Phase 2 Report

Improving the Allocative Efficiency of the HIV Response Across the Care Cascade in Zimbabwe

FINDINGS FROM A MODELLING ANALYSIS

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ABBREVIATIONS

AE	Allocative efficiency
AIDS	Acquired immune deficiency syndrome
ART	Antiretroviral therapy
Clients	Clients of sex workers
DALY	Disability-adjusted life year
DHS	Demographic and Health Survey
DTG	Dolutegravir
FSW	Female sex workers
GDP	Gross domestic product
Global Fund	The Global Fund to Fight AIDS, Tuberculosis and Malaria
HDI	Human development index
HIV	Human immunodeficiency virus
HTS	HIV testing services
MSM	Men who have sex with men
M&E	Monitoring and evaluation
NATF	National AIDS Trust Fund
PLHIV	People living with HIV
PMTCT	Prevention of mother-to-child transmission
STI	Sexually transmitted infection
UNDP	United Nations Development Program
VMMC	Voluntary medical male circumcision
VL	Viral load
YLL	Years of life lost
ZIMPHIA	Zimbabwe Population-based HIV Impact Assessment

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The core study and analysis and report-writing team comprised of Isaac Taramusi (National AIDS Council, NAC); Maria del Mar Quiroga, Mark Minnery, Rowan Martin-Hughes and Sherrie Kelly (Burnett Institute); and Chenjerai Sisimayi, Clemens Benedikt, Nejma Cheikh, Nicole Fraser, and Zara Shubber from the World Bank.

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EXECUTIVE SUMMARY

HIV REMAINS THE LEADING SINGLE CAUSE OF DEATH AND DISABILITY IN ZIMBABWE.[1] DESPITE ENCOURAGING REDUCTIONS SINCE THE PEAK OF THE EPIDEMIC IN 1993, THE COUNTRY HAS ONE OF THE HIGHEST RATES OF HIV INCIDENCE IN THE WORLD, WITH AN ESTIMATED 3.08 ANNUAL NEW INFECTIONS PER 1,000 POPULATION AS LAST REPORTED FOR 2017.[2]

The national government has set targets to achieve a 75% reduction in annual HIV infections by 2020 and 90% by 2030, from 2010 levels. However, continued progress towards these targets is susceptible to sustainability of domestically funded health services, which may be affected by ongoing austerity measures.[3], [4]

Efficiency is needed in the response to further the progress towards national HIV targets. To address this need, a two phased HIV epidemic and allocative and implementation efficiency analysis of the HIV response – with a particular focus on the HIV testing and treatment cascade—was conducted using Optima HIV. Optima HIV is a mathematical model for determining an optimized resource allocation across a combination of HIV programs for maximizing defined outcomes such as reductions in incidence and deaths.[5] It is informed by demographic, epidemiological, behavioral, and programmatic cost and coverage estimates and data. Optimization has the benefit of providing an objective approach to determining an optimized programmatic response to HIV. This report summarizes findings from the second of the two phases. The first phase focused on modeling the HIV epidemic in Zimbabwe and its provinces, and estimating future trends given the last reported resource allocation. Results from this phase have been presented in the report: "Phase 1 report, HIV acquisition and transmission estimated as a base for HIV allocative & implementation efficiency."[1] Results from phase 2 focused on modeling to identify allocative and implementation efficiencies for averting additional HIV infections and HIV-related deaths.

If the latest reported annual HIV budget allocation of $234[2] million to testing and treatment is maintained, Zimbabwe should be on track to reach its 2020 75% HIV incidence reduction target (achieving a 76% reduction in HIV incidence from 2010); however, the country may fall slightly short of its 2030 90% HIV incidence reduction target (achieving an 88% reduction in HIV incidence from 2010). Zimbabwe's HIV

1 Draft report, publication pending.

2 All costing values are provided in 2017 United States dollars (USD), unless specified otherwise.

testing and treatment budget is largely allocatively efficient with the majority of the budget committed to long-term treatment of PLHIV and PMTCT (91% of the testing and treatment budget). Any additional opportunity for allocative efficiency (small) would favor further scale up of HIV testing to identify undiagnosed PLHIV (the 'weakest link' in the HIV treatment cascade), particularly with decreasing yield over time as it becomes more difficult to identify the last undiagnosed.

A 25% increase in budget optimally invested could lead to an 89% reduction in annual new HIV infections in 2030 from 2010. That is, an additional 30,000 infections could be averted with optimized allocation of 125% budget from 2010. Thereafter, increases to the optimized budget above 125% only showed marginal reductions suggesting saturation in gains around this funding level. However, reducing the budget by as little as 5% could result in a 6% increase in new infections when compared to the fully-funded baseline allocation. Additional funding should be prioritized towards adult testing and viral load monitoring to increase the demand for treatment and ascertain its effectiveness.

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Implementation efficiencies in the HIV response can lead to savings and increased coverage. Given the high coverage across the HIV treatment cascade, alternative ways than inter-program reallocations need to be found and focused on. This analysis investigated the following options: optimization across adult HIV testing and ART refill modalities, switching to a Dolutegravir (DTG)-based ART regimen, and implementing a less frequent VL monitoring strategy in stable patients. By rolling out these implementation efficiencies, an additional 15,000-18,000 new HIV infections could be averted by 2030 and $2.7 million in costs could be saved each year. Any savings should be optimally reinvested in adult testing and increased coverage of regular viral load monitoring in line with recommendations from the optimization of increased budget.

KEY RECOMMENDATIONS

- **Scale up HIV testing to target the undiagnosed PLHIV, investing an additional $1.8 million and prioritizing index HIV testing for investment.** Due to lower cost, facility-based index HIV testing and partner index self-testing should be prioritized. Community-based index testing should be reserved for those who are unable to be reached through facility-based index and partner self-testing.

- **Shift eligible ART clients currently receiving standard individual ART refills to community ART group refill.** If 40% of stable ART clients who currently refill their ART prescriptions at primary health centres every three months, could be reassigned to community ART group refill, an estimated $2.7 million could be saved each year.

- **Switch non-pregnant adults living with HIV to a Dolutegravir (DTG)-based regimen.** Assuming that DTG has a 10-15% lower unit cost than current mainstream regimens, switching could result in $12-$18 million saved each year.

- **Switch those on stable treatment to biennial viral load (VL) monitoring instead of annual monitoring after the first year.** This strategy, referred to as 'VL lite', could save $8-$13 per ART client per year for a total of $3 million in savings through to 2030. Alternatively, with the same level of spending. If VL testing is done for between 80% and 95% of the ART population (assumed full VL program scale), then $5.6m–$10.8m per year could be saved

- **Optimally reinvest any savings from implementation efficiency gains into HIV testing, further scale-up ART, and efficiently invest in less frequent VL monitoring strategies for those on stable treatment.** Savings should be reinvested to increase diagnosis, treatment coverage, and viral suppression through better cost modalities.

- **Additional interventions, including ARV prophylaxis and non-ART prevention, and innovations to further reduce service delivery costs or increase effectiveness will be required if Zimbabwe is to reach its 2030 incidence target.** There are diminishing returns with the current available 'toolbox' of interventions. In countries with large existing disease burdens, reducing HIV incidence to such low levels is exceptionally hard and a long 'epidemiological tail' exists that needs to be addressed with personalized and preemptive HIV prevention strategies.

- It is imperative that the budget for HIV testing and treatment is at least maintained to avoid reversing the gains made against the HIV epidemic.

1. BACKGROUND

1.1 ECONOMIC AND DEVELOPMENT OUTLOOK IN ZIMBABWE

Economic instability in Zimbabwe may impact its future public financing and progress on human development. The country experienced an almost decade-long recession, from 2000 to 2009 (where annual gross domestic product (GDP) growth dropped to -17 and -18% in 2003 and 2008), after which it grew to a peak of 19% in 2010; with latest estimates at 5% (2017)[3]. It is expected to fall to 0.2% in the 2018–19 fiscal year.[6] Austerity measures are being implemented in the first quarter of 2019 after an extended period of fiscal deficit,[4] which has widened from 9% in 2016 to 15% in 2017.[6] Higher deficits are also expected for the 2018–19 fiscal year. An uncertain economy and high rates of unemployment have caused residents to seek informal work, accounting for over 80% of all employment in 2014.[3], [6] This has led to decreases in public tax revenue, and as such less domestic resources are available to be devoted to health and development. This uncertain economic outlook, coupled with a period of political change following deposition of the former president in 2017, necessitates now more than ever the need for increased cost-efficiency in financing public and social programs to ensure progress on human development.

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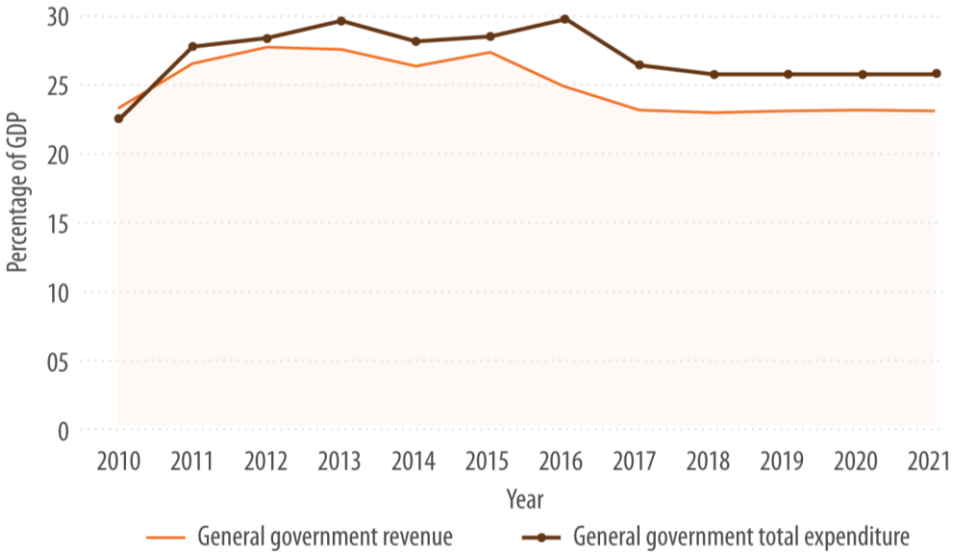
Figure 1.1 Government expenditure and revenue, 2010 to 2021



Source: World Bank Group and Zimbabwe Reconstruction Fund (ZIMREF); Analyzing fiscal space options for health in Zimbabwe, 2017.[7]

3 World Bank statistics. https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=ZW.

Development indicators paint a mixed picture of country progress. Economic uncertainty in the country has also led to increased poverty as the number of Zimbabweans living in extreme poverty, has risen from 2.3 million in 2014 to an estimated 2.8 million in 2016.[8] Approximately a quarter of total health expenditure in 2016 came from out-of-pocket spending.[6] High out-of-pocket spending on health is putting many Zimbabweans at risk of poverty or is deepening their poverty level.[6], [9] Despite recent improvements, purchasing power parity (adjusted per capita gross national income) was 27% lower in 2017, compared with 1990.[6] Still, with international funding and other general development gains, consistent improvements in life expectancy have been observed in Zimbabwe. From a low of 44 years of life expectancy at birth in 2002 during the peak of the HIV epidemic, to 61 years in 2016.[6] Under-five mortality rate has continued to decline from 85 child deaths per 1,000 live births in 2002 to the last estimates of 50 in 2017.[6] Levels of education have generally improved with both average expected years and mean years of schooling having increased from 1990 to 2017, from 9.8 to 10.3 and from 4.5 to 8.1, respectively.[6] Increasing life expectancy is inversely correlated to declining HIV-related deaths (see Figure A.1), which peaked around 2003.

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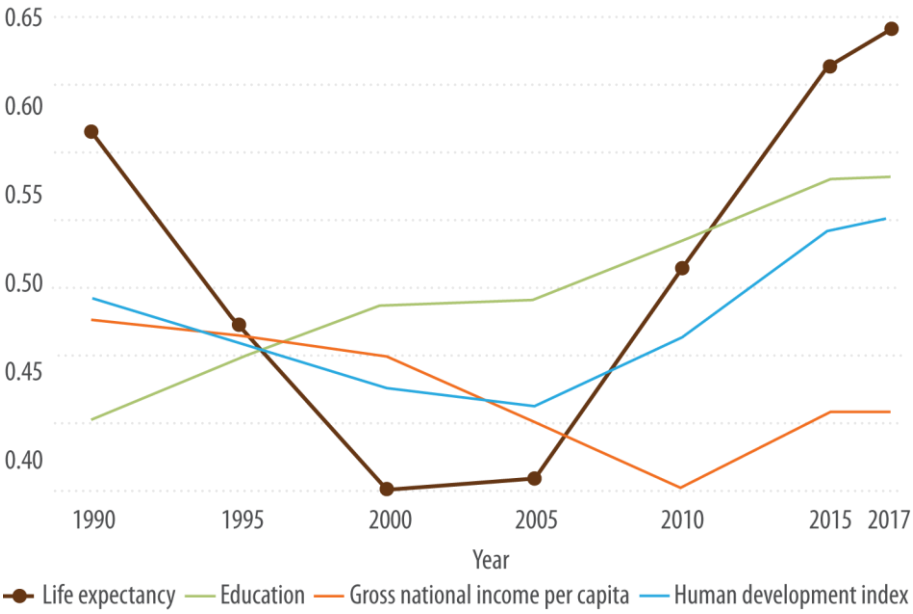
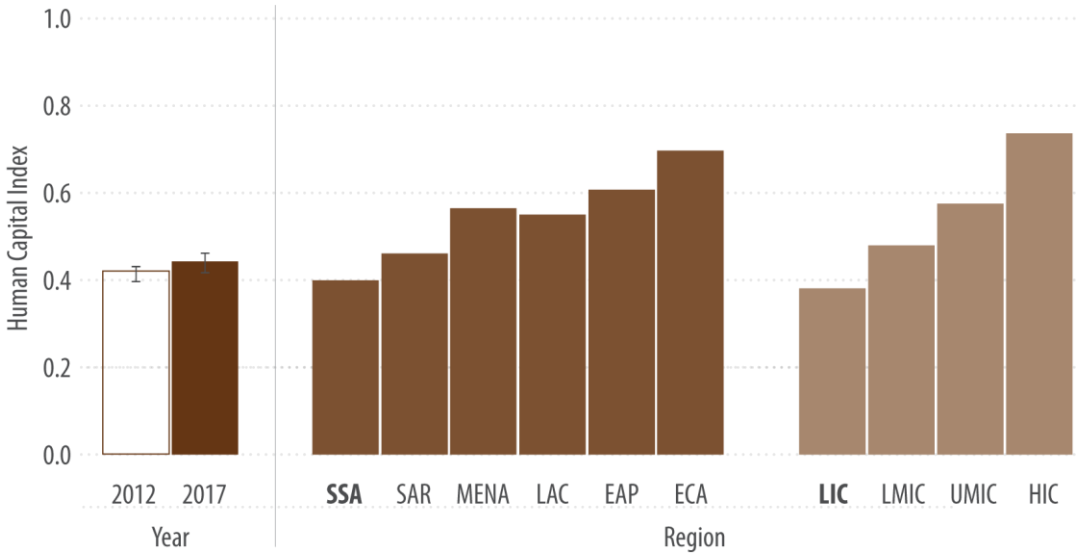
Figure 1.2 Human development index and constituent indicators, 1990–2017



Source: UNDP. Human Development Indices and Indicators: 2018 Statistical Update[10].

