Analyses for impact, efficiency, and sustainability of priority key population HIV services in Asia: Bhutan

2023

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Abbreviations

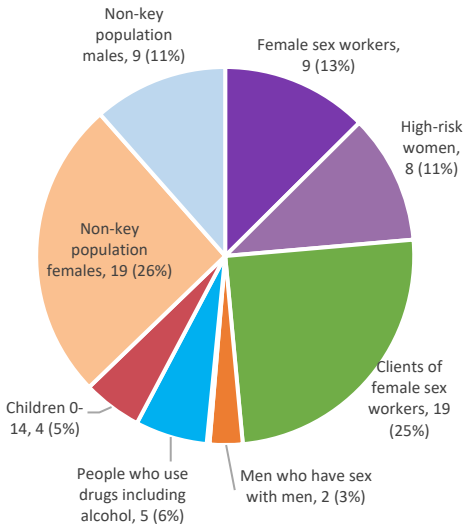
AIDS	Acquired immunodeficiency syndrome
ART	Antiretroviral therapy
ARV	Antiretroviral
BAU	Business as usual
BNCA	Bhutan Narcotics Control Agency
CBO	Community-based organisation
CSO	Civil society organisation
DIC	Drop-in-centre
HISC	Health information service centre
HIV	Human immunodeficiency virus
HTS	HIV testing services
HSS	HIV sentinel surveillance
IBBS	Integrated Biological and Behavioural Surveillance
KP	Key population (at risk of HIV transmission)
LGBTQI	Lesbian, gay, bisexual, transgender, queer and intersex
MSM	Men who have sex with men
NGO	Non-governmental organization
NACP	National AIDS control program
NSP	National Strategic Plan
PLHIV	People living with HIV
PMTCT	Prevention of mother-to-child transmission
PrEP	Pre-exposure prophylaxis
RGoB	Royal Government of Bhutan
SKPA	Sustainability of HIV Services for Key Populations in Asia
STI	Sexually transmitted infection
TGW	Transgender women
UNAIDS	Joint United Nations Program on HIV/AIDS
VL	Viral load
WHO	World Health Organization

Executive summary

A concentrated HIV epidemic centered around female sex work, their clients and regular partners

Bhutan has maintained a remarkable low-level HIV epidemic with less than 100 estimated annual new HIV infections since 2011. Still, there has not been any prior comprehensive modelling of the pathways to HIV infection by key populations, which is necessary to target HIV prevention programs most effectively with optimal resource allocation. An allocative efficiency analysis led by the National HIV, AIDS & STIs Control Program (NACP) conducted in 2022, with technical and financial support through the Sustainability of HIV Services for Key Populations in Asia program (SKPA program), explored pathways to transmission and subsequent resource optimisation using the Optima HIV model.[1]

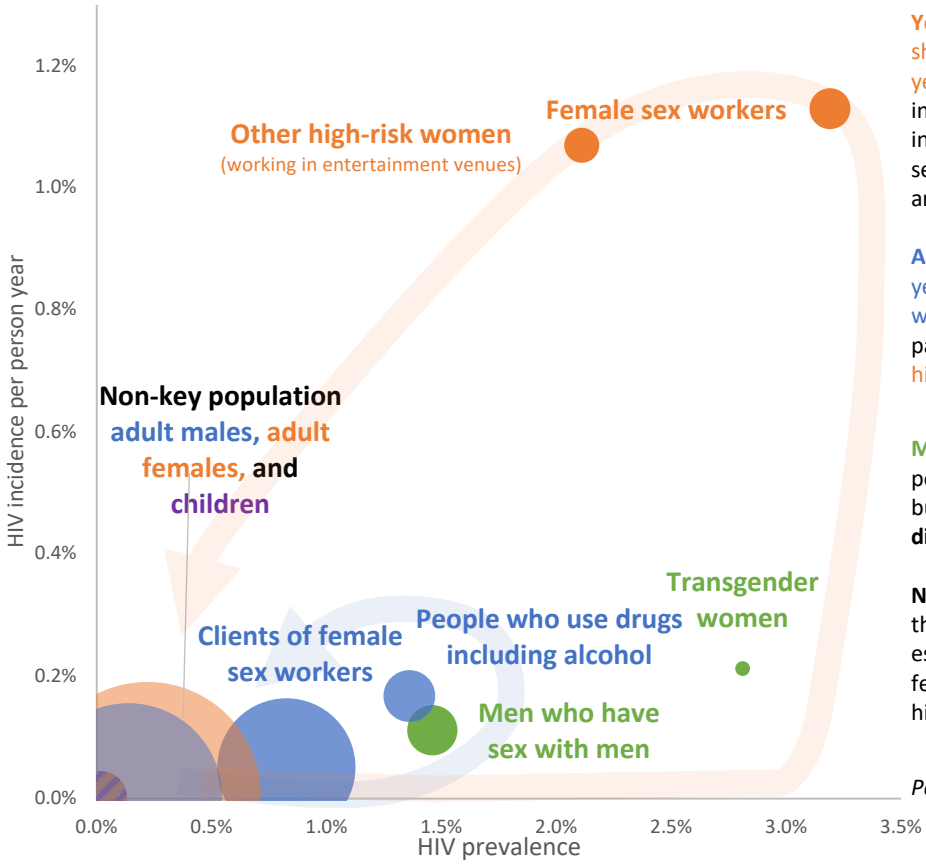
Optima HIV modelled proportion of new HIV infections (n=76) in Bhutan by population, 2021



Overall trends were closely calibrated to match national Spectrum projections for new HIV infections (peaking between 2003 and 2005 and steadily decreasing), total people living with HIV (continuing to increase to an estimated 1,341 in 2021), and HIV-related deaths (reducing more rapidly since 2015 in line with the rapid scaling up of HIV treatment in Bhutan). Calibration of the model was conducted to align with emerging national research into the population size estimates for key populations,[2] risk attribution of HIV infections (highlighting that from 1993 to 2019, more than 50% of new HIV infections could be attributed to transactional sex),[3] and behavioural dynamics of key populations,[4,5] supplemented by qualitative feedback from stakeholder discussions. Nearly half of new infections are estimated to be among female sex workers, other women with high-risk, and clients of female sex workers.

Mapping of HIV transmission pathways and the epidemic situation in Bhutan, 2021

Mapping of HIV prevalence (horizontal), HIV incidence (vertical), and total number of people living with HIV in 2021 (bubble size)
Shaded arrows represent movement of people between non-key populations and key populations.



Young females (mostly aged 20-24) may spend a short average duration as high-risk women (1.5 years) and/or female sex workers (3 years). working in high-risk venues where they are vulnerable to infection through partnerships with clients of female sex workers and people who drugs including alcohol, and then return to the non-key population.

Adult males of all ages may spend an average of 11 years as clients of female sex workers and/or males who use drugs including alcohol including partnerships with female sex workers and other high-risk women.

Men who have sex with men and transgender populations account for few people living with HIV but have rising prevalence and remain at **disproportionate risk.**

Non-key populations may account for over one third of new HIV infections, but the vast majority are estimated to be regular female partners of clients of female sex workers and male partners of previously high-risk women or female sex workers.

Populations are further defined in Appendix D

[1]NACP. Sustainability of HIV services for key populations in Bhutan: Findings from an Optima analysis. 2022.
[2]NACP. Mapping and population size estimation of men who have sex with men, transgender persons and high-risk women in Bhutan. 2020.
[3]NACP. Retrospective risk assessment of current living HIV cases diagnosed from 1993-2020. 2021.
[4]School of Planning Monitoring Evaluation and Research. IBBS survey among vulnerable and key peoples at higher risk in Bhutan. 2016.
[5]Khandu L, et al. HIV vulnerability and sexual risk behaviour of the Drayang girls in Bhutan. SAARC J.Tuberculosis, Lung Diseases and HIV/AIDS. 2019.

