increase substantially to at least 20 percent. This increase will require making pragmatic outreach approaches through informal networks while continuing current efforts to reduce stigma and discrimination, so that more ambitious targets can be set in future.

9 A **reduction in management cost** of approximately 20 percent could be explored further in a rapid technical efficiency analysis. Kazakhstan reported management and other cost as 56 percent of total HIV spending. This percentage includes infrastructure cost and can be partially explained by the inclusion of management cost of specific programs. However, the large share of this expenditure category, which could not be included in optimization analysis, justifies further technical efficiency review.

10 **Domestic investment in Kazakhstan's HIV programs will be critical to sustain the response,** including programs previously covered by the Global Fund, after the country graduates from Global Fund support in 2016.[7] If Kazakhstan can sustain the current total level of HIV funding and if the proposed technical efficiency gains can be realized, the country's 2013 level of HIV investment will remain

[7] The Global Fund is phasing out support for upper-middle income countries such as Kazakhstan.

sufficient to achieve the ambitious targets of reducing HIV incidence by 50 percent. If ARV costs cannot be reduced, it is necessary to increase HIV investment accordingly. This reduction is justified also by the fact that current levels of HIV spending as a share of total health spending is below the contribution of HIV disease burden to the overall disease burden. Furthermore, domestic investment, which can avert 5,300 new infections within 6 years (2015–20) will reduce future health care costs and thereby make achievement of the 2020 national HIV targets an investment with long-term benefits.

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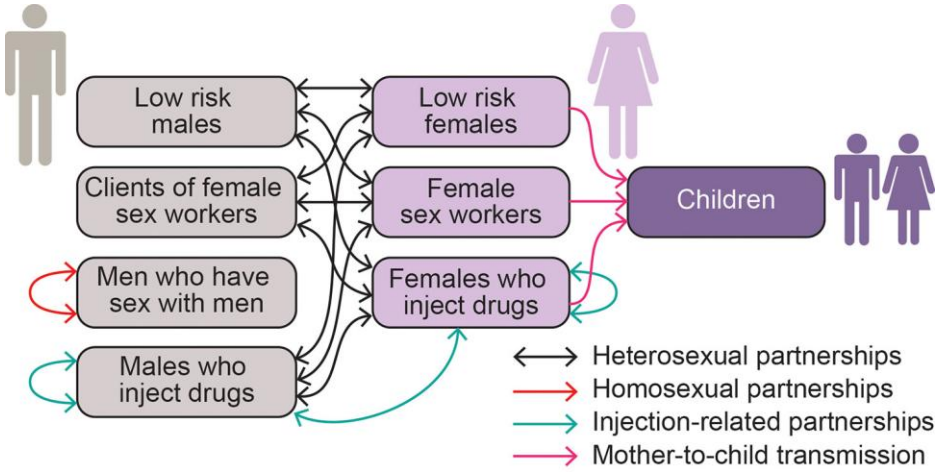
APPENDIXES

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.[8] 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

[8] 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.[9] 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.[10] 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.[11]

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[9] 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.