Zimbabwe's Human Capital Index (HCI) value currently stands at 0.44 (2017), which has increased from 0.42 in 2012 and is higher than the average for its region and economic group[10],[11] (see Figure 1.3). HCI measures the amount of human capital that a child born today can expect to attain by age 18. It conveys the productivity of the next generation of workers compared to a benchmark of complete education and full health. It is made up of five indicators: the probability of survival to age five, a child's expected years of schooling, harmonized test scores as a measure of quality of learning, adult survival rate (fraction of 15-year olds that will survive to age 60), and the proportion of children who are not stunted.

Figure 1.3. Benchmarking Zimbabwe's Human Capital Index



Source: World Bank. Human Capital Project, https://databank.worldbank.org/data/download/hci/HCI_2pager_ZWE.pdf.

Notes: Unless specified all data are for 2017; The uncertainty intervals (grey vertical lines) reflect uncertainty in the measurement of components of the index; ECA=Europe and Central Asia; EAP=East Asia and Pacific; HIC=High income countries; LAC=Latin America and Caribbean; LMIC=Low and middle income countries; LIC=Low income countries; MENA=Middle East and North Africa; SSA=Sub-Saharan Africa; UMIC=Upper middle-income countries.

Steady progress has been made on reducing HIV infections and HIV-related deaths in Zimbabwe; however, HIV remains a key health priority. Despite economic instability, HIV financing funded in part from the national AIDS levy and international donors, has supported continued progress in the HIV response in Zimbabwe. This progress has in turn led to improvements to human development, which in turn strengthens the HIV response synergistically.[7], [12] HIV incidence has been steadily declining since 2002 alongside steady progress towards the 90-90-90 HIV[4] targets[13]. As last reported in 2016, 73% of people living with HIV (PLHIV) know their status, 87% of those people received treatment, and 87% of those on treatment (and monitored for viral load) achieved viral suppression.[14] Nevertheless, HIV/AIDS remained the number one single cause of mortality, morbidity, disability adjusted life years (DALYs), and years of life lost (YLL).[1]

Nevertheless, HIV/AIDS remained the number one single cause of mortality, morbidity, disability adjusted life years, and years of life lost.

1.2 BURDEN OF HIV IN ZIMBABWE

A report from phase 1 of this analysis presented estimates for HIV transmission and acquisition for Zimbabwe from 2000 to 2017. Please refer to the *2017 Phase 1 Report on HIV Acquisition and Transmission Estimates as a Basis for HIV Allocative & Implementation Efficiency* report for further details. Key points from this report are summarised here.

HIV accounted for almost half of all YLL among women of reproductive age in 2016. HIV remains the primary cause of premature mortality among women of reproductive age

[4] 90% of people living with HIV (PLHIV) diagnosed, 90% of those diagnosed on treatment, and 90% of those on treatment achieving viral suppression[13].

(15–49 years) in Zimbabwe, accounting for 47% of all YLL in this group. This is despite HIV prevalence falling from an estimated 23.4% in 1997 to 13.5% in 2016[2] and impressive success in scaling up treatment coverage from 50% in 2010 to 84% in 2017 in this group.[2]

National level HIV prevalence continues to decline for both males and females; however, there is substantial regional variation in levels and trends of HIV prevalence. Declines in self-reported HIV sexual risk behavior between 1990s and 2010 may have begun to reverse since.[15] Risk behaviors remain more predominant in the south-western provinces of Zimbabwe, where HIV prevalence is elevated. In contrast to wide geographical variation in reported risk practices and HIV prevalence, HIV service coverage is relatively across uniform in Zimbabwe.

The HIV epidemic in Zimbabwe is projected to continue and age. Around half of all new HIV infections acquired and transmitted occur among the general population aged 25 and over. Among key populations, the largest share of HIV infections is attributed to female sex workers (FSW) and their clients. However, it was estimated that for all four key populations considered in this analysis, FSW, clients of FSWs, men who have sex with men (MSM), and people who inject drugs (PWID) experience high rates of HIV incidence above 1 in 100 person years. Unconfirmed reports also suggest that a key risk group in Zimbabwe is transgendered persons. In large part due to restrictive laws around people who identify as LGBTIQ, there has been little study surrounding this population. Overall, the number of people living with HIV is projected to decline moderately, which when combined with projected increases in HIV diagnoses, is sufficient to allow the country achieve its 90% diagnosis target by 2020.

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1.3 PUBLIC FINANCING FOR HEALTH AND HIV

A challenging economic environment is putting pressure on an already strained public financing system. The need for increased financing for health has been outlined in the 2017 Zimbabwe Health Financing Strategy.[3] The Federal Government and development partners are committed to transitioning their reliance away from international donor funding and to increase domestic funding.[3] However, since austerity measures were enforced on government spending from beginning of 2019, more needs to be done with available funds.

Zimbabwe spends a smaller percentage of their national public budget on health than neighbouring countries. As shown in figure 3, 2015 estimates suggest 8% of total government expenditure was spent on health in 2015;[16] this is around half of the 15% Abuja declaration threshold.[5] This translates to only $95 per capita being spent on health, $22 of which is funded through donor support.[3], [16] Health financing in Zimbabwe is heavily dependent on international financing and out-of-pocket expenditures. In 2015, 24% plus 23% of total health expenditures, for a total of 47%, were funded from international donors

[5] https://www.who.int/healthsystems/publications/abuja_declaration/en/.

and out-of-pocket sources.[16] Reliance on out-of-pocket expenditures often leads to catastrophic health costs.[6] Accordingly, in 2015 8% of Zimbabweans experienced increased risk of poverty due to household paying out-of-pocket health costs.[9] In the same year, only 34% of total health spending was publicly funded, suggesting heavy reliance on donor funding and the private sector.[3]

In contrast to overall health budgets, the HIV response is less reliant on out-of-pocket funding, subject in larger part to a targeted tax instrument paid for by formal sector employment.[3], [12] A large proportion of the HIV response is supported by the national AIDS levy.[17] This is an earmarked levy of 3% on all formal sector employment (employers and employees) which contributes to the HIV/AIDS response in Zimbabwe. It is administered by the National AIDS Trust Fund (NATF); whose primary goal is to reduce donor dependence. From its inception the trust has increased from $5.7 million in 2009 to $38 million in 2014. In 2014, the AIDS levy contributed 82% of the funds for the national HIV response, with 13% coming from the Global Fund for HIV, TB, and Malaria (GFATM), and other donors, 2% from interest from investment, and 2.5% from other fund raising initiatives.[12] As the HIV/AIDS response is in large part funded by the national AIDS levy, which is derived primarily from taxes based on declining formal sector employment, economic downturn is a threat to continued financing of the HIV response. Given this, areas of potential efficiency with the current available resources warrant investigation.

In the context of austerity and stagnating health expenditure, long term financial and technical support is needed in Zimbabwe. As Zimbabwe transitions to a decreased reliance on external funding for HIV/AIDS, efficiency and sustainability must be derived from the current response. With a combination of improved efficiency and efforts to maintain and expand domestic investment in health and HIV, Zimbabwe can sustain and potentially improve progress towards goals of eliminating HIV, and improving socio-economic development. Gains in health are likely to affect development outcomes, including economic productivity. Hence, investing in health remains essential for development.

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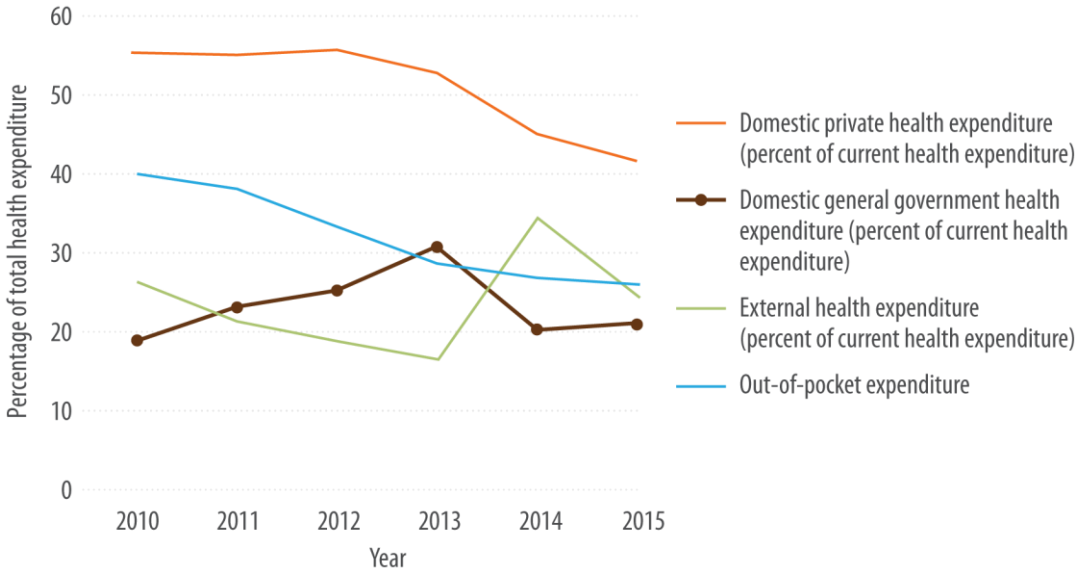
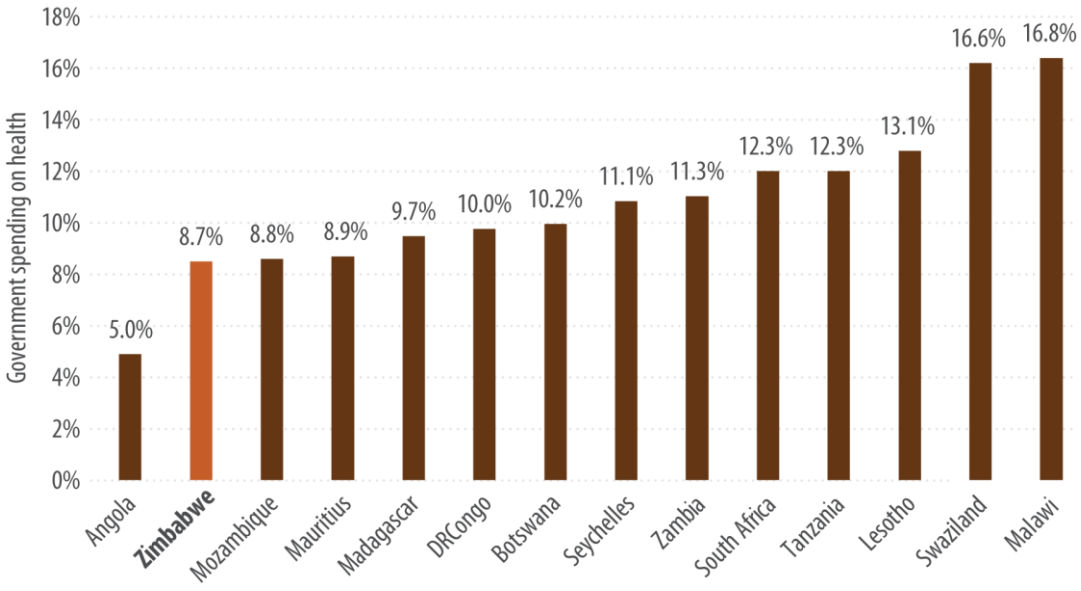
[6] As indicated by the number of households that spent more than 25% of total consumption (out-of-pocket expenditures included) on health in the calendar year[11].

Figure 1.4 Government health expenditure as a percentage of total government expenditure for Zimbabwe and neighbouring countries, 2014



Source: Recreated from graph provided in the 2017 Zimbabwe Health Financing Strategy; Original sources: for Zimbabwe, 2015 Zimbabwe National Health Accounts; for neighbouring countries, World Bank Open Database[3].

Figure 1.5 Health expenditure by source, 2010–15



Source: World Bank World Development Indicators[16].

2. HOW WILL THIS ANALYSIS IMPROVE HIV ALLOCATIVE AND IMPLEMENTATION EFFICIENCY?

2.1 THE OPTIMA HIV MODEL

Allocative efficiency analyses determine the best resource allocation within a defined resource envelope, with the aim to finance the right intervention for the right people at the right place, in order to maximize health outcomes. Implementation efficiency analyses determine the lowest cost combination of inputs wisely to maximize outputs. Just like in the first phase of this HIV modelling study, Optima HIV model was used in this second phase. Optima HIV uses HIV epidemic modeling techniques and incorporates data on biological transmission probabilities, CD4 progression, actual HIV prevalence and related data, sexual behavior, program funding allocations, program coverage, and sexual mixing patterns. Using a mathematical optimization algorithm, program cost and efficacy data are used in an integrated analysis to determine an optimized distribution of investment under defined scenarios. Optima HIV is calibrated to HIV prevalence data points available, for sub-populations (e.g. FSWs, MSM) at specific time points and specific geographical locations.

Allocative efficiency analyses determine the best resource allocation within a defined resource envelope, with the aim to finance the right intervention for the right people at the right place, in order to maximize health outcomes.