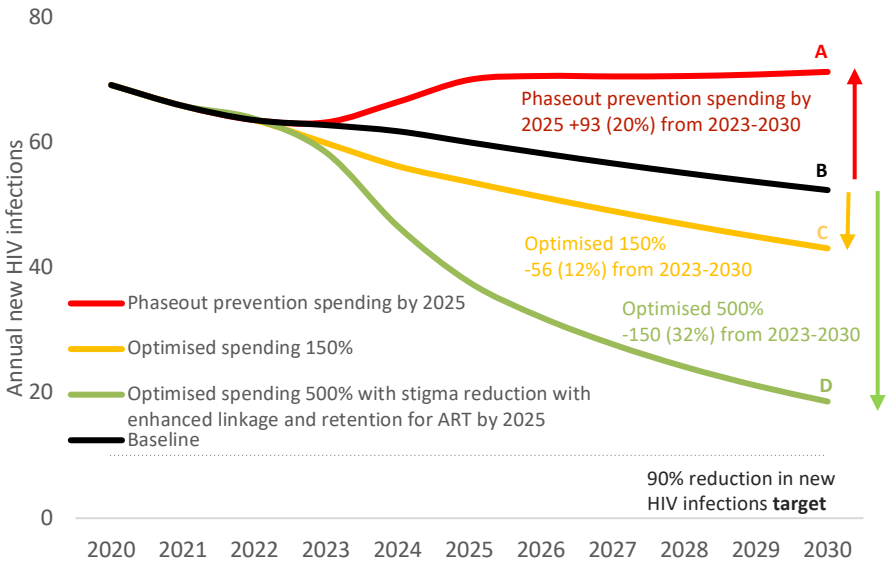
Optimising the resource allocation for targeted HIV prevention, testing and stigma reduction interventions

An estimated total of US$1.8M was spent on HIV in Bhutan in 2021, US$146,000 of this (less than 10%) was spent on targeted HIV prevention and testing and included in the analysis.

Scenarios were developed to optimise the resource allocation of targeted HIV prevention, testing and stigma reduction interventions to minimise new HIV infections and HIV-related deaths over 2023-2030.

Stigma reduction was considered an enabling intervention that could increase the proportion of each key population with accessible key population-focused HIV services (including self-testing) to 95%, by reducing structural barriers, including stigma and discrimination.

Projected impact of optimised spending on new HIV infections for four scenarios from 2020 to 2030



Expanded programmatic coverage of key populations has **accelerated baseline progress (B)** since 2018 in reducing HIV infections, and maintaining these programs is vital to avoid new infections increasing **(A)**.

There is an immediate opportunity to reduce new HIV infections through the investment of US$73,000 (150% of the current HIV prevention budget) to bring **current HIV prevention programs for key populations to capacity (C)**, but further expansion of these programs is limited by barriers to accessing HIV services.

Bringing the ambitious 2030 HIV targets within reach (D) will require expanded investment in innovative approaches (up to an additional US$586,000 per annum, 500% of current HIV prevention spending or 32% of the total HIV spending) that reduce stigma and related barriers to access to increase coverage of HIV prevention and testing, intensify HIV prevention through access to PrEP, reach people who have experienced historic risk for case detection, and enhance linkage and retention of ART.

Fully meeting the targets will require ongoing innovation in response to emerging evidence around the HIV epidemic in Bhutan, while implementation efficiencies may reduce the expanded investment necessary.

Key recommendations

Bhutan has a low prevalence HIV epidemic, emerging national research, innovative approaches available for implementation, civil society organizations that effectively support key populations, and strong government commitment to public health and stigma reduction for HIV. This Optima HIV analysis for HIV prevention and testing programs in Bhutan highlights the opportunities to maintain epidemic control of HIV with a modest additional investment, or to invest more substantially in achieving the elimination of HIV as a public health concern. Key recommendations are:

1. To minimise new HIV infections in Bhutan, focusing on the target of HIV elimination:
    - Expand coverage of comprehensive outreach HIV prevention and testing programs to as many sex workers, high-risk women, men who have sex with men, and transgender persons as can be reached;
    - Fund HIV testing for accessible people who use drugs including alcohol reached by existing programs;
    - Make pre-exposure prophylaxis (PrEP) available to key populations including men who have sex with men and transgender women, but with a focus on demand creation among sex workers,.
2. To reach 95% diagnosis by 2030 could be very challenging and there is a need for novel interventions for female sex workers, their clients, their partners, and others who have experienced historic risk.
    - The innovative package of interventions could include HIV self-testing, to expand testing of previously unreached populations, however this will require awareness, access and availability of self-testing, at an acceptable cost.
3. To achieve priorities (1) and (2), it will be necessary to focus on reducing stigma, discrimination and other structural barriers to accessing HIV testing and care.
4. Maintain effective and rapid linkage to treatment for people diagnosed with HIV in line with the on-track targets of continued 95%+ treatment, 95% viral suppression, and elimination of mother-to-child transmission.

1. Introduction

1.1 Country context

Bhutan is committed to achieving the national goal of eliminating AIDS as a public health threat by 2030 (1). Bhutan has a low-level HIV epidemic with HIV concentrated among key populations and their partners, though prevalence surveys. Since the first detection of HIV infection in 1993, the annual new HIV infections have been on the rise and appeared to have stabilised at less than 100 since 2011. The estimated number of people living with HIV (PLHIV) was 1,341 in 2021, with almost 50% of PLHIV estimated that know their status, almost 90% of those diagnosed on treatment, and more than 90% of those on treatment are virally suppressed (2).

There has been limited evidence on the modes of HIV transmission in Bhutan (3). The 2021 study on risk attribution found the most dominating risk behaviours contributing towards the mode of HIV transmission in Bhutan are through multiple heterosexual partnerships with sex workers, clients of sex workers and their spouses (4). At the same time, HIV sentinel surveillance and HIV testing through outreach have identified few HIV infections among female sex workers, leading to considerable uncertainty. Other key populations at elevated risk include men who have sex with men, transgender women, and people who use drugs or people who inject drugs (4, 5).

While substance use including alcohol is a major public health issue in Bhutan, currently there has been no evidence suggesting that people who use drugs (PWUD) or people who inject drugs (PWID) are pivotal drivers of HIV epidemic in Bhutan and there are currently no Population Size Estimates (PSE) of PWID, although one is planned in coming years. Previous studies have shown a high proportion of substance use among adolescents in Bhutan, who make up a third of the total population (6-8), leading to growing concerns about the potential role of substance use in the HIV epidemic. Arguably, substance use can lead to poor judgement and high-risk sexual behaviour which subsequently plays a role in the spread of HIV or sexually transmitted infection (STI) new infections (9, 10). Although injecting drug use does not appear to be a common practice in Bhutan, it has been estimated around 1% of HIV infections are transmitted through intravenous drug use (4, 11).

Key populations in Bhutan have reported experiencing some degree of stigma and discrimination while accessing HIV services (12). The Constitution of Bhutan protects against any form of stigma and discrimination, however at the time of writing, there is no specific HIV legislation in Bhutan to exclusively protect people living with HIV and those affected by HIV (13). Context-specific educational interventions targeting service providers may increase knowledge and reduce HIV-related stigma and discrimination in health care settings. Media awareness campaigns and community-based education to increase sensitisation on stigma and discrimination have been implemented – these interventions have had a positive impact in reducing anticipated and experienced social stigma.