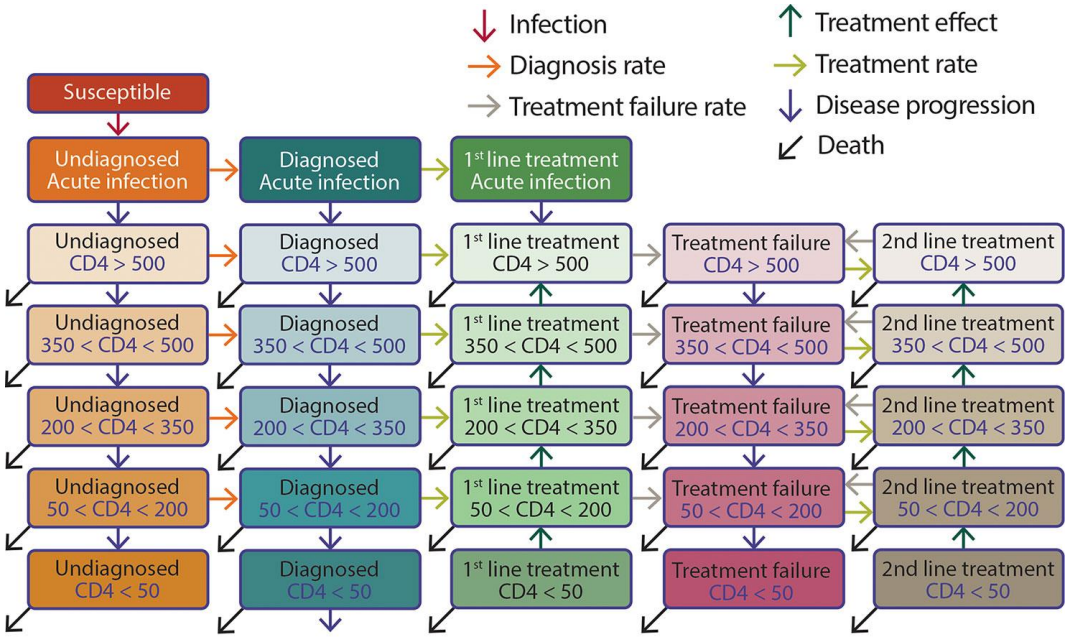
[10] First, individuals may die, either because of an average background death rate for that population (which is greater for older populations or for people who inject drugs) or because of HIV/AIDS (which depends on CD4 count). Second, in the absence of treatment, individuals progress from higher to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

[11] 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.

Table A.1 Input parameters of the model

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

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

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.

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.[12] 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 responses.[13] 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

[12] 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).

[13] 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).

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

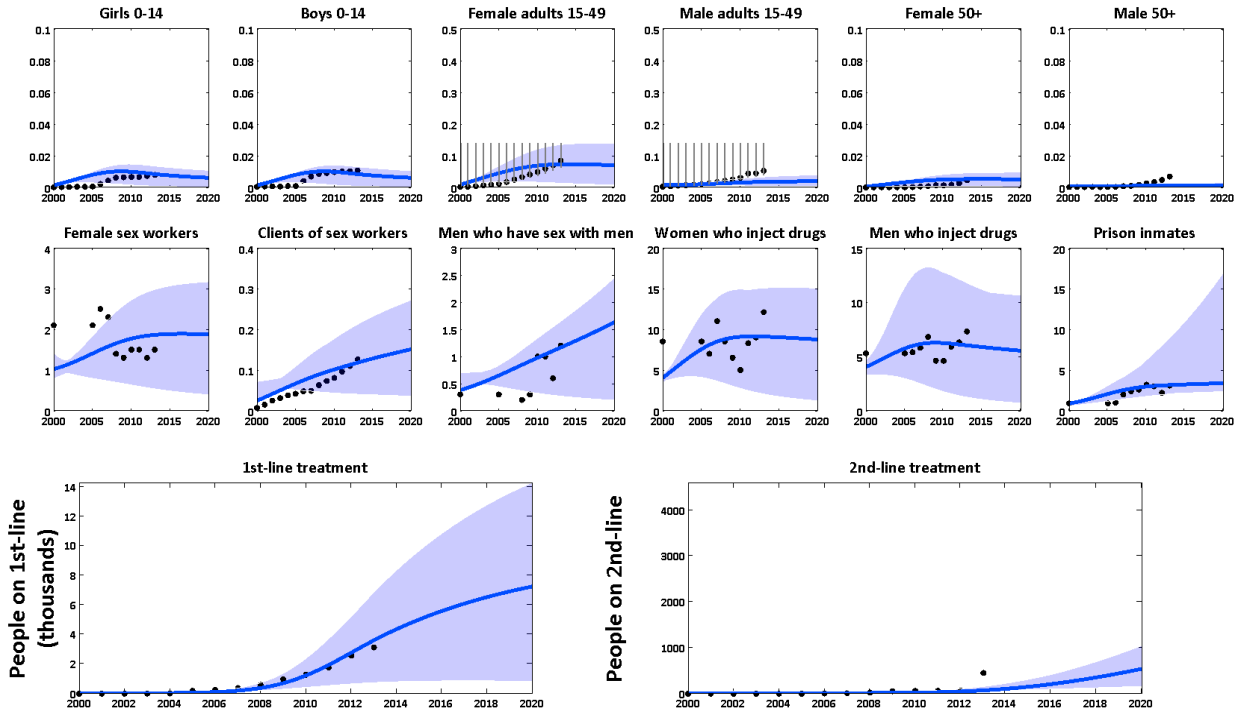
Optima uses a Markov chain Monte Carlo (MCMC) algorithm for performing automatic calibration and for computing uncertainties in the model fit to epidemiological data. With this algorithm, the model is run many times (typically, 1,000–10,000) to generate a range of epidemic projections. Their differences 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.[14]