2.1.1 Data inputs, calibration, and cost functions

Model parametrisation with data inputs and assumptions and calibrations were conducted in consultation with experts on the Zimbabwean epidemic. To assess how incremental changes in spending affect HIV epidemics and thus determine the optimized funding allocation, the model uses relationships between the cost of HIV intervention programs, the coverage level attained by these programs, and the resulting outcomes. Using the relationships between cost, coverage and outcome - in combination with Optima HIV's epidemic module—it is possible to calculate how incremental changes in funding allocated to each program will impact overall epidemic outcomes. Finally, by using a mathematical optimization algorithm, Optima HIV is able to determine an "optimized" allocation of funding across different HIV programs.

An overview of the data inputs, calibration process, unit costs, cost functions, cost and coverage, HIV care cascade values, and constraints and assumptions informing the Optima Zimbabwe analysis can be found in Table 2.1 below and also in the appendices. All costs are in US dollars. No discounting has been applied, but could be subsequently applied to any values.

Table 2.1 HIV program spending, unit costs, and saturation values

Program	Year last reported	Spending	Unit cost (USD)[a] (low)[a]	Unit cost (USD)[a] (high)[a]	Saturation (low)	Saturation (high)
Adult (15 years and older) testing (excluding prisoners)	2017	$9,428,438	$3.13	$4.69	60%	90%
ART (including refill spending)	2017	$213,842,302	$152.76	$229.14	90%	100%
ART client defaulter tracing	2017	$11,715	$6.75	$10.12	80%	95%
CD4 monitoring (6 months)	2017	$524,814	$23.59	$35.38	80%	95%
Child (0-14 years) testing	2017	$1,083,679	$2.41	$3.62	80%	100%
Community support: linkage to care	2017	$5,798	$4.68	$7.01	80%	95%
PMTCT	2017	$8,470,389	$117.56	$176.35	95%	100%
Pre-ART client tracing	2017	$6,419	$4.73	$7.09	80%	95%
Pre-ART text messaging	2017	$1,282	$0.94	$1.42	80%	95%
Prisoner testing	2017	$13,372	$2.66	$3.99	75%	90%
VL monitoring (6 months, year 1, year 2, year 3...) plus adherence	2017	$10,932,083	$26.82	$40.24	80%	95%
VL monitoring (6 months, year 1, year 3, year 5...) plus adherence	2017	$0	$18.53	$27.8	80%	95%
Text messaging adherence	2017	$0	$5.15	$7.73	80%	95%

Source: Populated Optima HIV model, 2018.
Notes: [a]=Unit costs calculated based on data sourced from national AIDS spending assessment[18] reports, global AIDS response progress reports[19], and from the Ministry of Health and Child Care (MOHCC).

2.2 OBJECTIVES

The overall objective of this analysis was to analyze the allocative and implementation efficiency of the HIV testing and treatment response in Zimbabwe. Analyses in the second phase were informed by the results from phase 1 during which a disease model had been developed to determine historical, current, and likely future trends in HIV incidence, prevalence and deaths in different sub- populations.

The broad objective of phase 2 was to **determine and analyse potential allocative and implementation efficiency improvements of HIV testing and treatment program spending**, designed to answer key questions relating to Zimbabwe's future HIV response. In concert with country and developed partners, four key questions were devised for the second phase of work.

Under current allocation and disease trends can 2020 and 2030 targets be met? This relates to targets which have been set by the national government for reductions in annual HIV incidence, based on a comparison year of 2010. The 2020 target aims at a reduction in HIV incidence by 75%, while the 2030 target aims at a 90% reduction.

What is an optimized HIV resource allocation under current budget and program conditions? This related to determining how the most recent (2018) HIV testing and treatment budget of $244 million could be optimized to minimize new HIV infections and HIV-related deaths through to 2030. The analysis was constrained to incorporate key practical and ethical concerns around service delivery in Zimbabwe. These included all PLHIV on treatment remaining on treatment unless being removed through natural attrition,

and the maintenance at current levels of PMTCT child testing and annual VL monitoring for children, pregnant women and unsuppressed patients. Baseline CD4 monitoring was also held constant due to clinical monitoring considerations for select populations that were outside the scope of the modelling analysis. Given the difficulty in measuring the direct effect of non-targeted programs, such as program management or health systems strengthening, the effect of these programs was not modeled. A consequent remaining budget of $11.3 million, or 4.3% overall, was optimized to estimate improvements in allocative efficiency.

What is an optimized allocation under different budget envelopes? An optimized budget may differ as funding is added or taken away. This objective optimized incremental levels of the most recent budget: 50%, 75%, 90%, 95%, 105%, 110%, 125%, 150%, 175%, and 200%. Outcomes were compared to an allocative optimized budget at 100%. Constraints were set to be similar to the previous objective of determining an optimized most recent budget. In the instance where budgets were less than 100%, constrained programs were scaled back in line with the budget decrease.

Can efficiency be gained by allocating resources differently across delivery modalities? Programs and interventions used in the HIV response have a variety of delivery modalities. Tailoring these programs to the epidemic context can result in greater efficiency and cost savings to be re-invested in the response. We analyzed and estimated cost savings and increased coverage when asking the following;

Tailoring these programs to the epidemic context can result in greater efficiency and cost savings to be re-invested in the response.

1. **Where should additional investments in HIV testing be prioritized?** The first phase of the allocative efficiency analysis highlighted the need for improved rates of testing. Adult HIV testing in Zimbabwe is currently diversified across different facility-based and community-based modalities, each with an option for self-testing[7]. A list of these modalities can be found in appendix F. Using the estimated unit cost per HIV+ diagnosis (taking into account the unit cost per test and yield), the modalities were ranked. Additional investments were prioritized using this ranking. estimated the cost per HIV cost savings and increased adult testing coverage when these modalities were optimized.
2. **What is an optimized allocation of resources across ART refill modalities?** A majority of PLHIV on treatment currently receive ART through standard refill. Zimbabwe delivers ART refill through a variety of delivery platforms in facility but also within the community to reach potential PLHIV unlikely to access treatment through traditional pathways. This includes community and facility based refill groups and clubs which often may be more effective in retaining PLHIV on treatment, able to reach more PLHIV, and often are associated with lower unit cost and clinic decongestion. This analysis estimated the potential cost savings with maintaining coverage of ART while optimizing refill across different modalities.

[7] Excluding HIV testing conducted at antenatal clinics.

3. **What is the impact of switching to lower intensity VL testing among stable patients ('VL lite')?** VL monitoring is critical for preventing treatment failure. Prior to 2017 a single modality was available for delivering VL monitoring services. This incorporated VL testing frequency of 6 months and 1 year after ART initiation, with yearly monitoring thereafter if virally suppressed. For the purpose of this analysis, a VL monitoring 'lite' service delivery strategy was considered in which non-pregnant stable adults were considered eligible to switch to a biennial (rather than annual) monitoring frequency at one year following ART initiation if suppressed. The analysis estimated cost savings and potential coverage increases when switching all eligible patients to VL lite. This was under a scenario of current coverage of VL monitoring, and under a scenario of full coverage (assumed to be between 80–95% of ART population who are suppressed).

4. **What is the impact of switching to DTG-based regimen for non-pregnant adult PLHIV?** It has been found that incorporating DTG into the ART regimen in sub-Saharan Africa, for non-pregnant adults, is associated not only with more DALYs averted when compared to alternative regimens but also cost-savings.[20] As an ''integrase inhibitor'' DTG is effective, well tolerated, easy to take, has few interactions with other medicines, a high barrier to resistance, and it can be more affordable. The WHO issued guidelines recommending DTG as an alternative option for first line treatment of HIV in 2016, and updated guidelines in July 2018 outlining how countries should proceed in rolling out DTG. The potential impact of reducing the latest reported unit cost of ART by switching to DTG, which was assumed to have a 10–15% lower unit cost ($117) than the unit cost for the mainstream ART regimen ($120–150 as latest reported for Zimbabwe) was assessed. Impact was assessed through estimation of the amount in saved US dollars if all non-pregnant adults on ART were to be switched to a DTG-based regimen and these savings were optimally reinvested.

It has been found that incorporating DTG into the ART regimen in sub-Saharan Africa, for non-pregnant adults, is associated not only with more DALYs averted when compared to alternative regimens but also cost-savings.

2.3 ANALYTICAL FRAMEWORK

2.3.1 Populations included in the analysis

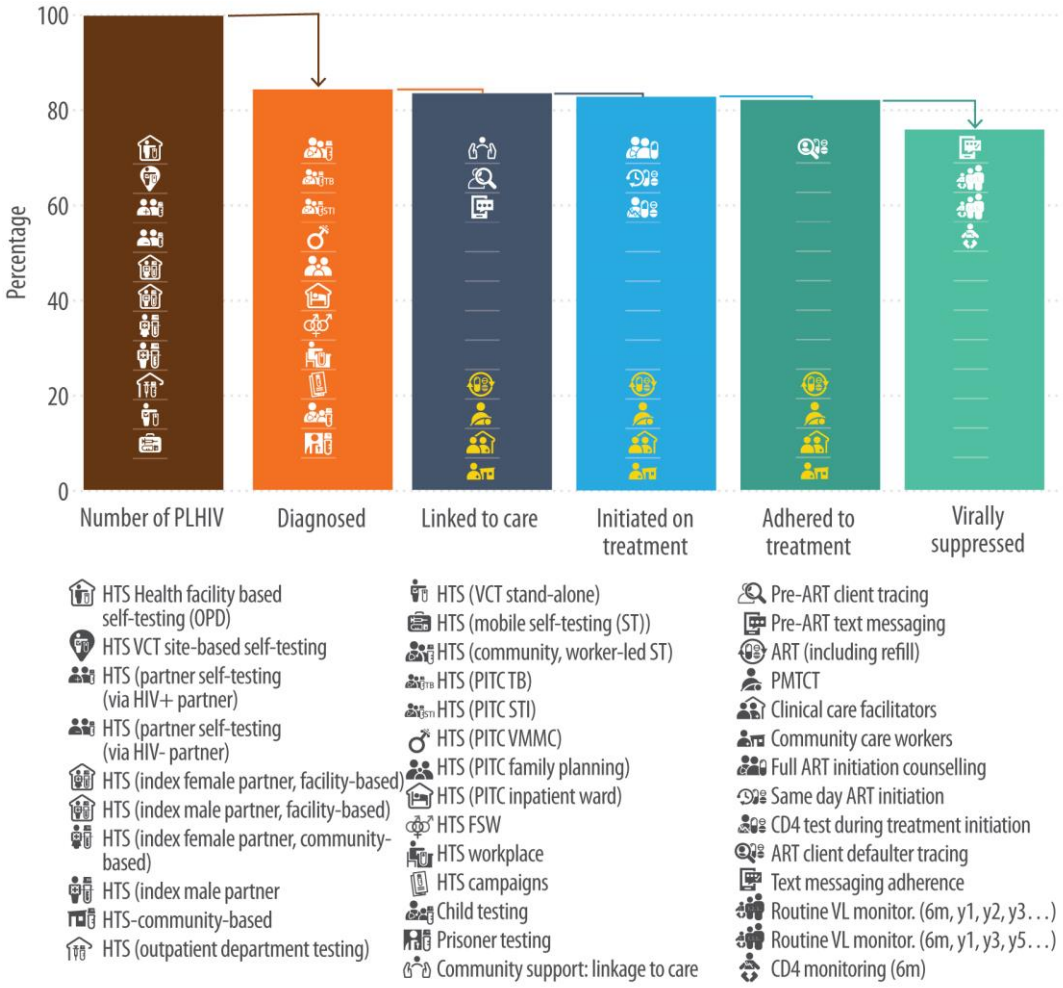
In accordance with country partners the following populations were included in the Optima model. General population: girls aged 0–14 years; boys aged 0–14 years; young women 15–19 years; young men 15–19 years; young women 20-24 years; young men 20–24 years; women 25–34 years; men 25–34 years; women 35–49 years; men 35–49 years; women 50+ years; men 50+ years. Key populations: female sex workers; clients of sex workers; men who have sex with men; prisoners. Due to limited information on prevalence transgender people were not included as a specific population in the model.

2.3.2 Programs and service delivery modalities included in the model

Following consultation with country partners the following programs, found in figure 6 below, were included in the analysis. Programs which had non-quantifiable effects on the

HIV epidemic were not included in the optimization analysis. Targeted programs were set to affect relevant parameters across the cascade.

Figure 2.1 HIV programs and service delivery modalities considered across the care cascade in the Optima HIV model for Zimbabwe[8]



Source: Populated Optima HIV model, 2018.

Notes: Interventions in yellow are cross-cutting to support other interventions, and together with those in black are essential and were not considered in the optimization; HTS adult modalities and ART refill options were combined into 2 separate programs, with further reallocation analysis subsequently conducted; ART=antiretroviral therapy, FSW=female sex worker, HTS=Health testing services, PMTCT=Prevention of mother-to-child-transmission; STI=sexually transmitted infections, VCT=voluntary counselling and testing, VL=viral load, VMMC=voluntary medical male circumcision,

2.4 LIMITATIONS OF THE ANALYSIS

As with any modeling study, there are limitations with this analysis. Therefore, these modeling results should be interpreted with caution. The following are key limitations which should be taken into account when considering results and recommendations from this analysis. First, limitations in data availability and reliability can lead to uncertainty about projected results. Although the model optimization algorithm accounts for inherent

[8] HIV programs and service delivery modalities were chosen for inclusion in the model in consultation with country representatives as lead by the World Bank Group.

uncertainty, it might not be possible to account for all aspects of uncertainty because of poor quality or insufficient data, particularly for important cost values. Coupled with epidemic burden, cost functions are a primary factor in modeling optimized resource allocations. Second, we include only costs from a provider perspective. However, we expect that the differentiated service delivery modalities for stable clients explored in this analysis for would likely result in reduced direct and indirect costs to clients through reduced clinic visits. Third, we used contextual values and expert opinion where available, and otherwise evidence from systematic reviews of clinical and research studies to inform model assumptions. Forth, we did not capture the effect of migration of people living with HIV from countries other than Zimbabwe, but instead modeled this Zimbabwe investment case in isolation. We acknowledge that the influence of migration on the Zimbabwe epidemic; however, this was not modeled. Fifth, we did not incorporate time-varying optimization where it might be optimal to scale up or to scale down programs over time. We anticipated that this approach would have more appropriately prioritized funding towards programs for which health gains from early investment will only be realised in the long-term. We expected this limitation to mostly affect funding for voluntary medical male circumcision – which was not included in our testing and treatment cascade - in generalised epidemic settings, such as in Zimbabwe, as shown for South Africa by Shattock and colleagues.[21] Sixth, as a population-based compartmental model, Optima HIV may not capture all heterogeneity in HIV acquisition risk and testing and treatment seeking behaviour. Seventh, it is important to note that this analysis focused on the HIV testing and treatment budget and did not include HIV budgets including prevention. The decision to prioritize the HIV testing and treatment cascade was taken in consultation with the Government of Zimbabwe. Eight, Finally, these findings are only modeling analysis projections and have not been confirmed in a practical setting in Zimbabwe. The model used in this study has been calibrated to reflect country-endorsed and UNAIDS-endorsed epidemiological estimates, but validation of results showing that optimal allocations are indeed more efficient in practice, has not been conducted. Shifting resources on the basis of evidence from resource optimization studies is not always feasible and is not necessarily politically favourable, but it should be considered if there is the will to make a greater impact.

