HIV Investment in Armenia: Analysis & Recommendations

April 2014

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Abbreviations

AIDS	acquired immunodeficiency syndrome
ART	antiretroviral therapy
BCC	behavior change communication
CI	confidence interval
DALY	disability-adjusted life year
FSW	female sex worker
GFATM	Global Fund to Fight AIDS, Tuberculosis and Malaria
HIV	human immunodeficiency virus
HTC	HIV testing and counseling
MSM	men who have sex with men
NSP	Needle and syringe program
OST	Opioid substitution therapy
PLHIV	people living with HIV
PMTCT	prevention of mother-to-child transmission
PWID	people who inject drugs
STI	sexually transmitted infection

1 Executive summary

- **HIV incidence appears to be increasing:** According to national surveillance data, the number of HIV diagnoses was 80 in 2000, 200 in 2005, and 340 in 2010. According to model-based estimates, HIV incidence follows a similarly increasing trend, with total new annual infections estimated to be 530 in 2014.
- **HIV prevalence is decreasing among people who inject drugs:** Prevalence is greatest among people who inject drugs, although a relatively high prevalence is also seen among other key populations at high risk of HIV exposure. HIV prevalence has been decreasing significantly among people who inject drugs, but appears to be increasing among men who have sex with men.
- **The health and economic burden of HIV in Armenia is substantial:** Unless there are substantial increases in funding, HIV incidence is expected to increase substantially. This will lead to large fiscal liability in care and treatment for people living with HIV in Armenia.
- **Armenia is dependent on international funding:** Reducing the dependency on external funding requires establishment of transitional funding mechanisms to domestic sources which will be sustainable in the medium-to-long term.
- **Past investments have saved lives:** According to model-based estimates, the US$18 million spent on HIV programs over the period 2007 – 2011 was extremely cost-effective, averting 11,000 infections and 2700 deaths by 2020, for an overall cost-effectiveness of US$170/DALY.
- **Critical services need to be scaled up**: According to model-based estimates, nearly 60% of PLHIV in Armenia are unaware of their infection. In addition, treatment rates are low – as of 2012, only 230 people on were on treatment out of an estimated 4200 PLHIV. This corresponds to a treatment rate of just 5%. Thus, there is a strong need to substantially improve testing and treatment of PLHIV in Armenia.
- **Opportunities exist to optimize investments**: Optimal resource allocations depend on the objective desired to be achieved. Armenia has allocated its HIV/AIDS resources relatively well, particularly when benchmarked against other countries. In order to minimize new infections, funding should be shifted towards PMTCT and primary prevention programs for high-risk populations (particularly female sex workers and people who inject drugs). To minimize overall health burdens in the population related to HIV it is also important to substantially scale-up antiretroviral therapy. If current budget amounts were allocated more optimally among key interventions then 1100 new infections could be prevented by 2030.
- **Universal coverage would halt the epidemic:** If universal coverage of treatment and prevention programs were implemented by 2015, the number of new infections in 2020 would be less than one-third of what they would be if current conditions continue. The resources required to achieve universal coverage would be roughly an additional US$18 million per year, of which the large majority would be increases in ART and indirect costs. This expenditure would be highly cost-effective at US$1500/DALY.
- **Mobilizing additional resources:** Innovative financing mechanisms are unlikely to be viable options to fund the HIV response. There is a need to shift domestic resources towards HIV. The amount of money required is relatively low, constituting 9% of health expenditure in Armenia and 0.3% of overall GDP. Extrapolating and benchmarking with other countries indicates that Armenia is funding a reasonable proportion of its HIV/AIDS response. However, in coming years there will be the need to fill in some of the resource gaps. Investing in responding to HIV/AIDS has substantial long-term health and economic returns.

2 Why is this report needed?

The HIV response is dependent on international sources

- Armenia is a lower-middle income country. Whilst some components of the economy of Armenia have increased substantially the government of Armenia is aiming for further improvements in many regional and global indicators.
- The majority of financial resources for Armenia's response to HIV/AIDS have been from the GFATM. The Global Fund resources are becoming more limited with the existing budget for Phase 2 of the program implementation of over €9.1 million now reduced by 25% over three years, down to a total of about €7 million.

The current HIV response is insufficient to meet all commitments

- HIV prevention and treatment do not cover all those in need.
- As a result people in Armenia have been and still are at substantial risk of HIV infection and related morbidities and mortality.
- HIV incidence and prevalence in Armenia are relatively stable. Model-based estimates suggest that both incidence and prevalence are declining among people who inject drugs, but are stable or increasing among the low-risk population and other high-risk populations (including female sex workers and men who have sex with men).

International aid is withdrawing

- The economic crisis in North America and Western Europe has reduced the perspective of stable or even growing international funding for national HIV responses in the region.
- Changing eligibility and co-financing requirements under the new funding model of the GFATM which provide primary support for key prevention, treatment and care programs in Armenia, leads to concern around the sustainability of the long-term national HIV/AIDS response.
- Donors are increasingly supporting countries to establish transitional funding mechanisms from international to domestic sources.

Objectives of this report

- Characterize the current state of the epidemic.
- Calculate the costs of past HIV prevention and treatment interventions and activities, and the benefits they have produced.
- Assess modes of transmission and project future epidemic trajectories until 2030 under three transition scenarios: a) continue with current investment mix and current budget ceiling; b) continue with optimized investment mix and current budget ceiling; c) continue by scaling up to universal coverage of HIV prevention and treatment services under a rights-based approach.
- Estimate the costs for each scenario in the mid-term (2020) perspective, and the impact on the "getting to zero" goals in the long-term (2030) perspective.
- Explore alternative financing options and ways to reduce inefficiencies.

3 What is the current state of the epidemic?

Prevalence is stable, but is expected to increase

- Overall prevalence in 2011 (the most recent year data are available) was 0.15%. According to model-based estimates, it is expected to increase to 0.19% by 2020 (**Figure 1**).
- This is due to an increase in the number of people living with HIV (PLHIV) from a current (2014) model-based estimate of 4200 to 5200 by 2020 (**Figure 2**).
- The majority of these new PLHIV will be among the low-risk population. In contrast, the model estimates a significant decrease in the number of HIV-positive people who inject drugs (PWID), from 1050 in the year 2000, to 510 currently (2014), to 390 by 2020, corresponding to a drop in PWID prevalence from 15% in 2000 to 4% in 2020.
- According to model-based estimates, prevalence is high and increasing in the other high-risk groups of female sex workers (FSW), clients of sex workers (CSW), and men who have sex with men (MSM). While these population groups do not have as many PLHIV as the low-risk population due to their small overall sizes, they nonetheless contribute significantly to the epidemic. By 2023, if current trends continue, MSM will overtake PWID as the group with highest prevalence.

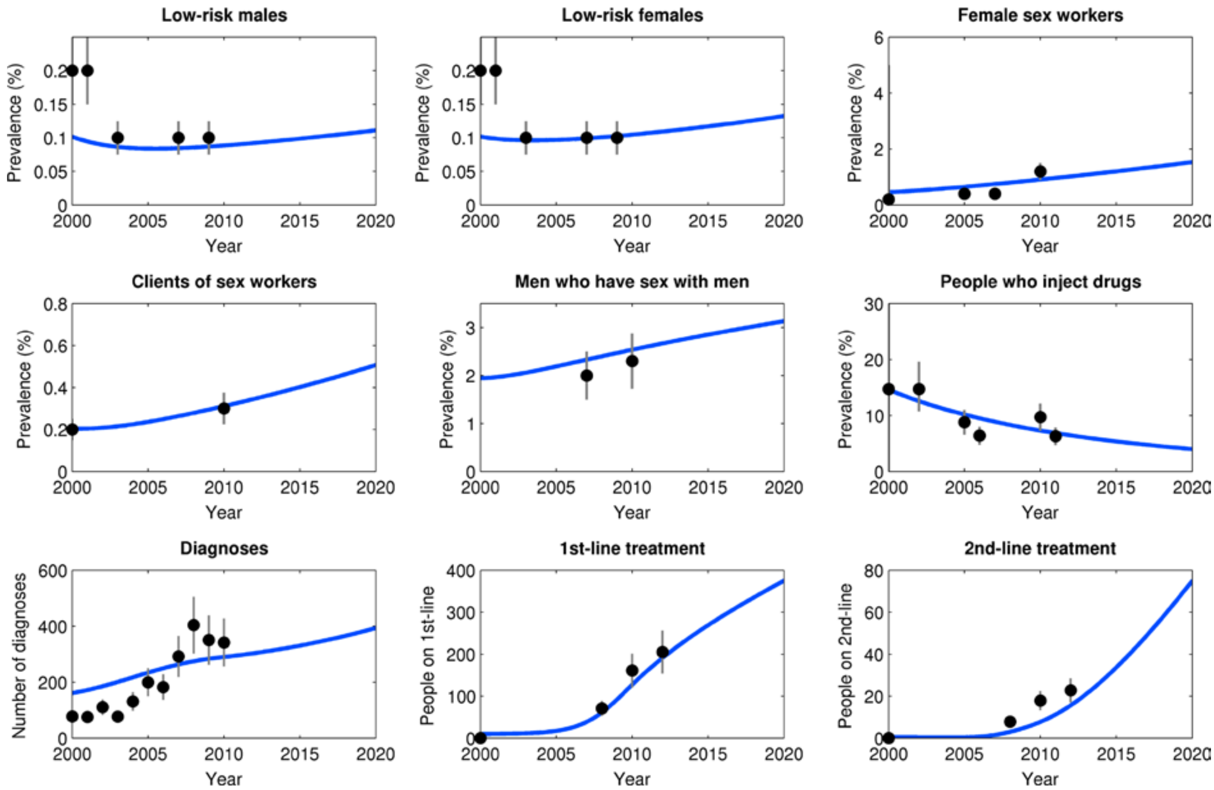


Figure 1: Prevalence, diagnoses, and number of people on treatment in Armenia, showing data (black dots) and the model fit (solid line). Overall prevalence is increasing in all populations except people who inject drugs.

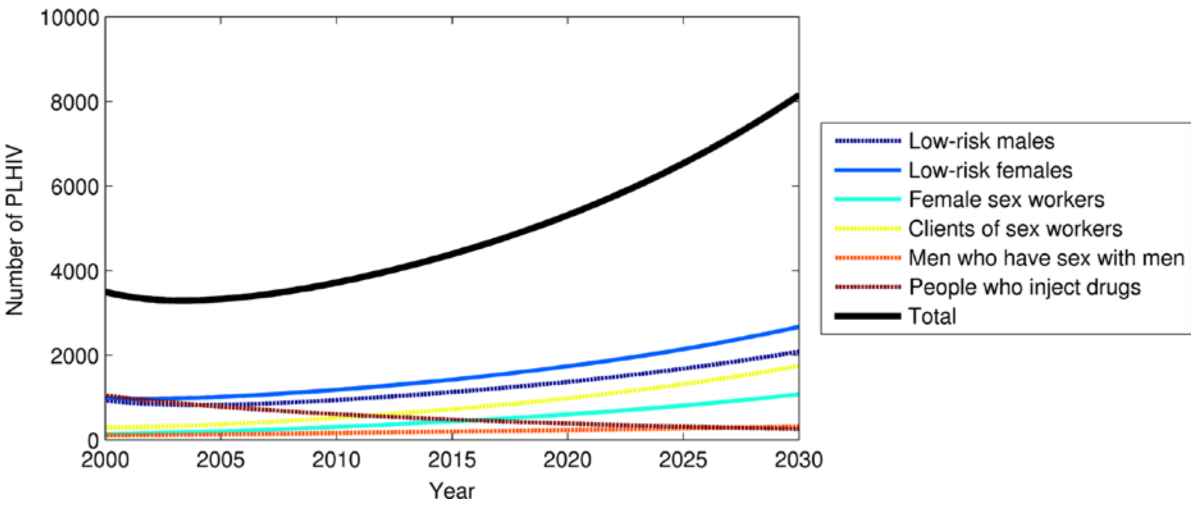


Figure 2: Modeled number of people living with HIV (PLHIV) across population groups.