Existing evidence indicates that risk patterns, networks, vulnerabilities and access to HIV-related services are diverse – not only between female sex workers, high-risk women, clients of sex workers, men who have sex with men and people who use drugs but also within subsets of these key population groups and key populations who are not easily reachable through traditional prevention interventions (4, 8, 14-17).

HIV prevention services for key populations are available through civil society organisations (CSOs) and community-based organisations (CBOs) namely Lhaksam, Pride Bhutan, Red Purse Network and Chithuen Phendhey Association, with support primarily from the Global Fund. Each CSO/CBO provides a package of HIV prevention interventions including providing information on HIV and STIs, community

outreach activities, distributing condoms, promoting safe sex, assisting in referrals for testing and providing psychosocial support (18). Prevention services are also delivered by the Health Information and Service Centres (HISCs) to provide health education and awareness on prevention of HIV and STIs, voluntary counselling and testing services for HIV/STIs, condom distribution and outreach-related activities.

The HIV testing and treatment services are primarily financed by the Royal Government of the Bhutan (RGoB) and the primary external donor, The Global Fund, funds all the HIV prevention programs and viral load (VL) monitoring. There is additional support from other international development partners including the UN organisations such as UNAIDS, UNICEF and WHO, however funding from these donor agencies has decreased over time (19). In line with this, RGoB is committed to provide equal access to essential health services, including diagnosis and treatment of HIV/AIDS and STIs, and is projected to increase the annual domestic co-financing from US$550,000 to $782,142 for the current national Global Fund grant (period 2021-2024) (1, 19).

1.2 Rationale for analysis

To maintain the HIV response in Southeast Asia (SEA), national HIV programs must be sustainably financed. With regional transition away from donor support expected to continue, there will be increased demand on domestic HIV financing. Strengthened commitments by national governments is critical. It is more important than ever to invest available HIV resources cost-effectively to maximise impact.

The Australian Federation of AIDS Organisations (20) is the Principal Recipient of the Sustainability of HIV Services for Key Populations in Asia (SKPA-2) Program. The program is a multi-country grant funded by the Global Fund covering four (4) countries: Bhutan, Mongolia, the Philippines and Sri Lanka. It aims to promote sustainable services for key populations at higher risk of HIV exposure including sex workers, men who have sex with men, transgender women and people who use drugs (injecting or non-injecting), in the region. This analysis formed part of the SKPA and SKPA-2 contracts, and the allocative efficiency analysis presented here can support the RGoB to prioritise investment decisions as part of developing action plans and budgets for the HIV response throughout the SKPA-2 grant period and beyond the life of the project.

Bhutan specifically has maintained a remarkable low-level HIV epidemic with less than 100 estimated annual new infections since 2011. The RGoB is committed to preventing and controlling the spread of HIV, and has seen an opportunity to eliminate new infections leading to ending AIDS as a public health threat by 2030. Much has been accomplished to date (detailed in the previous and following sections), but gaps in diagnosis and treatment remain. Innovative approaches to prevention and testing such as self-testing, pre-exposure prophylaxis (PrEP) and online access to services are becoming available that may address the HIV response gap among key and vulnerable populations.

1.3 Study objectives

The purpose of this study is to develop a sustainable HIV investment case tailored to the unique and specific investment needs in Bhutan. Specifically, the objectives of this study were to:

1) Develop an improved understanding of the pathways to HIV infection in Bhutan by key population;
2) Estimate current spending on targeted HIV interventions in Bhutan;

3) For varying budget levels, determine how resource allocation for targeted HIV prevention, testing, and stigma reduction interventions can be optimised to minimise new HIV infections and HIV-related deaths over 2023-2030;
4) Assess the impact of optimised resource allocation on projected new HIV infections and HIV-related deaths compared to the HIV outcomes if current spending were maintained;
5) Determine the resources required and optimised allocation to achieve both 90% reduction of new HIV infections relative to 2010 and 95-95-95 Fast Track targets by 2030;

2. Methodology

An allocative efficiency analysis was conducted using Optima HIV, a mathematical model developed by the Optima Consortium for Decision Science in partnership with the World Bank. A detailed description of the Optima HIV model is available in Kerr et al (21) and Appendix A. In brief, Optima HIV is a population-based compartmental model of HIV transmission and disease progression integrated with an economic and program analysis framework. It applies an algorithm to estimate the optimised allocation of resources across a combination of HIV programs to meet a given objective (21). Detailed epidemiological, behavioural, programmatic, and cost data were collated through desk review and stakeholder consultations to inform the Optima HIV model for Bhutan (see Appendix A2). HIV epidemic patterns and projections were calibrated to align with existing and accepted output from the EPP-Spectrum model and published by UNAIDS (22). Detailed calibration plots are shown in Appendix B. Country teams were consulted before and after the workshop on data collation and validation, assumptions, objective and scenario building, and results validation [Appendix C].

This section further describes (2.1) an overview of the process (2.2) the populations and HIV programs included in this analysis, (2.3) baseline spending (2.4) a description of the scenarios modelled, (2.5) the model constraints applied to budget reallocations, and (2.6) the weighting applied to the model objectives.

2.1 Overview of modelling process

This efficiency analysis was conducted from February 2022 to May 2023. The analysis commenced with stakeholder consultations to identify relevant key populations, programs to reach these populations and their subsequent impacts. These consultations were conducted from April 2022 to June 2022 with relevant stakeholders from the National AIDS Control Program (NACP), Save the Children Bhutan, community stakeholders, and key population representatives. A Technical Working Group (TWG) with a core set of local stakeholders was set-up to identify relevant modelling objectives and scenarios, validate the epidemiological situation, provide input on key population programs and their impacts and to provide feedback on results (Appendix C). A costing study conducted as part of the SKPA process was used to inform costing of key population programs.

2.2 Populations and HIV programs

Populations were disaggregated by risk and age and further defined in Appendix D. In brief, the populations considered in this analysis were:

- Key populations (aged 15-49)
    - Female sex workers (FSW)
    - Clients of female sex workers (Clients)
    - High-risk women (HRW)

    - Men who have sex with men (MSM)
    - Males who use drugs including alcohol
    - Transgender women (TGW)
- General population
    - Females 0-14, 15-19, 20-24, 25-49, 50+
    - Males 0-14, 15-19, 20-24, 25-49, 50+

High-risk women are women who work at or visit environments where high risk sexual behaviours are frequently initiated, including entertainment workers. Males who use drugs including alcohol were modelled as a single population due to a lack of data to disaggregate by specific substance use, due to this being an accessible population reached collectively by other social support outreach not funded through the HIV program, and in order to evaluate the potential role of substance use in the HIV epidemic in line with stakeholder concerns.

Targeted HIV programs modelled in this study are provided in the Table 1 and described in Appendix E. Antiretroviral therapy (ART) and prevention of mother-to-child transmission (PMTCT) were assumed to be available to all diagnosed people living with HIV retained in care and were not included in the spending optimisation.

Table 1. Targeted HIV programs modelled in the analysis.

Targeted HIV programs
HIV programs for female sex workers
HIV programs for high-risk women
HIV programs for men who have sex with men
HIV programs for transgender women
HIV programs for people who use drugs including alcohol (outreach)^
HIV testing for people who use drugs including alcohol (marginal)^
Pre-exposure prophylaxis (PrEP) for female sex workers including demand creation
PrEP for men who have sex with men and transgender women including demand creation
HIV self-testing
Stigma reduction *

* Implemented as an enabling intervention with no direct impact on HIV parameters, but increases maximum achievable coverage through other targeted interventions for key populations.
^Outreach: venue-based outreach. Marginal: to provide HIV testing that supplements existing outreach.