Although the model optimization algorithm accounts for inherent uncertainty, it might not be possible to account for all aspects of uncertainty because of poor quality or insufficient data, particularly for important cost values.

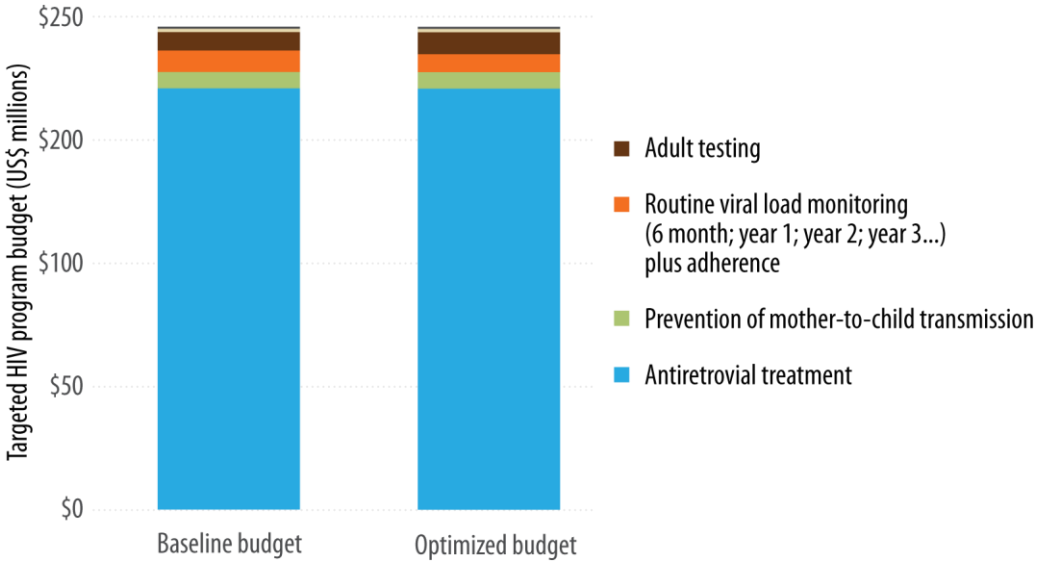
3. KEY FINDINGS

Based on the first phase report, **new HIV infections and HIV-related deaths have continued to decline both nationally and among key populations**. Annual new infections are estimated to reduce by 76% from 2010 to 2020, just over the 75% reduction target, while annual HIV-related deaths are estimated to decline by 86% within the same time period. The Optima model predicts a continued trend of reduction in both HIV-related deaths and new HIV infections. **However, under the current epidemic patterns and program coverage, the 2030 HIV incidence target is unlikely to be reached.**

Most resources are already largely committed to long term treatment, meaning that Zimbabwe's HIV testing and treatment response is allocatively efficient, leaving little room for further allocative efficiency gains (see Figure 3.1). Reductions in new HIV infections and HIV-related deaths, based on an optimized allocation of the most recent testing and treatment budget, are marginal. The optimized allocation estimated to result in a total 1,000 fewer infections and 100 fewer deaths 2018–30 when compared to the baseline allocation. Both the baseline and optimized budget scenarios are estimated to result in 76% and 88% reductions in annual new HIV infections in 2020 and 2030, respectively. Modest improvements associated with the optimized response are due to the fact that about 96% of the most recent budget being appropriately committed to, ART, PMTCT, and other essential services. Any additional opportunity for allocative efficiency (small) would favor further scale up of HIV testing to identify undiagnosed PLHIV (the 'weakest link' in the HIV treatment cascade), particularly with decreasing yield over time as it becomes more difficult to identify the last undiagnosed (see Table 2.1). The additional investments for HIV testing should be used to scale-up HIV index testing, which was deemed to be the most cost-effective testing modality and remains relatively underutilized. HIV index testing can be facility-based, community-based or through partner HIV self-testing, with the latter having the highest cost per HIV+ diagnosis of all index modalities and should therefore be reserved for those that are unable to be reached through facility-based index testing and HIV partner self testing. While additional investments for HIV testing (in line with improving progress towards 90% of PLHIV diagnosed) would come from VL monitoring, there is an opportunity to maximize VL monitoring investments through a 'VL lite' strategy (see below).

The additional investments for HIV testing should be used to scale-up HIV index testing, which was deemed to be the most cost-effective testing modality and remains relatively underutilized.

Figure 3.1 Annual optimized budget allocations for targeted HIV programs for 2018 through to 2030



Source: Populated Optima HIV model, 2018.

Table 3.1 Baseline and optimized budget allocations for ART, adult testing, and viral load monitoring

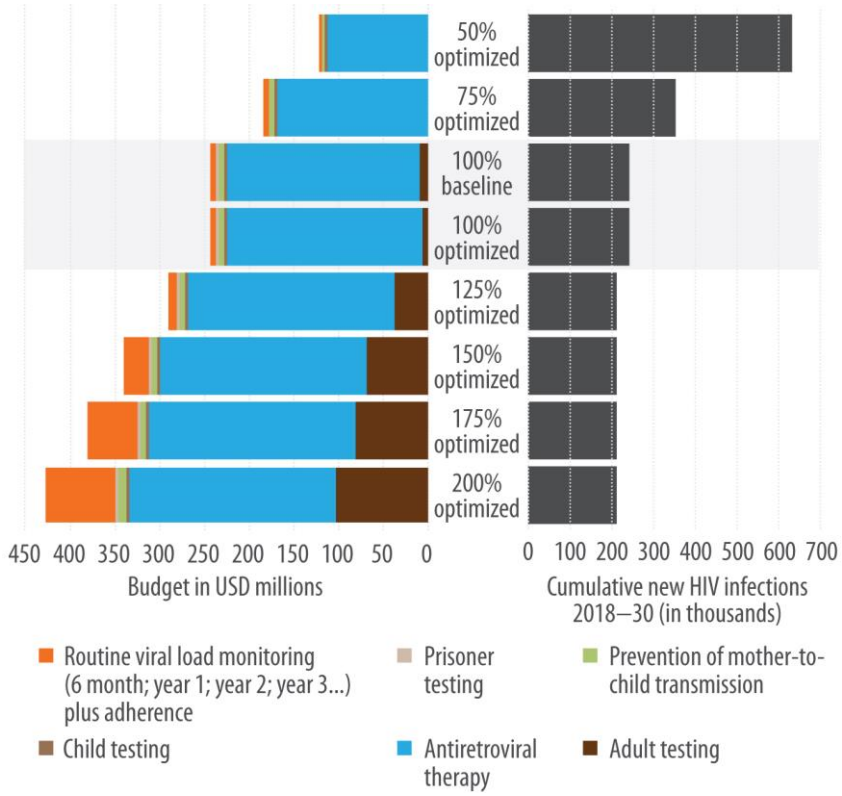
Programs	Baseline budget (USD)	% budget	Optimized budget (USD)	% budget	% change
ART	$213,842,302	87.5%	$213,842,302	87.5%	0%
Adult testing	$9,441,810	3.9%	$11,266,484	4.6%	19%
Routine viral load monitoring (at 6 months, year 1, year 2, year 3, etc.) plus adherence	$10,932,083	4.5%	$9,131,569	3.7%	-16%

Source: Populated Optima HIV model, 2018.

Increasing the HIV testing and treatment budget would have a marginal impact on reducing new HIV infections, conversely, small decreases would result in substantial slowing in the rate of reduction. Even when optimized, a 5% decrease in the budget could result in 15,000 more new infections and 6,000 more deaths than a fully funded optimized budget between 2018 and 2030 (Figures 3.1–3.11). Decreases in the budget would prioritize maintaining as many people on treatment over HIV testing and routine viral load monitoring. An optimized 25% increase in budget prioritizing scale up of HIV testing, ART and routine viral load monitoring, however, could lead to an additional 28,000 new HIV infections being averted compared to optimized most recent budget levels. This is estimated to result in an 88.5% annual reduction in new HIV infections in 2030 compared to 2010. As such, while increasing the budget may bring Zimbabwe closer to the 2030 incidence reduction target, it may still fall short of reaching the target.

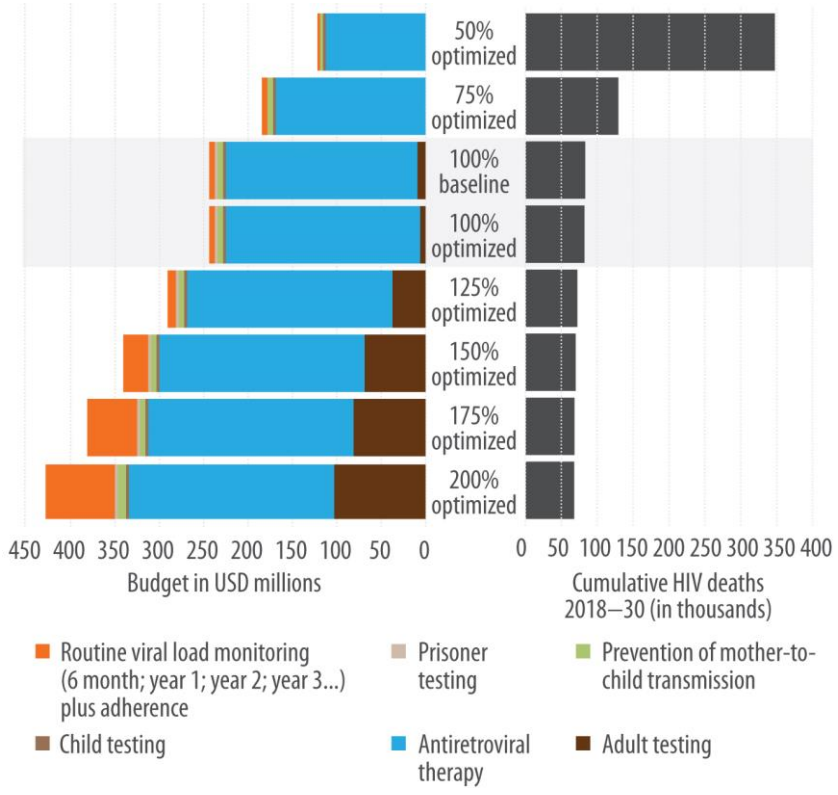
An optimized 25% increase in budget prioritizing scale up of HIV testing, ART and routine viral load monitoring, however, could lead to an additional 28,000 new HIV infections being averted compared to optimized most recent budget levels..

Figure 3.2 Annual optimized allocations with varying budget and resulting estimated new HIV infections, 2018 to 2030



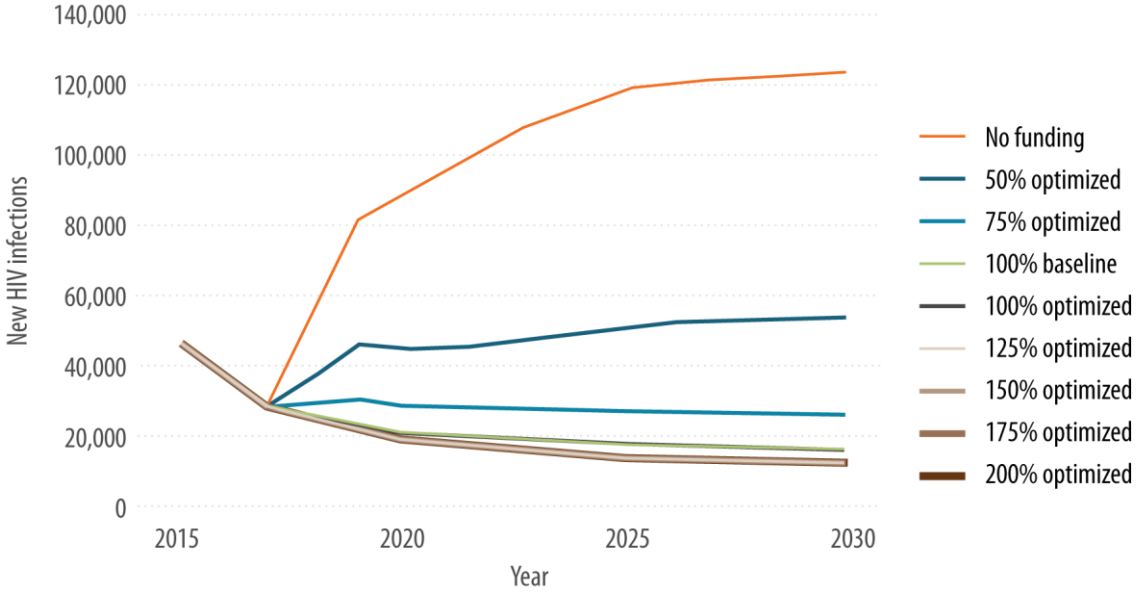
Source: Populated Optima HIV model, 2018.