Incidence is increasing

- Underlying these increases in prevalence is an expected increase in incidence (i.e., the number of new infections per year). According to model-based estimates, since 2000, the decrease in incidence among PWID counteracted the increases among all other population groups, but overall incidence still increased (**Figure 3**). The model predicts that incidence will increase, from 530 new infections per year currently (2014) to 670 cases per year in 2020, and 840 cases per year in 2025.
- Most of this increase is driven by the low-risk population and clients of sex workers; although prevalence is highest among men who have sex with men, due to their small population size they are predicted to currently constitute less than 5% of new infections (**Figure 4**).

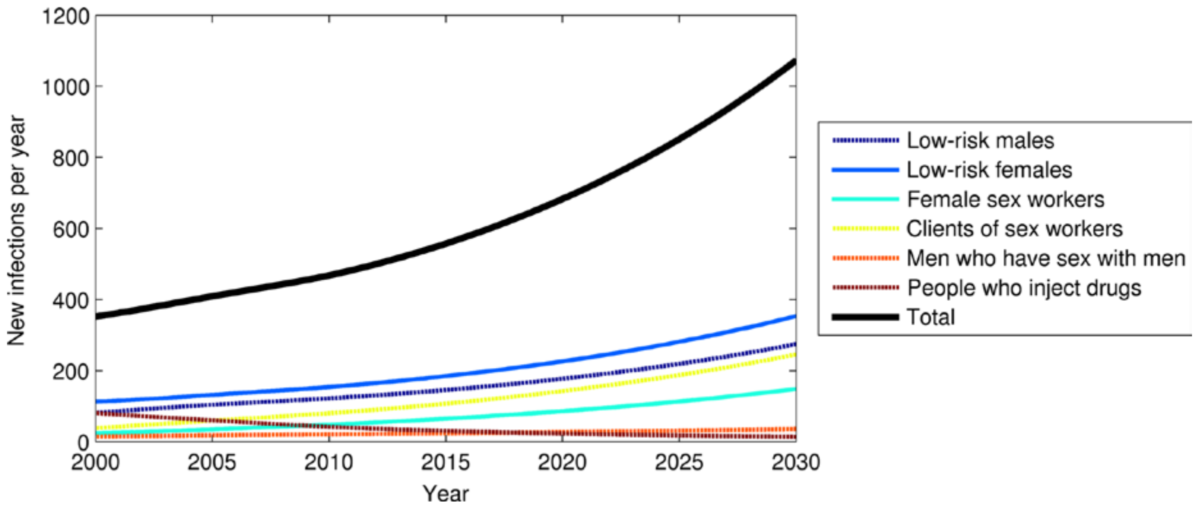


Figure 3: Modeled new infections per year across population groups.

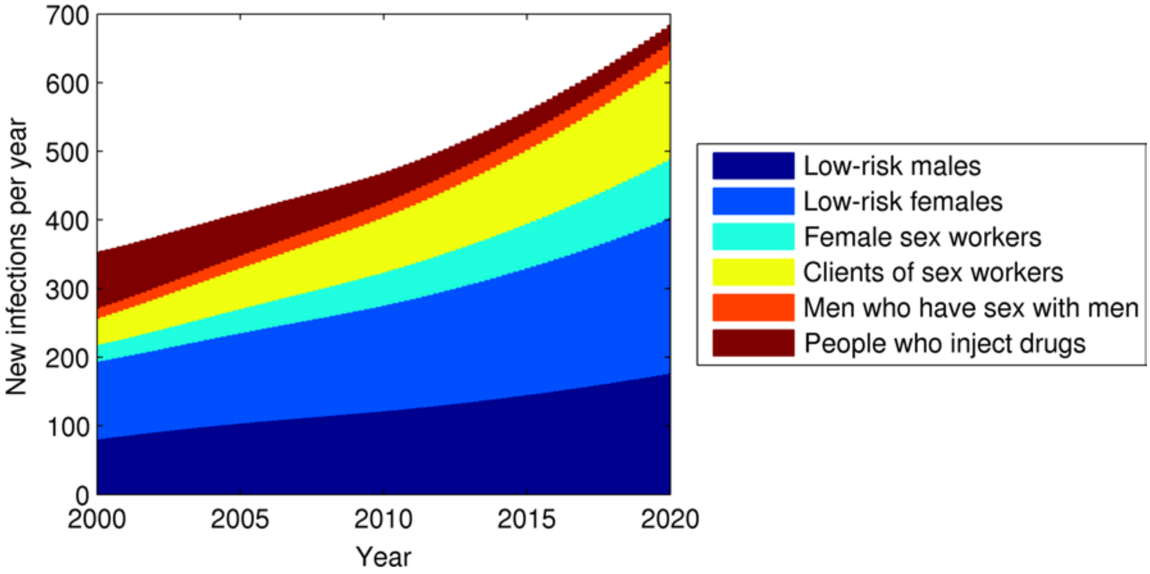


Figure 4: Modeled new infections by year and population group.

Deaths are currently low, but are starting to increase

- According to model-based estimates, HIV-related deaths have decreased substantially over the last 10 years, from 440 per year in 2000 to a low of 300 in 2010. However, they are predicted to slowly increase again, reaching 400 by 2020.
- Similar to the predicted trend in incidence, this increase is driven predominantly by the low-risk population, and until 2010 was counteracted by a decrease in HIV-related deaths among people who inject drugs, from a high of 130 per year in 2000 to approximately 30 by 2020.

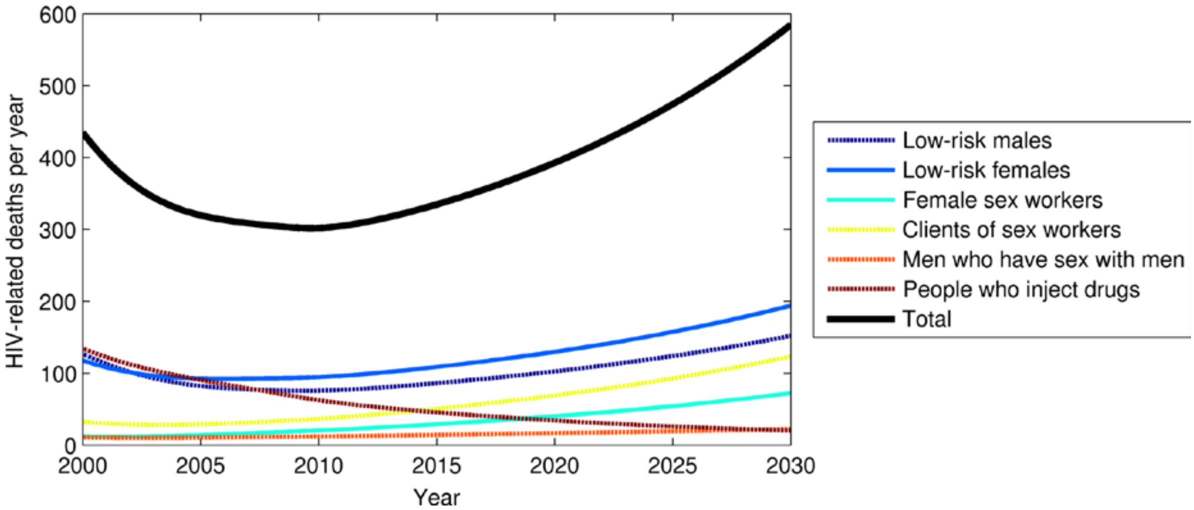


Figure 5: Modeled HIV-related deaths by population group.

The proportion of undiagnosed PLHIV is increasing

- Due to relatively high continuing incidence and relatively low testing rates, the model predicts that the fraction of PLHIV who are undiagnosed is high, at approximately 60% (**Figure 6**).

- The number of people who are on treatment is extremely low – fewer than 200 people in 2010, out of a total number of PLHIV of 3800. According to model-based estimates, this number is expected to increase, but to remain below 10% even by 2020.

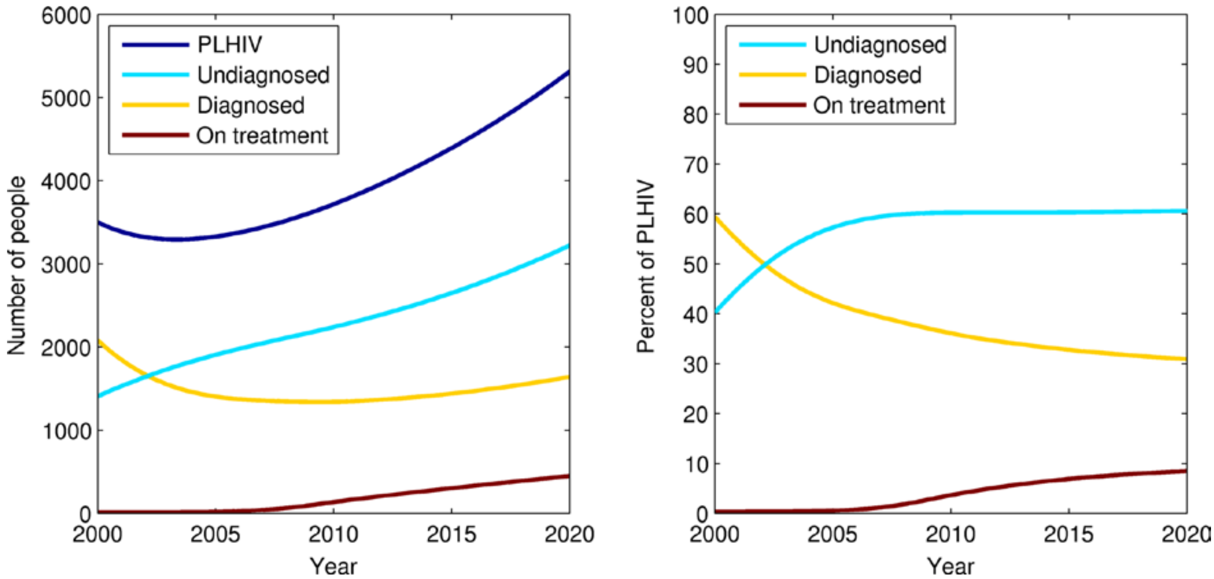


Figure 6: Number of PLHIV (left) and percent of PLHIV (right) who are undiagnosed, diagnosed but not on treatment, and on treatment. Each category is exclusive, i.e. the number diagnosed does not include the number on treatment.