HIV programs for people who use drugs, including alcohol, were modelled as two separate programs with differing costs and impacts. The outreach program represents a prospective program incorporating HIV testing and prevention services. The marginal program includes only HIV testing and is based on the marginal increase in cost to deliver HIV self-testing, namely the commodity cost of self-tests, as this would be implemented through existing services for people who use drugs including alcohol.

Structural barriers including stigma, discrimination, legal barriers, and geographical access to services contribute to a reluctance to engage with HIV prevention programs, poor experiences when receiving HIV care, and a fear of HIV testing in Bhutan. Stigma reduction was considered an enabling intervention that could increase the proportion of each key population that can access key population-focused HIV services, including self-testing, to 95% by reducing these structural barriers including (but not limited) to stigma and discrimination (Appendix E). These enabling interventions were deemed necessary by stakeholders to progress towards achieving 95-95-95 UNAIDS Fast-Track targets. No other direct impacts on HIV parameters were modelled. Annual costs for stigma reduction were estimated using an excel template completed by country partners, reflecting interventions such as 1) Key population-friendly health services to ensure increased HIV and STI service uptake; 2) Availability of knowledgeable and specialised health personnel to provide key population-friendly services; 3) School and workplace support for equal opportunities for the lesbian, gay, bisexual, transgender, queer and intersex (LGBTQI) community; 4) Enabling legal and policy environment for LGBTQI community members to receive equal rights by law and in society; 5) Promoting and ensuring humane, health and social rights of drug users and reducing stigma and discrimination in the society; and 6) Key population networks, CSO and members flourish in a socially nurturing environment (Appendix F).

2.3 Baseline spending

Baseline spending was estimated for 2021 using bottom-up cost estimates, whereby $program\ spending\ = unit\ cost\ \times coverage$. Unit costs for key population programs were derived from the 2022 SKPA costing study (20). Coverage was based on latest reported coverage from program records by CSOs and CBOs for 2021. SKPA costing estimates were validated with top-down costing estimates through the Global Fund Disbursement 2020-2021 (23) and the funding landscape at the national program level as part of planning for financial sustainability 2021-2024 (19). The derived baseline spending is outlined by program in Appendix E.

Budget optimisations were based on targeted HIV spending for HIV prevention and testing programs with a direct and quantifiable impact on HIV parameters included in the model. ART and PMTCT were excluded from the baseline optimisation budget, as it was that independent funding would remain available to continue providing treatment for all diagnosed people living with HIV retained in care. Unit costs for ART were derived from the 2018 National AIDS Spending Assessment (NASA) for the purpose of assessing future ART resource needs (24).

2.4 Scenario analyses

Based on input from stakeholders, a range of scenarios were identified for inclusion (Table 2). These incorporated the risk of reduced availability for HIV prevention and testing programs for key populations in the future, optimised resource allocation scenarios, and the opportunity for increased funding through additional investments in HIV prevention. The optimised spending scenarios determine the most cost-effective distribution of spending across HIV prevention and testing programs projected to maximise the reduction of new HIV infections and AIDS-related deaths by 2030. The modelled impact of optimisation scenarios on the HIV epidemic assumes that treatment coverage as a proportion of diagnosed people living with HIV remains fixed at 2021 levels. Each optimisation assumes spending is reallocated in 2023 and the same amount of optimised spending for each program is allocated for each year up until 2030. Full details of modelled program impacts and the maximum proportion of the target population who could access each HIV service with sufficient spending are given in Appendix E, including the differences in achievable coverage with and without interventions reducing stigma and legal barriers (Table E2).

Table 2. Optimisation and scenario analyses for HIV prevention and testing spending.

Scenario	Description
Phaseout HIV prevention	A counterfactual scenario exploring the impact if Global Fund-supported HIV prevention programs were phased out from 2024 to 2025 after the current grant commitments conclude.
Baseline scenario	Continued spending and fixed allocation of US$146,000 (100% HIV prevention and testing) reflecting 2021 distribution of funds.
Optimised spending 100%	Continued spending of US$146,000 (100%) for HIV prevention and testing programs with allocation optimised to reduce new infections and HIV-related deaths by 2030. Scenario constrained so that only 10% of each program can be reallocated.
Reduced optimised spending (50%, 90%)	Considers if available resources for HIV prevention and testing programs were reduced. Percentages are relative to the most recent targeted prevention spending. Allocations are optimised to reduce new infections and HIV-related deaths by 2030.
Increased optimised spending (150%, 200%, 300%, 400%, 500%)	Considers if additional resources for HIV prevention and testing programs were made available. Percentages are relative to the most recent targeted prevention spending. Allocations are optimised to reduce new infections and HIV-related deaths by 2030. These scenarios were explored with and without stigma reduction interventions included in the model. Scenario constrained so that only 10% of each program can be reallocated.
95-95-95 targets	Explores the pathway to maximizing progress toward 95% diagnosis, 95% treatment coverage among diagnosed people living with HIV, and 95% viral suppression among people on treatment.
Additional sensitivity analyses	These analyses were run on each scenario to capture the range of possible outcomes depending on the time to reach scale, the effectiveness of programs, and the potential to further enhance linkage to care, retention on ART and viral suppression: - Implementation of enhanced linkage and retention on ART and viral suppression by 2025 and 2030; - Uncertainty over future HIV infections; - Uncertainty over behavioural change or risks in the future; - Uncertainty over acceptability of PrEP; - Uncertainty over program impacts and time to achieve increased coverage; - Uncertainty over stigma reduction interventions; - Uncertainty over the uptake of HIV self-testing.

2.5 Model constraint

Each program was constrained to not reduce by more than 10% from 2022 spending, unless optimising a reduced budget, then no constraints were applied. A maximum level of change in spending was not set. This constraint was informed by discussion with key stakeholders based on the potential harms of defunding key population programs (25) and was assumed to represent achievable "implementation efficiencies". In the optimisation, the stigma reduction program to reduce barriers to accessing HIV services was modelled as being a single enabling package of interventions that could be fully funded or not funded; other programs could be increased or decreased relative to baseline spending based on the objective weightings.

2.6 Model objective weightings

Budget optimisation weightings to minimise new HIV infections and HIV-related deaths by 2030 for a given budget were weighted as 1 to 5 for infections to deaths. This weighting was selected to balance progress against both indicators while reflecting a higher importance of preventing deaths, consistent with previous analyses (26, 27).

3. Results

3.1 Current HIV epidemic in Bhutan

The model was calibrated to align with empirical data received from the country team. In particular, it was aligned with emerging national research into the population size estimates for key populations (15), risk attribution of HIV infections (which highlighted that from 1993 to 2019 more than 50% of new HIV infections could be attributed to transactional sex) (4), and behavioural dynamics of key populations (14, 17), all supplemented by qualitative feedback from stakeholder discussions. Inputs for the model were built based on sources shared by stakeholders including epidemiological, survey, and programmatic data (Appendix A2), with historical trends calibrated closely to 2022 modelled values from Spectrum (modelling conducted for national HIV estimates).

Consistent with Spectrum projections, new HIV infections were estimated to have peaked between 2003 and 2005 and have been steadily decreasing since, estimated at 76 in 2021 (Figure 1). Total people living with HIV have continued to increase to an estimated 1,341 in 2021 (Figure 2), while HIV-related deaths (Figure 3) have been reducing more rapidly since 2015 in line with the rapid scaling up of HIV treatment in Bhutan (Figure 4).