Figure 3.3 Annual optimized allocations with varying budget and resulting estimated HIV-related deaths, 2018 to 2030



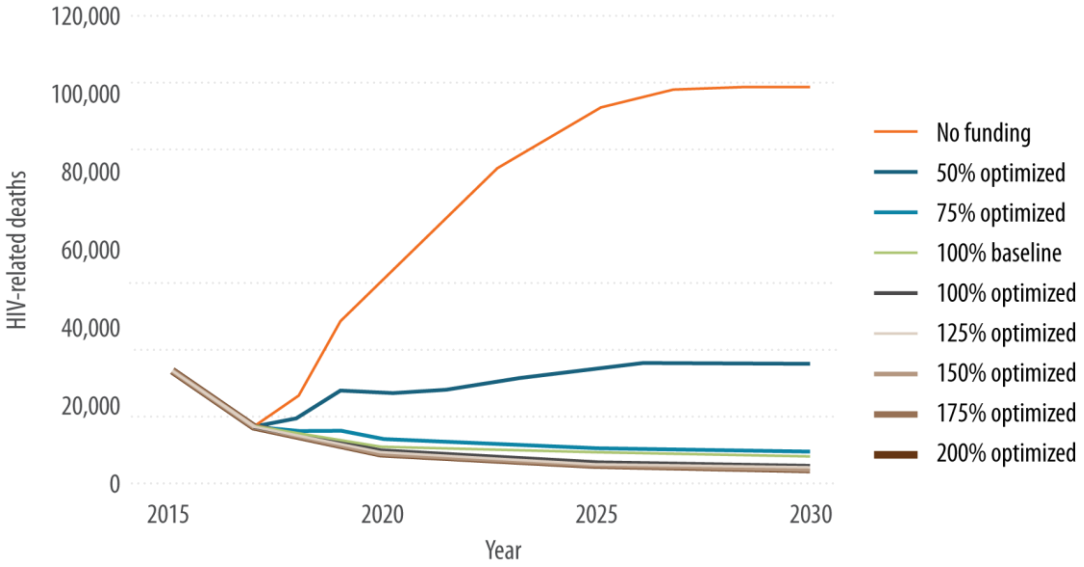
Source: Populated Optima HIV model, 2018.

Figure 3.4 Estimated new HIV infections with varying optimized budget, 2015–30



Source: Populated Optima HIV model, 2018.

Figure 3.5 Estimated HIV-related deaths with varying optimized budget, 2015–30

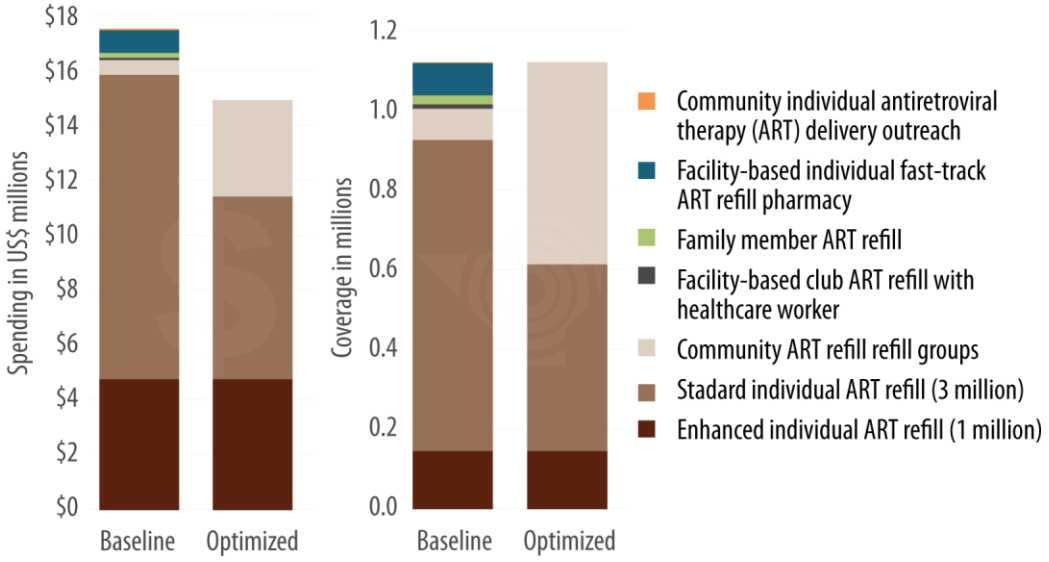


Source: Populated Optima HIV model, 2018.

Cost-savings may be possible through improved implementation efficiency of ART refill modalities. The cost-effectiveness of ART refill options were ranked and the ART budget was redistributed across the most cost-effective modalities; community based groups, three month standard individual refill and, one month enhanced individual refill. Ranked modalities can be seen in appendix 8. These values were used to derive differential unit cost values which were then incorporated into the Optima HIV model and used to optimize the coverage of ART refill across different saturation and population parameters. Optimized allocation of ART refill modalities prioritized community based refill groups. Switching 40% of stable PLHIV receiving standard ART refills to these groups may result in

an estimated US$ 2.7 million in savings (Figure 3.6). These savings should be optimally reinvested in further scaling up HIV testing.

Figure 3.6 Optimized budget allocation and coverage by ART refill modality from 2018 to 2030



Source: Populated Optima HIV model, 2018.

Switching from biennial routine VL monitoring to `VL lite' could improve implementation efficiency of the HIV response. VL lite is estimated to have a lower average unit cost ($27) compared to routine VL monitoring ($34). As 78% of all PLHIV on ART are eligible to switch, maintaining the current VL monitoring coverage of 30% and switching to VL lite for all eligible non-pregnant PLHIV on treatment could result in an estimated $210,000–$350,000 savings per year. Reinvesting these savings into the VL programme, could result in an increase of 16,000-44,000 treatment clients being covered by routine VL monitoring per year. Scaling the VL testing to program coverage limits (80%–95% of PLHIV on treatment) $5.6–$10.8 million per year could be saved by using VL lite over routine VL monitoring for eligible PLHIV on treatment.

Switching non-pregnant adults on ART to a Dolutegravir based regimen could result in $12 million to $18 million saved annually. A generic DTG-based regimen has a substantially lower unit cost ($135) and is 10-15% cheaper than the current regimens. Optimal reinvestments would prioritize further scale-up of ART as well as HIV testing and routine VL monitoring. Optimally reinvesting savings to these interventions could avert an additional 13K-14K new HIV infections and 4K-6K AIDS deaths by 2030.

If all implementation efficiencies explored by this analysis were to be rolled-out, an additional 15,000–18,000 new HIV infections could be averted by 2030. However, this would not be sufficient to reach the 2030 HIV incidence reduction target.

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4. RECOMMENDATIONS

While Zimbabwe's HIV testing and treatment budget is allocatively efficient, additional impact (small) could be achieved by prioritizing additional investment for HIV testing over routine VL monitoring and adherence; an additional 1% of new HIV infections (600 more infections) and <1% HIV-related deaths (200 more deaths) may be averted by 2030 compared with maintaining the latest 2017 allocation.

- **At minimum maintain the current total HIV budget.** This is to avoid reversing the gains made in the HIV response. As an example a 50% reduction in budget is estimated to result in a total 270,000 more HIV infections when compared to baseline 2018 to 2030.

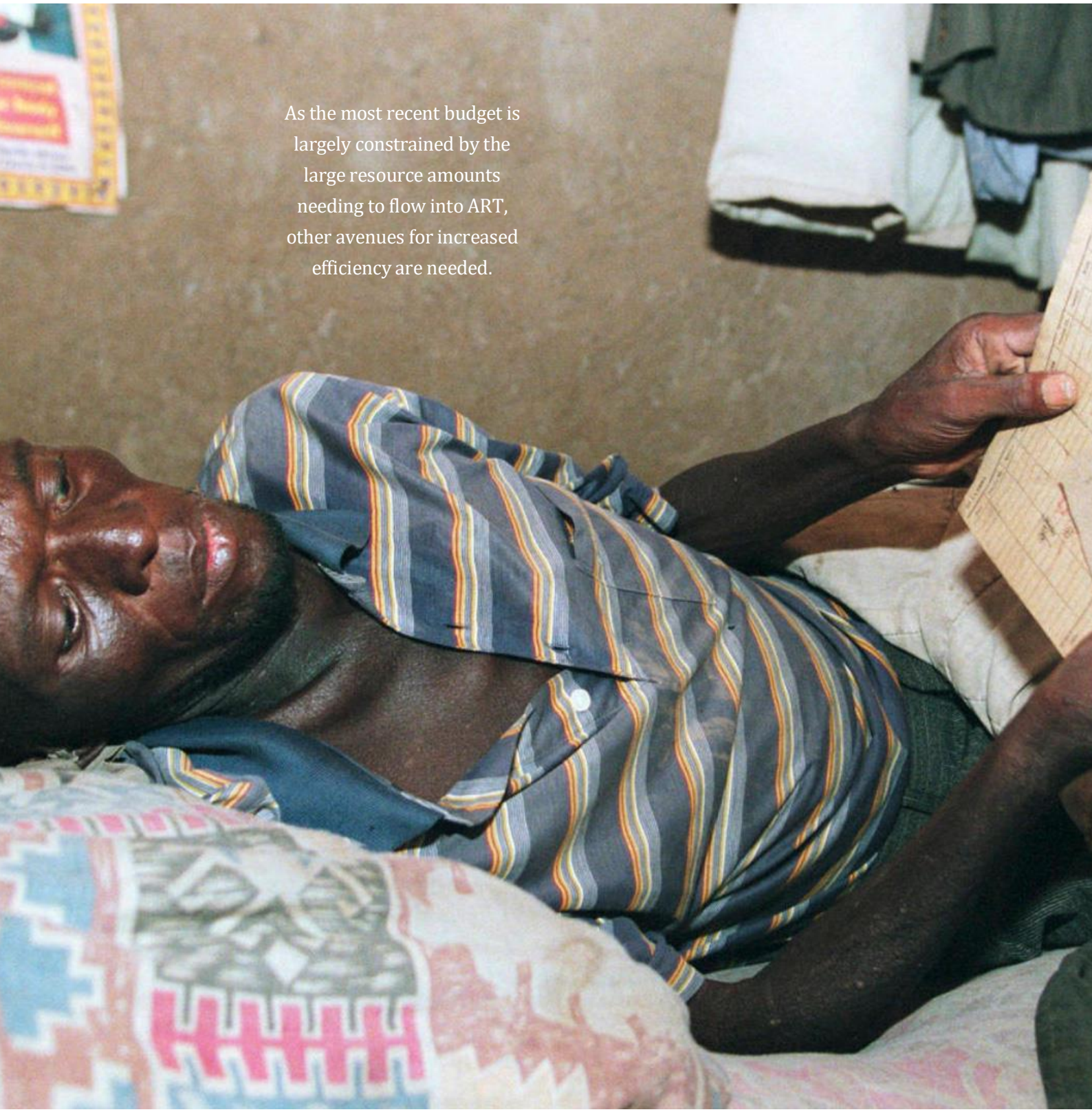
- **Consider increasing the HIV program budget by 25% to potentially achieve an 89% reduction of annual new infections in 2030 from 2010.** A 25% increase in budget under optimized allocation could also lead to additional 11,000 HIV-related deaths being averted from 2018-2030 compared with maintaining the latest reported level and budget allocation. Optimized budgets at higher level budgets prioritized adult testing and viral load monitoring to focus on increasing the number of adult PLHIV in the general population able to receive, and remain on effective treatment. It was shown that potential reductions in new HIV infections would be minimal past budget increases of 25%. This is due to decreasing marginal returns with increases of the current mix of HIV testing and treatment interventions as potential gains become saturated.

- **Consider new service delivery modalities and other sources of implementation efficiency.** As the most recent budget is largely constrained by the large resource amounts needing to flow into ART, other avenues for increased efficiency are needed. Implementation of cost-effective treatment delivery modalities (community-based ART groups), and switching to a DTG-based regime and VL lite for eligible PLHIV could be considered.

- **Additional interventions, including ARV prophylaxis and non-ART prevention, and innovations to further reduce service delivery costs and increase effectiveness will be required if Zimbabwe is to reach its 2030 incidence target.** Even with a doubling of budget for HIV testing and treatment, or by implementing efficiency strategies the 2030 HIV incidence reductions targets are unlikely to be met, meaning there are diminishing marginal returns with the current available 'toolbox' of interventions. In countries with large existing disease burdens such as Zimbabwe, reducing HIV incidence to such low levels is exceptionally hard and a long 'epidemiological tail' exists that needs to be addressed with personalised and pre-emptive HIV prevention strategies. Little

In countries with large existing disease burdens such as Zimbabwe, reducing HIV incidence to such low levels is exceptionally hard and a long 'epidemiological tail' exists that needs to be addressed with personalised and pre-emptive HIV prevention strategies.

evidence is available for transgender populations and consequently remain understudied. A further recommendation is to include this population as an at risk group. This will help to understand the epidemic amongst transgendered people and better tailor an appropriate response.



As the most recent budget is largely constrained by the large resource amounts needing to flow into ART, other avenues for increased efficiency are needed.

5. CONCLUSION

Zimbabwe has one of the world's highest incidence generalized HIV epidemic, which is declining due to (a) substantial investments in testing, treatment and care, (b) a good allocation of resources across programs, and (c) government commitment to sustained financing of the HIV response. Highest priority for Zimbabwe is to continue treatment scale-up through targeted testing towards the general population and treatment with a focus on viral load monitoring to achieve 90-90-90 targets and beyond. Despite annual incidence having peaked in 2002 an increased commitment to maintaining and improving testing, treatment coverage and adherence is needed into the future to continue encouraging progress.

Additional implementation efficiency gains, including optimized adult testing and ART refill service delivery modalities, along with switching eligible PLHIV on treatment to a DTG-based regimen and/or a VL lite strategy, may enable an increasingly strong response to HIV into the future. Finding areas for improved cost-savings without reducing coverage, or improving effectiveness with reducing cost may be important in the face of potential austerity towards HIV spending. Zimbabwe uses a wide mix of HIV testing, treatment and prevention programs. While some of these may be justified in particular contexts, to reach all people, with limited resources, the greatest impact can be achieved by using the most cost-effective delivery mechanisms. A thorough review of the funds spent on modalities with higher unit costs or lower effectiveness is recommended.

In addition to the efficiency gains identified for the HIV testing and treatment response in this report, a range of efficiency gains could be explored across the health sector including: evidence-informed prioritization; results-based approaches to financing while considering disease burden and cost-effectiveness; active performance management of facilities and other implementers; improved patient-level tracking systems including electronic health records; enhanced accountability in use of resources; and optimized procurement while maximizing use of generic products.