4 What is the impact of past and current spending?

Spending is mostly from international sources

- Most HIV funding in Armenia comes from international sources (**Figure 7**). However, the ratio (and total amount) has varied substantially over time.
- Total spending was roughly US$2 million from 2007-2009 and US$5 million for 2010 and 2011. Domestic spending has accounted for 17%-39% of the total depending on year.
- The major contributor of international funds has been the GFATM. Given GFATM's reduced capacity to provide funding in future, it is essential that Armenia move towards a greater proportion of domestic spending if the HIV epidemic is to stay under control.

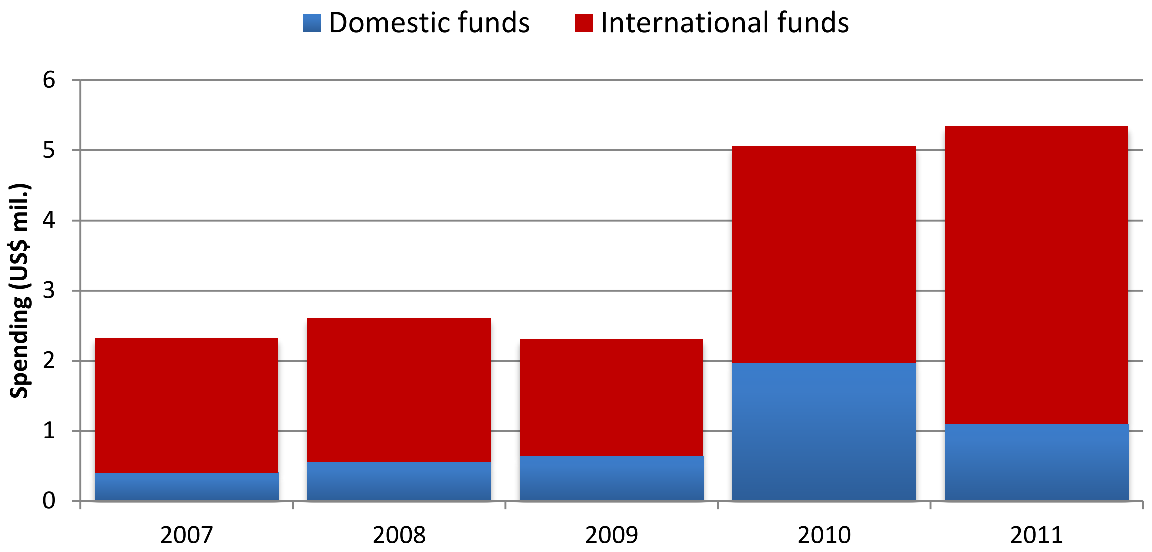


Figure 7: Funding for HIV in Armenia by funding source. Historically, the majority of funding has come from international sources.

Most funding is for prevention

- Funding for HIV in Armenia over the period 2007 – 2011 is divided between prevention, treatment, and indirect costs; of these, prevention is by far the largest expenditure (**Figure 8**).
- Within prevention, the largest single component is for the low-risk population (19%). However, if taken together, funding for high-risk populations is 25% (**Figure 9**).
- Funding between different programs has varied substantially, even in consecutive years. For example, funding for prevention of mother-to-child transmission (PMTCT) was US$82,000 in 2010, but US$571,000 in 2011 (**Figure 10**). However, some of this variability may be due to inconsistent reporting of funding data, since behavioral outcomes tend to be more consistent (e.g. PMTCT coverage was reported to be 55% in 2009 and 75% in 2010).

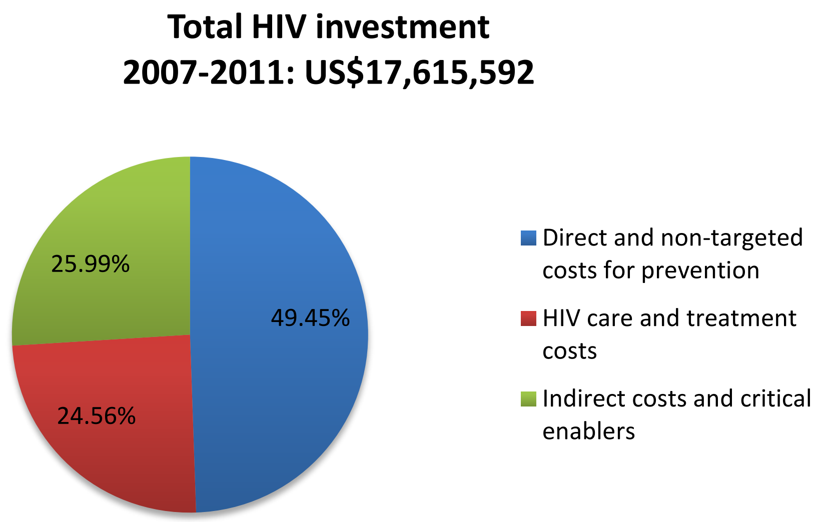


Figure 8: HIV funding by type. Roughly half of all HIV spending is towards prevention, with one quarter going towards treatment and administrative overhead.

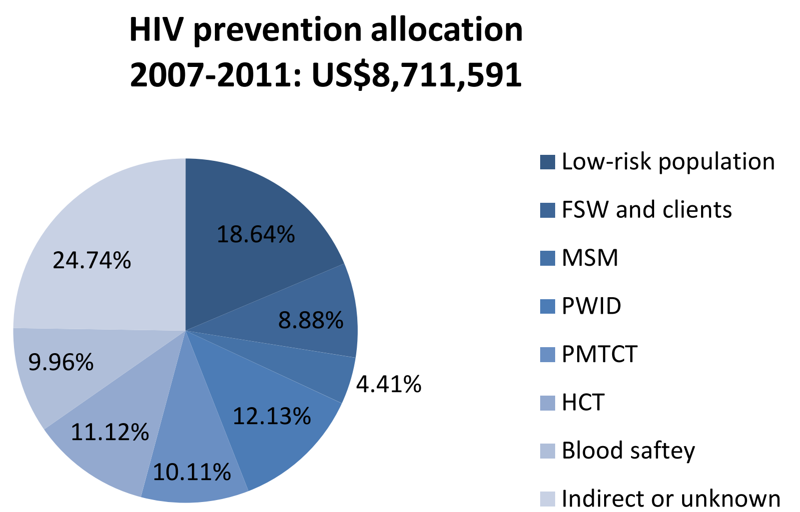
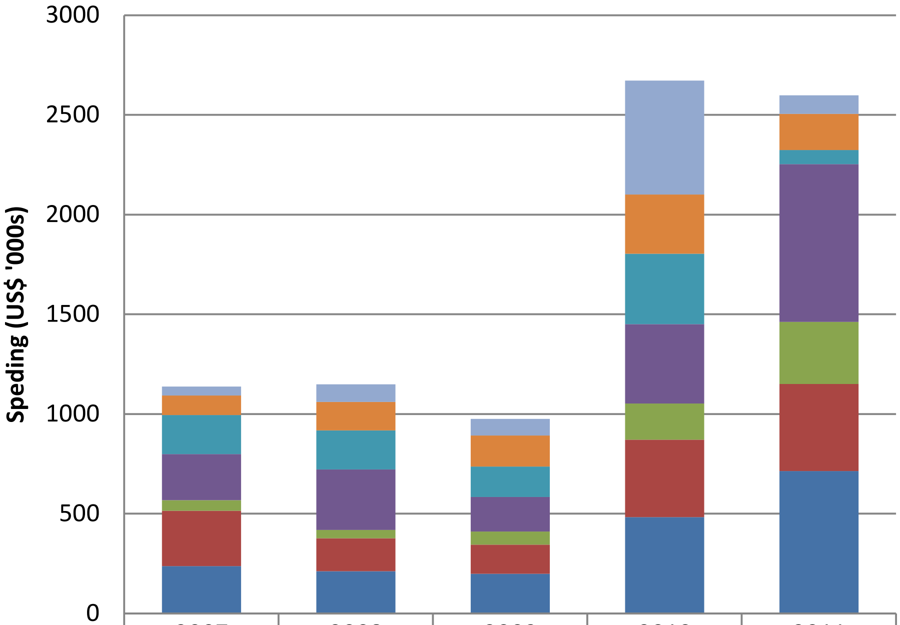


Figure 9: HIV prevention funding. Past spending has been divided relatively equally between programs, with a slight emphasis towards the low-risk population.



	2007	2008	2009	2010	2011
PMTCT	45	89	82	571	94
ART	98	142	156	296	181
HTC	197	197	153	353	69
PWID	230	303	174	399	793
MSM	54	42	65	181	311
FSW	278	164	146	388	436
LRP	237	212	198	483	714

Figure 10: Trends in spending across prevention and treatment programs. Values are shown in thousands of US$. PMTCT = prevention of mother-to-child transmission; ART = antiretroviral therapy; HTC = HIV testing and counseling; PWID = people who inject drugs; MSM = men who have sex with men; FSW = female sex workers and their clients; LRP = low-risk population.

Investments have averted infections

- Modeling of the HIV epidemic in Armenia confirms that if the prevention and treatment programs had not been implemented, then HIV prevalence, incidence, and deaths would have been far greater (**Figure 11**). In fact, by 2020, prevalence would be nearly twice as high as it otherwise would (0.4% vs. 0.7%).
- According to model-based estimates, the US$17.6 million spent 2007-2011 will have averted 11,000 infections, 2700 deaths, and 100,000 disability-adjusted life years (DALYs) by 2020, for a cost-effectiveness of US$170/DALY, which is extremely cost-effective.

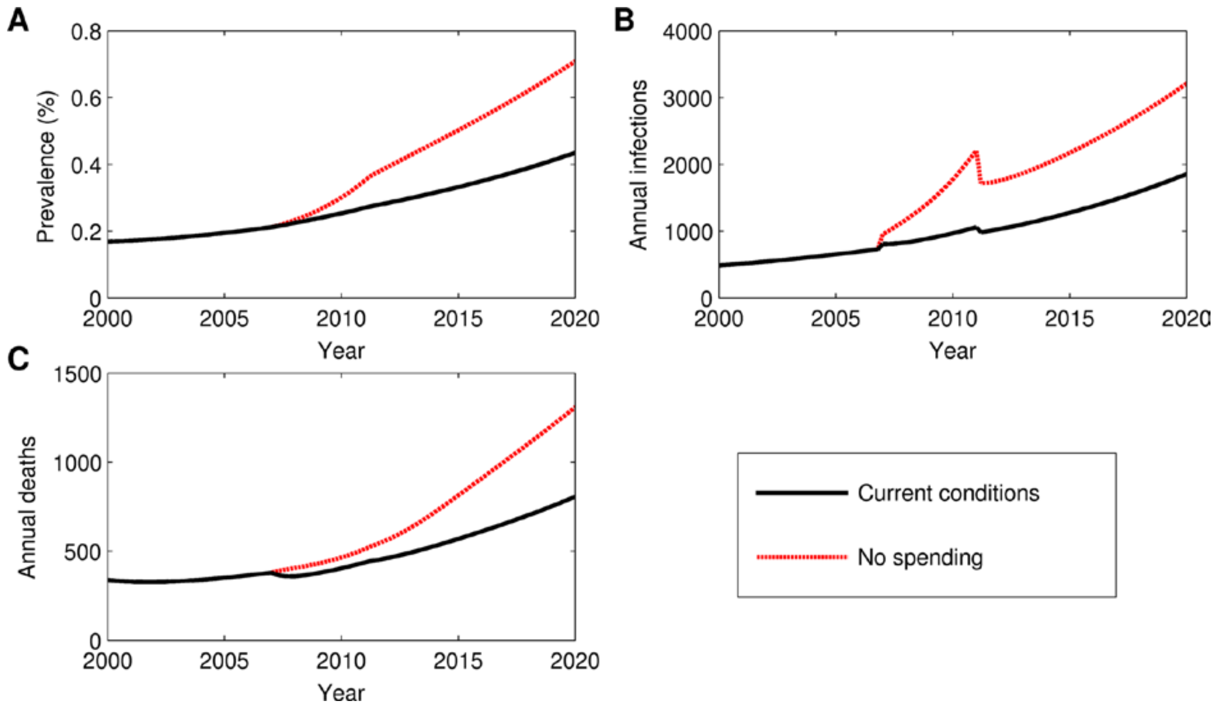


Figure 11: Impact of spending, 2007-2011. Note that even after the spending in the two cases returns to the same level (2011), the curves continue to diverge.