[14] 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

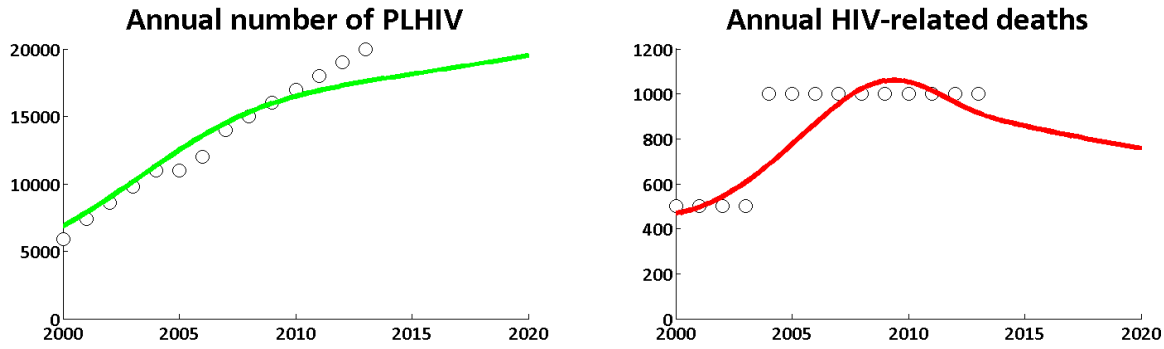
The calibration to HIV prevalence data points is shown in Figure B.1 and the calibration to data points on the number of people on ART is shown in Figure B.2. These calibrations were produced in collaboration with Kazakhstan experts.

Figure B.1 Calibration of Optima Model to the HIV Epidemic in Kazakhstan, 2000–20



Source: Populated Optima model for Kazakhstan.
Note: Black dots represent available data for HIV prevalence. Lines attached to these discs represent uncertainty bounds. The solid curve is the best fitted estimation of HIV prevalence in each subpopulation.

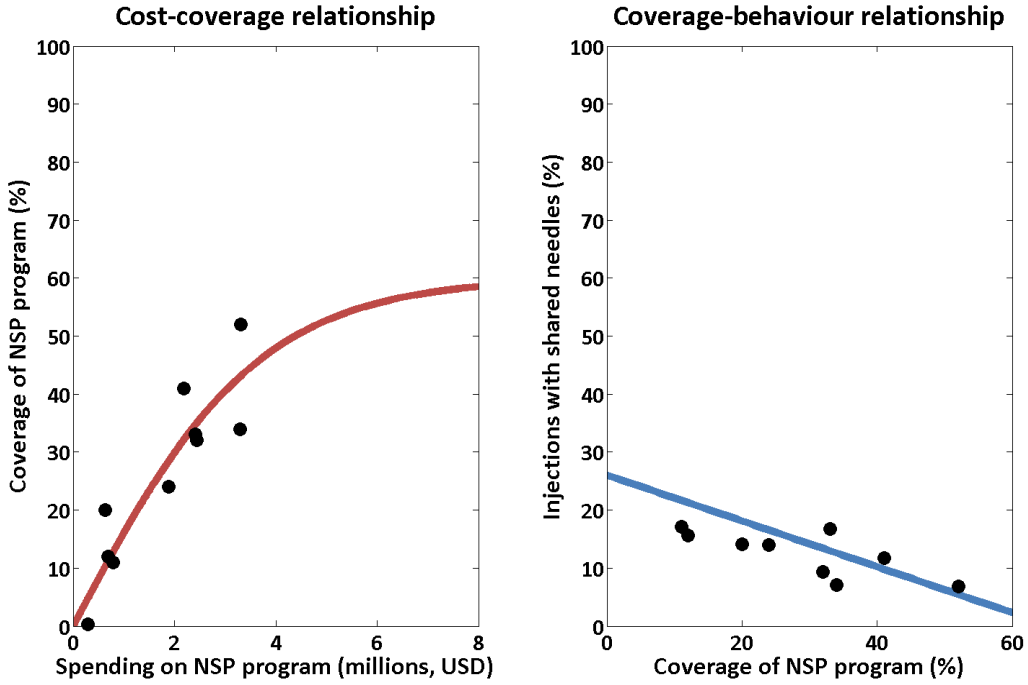
Figure B.2 Calibration of Optima Model to the HIV Epidemic, 2000–20