The primary benefit of optimization to improve allocative and implementation efficiency lies in creating an objective platform to make evidence-informed resource decisions. This is with the caveat that modelling relies on strong assumptions of data quality and the impact of targeted and non-targeted programs. Deploying the recommendations provided in this report should consider the costs and benefits of using optimization as a basis for resource allocation.

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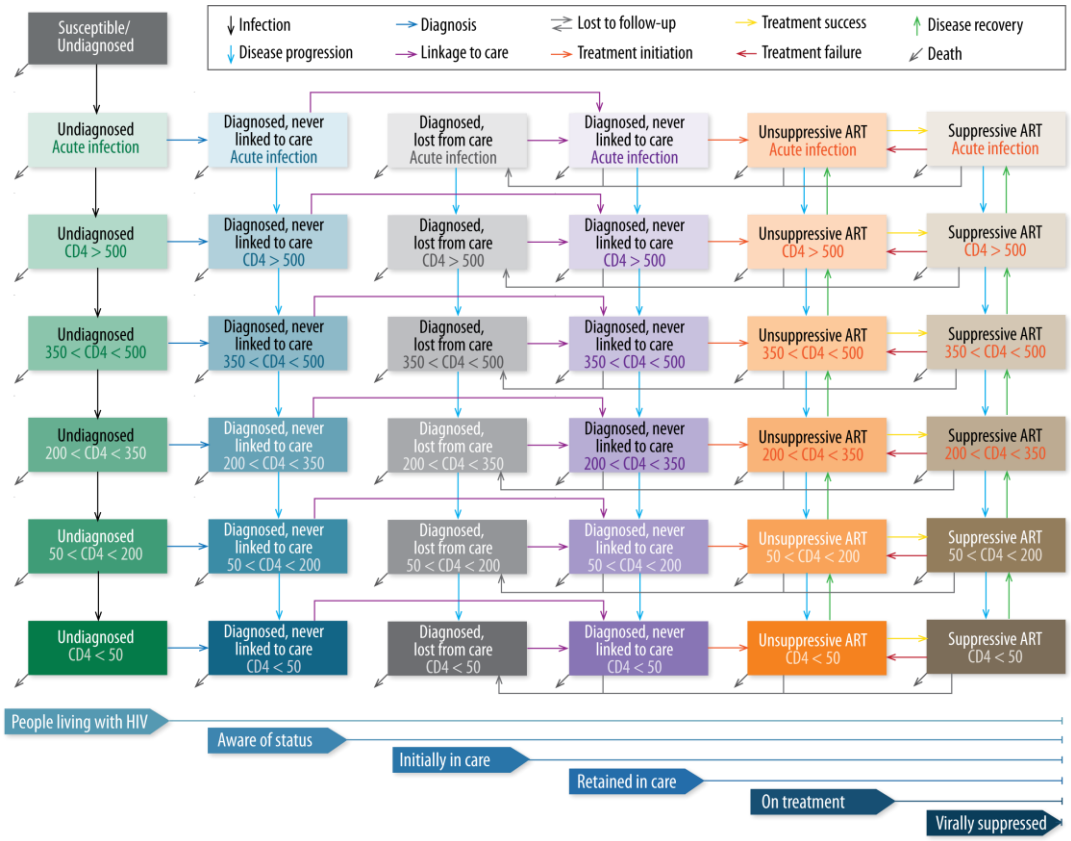
APPENDICES

Appendix A OPTIMA HIV MODEL

This appendix provides a brief technical overview of Optima. A more detailed summary of the model and methods is provided elsewhere.[5] Optima is based on a dynamic, population-based HIV model. Figure A.1 shows the disease progression implemented in the model. Optima tracks the entire population of people living with HIV (PLHIV) across stages of CD4 count. Key aspects of the antiretroviral therapy (ART) service delivery cascade are included. Figure A.2 provides a summary of the populations and mixing patterns used in the Optima HIV.

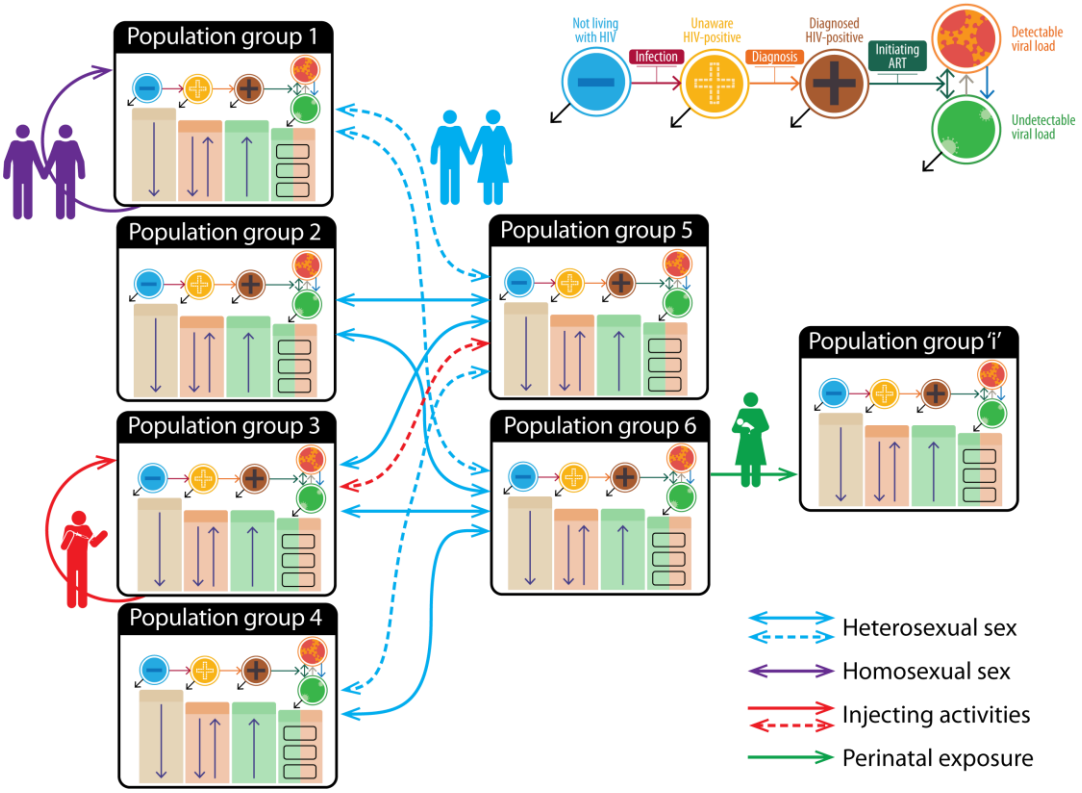
Figure A.1 Compartmental HIV health states and transmission-related interactions across the care cascade as represented in Optima HIV



Source: Kerr, 2015.[5]

Schematic diagram of the health state structure of the model. Each compartment represents a single population group with the specified health state while each arrow represents the movement of numbers of individuals between health states. All compartments except for susceptible represent people living with HIV. Death includes all causes of death.

Figure A.2 Risk-based population mixing patterns represented in Optima HIV



Source: Kerr, 2015.[5]

The model uses a linked system of ordinary differential equations to track the movement of PLHIV between HIV health states; the full set of equations can be accessed via the Optima supplementary index provided in the overall population is partitioned in 2 ways: by population group and by HIV health state. Individuals are assigned to a given population group based on their dominant risk. [9] HIV infections occur through the interaction between 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, and it 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 (i.e., n gives the average number of interaction events with HIV-infected people where HIV transmission may occur).

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

There is one force-of-infection term for each type of interaction [e.g., 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. In addition to the force-of-infection rate, which is the number of individuals who become infected with HIV per year, there are 7 other ways individuals may change health states. 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.

Appendix B POPULATION SIZE, HIV PREVALENCE, TESTING RATES FOR LAST YEAR REPORTED

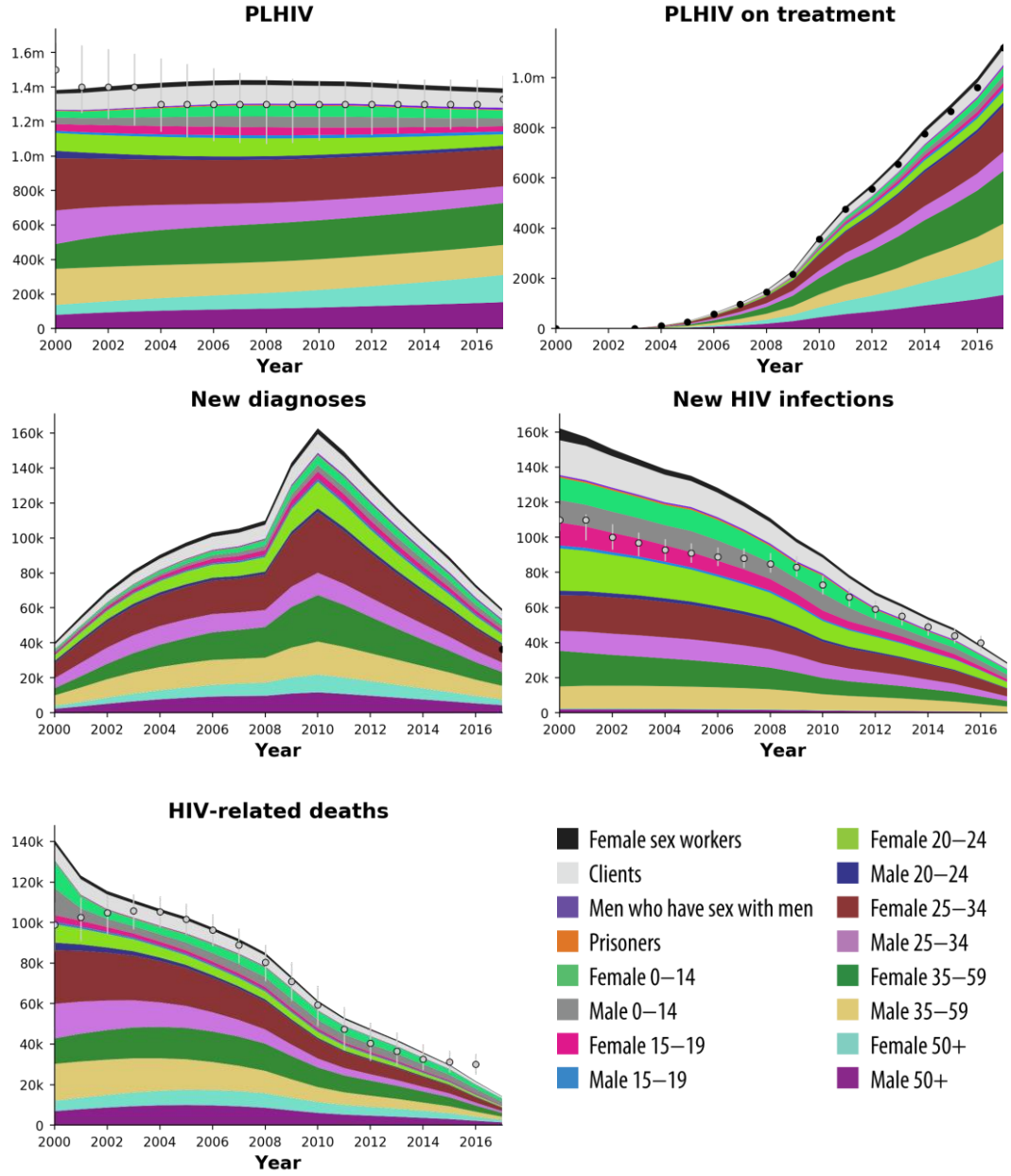
Table B.1 Population size, HIV prevalence, and HIV testing rates used to inform the Optima HIV model

Population	Population size (2017)[a]	HIV prevalence (year last reported)	Testing rates (2015)[h]
FSW	45,450	56.1%[b] (2017)	72.0%
Clients	288,337	15.8%[c] (2015)	35.9%
MSM	47,662	23.5%[d] (2013)	35.9%
Prisoners	18,014	26.8%[e] (2012)	35.9%
F0–14	2,828,426	1.5%[f] (2016)	29.8%
M0–14	2,817,896	1.7%[f] (2016)	19.4%
F15–19	739,260	3.9%[g] (2016)	29.8%
M15–19	652,338	3.2%[g] (2016)	19.4%
F20–24	676,406	8.1%[g] (2016)	57.8%
M20–24	507,020	2.7%[g] (2016)	37.7%
F25–34	1,129,488	18.2%[g] (2016)	58.6%
M25–34	898,767	9.3%[g] (2016)	47.1%
F35–49	847,664	28.2%[g] (2016)	46.7%
M35–49	739,087	23.7%[g] (2016)	39.0%
F50+	859,891	17.2%[g] (2016)	38.5%
M50+	631,788	23.0%[g] (2016)	35.8%

Notes: [a] = ZimStat 2013 projections[22]; [b] = 2018 Global AIDS Monitoring draft report, based on CeSHHAR routine monitoring; [c] = NAC expert opinion from workshop May 2018; [d] = Biomedical Remote Training Institute (BRTI); [e] = Personal communication with NAC representative May 2018 based on draft HIV report focusing on prisoners; [g] = Ministry of Health and Child Care (MOHCC), Zimbabwe. Zimbabwe Population-Based HIV Impact Assessment (ZIMPHIA) 2015–16: First Report. Harare, MOHCC. July 2017.

Appendix C MODEL CALIBRATION

Figure C.1 Calibration graphs for people living with HIV (PLHIV), new diagnoses, PLHIV on treatment, new HIV infections, and HIV-related deaths



Source: Populated Optima HIV model, 2018; plotted values sourced from AIDSinfo[2].