Figure 1. Number of new HIV infections calibrated to Bhutan Spectrum estimates, 1990 to 2022.

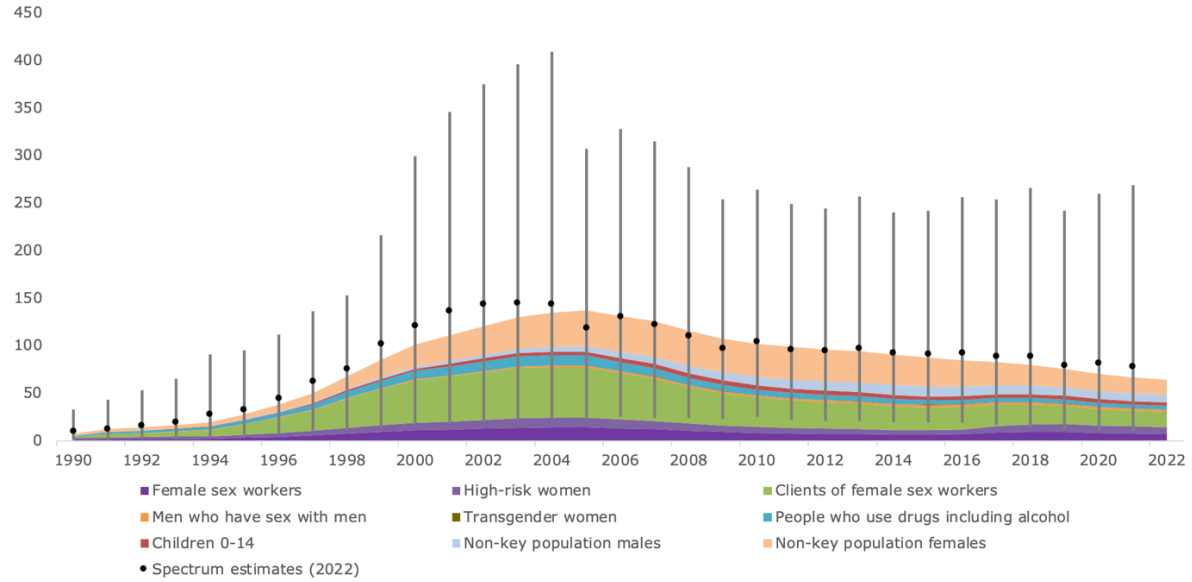


Figure 2. Number of people living with HIV calibrated to Bhutan Spectrum estimates, 1990 to 2022.

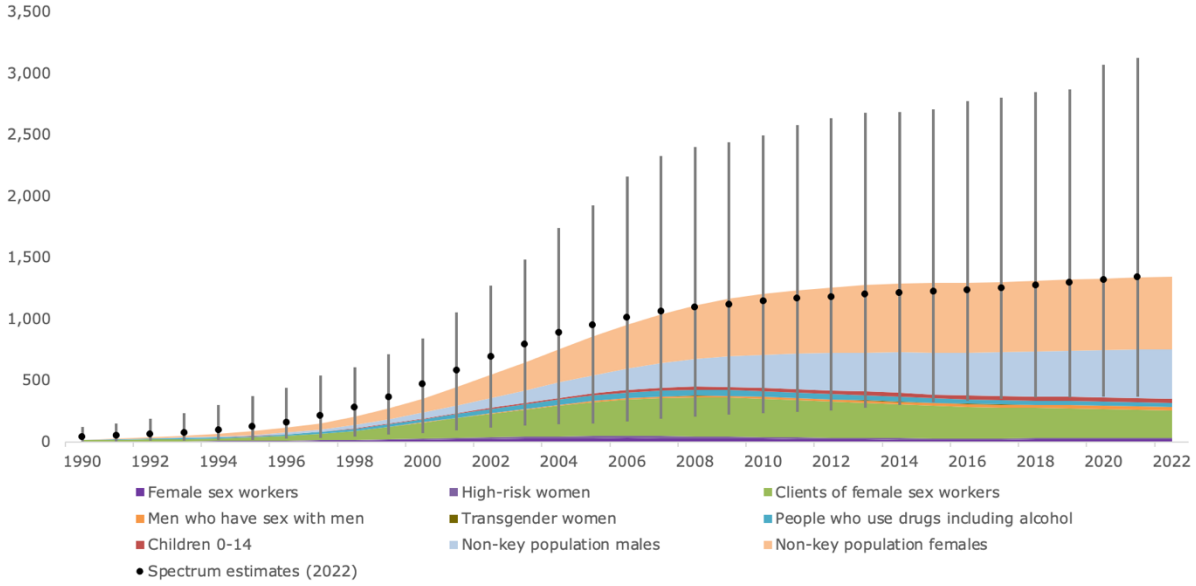


Figure 3. Number of HIV-related deaths calibrated to Bhutan Spectrum estimates, 1990 to 2022.

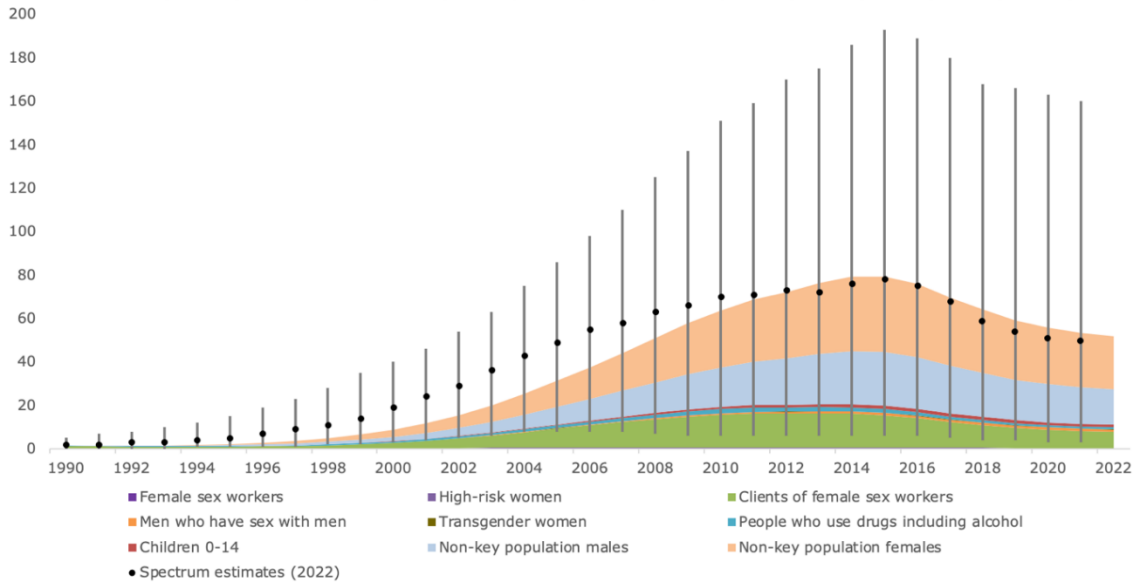
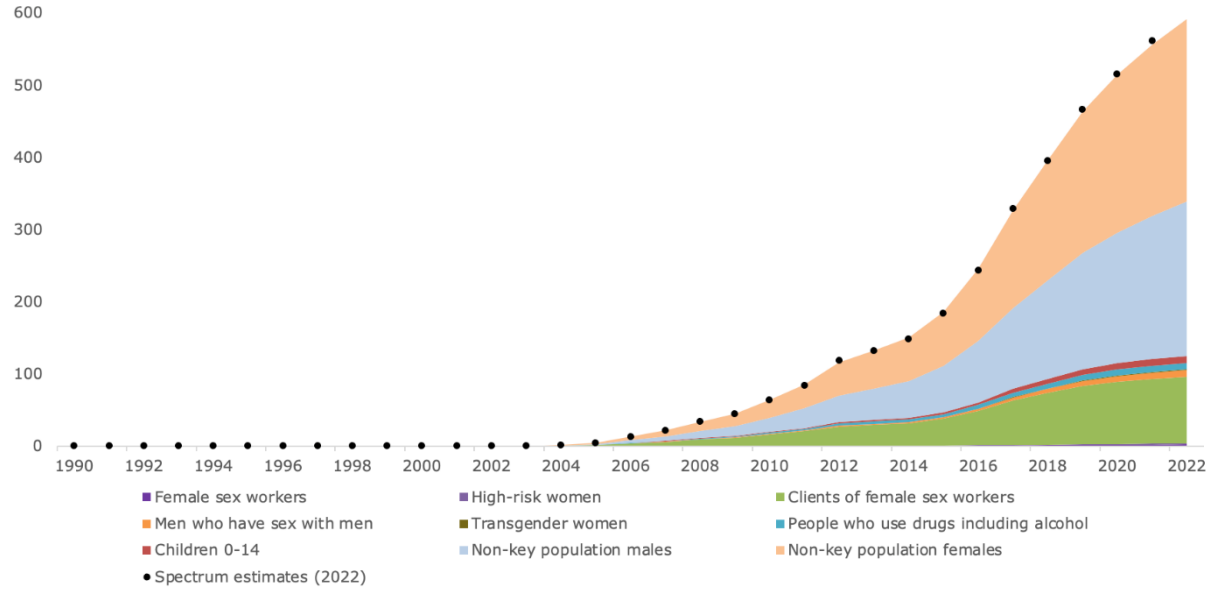