5 What would optimal spending look like?

Current spending in Armenia is near-optimal

- Current (2010) HIV spending in Armenia is distributed across a wide range of prevention and treatment programs. According to model-based analyses, the status quo distribution of funding (using 2010 as a baseline, due to potential irregularities in the 2011 data, as noted earlier) is fairly similar to an optimal allocation that minimizes both incidence and DALYs (**Figure 12**).
- The one difference is that the optimal allocation diverts funding currently devoted to ART to PMTCT. PMTCT coverage in Armenia is still quite low by global and regional standards (75%, compared to up to 95% in comparable countries). Thus, attaining universal PMTCT coverage is a priority, since it has all the benefits of ART for the mother, with additional benefits for the child.

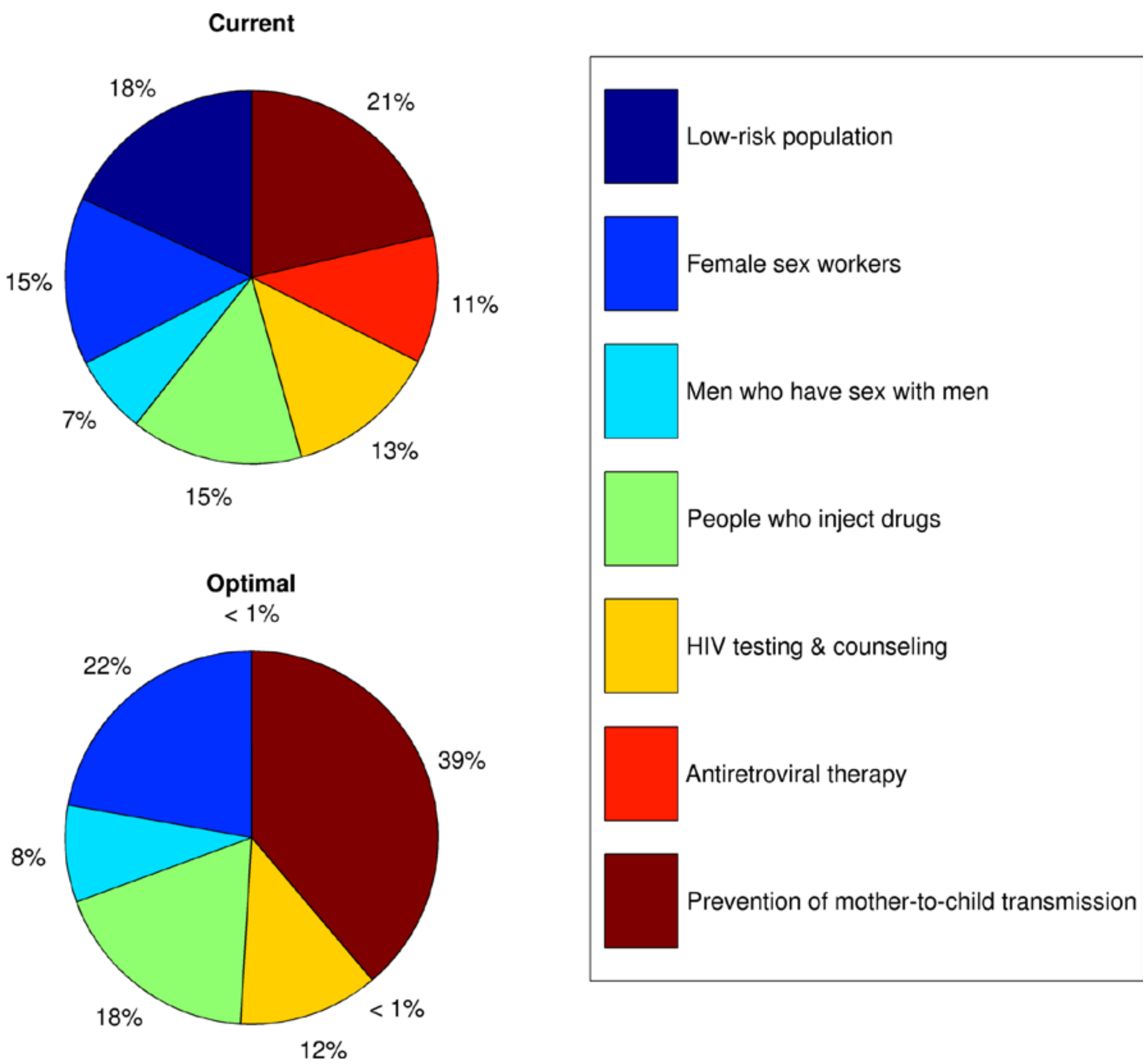
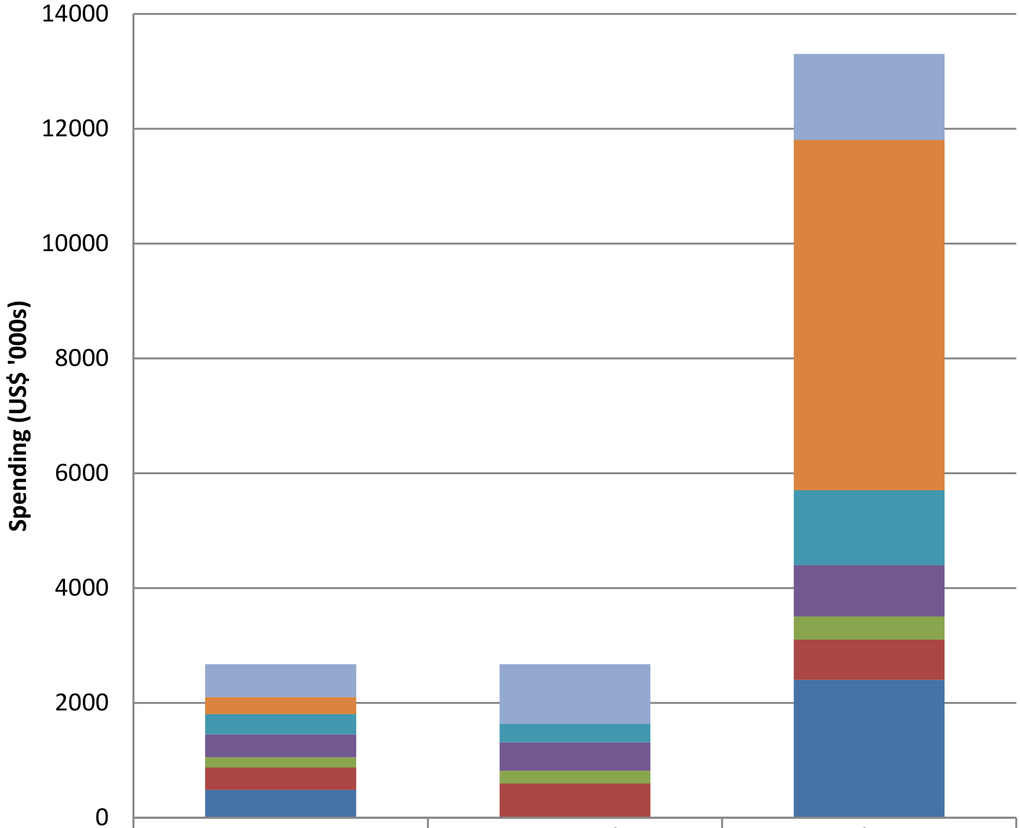


Figure 12: Current (top) and optimal (bottom) allocations of funding in Armenia. Distributions are similar, except the optimal allocation does not allocate funds for the low-risk population or ART.

- A second difference is that spending on the low-risk population is diverted to high-risk groups, despite the fact that the low-risk population accounts for a majority of new infections. This is because funding targeted to the low-risk population has low effectiveness, due to its large size and the relatively low risk of any given individual for contracting HIV. Thus, it is more efficient to target high-risk groups, who go on to infect people in the low-risk population. Overall prevalence among the low-risk population in Armenia is still very low (0.1%), and is thus categorized as a concentrated epidemic. Since the epidemic in the low-risk population is too small to be self-sustaining, the most effective strategy is to target infections among high-risk groups.

- Extrapolating from current estimated coverage levels, universal coverage could be achieved with a total annual spend of approximately US$23 million. By far the largest increase would be in ART, from US$300,000 currently to US$6.1 million. Large increases in spending on PMTCT, the low-risk population, and HIV testing and counseling are also required to achieve universal coverage.



	Current	Optimal	Universal coverage
PMTCT	571	1037	1500
ART	296	0	6100
HTC	353	324	1300
PWID	399	493	900
MSM	181	224	400
FSW	388	593	700
LRP	483	0	2400

Figure 13: Comparison of HIV spending under current conditions, optimal conditions, and universal coverage. Only prevention and treatment spending is shown, excluding indirect costs and the costs of other programs, which contribute an additional 85%. Values are shown in thousands of US$.

Universal coverage is highly cost-effective

- Compared to a continuation of current spending, the optimal allocation averts 1100 infections, 210 deaths, and 7800 DALYs by 2030 (**Figure 14**). In comparison, universal coverage averts 8800 infections, 4800 deaths, and 170,000 DALYs. At an additional cost of US$18 million per year, this represents a cost-effectiveness of US$1500/DALY. The main difference between optimal and universal coverage scenarios is the number of people on ART (**Figure 15**).