Figure C.2 Calibration graphs of HIV prevalence by population

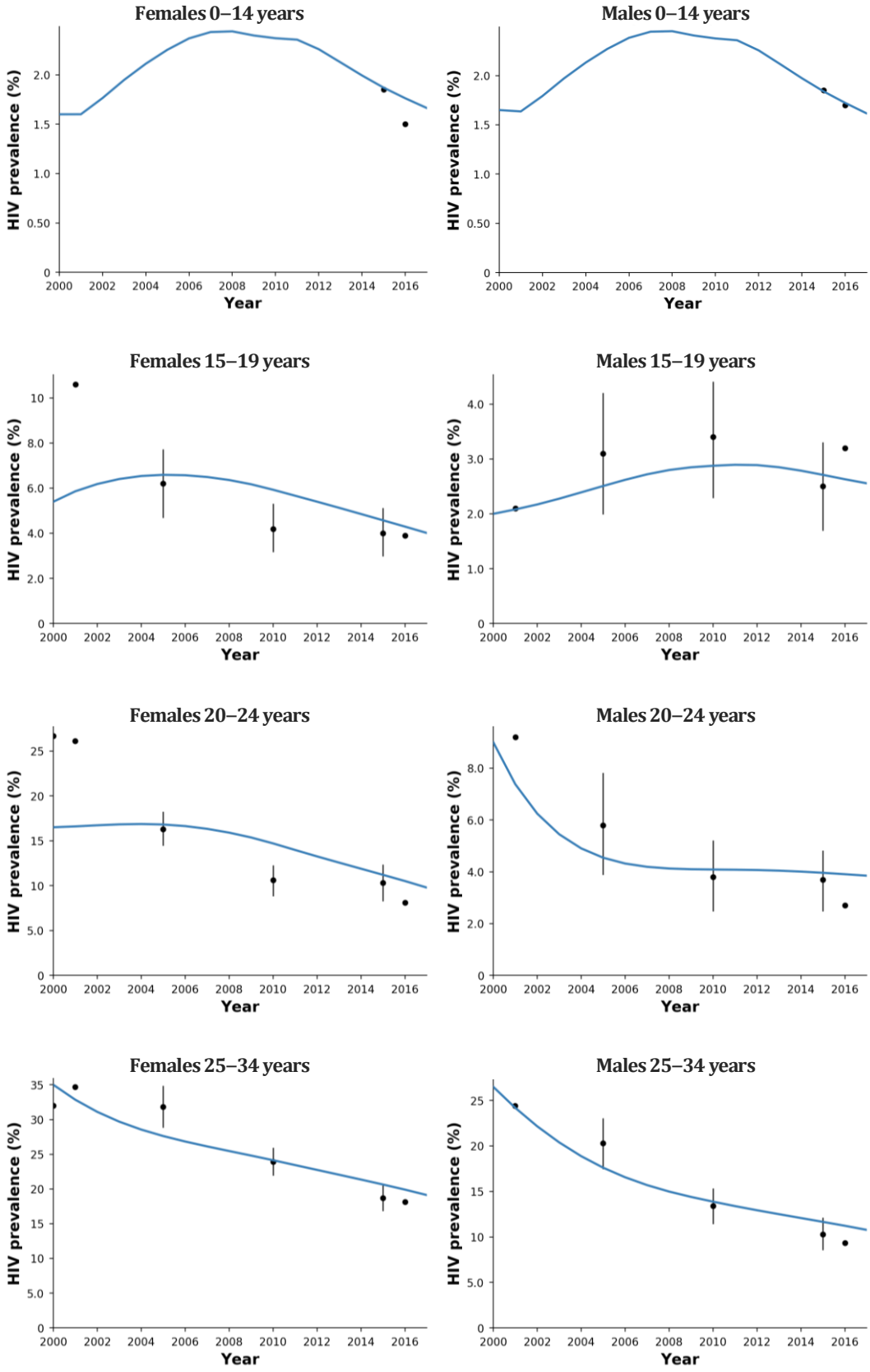
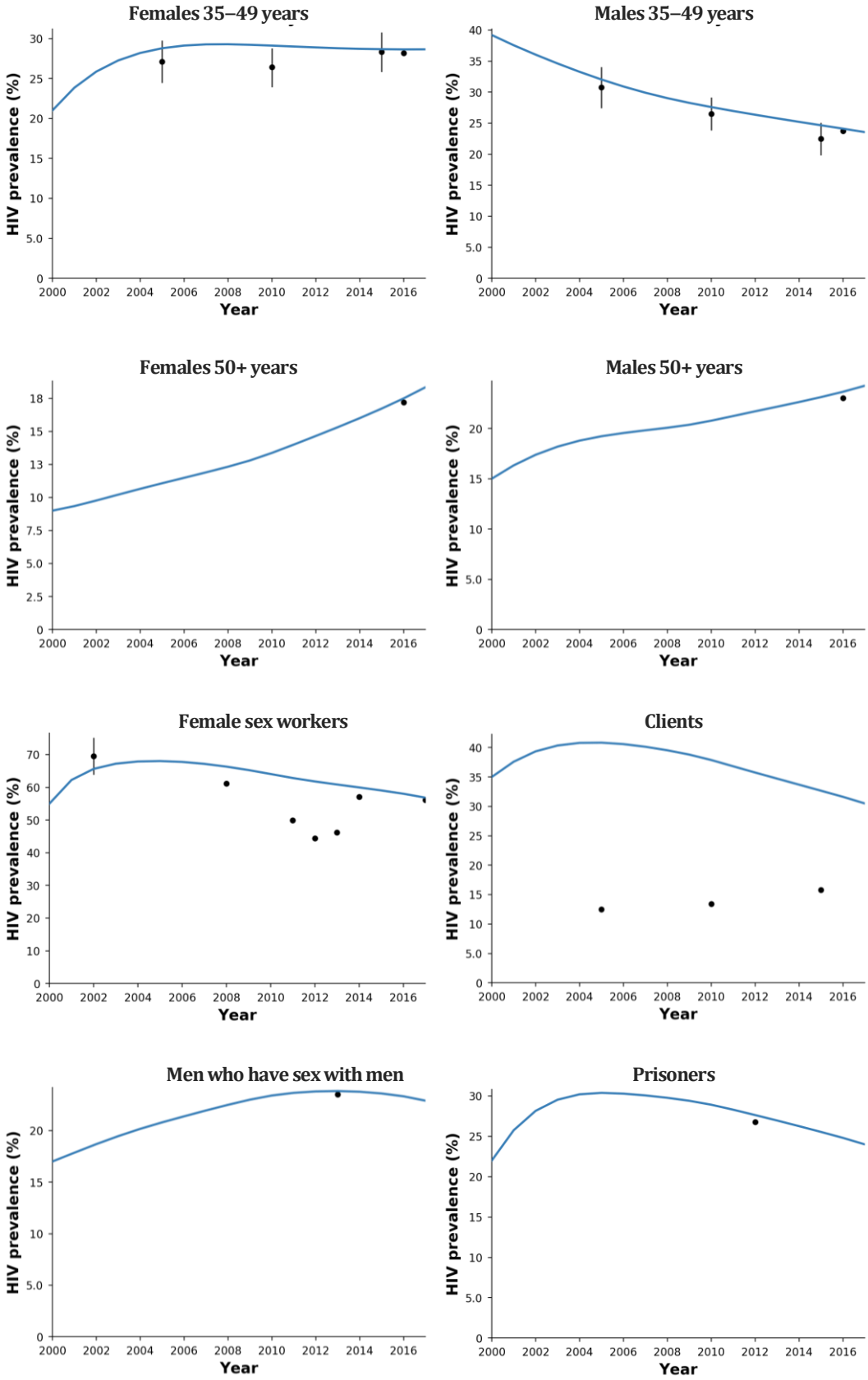


Figure C.2 continued

Figure C.2 Calibration graphs of HIV prevalence by population (continued)



Source: Populated Optima HIV model, 2018.

Appendix D MODEL PARAMETERS

Table D.1 Model parameters for HIV transmissibility and progression

MODEL PARAMETERS	
Interaction-related transmissibility (% per act)	
Insertive penile-vaginal intercourse	0.04%
Receptive penile-vaginal intercourse	0.08%
Insertive penile-anal intercourse	0.11%
Receptive penile-anal intercourse	1.38%
Mother-to-child (breastfeeding)	29.40%
Mother-to-child (non-breastfeeding)	17.00%
Relative disease-related transmissibility	
Acute infection	5.60
CD4 (>500)	1.00
CD4 (350–500)	1.00
CD4 (200–350)	1.00
CD4 (50–200)	3.49
CD4 (<50)	7.17

Source: Optima HIV User Guide Volume VI, 2019[23].

Table D.2 Model parameters for disease progression

MODEL PARAMETERS	
Disease progression (average years to move)	
Acute to CD4 (>500)	0.24
CD4 (500) to CD4 (350–500)	0.95
CD4 (350–500) to CD4 (200–350)	3.00
CD4 (200–350) to CD4 (50–200)	3.74
CD4 (50–200) to CD4 (<50)	1.50

Source: Optima HIV User Guide Volume VI, 2019.[23]

Table D.3 Model parameters for treatment recovery and CD4 change due to non-suppressive ART

MODEL PARAMETERS	
Treatment recovery due to suppressive ART (average years to move)	
CD4 (350–500) to CD4 (>500)	2.20
CD4 (200–350) to CD4 (350–500)	1.42
CD4 (50–200) to CD4 (200–350)	2.14
CD4 (<50) to CD4 (50–200)	0.66
Time after initiating ART to achieve viral suppression (years)	0.20
Number of VL tests recommended per person per year	0.85
CD4 change due to non-suppressive ART (% per year)	
CD4 (>500) to CD4 (350–500)	3.00%
CD4 (350–500) to CD4 (>500)	15.00%
CD4 (350–500) to CD4 (200–350)	10.00%
CD4 (200–350) to CD4 (350–500)	5.00%
CD4 (200–350) to CD4 (50–200)	16.00%
CD4 (50–200) to CD4 (200–350)	12.00%
CD4 (50–200) to CD4 (<50)	9.00%
CD4 (<50) to CD4 (50–200)	11.00%

Source: Optima HIV User Guide Volume VI, 2019.[23]

Table D.4 Model parameters for death rate

MODEL PARAMETERS	
Death rate (% mortality per year)	
Acute infection	0.00%
CD4 (>500)	0.00%
CD4 (350–500)	1.00%
CD4 (200–350)	1.00%
CD4 (50–200)	6.00%
CD4 (<50)	29.00%
Relative death rate on suppressive ART	23.00%
Relative death rate on non-suppressive ART	84.00%
Tuberculosis cofactor	217.00%

Source: Optima HIV User Guide Volume VI, 2019.[23]

Table D.5 Model parameters for changes in transmissibility and disutility weights

MODEL PARAMETERS	
Changes in transmissibility (%)	
Condom use	85.00%
Circumcision	58.00%
Diagnosis behavior change	0.00%
STI cofactor increase	265.00%
PMTCT	93.00%
Pre-exposure prophylaxis	73.00%
Suppressive ART	80.00%
Unsuppressive ART	30.00%
Disutility weights	
Untreated HIV, acute	0.146
Untreated HIV, CD4 (>500)	0.008
Untreated HIV, CD4 (350–500)	0.020
Untreated HIV, CD4 (200–350)	0.070
Untreated HIV, CD4 (50–200)	0.265
Untreated HIV, CD4 (<50)	0.547
Treated HIV	0.053

Source: Optima HIV User Guide Volume VI, 2019.[23]

Appendix E COST FUNCTIONS

Figure E.1 Model cost-coverage curves by HIV program or service delivery modality