Figure 4. Number of people living with HIV on treatment calibrated to Bhutan Spectrum estimates, 1990 to 2022.



The HIV epidemic in Bhutan has remained concentrated in key populations. Most new HIV infections are associated with commercial sex, with new HIV infections in female sex workers (9 new infections; 13%), other high-risk women who have less frequent transactional sex (8 new infections; 11%), clients of female sex workers (19 new infections; 25%), and people who use drugs including alcohol (5 new infections; 6%) (Figure 5). Over one third of new HIV infections are estimated to be among non-key populations, especially regular female partners of clients of female sex workers and male partners of previously high-risk women.

Figure 5. Modelled new HV infections by population.

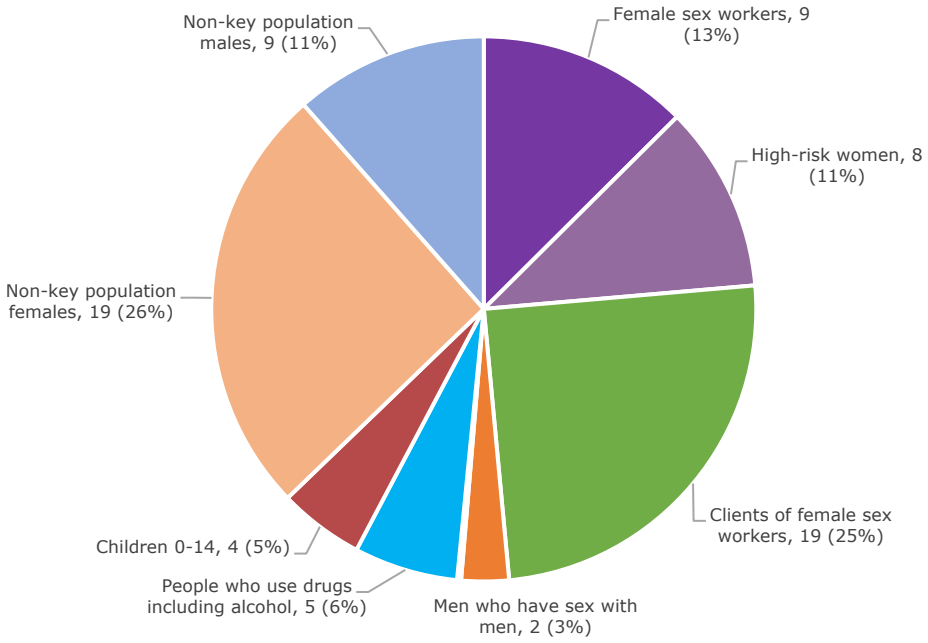
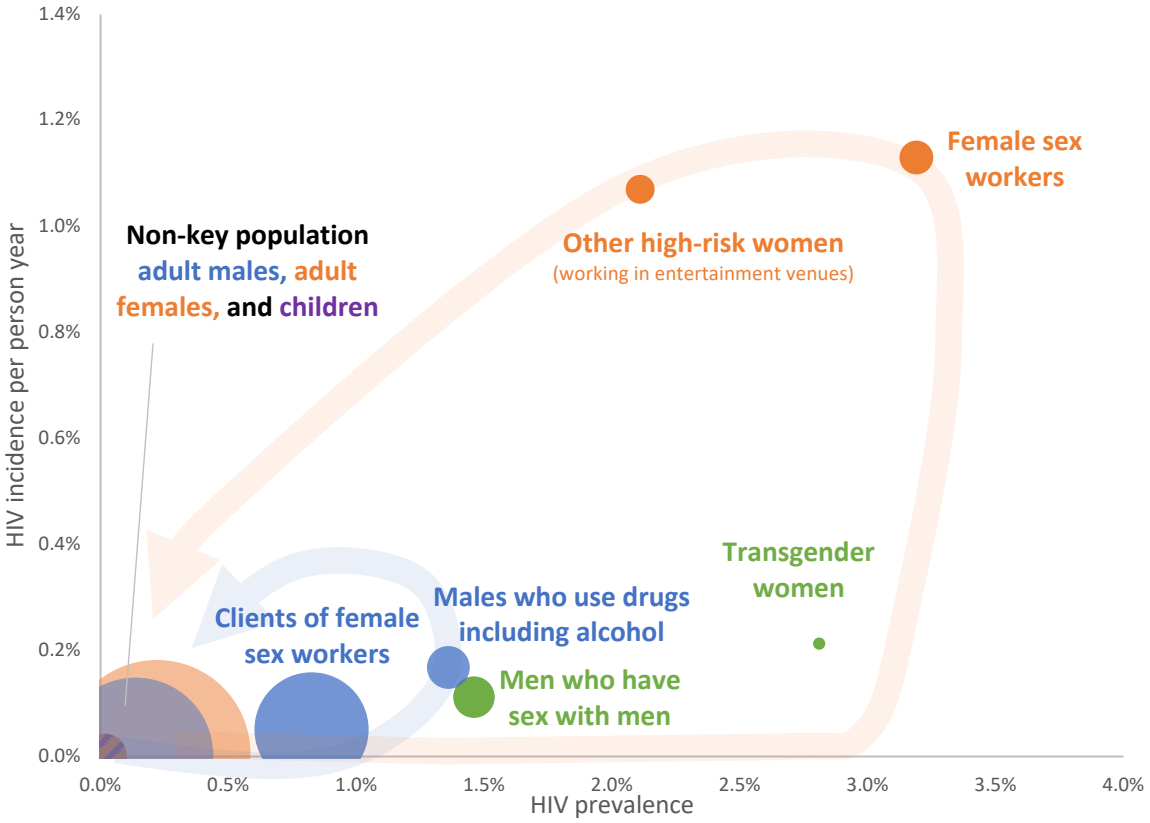


Figure 6 depicts a map of HIV prevalence by incidence to understand the HIV transmission pathways and epidemic situation in Bhutan. Some young females, mostly aged 20 – 24 years, may spend a short duration either working as home-based or venue-based female sex workers (estimated average duration 3 years). Young women working in entertainment venues, referred to as "high-risk women", are estimated to work in venues for an average duration of 8.4 months (12). However, stakeholders reported it was more common for young women to work multiple seasons at different venues, so the overall duration was modelled at 1.5 years for high-risk women. After these so-called seasons of risk, young women typically return to the female non-key population. However, it was estimated by stakeholders that home-based female sex workers, who are also least likely to receive programmatic coverage, were likely to have a longer working duration.