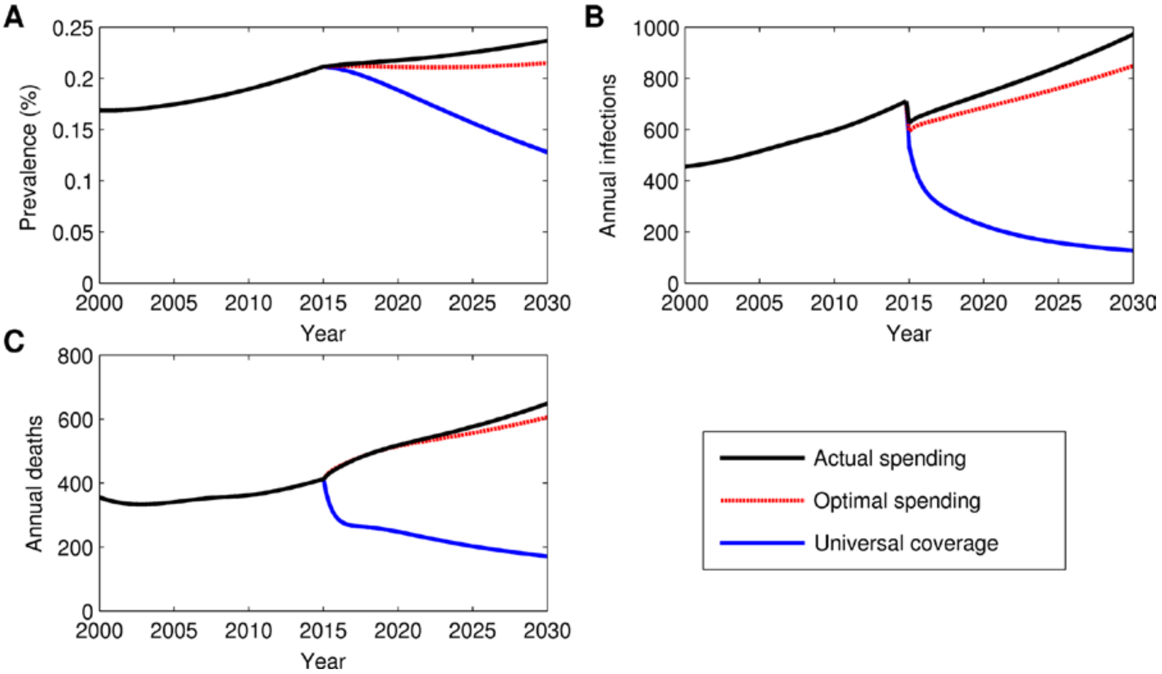


Figure 14: Spending scenarios, showing (a) prevalence, (b) incidence, and (c) deaths.

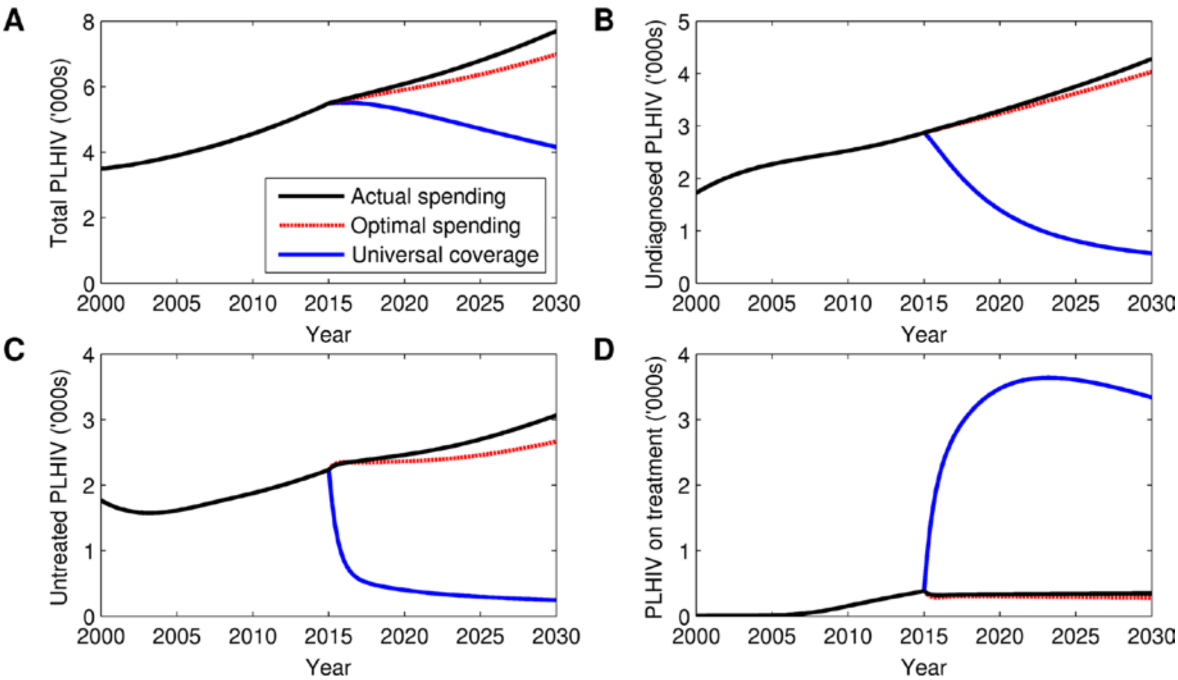


Figure 15: Spending scenarios, showing (a) number of PLHIV, (b) undiagnosed PLHIV, (c) diagnosed but untreated PLHIV, and (d) treated PLHIV.

6 What financing options are available?

Value-for-money through increased efficiency

- With the need to do more, or at least attain the same coverage and quality of services, with less money, it is important to consider how unit costs can be reduced. If unit costs are reduced, more can be done with the same resources.
- Following examination of current budget allocations, the following areas may contain some inefficiencies. For example:
  - Management and administration costs seem to be high; for example, 68% of costs for maintaining outreach workers is allocated to management and administration.
  - Office equipment can be reduced to match the number of premises rented. In addition, items like mobile phones, computers, and software do not need to be replaced every year.
  - There appear to a large number of training sessions; it may be possible to reduce their number without significantly harming overall competence.
- Indirect costs accounted for 26% of overall funding in 2007 – 2011. While not exceptionally high, it is nonetheless higher than other comparable countries, which have managed to keep costs below 20% (for example, indirect costs in Uzbekistan over 2011 – 2012 were 18%). Thus, it is valuable to consider whether the same services could be provided with less overhead costs. It is also valuable to consider the most efficient models of service delivery and removing exogenous barriers which limit the effectiveness and efficiency of service delivery.

Increasing government spending

- An increase in the contribution of the government is important in taking leadership and to fund the response required to address HIV targets in Armenia.
- It is recommended that Armenia: (a) maintains existing programs; (b) aims to control incidence by reducing new infections by 50% among most-at-risk populations by 2020, and (c) attains universal treatment coverage among people in need, including PLHIV who have not yet been diagnosed with their infection and are likely to present with late-stage HIV/AIDS.
- The resources required to achieve this are estimated to be an additional US$11 million per year. All HIV/AIDS resources would need to be allocated optimally among key intervention programs.

Innovative financing

Several countries are now experimenting with innovative financing to fund the gaps in HIV responses. Innovative approaches could also be considered in Armenia, including the following:

- **A national, regional or global tax or levy:** The levy would be a very small tax but on a large number of sales. This could include the following.
  - **Levy on airline ticket sales:** Enacting a small fee on all outbound flights from Yerevan. The amount levied could depend on class of ticket (e.g. France has a €1 tax on a domestic

economy ticket and a €10 tax on a domestic first-class ticket), whether the flight is domestic or international (e.g. Niger has a US$1.20 tax on a domestic economy ticket and a US$4.70 tax on an international economy ticket), or length of flight. Several other countries including Botswana, Burkina Faso, Cameroon, Gabon, and Malawi are investigating an airline levy specifically for HIV financing.

  - **Tax on the sale of tobacco products:** In the Philippines, 2.5% of the tax on alcohol and tobacco products is used to fund universal health care coverage and disease prevention. In Thailand, a 2% surcharge on alcohol and tobacco is pooled in the Thai Health Promotion Fund. In Indonesia, 2% of total government revenue from tobacco products can be used for health and social welfare programs.

  - **Telecommunications levy:** Several countries, including Rwanda and Uganda, impose a levy on the use of mobile phones to fund health programs. Gabon applies a 10% tax on mobile phones for health care of low-income groups.

  - **Tax on financial transactions:** A Currency Transactions Tax on foreign exchange transactions or a Financial Transactions Tax on the sale of shares/bonds/derivatives could raise significant new revenue.

  - **General taxation:** Zimbabwe's AIDS levy has generated more than US$26 million in 2011. Chile uses 1% of its VAT to fund health (total rate 19%); Ghana introduced an additional 2.5% tax to fund its National Health Insurance Scheme (total rate 15%). Similar steps are being considered in Kenya and Zambia.

- **Lotteries:** Sales from existing or new lotteries could be directed to fund health programs:

  - **National:** A lottery conducted by the government or a company, with a percentage of sales distributed to health and social programs including HIV responses.

  - **Regional:** A lottery conducted in several countries and coordinated regionally (e.g. by a Central Asian or CIS Lottery Board) or run by a single organization, with the pooled revenues distributed to health programs in different countries. Existing regional European lotteries (e.g., EuroMillions, Eurojackpot) could be considered as a model.

- **Impact investment funds:** Using private sector investors who desire to make a social impact and potentially a small financial profit. This could be conducted through debt financing (i.e., the government borrows from the investment fund and repays a fixed rate of return); or social impact bonds, where the government pays a return based on results (such as numbers of people initiating ART).

- **Voluntary consumer donations:** Systems can be established to provide consumers of specific goods or services the option to make a voluntary donation as an additional amount for HIV or another health cause. This can work effectively as a recurring donation on a subscription service (e.g. utilities service).

The need to shift domestic resources towards HIV

- Innovative financing may be a possible solution to generate greater revenue. However, if there are large, viable sources of increased revenue then it is likely that these would already be explored; alternatively, if they have already been implemented then any additional revenue is likely not to go to HIV because HIV is generally not considered an overall national priority.

- There is strong rationale for why it would be appropriate to shift domestic funding towards HIV.

- Globally, between 1.5% and 20% of overall expenditure is on health (Figure 14). Approximately 4.3% of GDP in Armenia is on health (World Health Organization, 2011 data). Proportional spending on health is observed to increase as GDP increases. There is also strong global and regional relationship between a country's GDP per capita and the proportion of the country's HIV response which is funded from domestic sources (**Figure 16**). This relationship also holds over time for a single country. Extrapolating and benchmarking with other countries indicates that Armenia is funding a reasonable proportion of its HIV/AIDS response. However, in coming years there will be the need to fill in some of the resource gap.
- The total annual HIV expenditure in Armenia is approximately US$5 million. This equates to approximately US$1.30 per capita. Even if Armenia were to fully fund its own HIV program at current levels, this would account for 9% of health expenditure and 0.3% of GDP. Consequently, the amount of money required is relatively very small.
- Investing in responding to HIV/AIDS has substantial long-term health and economic returns, unlike other non-health investments and also non-infectious disease health investments.

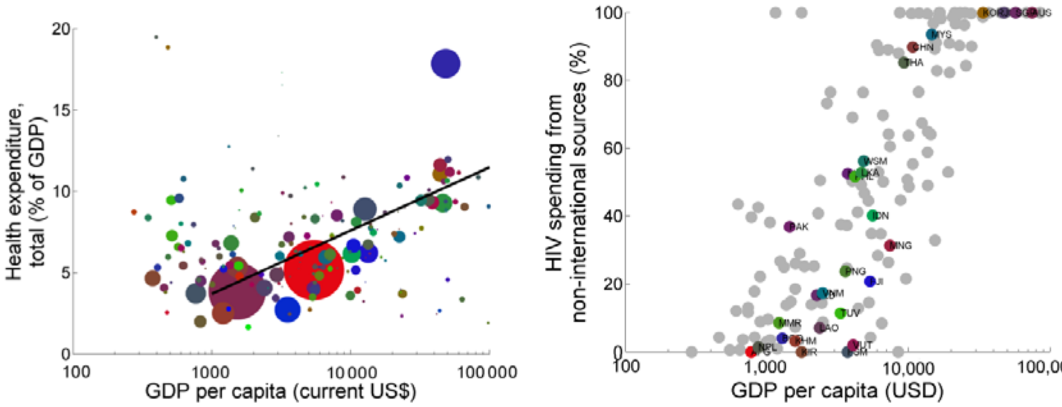


Figure 16: Health expenditure versus GDP per capita for all countries, size-weighted by population, 2011 (right), and percentage of HIV funding from domestic sources versus GDP per capita, 2011 (left).