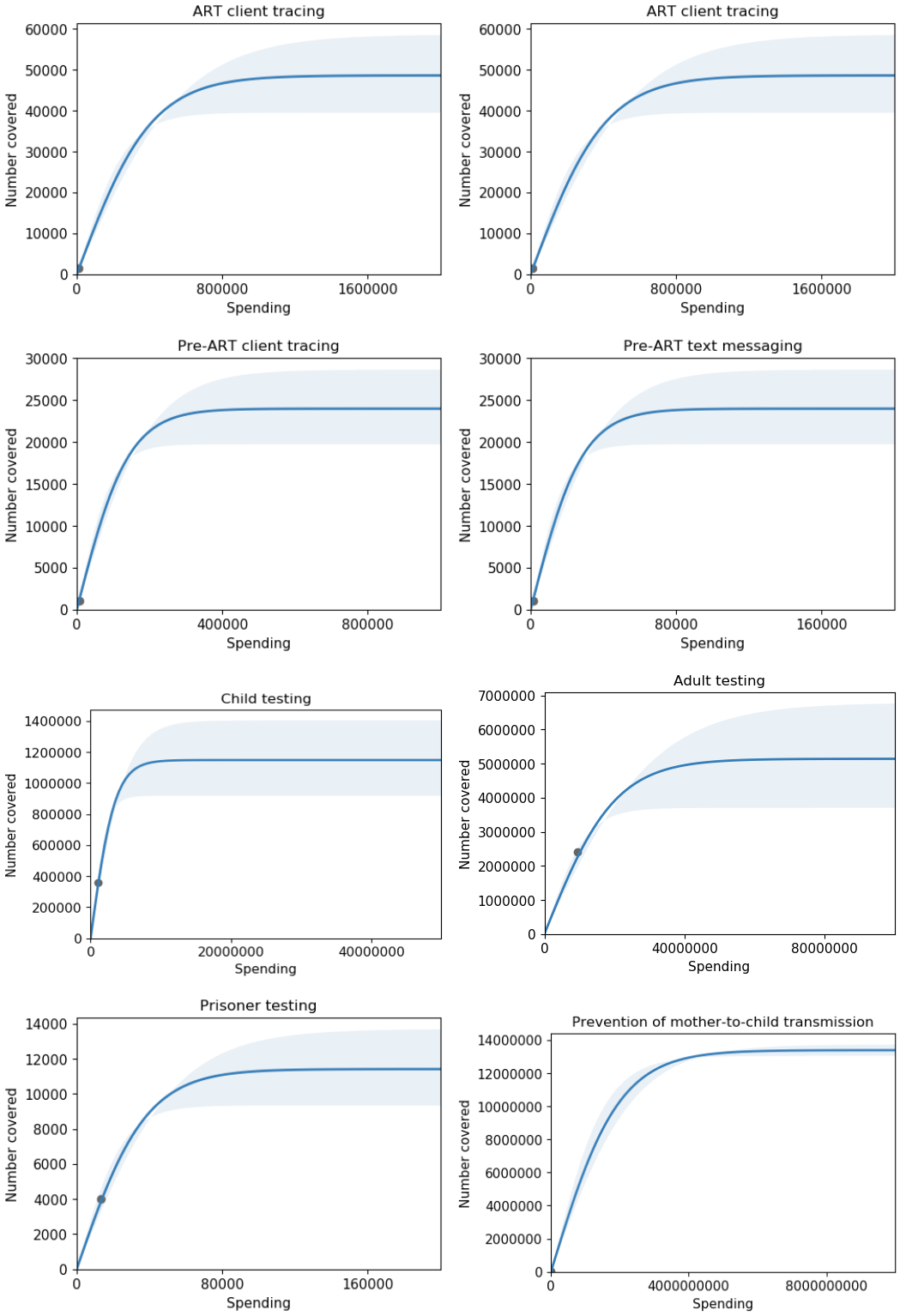
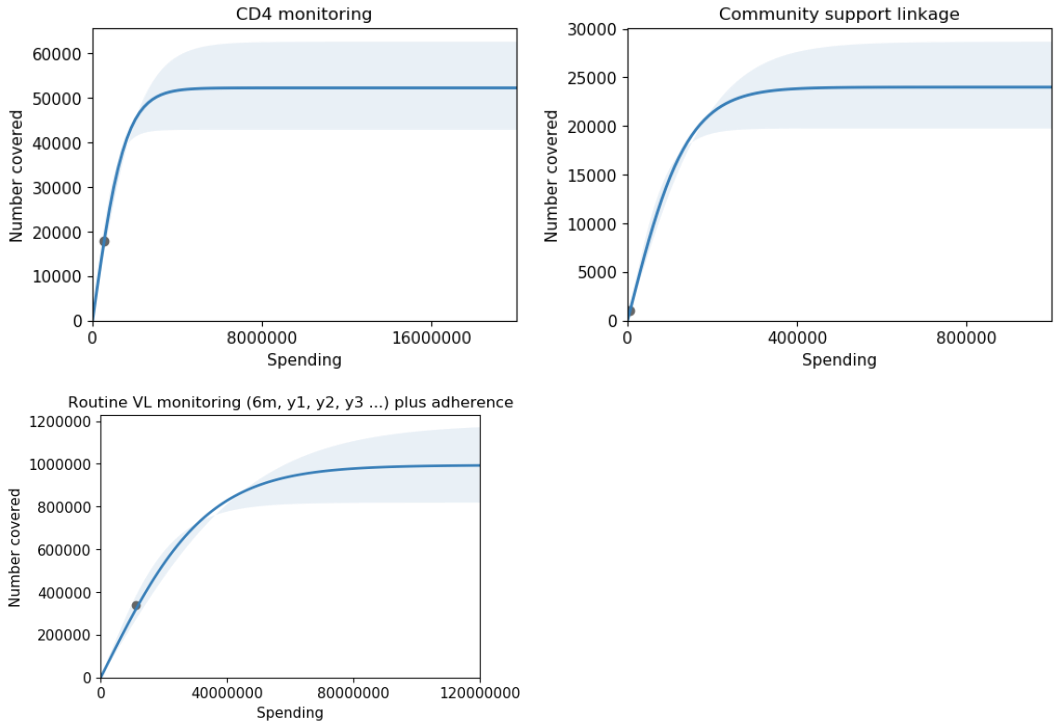


Figure E.1 continued

Figure E.1 Model cost-coverage curves by HIV program or service delivery modality (continued)



Source: Populated Optima HIV model, 2018

Appendix F RANKING FOR ADULT HIV TESTING MODALITIES

Table F. 2 Average unit cost, penalties, and yield used to derive rankings for adult HIV testing modalities

Adult HIV testing program	Average unit cost (USD)	Unit cost penalty[a]	Yield	Yield penalty[b]	Total penalty	Ranking
Partner self-testing (via HIV+ partner)	$3.84	0.0253	25.58%	0.0000	0.0253	1
Index female partner HTS - facility-based	$3.37	0.0041	17.47%	0.3217	0.3258	2
Index male partner HTS - facility-based	$3.36	0.0036	15.32%	0.4068	0.4104	3
HIV testing services for female sex workers (HTS FSW)	$4.62	0.0605	14.85%	0.4257	0.4862	4
Provider initiated testing and counselling (PITC) for those co-infected with tuberculosis (TB)	$3.38	0.0048	11.42%	0.5619	0.5667	5
Outpatient department (OPD) testing	$3.32	0.0020	9.00%	0.6579	0.6599	6
Health-facility based self-testing (OPD)	$3.59	0.0141	9.00%	0.6579	0.6720	7
PITC STI	$3.36	0.0036	8.63%	0.6723	0.6759	8
PITC inpatient ward	$3.34	0.0027	6.44%	0.7593	0.7619	9
Voluntary counselling and testing (VCT) stand-alone	$3.31	0.0013	5.88%	0.7815	0.7827	10
VCT site-based self-testing	$3.54	0.0120	5.88%	0.7815	0.7934	11
Community-worker led self-testing	$3.50	0.0102	3.20%	0.8879	0.8981	12
Partner self-testing (via HIV- partner)	$3.50	0.0102	3.20%	0.8879	0.8981	13
HTS workplace	$4.49	0.0548	3.56%	0.8737	0.9286	15
PITC FP	$3.29	0.0006	1.65%	0.9495	0.9501	16
Mobile self-testing	$4.70	0.0642	3.20%	0.8879	0.9521	17
HTS campaigns	$4.49	0.0545	2.15%	0.9295	0.9840	18
Index female partner HTS - community-based	$25.48	1.0000	25.58%	0.0000	1.0000	19
PITC VMMC	$3.28	0.0000	0.38%	1.0000	1.0000	20
Index male partner HTS - community-based	$25.48	1.0000	25.58%	0.0000	1.0000	21

Notes: [a] = Unit cost penalty was calculated as the unit cost for a given modality minus the minimum unit cost for all adult testing modalities, this is divided by the difference between the maximum unit cost for all adult testing modalities and the minimum unit cost for all adult testing modalities, as follows: (modality unit cost – min unit cost all modalities)/(max unit cost all modalities – min unit cost all modalities); [b] = Yield penalty was calculated as one minus, the yield for a given modality minus the minimum yield for all adult testing modalities, this is divided by the difference between the maximum yield for all adult testing modalities and the minimum yield for all adult testing modalities, as follows: 1 – [(modality yield – min yield all modalities)/(max yield all modalities – min yield all modalities)]; Total penalty was calculated by multiplying the unit cost penalty by the yield penalty; Unit cost values were calculated using data from the Ministry of Health and Child Care[24].

Appendix G RANKING FOR ART REFILL MODALITIES

Table G. 1 Average unit cost and upper saturation values used to derive rankings for ART refill modalities

ART refill modality	Average unit cost (USD)[a]	Saturation (upper bound)	Ranking
Community ART refill groups	$6.68	50%	1
Facility-based club ART refill with healthcare worker (HCW)	$8.04	50%	2
Family member ART refill	$8.13	50%	3
Facility-based individual fast-track ART refill pharmacy	$10.11	70%	4
Community individual ART delivery outreach	$17.56	50%	5

Note: [a] = Unit costs calculated based on data sourced from the Ministry of Health and Child Care (MOHCC), the International Training and Education Center for Health, Organization for Public Health intervention and development, Population Services International (PSI), Family Health International (FHI), and the Elizabeth Glaser Pediatric AIDS Foundation.

Table G. 2 Average unit cost, saturation, and model constraints for enhanced and standard individual ART refill modalities

ART refill modality	Average unit cost (USD)[a]	Saturation (upper bound)	Model constraint
Enhanced individual ART refill (1 month visit spacing)	$32.53	100%	No transfer away from this modality
Standard individual ART refill (3 month visit spacing)	$14.11	60% (100% for all other analysis)	40% transferred from this modality to highest ranked modality up to saturation

Note: [a] = Unit costs calculated based on data sourced from the Ministry of Health and Child Care (MOHCC), the International Training and Education Center for Health, Organization for Public Health intervention and development, Population Services International (PSI), Family Health International (FHI), and the Elizabeth Glaser Pediatric AIDS Foundation. *Outcomes for the variable budget optimization*

Appendix H OUTCOMES FOR THE VARIABLE BUDGET OPTIMIZATION

Table H. 1 Estimated impact on new HIV infections through optimization of variable budget levels compared with 100% budget under latest reported allocation

	ESTIMATED NEW HIV INFECTIONS						
Budget level and allocation	in 2017	in 2018	in 2030	Cumulative 2018–30	Averted or additional 2018–30	% averted or additional 2018–30	Averted or additional
50% optimized	28,758	37,036	53,703	637,507	387,317	+155.0%	Additional
75% optimized	28,758	29,453	26,175	362,324	112,134	+45.0%	Additional
90% optimized	28,758	25,391	19,512	284,296	34,106	+13.6%	Additional
95% optimized	28,758	25,007	17,551	265,629	15,439	+6.2%	Additional
100% baseline	28,758	24,964	16,064	250,190	NA	NA	NA
100% optimized	28,758	24,980	15,972	249,554	636	- <1.0%	Averted
105% optimized	28,758	24,958	14,633	236,548	13,642	- 5.5%	Averted
110% optimized	28,758	24,922	14,010	229,276	20,914	- 8.4%	Averted
125% optimized	28,758	24,762	13,386	221,510	28,680	- 12.0%	Averted
150% optimized	28,758	24,698	13,232	219,580	30,610	- 12.0%	Averted
175% optimized	28,758	24,675	13,225	219,467	30,723	- 12.0%	Averted
200% optimized	28,758	24,672	13,224	219,448	30,742	- 12.0%	Averted

Note: NA=not applicable.

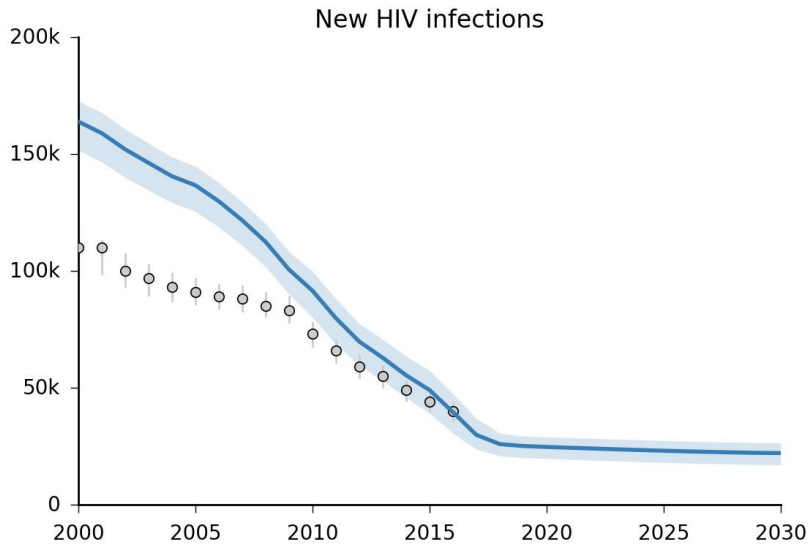
Table H. 2 Estimated impact on HIV-related deaths through optimization of variable budget levels compared with 100% budget under latest reported allocation

	ESTIMATED HIV-RELATED DEATHS						
Budget level and allocation	in 2017	in 2018	in 2030	Cumulative 2018–30	Averted or additional 2018–30	% averted or additional 2018–30	Averted or additional
50% optimized	14,192	16,815	30,765	351,536	269,547	+329.0%	Additional
75% optimized	14,192	13,454	8,224	129,630	47,641	+58.0%	Additional
90% optimized	14,192	11,182	5,456	95,474	13,485	+16.0%	Additional
95% optimized	14,192	11,039	4,504	87,409	5,420	+7.0%	Additional
100% baseline	14,192	11,013	3,963	81,989	NA	NA	NA
100% optimized	14,192	11,031	3,896	81,746	243	- <1.0%	Averted
105% optimized	14,192	11,019	3,446	77,661	4,328	- 5.0%	Averted
110% optimized	14,192	10,995	3,151	74,477	7,512	- 9.0%	Averted
125% optimized	14,192	10,860	2,867	70,553	11,436	- 14.0%	Averted
150% optimized	14,192	10,806	2,767	69,188	12,801	- 16.0%	Averted
175% optimized	14,192	10,786	2,763	69,113	12,876	- 16.0%	Averted
200% optimized	14,192	10,783	2,763	69,104	12,885	- 16.0%	Averted

Note: NA=not applicable.

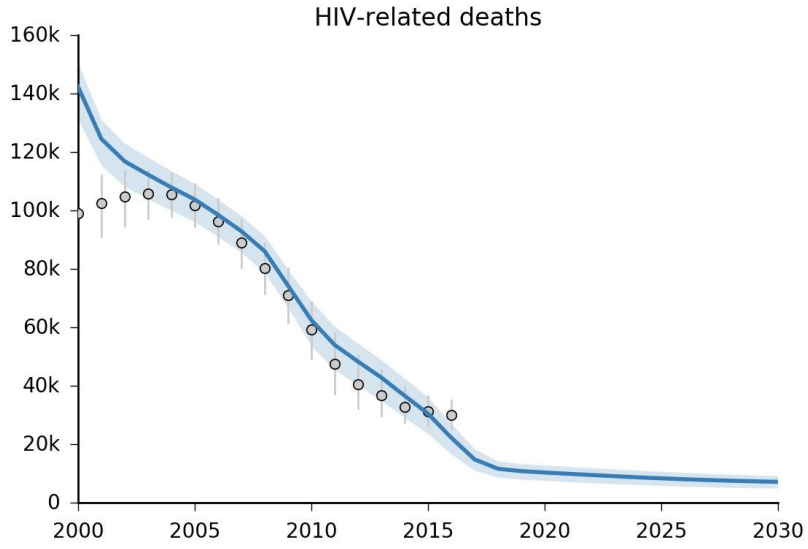
Appendix I UNCERTAINTY

Figure I. 1 Estimated number of new HIV infections under optimized budget from 2018 to 2030 with uncertainty (shaded area)



Source: Populated Optima HIV model, 2018. Source for plotted values (white dots): AIDSinfo.

Figure I. 2 Estimated number of HIV-related deaths under optimized budget from 2018 to 2030 with uncertainty



Source: Populated Optima HIV model, 2018. Source for plotted values (white dots): AIDSinfo.