APPENDIX C. COST-COVERAGE-OUTCOME CURVES

The relationship between program spending and coverage is shown in subfigure C.1.a. 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$1,000,000. The relationship between coverage levels and outcomes is shown in subfigure C.1.b. This relationship describes the proportion of people who will adopt a specific behavior (such as condom use or consistent use of ARVs leading to viral suppression). These relationships were produced in collaboration with Kazakhstan experts.

Figure C.1 Logistic cost-outcome relationships for Kazakhstan



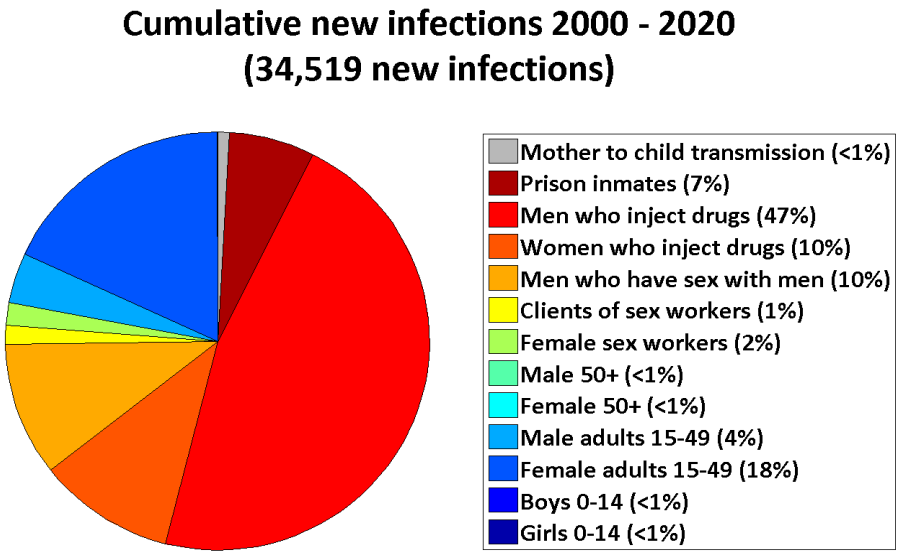
Note: Black discs represent available spending and coverage data and associated behaviors. The solid curves are the best fitting or assumed relationship.

The cost-coverage relationships also reflect the current costs per person reached in the HIV response.

APPENDIX D. OTHER RESULTS

Appendix D includes additional charts that were not included in the main report but that may be relevant for some readers.