- Not only is the amount of current investment for HIV/AIDS not sufficient to meet the 50% reduction targets, but the current financing mechanisms of dependency on international sources is not sustainable. The implementation of sustainable and innovative financing mechanisms and an adequate scale-up of financial investments in HIV are necessary to close the current funding gap. Hence, mobilization of domestic resources to close the AIDS resource gap has become a national priority for most low- and middle-income countries. However, this alone is unlikely to allow full and sustainable responses in most countries. "Business as usual" will not be sufficient. Some different approaches are recommended if the overall epidemiological objectives are to be realized.
- In the context of competing demands for limited resources, it is essential that HIV/AIDS investment is done smartly for greatest returns. Resources must be prioritized towards programs which have proven effectiveness, are acceptable, and are feasible to be implemented to scale. There is substantial potential for efficiency gains. Money cannot be wasted and should be spent in ways that have greatest returns. The most cost-effective programs should be prioritized which have greatest impact at least cost. Programs need to be implemented in the most efficient manner. Service provision can be optimized to minimize unit costs, without compromising effective quality and also ensuring continuum of services. This can be done at the service provider level as well as in the central coordination and enabling environment.

- Calculations on the overall greater benefits of increased and earlier investment are valuable for the government to realize that greater HIV/AIDS spending will (i) avert health burdens; (ii) save future resource spending and be cost-saving overall.

Enabling factors must also be supported

- International experience has provided evidence that true partnerships between government, communities, program implementers and other stakeholders constitute the most effective approach to HIV/AIDS responses. Mobilization of affected communities can contribute to effective prevention and treatment. Civil society organizations working with groups at higher risk, key vulnerable populations, and PLHIV in Armenia have been entirely supported by international funding. Therefore, it is essential that domestic funding streams be directed to supporting community-based organizations.
- Leadership, implementation, evaluation and strategy will all need to be conducted by local members. It is essential that capacity is developed in-country to respond most effectively in every component of the HIV response.
- Comprehensive and efficient programs must integrate with relevant systems and structures. It is essential that linkages and referrals occur between relevant programs directly within the HIV program response, within the broader health system, and across the social system. There is also a need for strengthening information systems and minimizing management overheads.
- Political will must move beyond rhetoric to mobilization of resources and to creating an enabling environment in which prevention programs can be implemented effectively. An enabling legal environment is also required to minimize and eliminate structural discrimination against PLHIV and people at risk of acquiring HIV.
- Rights are central to creating an environment in which the “getting to zero” goals can be realized. Numerous political and legal impediments remain in Armenia and in the region. These impediments are to be removed if governments are to be serious about rights and pragmatically addressing HIV/AIDS needs.
- The law plays an important role in creating and maintaining social relationships of equality and inequality, and is also one of the mechanisms through which social determinants are transformed into health and development outcomes. Laws not grounded in human rights and not based on evidence create social inequalities. Therefore, it is important to consider the effect of sex and gender norms, inequalities amongst racial and ethnic groups, the marginalized status of communities, and other social, political, and economic factors when assessing the way the law’s application can disparately impact particular groups.

7 Conclusions

- Armenia's response to its HIV epidemic is underfunded, and currently prevalence and incidence are still increasing. Most of Armenia's HIV funding has historically come from international sources.
- The current allocation of HIV spending across prevention and treatment programs is well-balanced, and only slight improvements in efficiency are possible. Furthermore, this would require shifting funding from ART towards PMTCT, which is not politically feasible, as it would violate the rights of those currently receiving treatment.
- Thus, if possible, additional sources of funding should be obtained to move towards the goal of universal coverage. Universal coverage would be extremely cost-effective in the medium- and long-term.
- It may be possible to cover some of the funding gap via efficiency improvements and/or innovative financing.
- If Armenia is unable to increase its total expenditure on HIV prevention in treatment in the near future, model-based estimates show that it is likely to experience significant increases in HIV prevalence and incidence, including a doubling of the number of people living with HIV by 2030.

8 Methodology

Summary of costs and unit costs

National spending on HIV in Armenia was examined by major funding sources with the use of national statistics, sector reports, and data reported by public health service institutions for the years 2007 – 2011. Standard accountancy estimation methods were used to generate a complete dataset of national spending on HIV. Costs were broken down by financing sources, agents, service providers, HIV spending categories, and beneficiary populations using functional NASA classifications and definitions. Data collection covered spending on AIDS response funded from domestic public and international funding sources. A summary of the NASA information is provided in **Table 1**.

	2007	2008	2009	2010	2011
Prevention programs	**$1,007,525**	**$917,802**	**$736,930**	**$1,804,083**	**$2,323,109**
Low-risk population	$236,814	$211,847	$198,119	$482,731	$714,470
FSW and their clients	$277,790	$164,209	$146,367	$388,090	$435,511
MSM	$66,197	$41,737	$65,242	$181,130	$311,136
PWID: NSP	$224,523	$296,056	$162,958	$396,380	$689,522
PWID: OST	$0	$0	$0	$0	$90,148
PWID: Other	$5,679	$7,266	$10,804	$2,733	$12,927
HTC	$196,522	$196,688	$153,439	$353,018	$69,394
Indirect costs	**$784,525**	**$800,130**	**$717,910**	**$756,690**	**$1,518,222**
Program management/administration	$286,615	$425,430	$305,392	$613,015	$1,181,331
Human resources	$151,412	$296,108	$305,343	$137,908	$109,591
Social protection and social services	$44,700	$0	$0	$0	$59,333
Enabling environment	$195,898	$53,813	$98,735	$5,767	$167,968
Research	$105,900	$24,780	$8,440	$0	$0
Other indirect costs	$0	$0	$0	$0	$0
HIV treatment, care, and support	**$238,538**	**$704,818**	**$689,601**	**$1,347,818**	**$1,345,748**
Care and treatment	$136,012	$562,778	$534,095	$1,051,804	$1,164,738
Antiretroviral therapy	$98,287	$142,040	$155,505	$296,014	$181,011
Other care and treatment costs	$0	$0	$0	$0	$0
Orphans and vulnerable children	$4,239	$0	$0	$0	$0
Essential programs	**$115,168**	**$181,767**	**$156,631**	**$1,143,773**	**$151,836**
PMTCT	$44,664	$89,263	$82,213	$571,170	$93,802
Blood safety	$70,505	$92,504	$74,417	$572,603	$58,034
Total	**$2,145,757**	**$2,604,517**	**$2,301,071**	**$5,052,364**	**$5,338,915**

Table 1: Budget for national HIV spending in Armenia. Amounts shown are in US$ (2011).

Modeling approach

Overview

To assess HIV epidemic trends, resource needs, the cost-effectiveness of past programs, and the impact of potential future programs, we developed a detailed mathematical model of HIV transmission and disease progression, called the Projection and Evaluation Tool (Prevtool).

Prevtool is an extremely flexible population-based HIV model. The basic disease progression implemented in the model is shown in **Figure 17**. This is the only aspect of model structure that is fixed, and specifies it as an being an HIV model instead of a universal epidemic model.

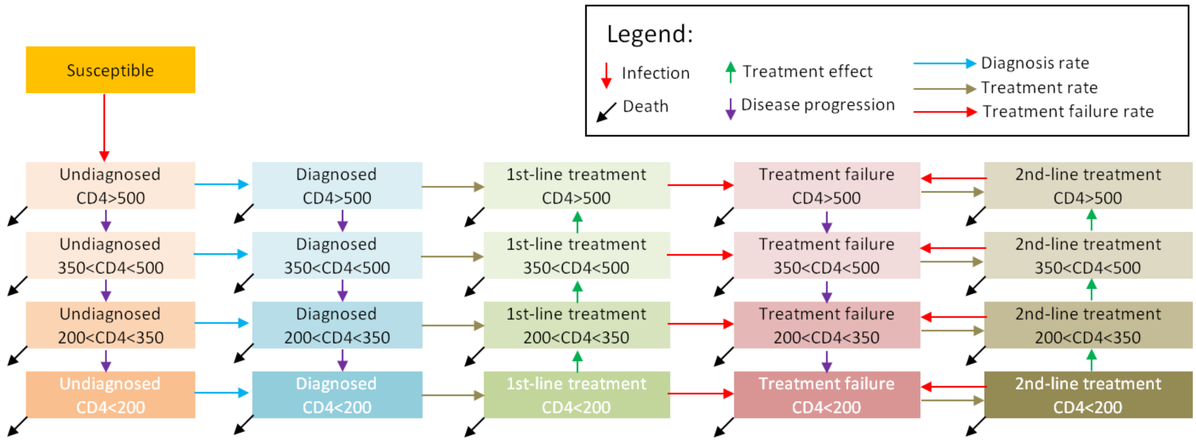


Figure 17: Schematic diagram of model structure. Each compartment represents a single population group with the specified health state, while each arrow represents the movement of individuals between health states. All compartments except for Susceptible represent individuals infected with HIV. Death includes all causes of death.

However, in contrast to most other HIV models, the population groups used in Prevtool are not fixed. Instead, up to 14 user-defined population groups may be used. A typical example for a concentrated HIV epidemic, such as Belarus, is shown in **Figure 18**. Here, seven population groups are used, including low-risk males and females, sex workers and their clients, male and female injecting drug users (IDUs), and men who have sex with men (MSM). However, for generalized epidemics, other choices (such as different age groups) can easily be implemented.

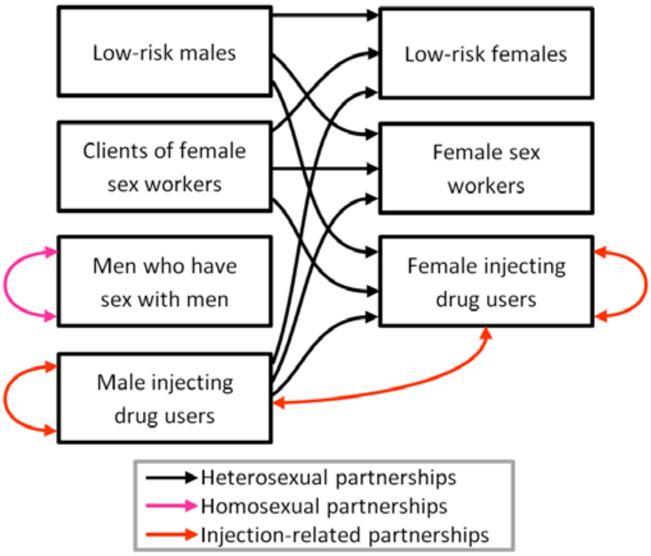


Figure 18: Example population groups and interactions in Prevtool.