A high proportion of males aged 15-49 (14%) in Bhutan are estimated to be clients of female sex workers (28), relative to the estimated number of female sex workers and high-risk women (1% of all women aged 15-49). Each female sex worker or high-risk woman may be exposed to HIV (and other STIs) through both commercial sexual partnerships with multiple clients of female sex workers and/or casual sexual partnerships, including with males who use drugs including alcohol. HIV infections experienced by high-risk women are estimated to remain under-diagnosed because the relatively short duration of risk activity means they are less likely to receive HIV testing through outreach services before they return to the non-key populations. HIV infections experienced by female sex workers are estimated to remain under-diagnosed because there are challenges in identifying and reaching home-based female sex workers with HIV services.

Figure 6. Mapping of HIV prevalence (horizontal), HIV incidence per person-year (vertical), and total number of people living with HIV in 2021 (bubble size). Shaded arrows represent movement of people between non-key populations and key populations.



Clients of female sex workers and males aged use drugs including alcohol may be engaged in buying sex and substance use, respectively, for an average of 11 years. One third of new HIV infections are estimated to be among clients of female sex workers and people who use drugs including alcohol despite a relatively low number of commercial acts per year per individual client in Bhutan.

While injecting drug use is rare in Bhutan (estimated to be 10% of people who use drugs (6)), historical needle sharing was high due to a lack of risk awareness (informed by stakeholder consultations) and harm minimisation programs are not yet meeting the needs of people who use drugs. HIV infections are estimated to remain under-diagnosed in clients of female sex workers as there is currently no direct way to reach clients with HIV services in Bhutan. At the same time, there is a lack of programmatic coverage available to meet the needs of people who use drugs including alcohol.

Men who have sex with men and transgender women were estimated to account for a small number of people living with HIV in 2021 (28 and 2 respectively). However, HIV prevalence is estimated to be rising (Appendix B, Figure B2), and these populations remain at disproportionate risk. Evidence from countries in the region (29, 30) of rapid rises in new HIV infections among men who have sex with men means that continued HIV prevention efforts and HIV testing among men who have sex with men and transgender women remains critical. Transgender men were not modelled separately in this analysis due to predominantly having partnerships with women and relatively lower biological risk of HIV transmission. Nonetheless, transgender men have been previously identified as a key population exposed to health risks including HIV through sexual violence or through overlap with people who use alcohol and other drugs (13). Subsequently, programmatic coverage for transgender men remains important.

Mother-to-child transmission (MTCT) rates are estimated to be low, with approximately 3 new infections per year, consistent with national Spectrum estimates. Despite low incidence rates of MTCT, antenatal testing and PMTCT remains an important part of eliminating MTCT.

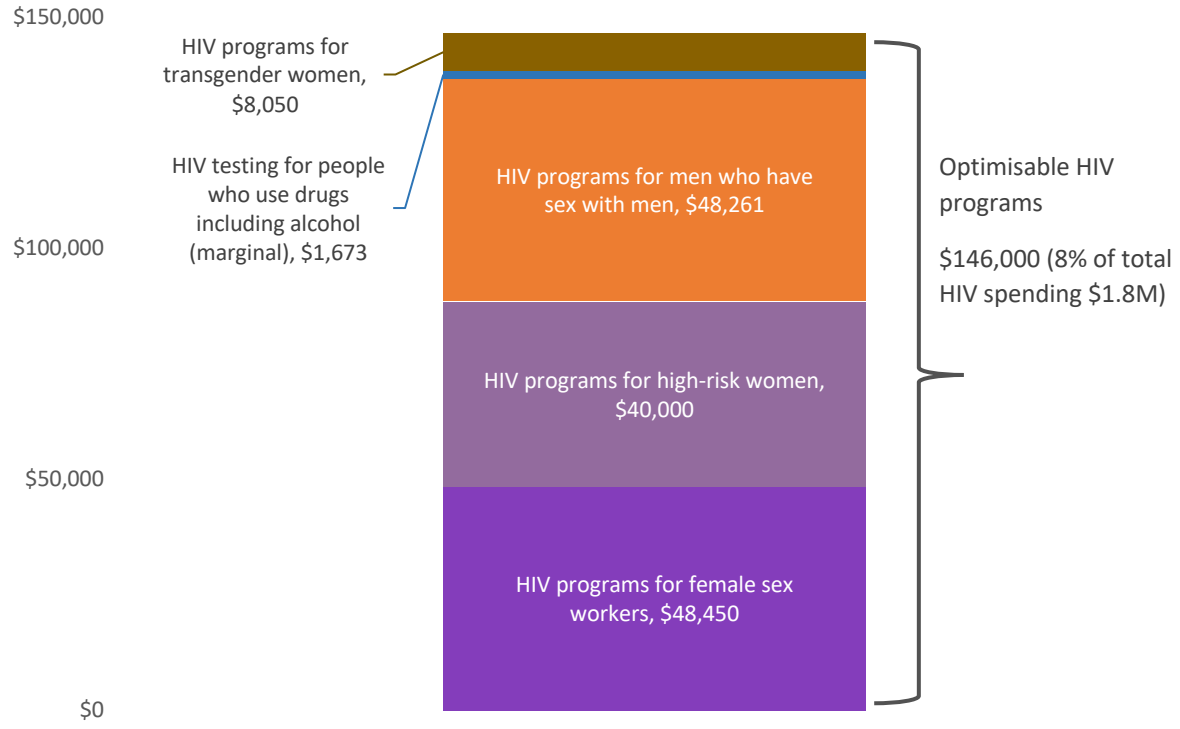
Model calibration outputs in relation to epidemiological outcomes and individual calibration plots from each population are presented in Appendix B.

3.2 Baseline HIV spending

In 2021, an estimated total of US$1.8M was spent on HIV in Bhutan based on the national planning for financial sustainability (19). This includes program implementation costs financed by the RGoB and supported by the Global Fund through national and regional grants. Less than ten percent of the total HIV budget, US$146,000, was spent on HIV targeted prevention and testing (Figure 7) – these programs were included as the optimisable HIV programs in this analysis.

Detailed spending on key population prevention and testing programs included in the optimisation were derived from the 2022 SKPA costing study (20). Full program details are given in Appendix E.

Figure 7. Overview of total direct spending for HIV prevention and testing (US$146,000) for HIV in 2021.