Figure D.1 Model-predicted cumulative HIV infections, 2000–20

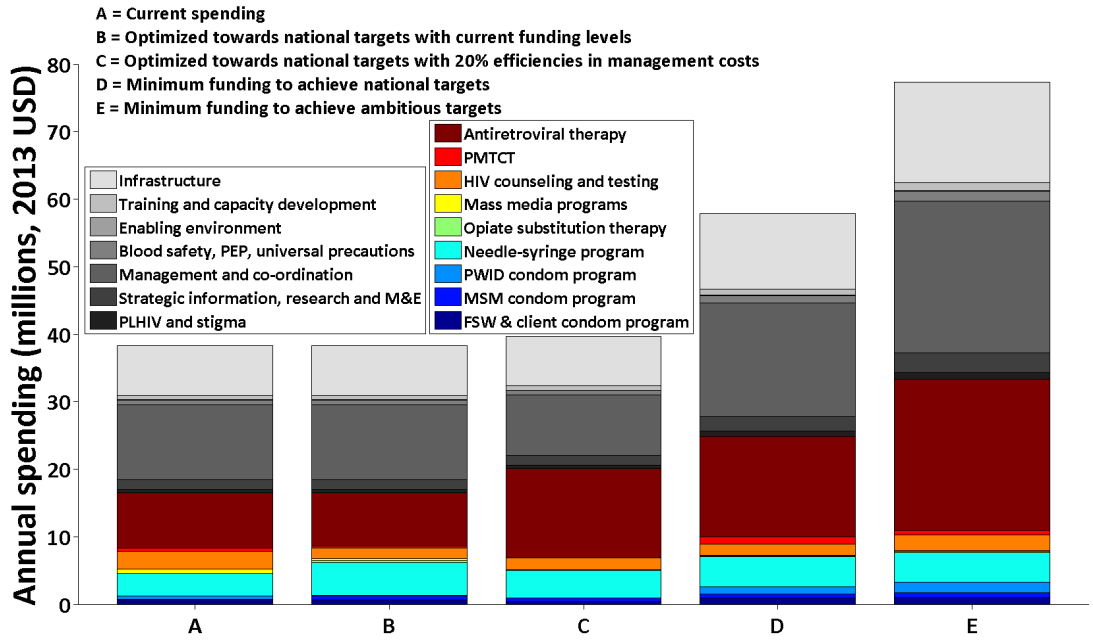


To investigate whether allocations would be different **with a longer time frame**, some key analyses were repeated using **2030** as the time frame for investment and tracking impact. These results appear in Figure D.2 and Figure D.3.

These figures show the optimized allocations for the same targets as analyzed in section 4.3.1, but for 2015–30. The allocations presented in Figure D.2 and Figure D.3 are the same as those in Figure 4.2 and Figure 4.3, although they are analyzed for the longer time frame (2015–30, rather than 2015–20). The results are similar to those obtained for 2015–20. However, the results for the longer time frame show a slight emphasis toward prevention programs and away from treatment programs, particularly when limited funding is available. This emphasis is not surprising because preventing an infection in the short term means that resources will not have to be used to treat such an individual in the longer term.

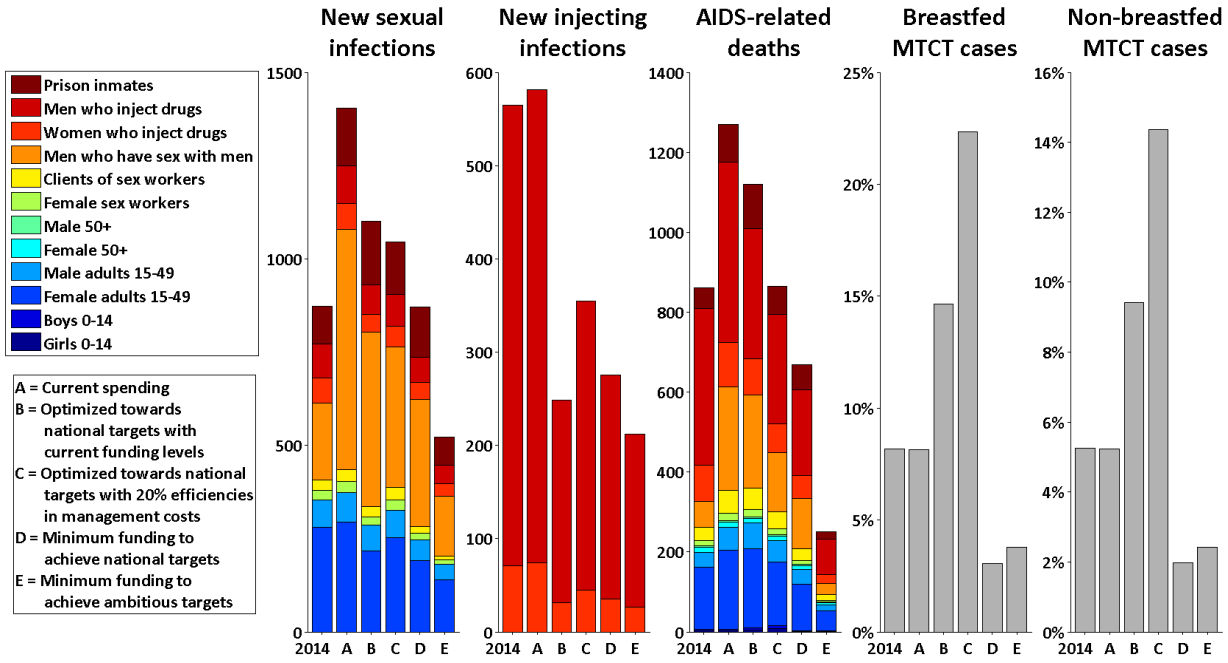
Figure D.3 shows the projected national health outcomes in 2030 under each of the scenarios represented in **Error! Reference source not found.** Figure D.2. The first bar in each of the subplots shows the estimated 2014 values of the respective health outcome indicator.