Data are entered into Prevtool by means of an Excel spreadsheet, as shown in **Figure 19**. Data entry is flexible, allowing everything from a separate data point for every population for each year, or a single data point for all populations over the entire time period. (Parameters with no data entered are assumed to be zero.)

	A	B/C	D	E	F	G	H	I	J	K	L	M	
1			2000		2001		2002		2003		2004		
2	Population size (thousands)	Low-risk males	2,522.393	2,648.513	2,510.536	2,636.063	2,498.735	2,623.672	2,486.990	2,611.339	2,475.299	2,599.064	2,5
3				2,396.274		2,385.009		2,373.798		2,362.640		2,351.534	
4		Low-risk females	2,629.521	2,760.997	2,617.161	2,748.020	2,604.860	2,735.103	2,592.617	2,722.248	2,580.431	2,709.453	2,6
5				2,498.045		2,486.303		2,474.617		2,462.986		2,451.410	
6		Direct FSW	24.784	26.688	24.668	26.564	24.552	26.439	24.437	26.316	24.323	26.192	
7				22.879		22.772		22.665		22.559		22.454	
8		Indirect FSW											
9													
10		Clients of FSW											
11													
12		MSM	62.383	72.366	62.091	72.027	61.801	71.690	61.512	71.355	61.224	71.021	
13				52.401		52.156		51.912		51.669		51.427	
14		Bisexual MSM											
15													
16		Transgender											
17													
18		Male high-risk IDUs	30.224	31.377	30.082	31.230	29.941	31.083	29.800	30.937	29.660	30.792	
19				29.070		28.934		28.798		28.663		28.528	
20		Female high-risk IDUs	11.695	12.142	11.641	12.085	11.586	12.028	11.532	11.972	11.477	11.915	
21				11.249		11.197		11.144		11.092		11.039	
22		Male low-risk IDUs											
23													
24		Female low-risk IDUs											
25													
26		High-risk males											
27													
28		High-risk females											
29													
30													
31													
32													

Figure 19: Example of data entry spreadsheet for a concentrated epidemic (in this case, Belarus). In addition to best-estimate data, upper and lower bounds are provided (or estimated) for each point.

Mathematical model

The model uses a coupled system of ordinary differential equations to track the movement of people between health states. The overall population is partitioned in two ways: by group and by health state. Individuals are assigned to a given population based on their dominant risk; however, to capture important cross-modal types of transmission (e.g., FSW becoming infected via injecting drug use), relevant behavioral parameters can be set to small but nonzero values (e.g., male drug users occasionally engage in commercial sex; MSM occasionally inject drugs).

The rate at which uninfected individuals in each population group become infected is determined by the force-of-infection for that population. This depends on the number of risk events an individual is exposed to in a given period of time and the infection probability of each event. Sexual transmission risk depends on the number of people in each HIV-infected stage (that is, the prevalence of infection in the population of partners), the average number of casual, regular, and commercial homosexual and heterosexual partnerships per person, the average frequency of sexual acts per partnership, the proportion of these acts in which condoms are used, the efficacy of condoms, the extent of male circumcision, and the prevalences of ulcerative STIs (which increase transmission probability) and HIV. The stage of infection (chronic, AIDS-related illness/late stage, or on treatment) for the HIV-positive partner in a serodiscordant couple also influences transmission risk due to different levels of infectiousness in each infection stage. Intravenous transmission risk depends on the number of injecting partners per person per year, frequency of injecting per year, frequency of sharing injecting equipment and percentage of shared syringes that are cleaned before re-use and the efficacy of cleaning.

Mathematically, the force-of-infection is given by:

$$\lambda = 1 - (1 - \beta)^n$$

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 (thus n gives the average number interaction events with infected people where HIV transmission may occur). The value of the transmission probability β is inversely related to CD4 count, differs for different modes of transmission (intravenous drug injection, heterosexual intercourse, and homosexual intercourse), and may be modified by behavioral interventions (for example, condom use or circumcision). The number of events n not only incorporates the total number of events, but also other factors that moderate the possibility that these events are capable of transmitting infection, such as condom use or circumcision. There is one force-of-infection term for each type of interaction (for example, casual sexual relationships between low-risk males and indirect female sex workers), and the force-of-infection for a given population will be the sum of overall interaction types.

In addition to the force-of-infection rate, in which individuals move from uninfected to infected states, there are seven other means by which individuals may move between health states. First, individuals may die, either due to the background death rate (which affects all populations equally), due to injecting behavior, or due to HIV/AIDS (which depends on CD4 count). Second, in the absence of intervention, individuals progress from higher to lower CD4 counts. Third, individuals can move from undiagnosed to diagnosed states based on their HIV testing rate, which is a function of CD4 count (for example, people with AIDS symptoms have a higher testing rate) and population type (for example, IDUs usually get tested more frequently than low-risk males). Fourth, diagnosed individuals may move onto treatment, at a rate which is dependent on CD4 count. Fifth, individuals may move from treatment to treatment failure, and sixth, from treatment failure onto second-line treatment. Finally, while on successful first- or second-line treatment, individuals may progress from lower to higher CD4 count.

In total, the model can accommodate up to 294 compartments (14 populations each with 21 health states), and the change in the number of people in each compartment is determined by the sum over the relevant rates described above multiplied by the compartments on which they act. For example, the number of individuals in the compartment corresponding to undiagnosed female sex workers with a CD4 count between 200 and 350 cells/□L changes according to the following equation:

$$\frac{dU_{FSW200-350}}{dt} = U_{FSW_{350-500}}\tau_{350-500} - U_{FSW_{200-350}}(\mu_{200-350} + \tau_{200-350} + \eta_{FSW_{350-500}})$$

where $U_{FSW_{350-500}}$ is the current population size of people with undiagnosed HIV and with a CD4 count between 350 and 500 cells/μL, $U_{FSW_{200-350}}$ is the population size of the compartment with lower CD4 count (200-350 cells/μL), τ is the disease progression rate for the given CD4 count, μ is the death rate, and η is the HIV testing rate. (Note: this example does not consider movement between populations, such as female sex workers returning to the low-risk female population and vice versa.) Each compartment (**Figure 17**, boxes) corresponds to a single differential equation in the model, and each rate (**Figure 17**, arrows) corresponds to a single term in that equation.

Table 2: Input parameters of the model.

	Biological parameters	**Behavioral parameters**	**Epidemiological parameters**
Population parameters	Background death rate		Population sizes (TP)
HIV-related parameters	Sexual HIV transmissibilities* (H) STI-related transmissibility increase* Condom efficacy* Circumcision efficacy* HIV health state progression rates (H) HIV-related death rates (H)	Number of sexual partners* (TPS) Number of acts per partner* (S) Condom usage probability* (TP) Circumcision probability* (T)	HIV prevalence (TP) STI prevalence (TP)
MTCT parameters	Mother-to-child transmission probability	Birth rate PMTCT access rate (T)	
Injection-related parameters	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* ART failure rates	HIV testing rates (TPH)	Number of people on ART (T)

Key: T = parameter value changes over time; P = parameter value depends on population group; H = parameter depends on health state; S = parameter depends on sexual partnership type; * = parameter is used to calculate the force-of-infection.

Most of the parameters in the model are related to calculating the force-of-infection; a list of model parameters is provided in **Table 2**. Empirical estimates for model parameter values can be interpreted in Bayesian terms as prior distributions. The model must then be calibrated, which is the process of finding posterior distributions of the model parameter values such that the model generates accurate prevalence estimates. Given the challenges inherent in quantifying all known constraints on the epidemic, initial calibration is performed manually, with oversight by and collaboration with in-country stakeholders where possible. This prior distribution is then used in a Monte Carlo Markov chain (MCMC) algorithm, which uses both epidemiological and behavioral data to calculate the log-likelihood for a given set of model parameters. The distribution of parameter values produced by the MCMC are the posterior, which are then used for all epidemiological and economic analyses.

Counterfactual analysis

Relationships between spending and risk behaviors

In our analysis, we will use a logistic/sigmoid function to describe the relationships between a behavioral parameter affected by a HIV prevention program and the level of spending on that program. Using this function with assumed uncertainties bounds, we will obtain logistic curve fits to available datasets for overall program spending and associated behaviours. Indirect costs have no direct impact on HIV transmission parameters; but changes to HIV programs may affect these costs to supply additional condoms, clean syringes, and methadone, for example. Using these relationships, any change in HIV program funding directly affects risk behaviors and changes to the HIV epidemic; an example of this is demonstrated in **Figure 20**. The fitted logistic relationships will represent the change in behaviors with spending.

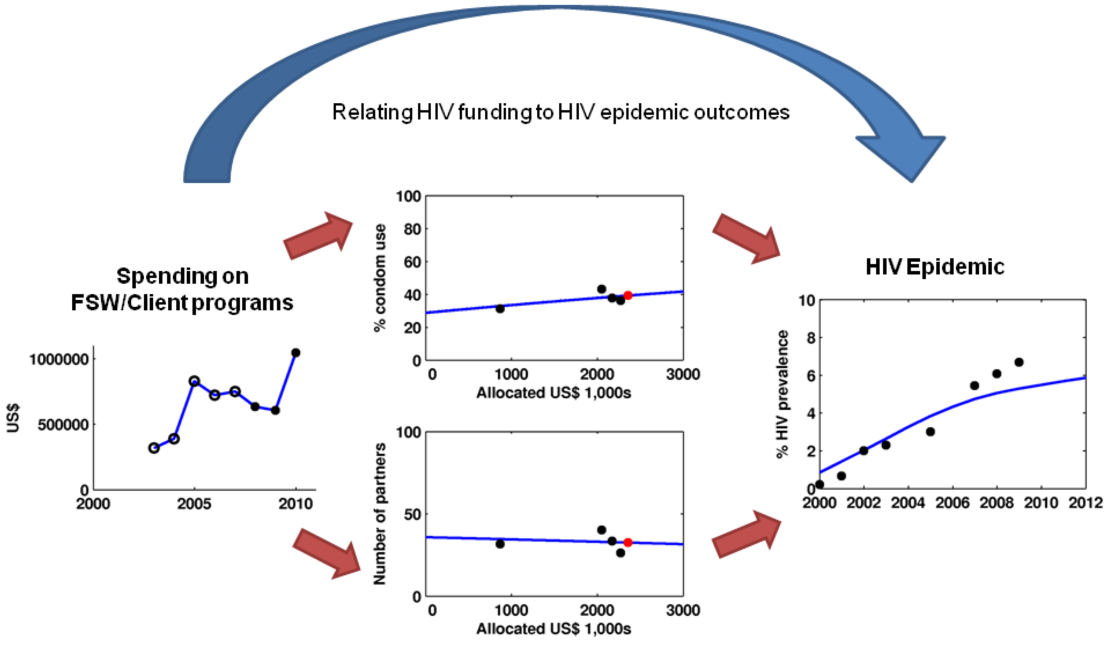


Figure 20: Example of the relationship between spending on FSW/client programs and the HIV epidemic (numerical values are for illustrative purposes only).

Counterfactual scenarios

Prevtool calculates the cost-effectiveness of past HIV programs by comparing the expected number of new infections and HIV/AIDS related deaths according to current and past conditions with the estimated numbers under counterfactual scenarios in the absence of funding for specific programs.

We simulate counterfactual scenarios using Prevtool based on the assumed effect of the removal or enhancement of specific programs. The calibrated simulations with the programs in place represent the baseline scenario. For each prioritized population, we will develop counterfactual scenarios for the behavioral parameters affected by prevention programs prioritizing that population—with the parameters for the other populations remaining at their values obtained through the calibration process. Specific counterfactual scenarios used depend on the implementation and characteristics of HIV prevention programs in each country and the data available. We will fit a logistic function to behavioral parameters affected by prevention programs; **Figure 21** shows the logistic functions for Armenia.

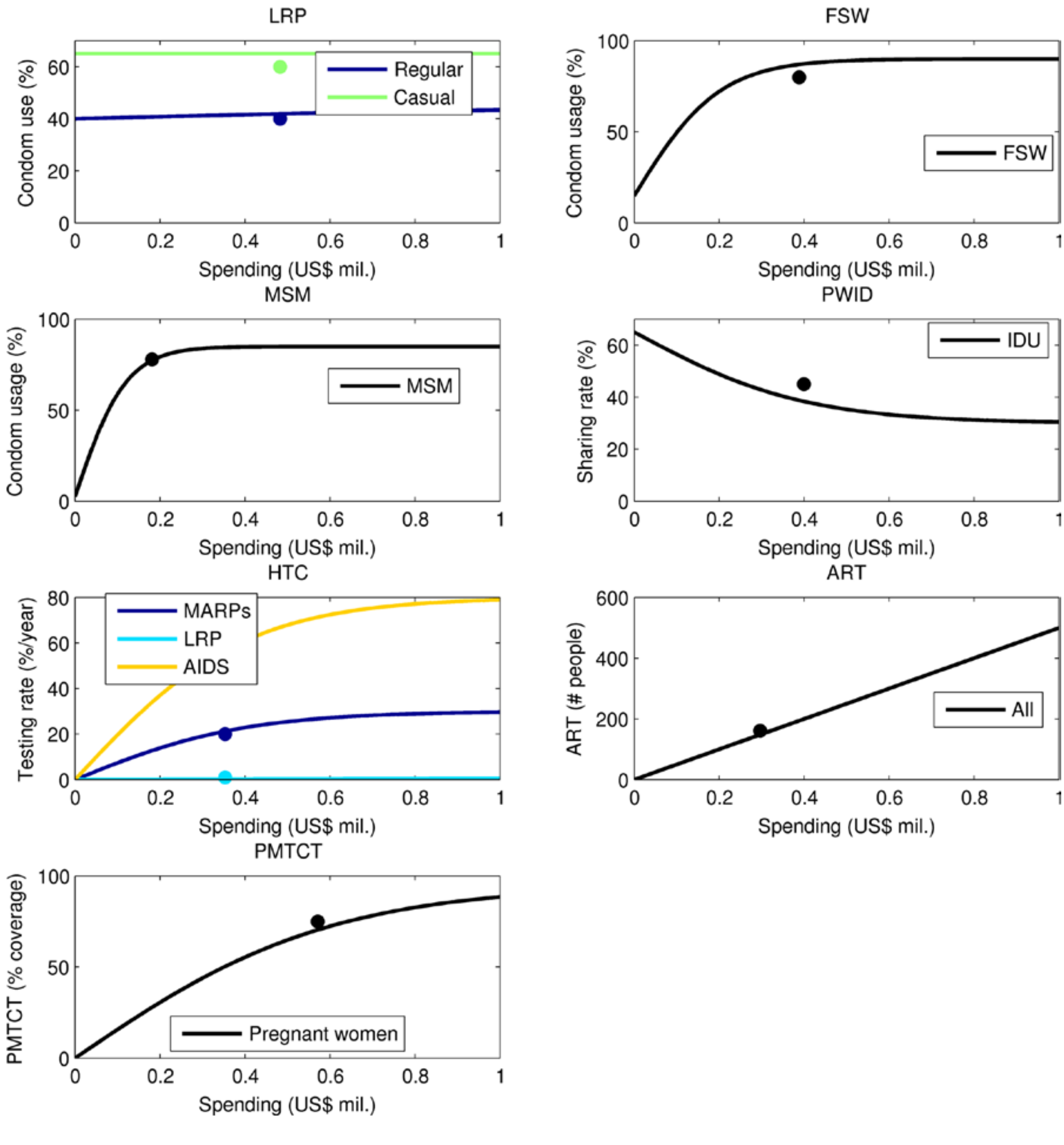


Figure 21: Logistic curves for Armenia. Black dots represent empirical data. Green curves represent the assumed relationship between program funding and behavior. To calculate a counterfactual scenario, a funding level is provided, and then the corresponding behavioral parameter is calculated from these curves.

Cost-effectiveness calculations for past evaluations

For each counterfactual scenario, we will measure the health benefits of a specific HIV intervention program in terms of HIV infections averted as well as life years and QALYs gained or DALYs saved compared to the baseline scenario. We will calculate incremental cost-effectiveness ratios (ICERs) to estimate the cost-effectiveness of each program. These are calculated based on the counterfactual scenarios and comparing the spending of each program (discounted annually), as well as estimated annual healthcare costs incurred/saved (using unit health costs and utilities for each country obtained from our data synthesis), with the estimated effectiveness of the programs. Determining whether a past HIV program is cost-effective is dependent on country-specific thresholds. Appropriate thresholds for each country will be determined after consultation with in-country stakeholders.

Future impact of HIV programs and optimal allocation of resources

To investigate the potential impact of future HIV prevention programs we will run model projections for each scenario. Specific program options will be investigated for each country but will be based on core prevention methods (harm reduction), along with programs based on using antiretroviral treatment as prevention in combination with other programs. We will then compare projections where parameters and funding remained at current values and calculate the annual incidence, the number of infections averted, and the total cost required for each scenario.

Prevtool will be used to determine the optimal allocation of funding using an adaptive stochastic linear gradient-descent optimization method. This will calculate the allocation of funding to programs with the minimum total infections, minimum prevalence, minimum HIV/AIDS deaths, or maximum QALYs/DALYs gained. It is also possible to invert this analysis and calculate the minimum spend required to achieve a particular target in terms of one of those quantities.

Data inputs and assumptions

This section lists the parameters that the model parameters were fitted to. Behavioral and epidemiological parameters for Armenia are listed in **Table 3**, while biological constants that are used across settings are listed in **Table 4**.

Table 3: Behavioral and epidemiological parameters.

	Population size ('000s)												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM					898500						1028000		
LRF					898500						1170000		
FSW									6200	6200			
CSW									72230	72230			
MSM									6600	6600			
PWID			7250	7600	8000	8500	8900	9400	9900	10400	10600		

	HIV prevalence (%)												
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM	0.2	0.2		0.1				0.1		0.1			
LRF	0.2	0.2		0.1				0.1		0.1			
FSW	0.2					0.4		0.4			1.2		
CSW	0.2										0.3		
MSM								2			2.3		
PWID	14.7		14.7			8.8	6.4				9.7	6.3	

STI prevalence (%)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM											3		
LRF											3		
FSW											12		
CSW											6		
MSM											1		
PWID											4		

Testing rate (%/year)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM											5		
LRF											5		
FSW						33		18			25		
CSW											5		
MSM								5			46		
PWID						21		23			20		

Testing rate AIDS (%/year)													
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
										80		

1st-line treatment rate (%/year)	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
CD4>500											2		
CD4>350											2		
CD4>200											10		
CD4<200											30		

2nd-line treatment rate (%/year)												
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
										50		

Birth rate (%/woman/year)												
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
2.8	2.8	2.9	3.0	3.0	3.1	3.1	3.2	3.2	3.2	3.2	3.2	

PMTCT coverage (%)												
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0.01												

Breastfeeding probability (%)												
2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
28.8												

New HIV diagnoses per year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
	78	76	111	77	131	200	183	292	404	351	342		

Number of PLHIV on treatment													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
1st-line	0.01								71		161		205
2nd-line	0.01								8		18		23

Number of regular acts per year													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM	60												
LRF	60												
FSW	60												
CSW	60												
MSM	60												
PWID	60												

Number of casual acts per year													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM	1												
LRF	1												
FSW	1												
CSW	5												
MSM			14.28		19.44			11.88					
PWID	1												

Number of commercial acts per year													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM													
LRF													
FSW	20												
CSW	2												
MSM	2												
PWID													

Condom probability for regular acts (%)													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM											10		
LRF											10		
FSW											10		
CSW											10		
MSM											40		
PWID						25		56.3			39		

Condom probability for casual acts (%)													
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012

LRM						74		75			62		
LRF						74		75			62		
FSW						43		28			30		
CSW											62		
MSM						55		81			78		
PWID						88		75			51		

Condom probability for commercial acts (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM													
LRF													
FSW						61		81			80		
CSW											80		
MSM						55		81			78		
PWID													

Circumcision probability (%)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM	0.1										0.1		
LRF													
FSW													
CSW	0.1										0.1		
MSM	0.1										0.1		
PWID	0.1										0.1		

Number of injections per person per year

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LRM													
LRF													
FSW													
CSW													
MSM													
PWID			300			180		48			60		

Syringe sharing probability (%)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
		43			29		31			45		

Methadone usage probability (%)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
0.001										0.8		

Syringe cleaning probability (%)

2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
					41		39			46		

Table 4: Biological constants.

Interaction-related transmissibility (% per act):	Male & female (insertive)	0.09	0.1 0.0001
	Male & female (receptive)	0.25	0.6 0.0006
	Male & male (insertive)	0.02	0.2 0.002
	Male & male (receptive)	0.02	2 0.002
	Injecting	0.3	1 0.1
	Mother-to-child	35	50 20
Disease-related transmissibility	CD4(500)	4	5 1.2
	CD4(350,500)	1	1.2 0.8
	CD4(200,350)	1	1.2 0.8
	CD4(200)	3.8	4 3.6
	Treatment	0.25	0.5 0.02
Disease progression rate: (% per year)	CD4 (500) to CD4 (350,500)	24.5	26.4 22.6
	CD4 (350,500) to CD4 (200,350)	51	55 47
	CD4 (200,350) to CD4 (200)	51	55 47
Treatment recovery rate: (% per year)	CD4 (350,500) to CD4 (500)	45	93 14
	CD4(200,350) to CD4 (350,500)	70	111 29
	CD4 (200) to CD4 (200,350)	36	43 28
Death rate: (% mortality per year)	Background	1.45	1.96 0.94
	Injecting	1	1.25 0.75
	CD4 (500)	0.0515	0.068 0.035
	CD4 (350,500)	0.128	0.164 0.092
	CD4 (200,350)	1.1	2 0.2
	CD4 (200)	50	66 40
	Treatment (CD4<200)	4	10 1
Treatment failure rate: (% per year)	1st-line	4.5	6 3
	2nd-line	4.5	6 3
Efficacy/change in transmissibility due to:	Condom (%)	80	99 60
	Circumcision (%)	60	65 50
	Diagnosis (%)	30	60 0
	STI cofactor increase (%)	700	1000 100
	Syringe cleaning (%)	75	80 70
	Methadone (%)	95	99 90
	PMTCT (%)	78	99 40
	Treatment risk compensation (%)	100	200 95