Figure D.2 Optimizing spending toward achieving national targets by 2030



Note: Figure D.2 corresponds to Figure 4.2 but for an extended time frame.

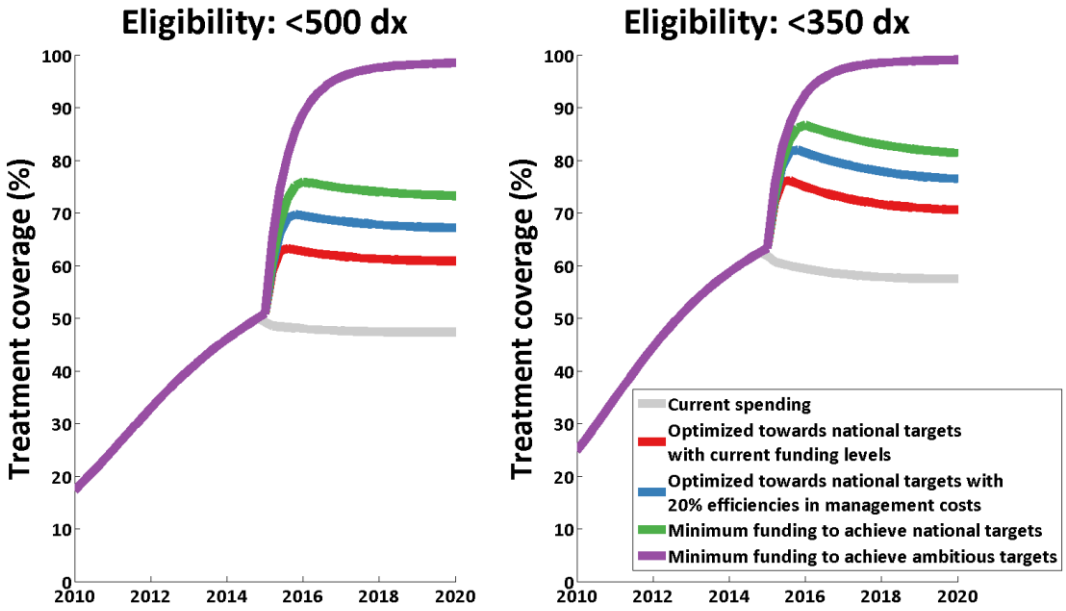
Figure D.3 Comparison of 2014 epidemic outcomes with outcomes key to the national targets in 2030 (Allocations A-E)



Note: Figure D.3 corresponds to Figure 4.3, but for an extended time frame.

Figure D.4 shows the levels of ART coverage under different allocation scenarios between 2010 and 2020. Treatment coverage is shown for two different ART eligibility criteria (CD count of less than 350 and CD4 count of less than 500 in line with 2010 and 2013 WHO treatment guidelines, respectively).

Figure D.4 Treatment coverage under different definitions of coverage, 2010–20 (%) (Allocations A-E)



APPENDIX E. GLOSSARY

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

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

APPENDIX F. REFERENCES

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