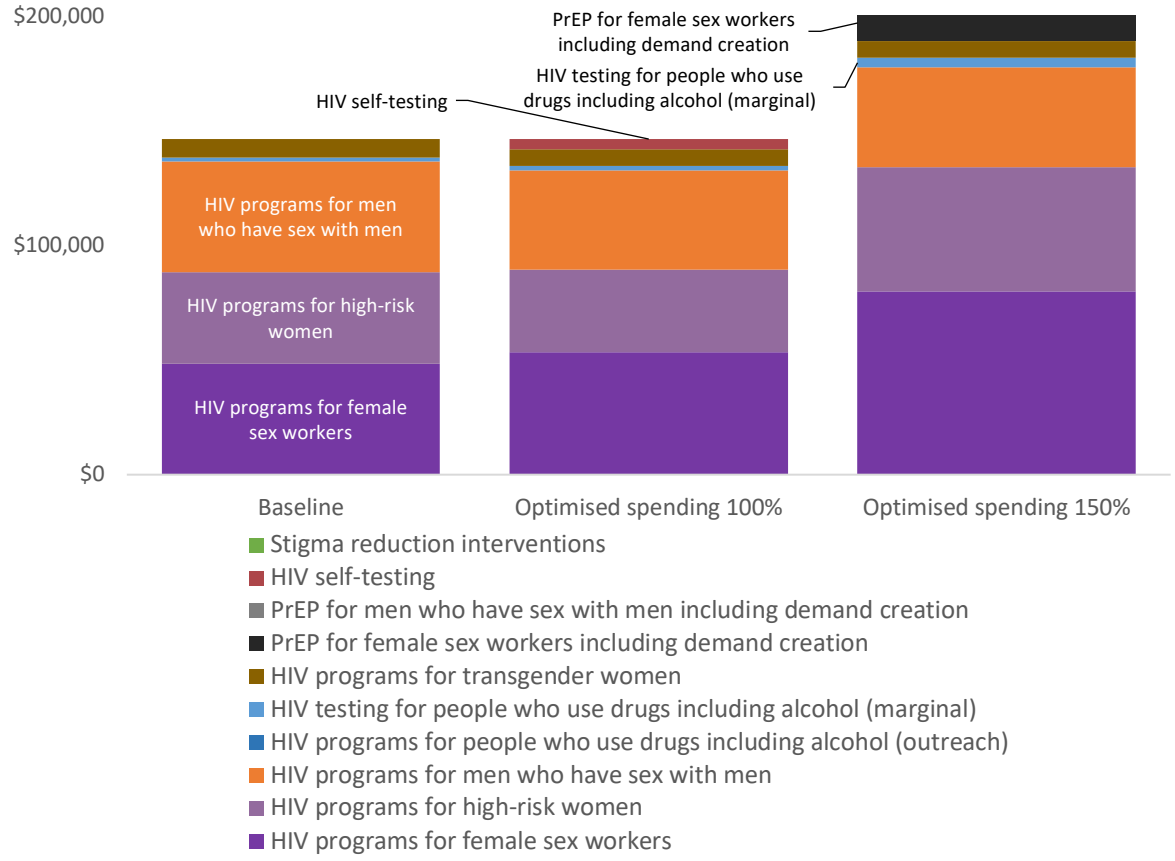


3.3 Optimised resource allocation of prevention and testing spending with current and increased budgets

The Optima HIV model aims to optimise the latest reported spending, by reallocating spending to programs that maximise the impact on the HIV epidemic, informed by epidemiological, behavioural, and economical data. When optimising 100% and 150% of 2021 spending for prevention and testing to reduce new HIV infections and deaths, the highest priority is to maintain coverage of existing outreach services and to intensify HIV prevention by incorporating PrEP and HIV self-testing for accessible key populations (Figure 8). Subsequently, programs for female sex workers and high-risk women are prioritised for expansion at 150% spending ahead of programs for men who have sex with

men based on relatively higher HIV incidence and lower existing program coverage. Recommended spending by program at each budget level is outlined in Appendix G.

Figure 8. Optimised allocations at 100% and 150% budget levels of annual HIV prevention and testing budgets for 2023-2030.



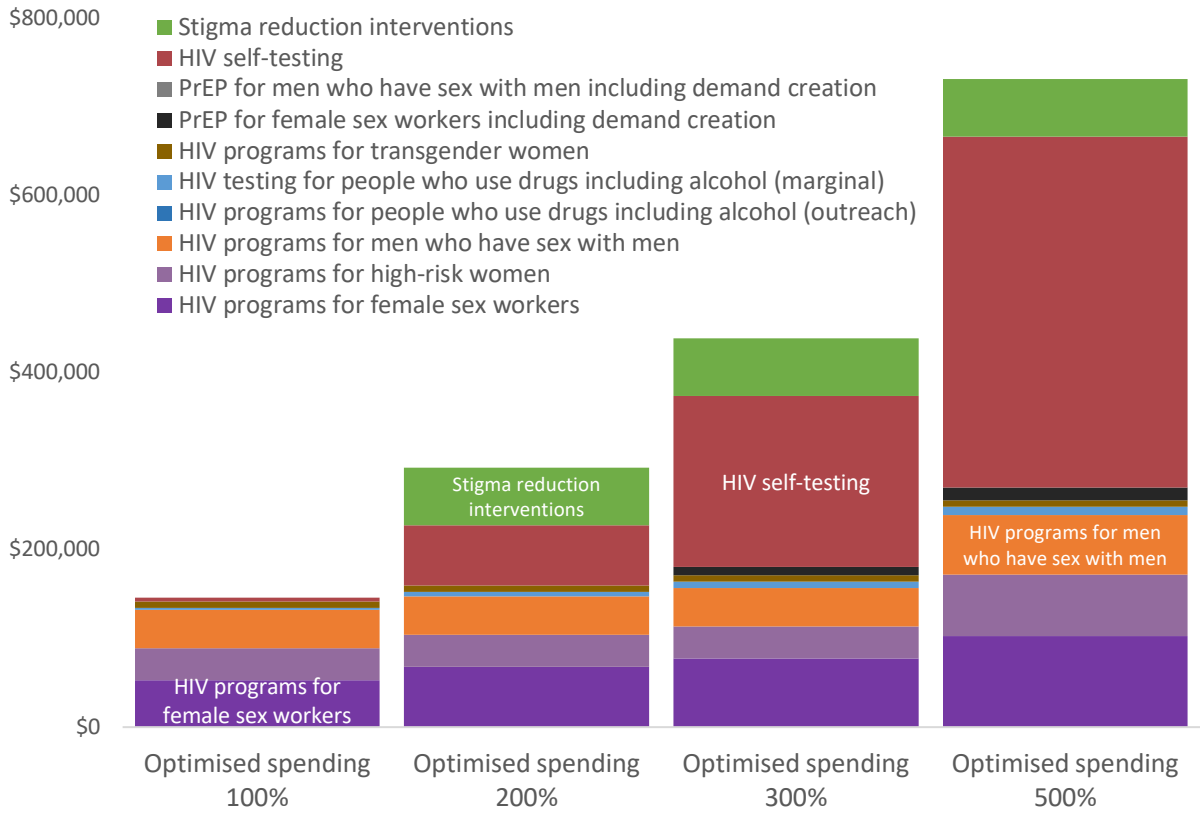
With additional resources, allocating spending for stigma reduction interventions may enable prioritised expansion of HIV prevention and self-testing programs for key populations to reach previously unreachable people who have experienced HIV acquisition risks, ahead of expanding prevention and testing programs including PrEP for people already reached (Figure 9). The stigma reduction interventions are modelled as a package that can be either be fully funded or not funded at all. At or below total resource availability of 150% of 2021 spending ($219,000), funding for the stigma reduction program would come at the cost of reduced spending on current HIV prevention programs, therefore PrEP is prioritized with additional spending. At 200% of 2021 spending ($292,000), the entire stigma reduction program can be funded while having sufficient resources to meet the additional estimated demand for HIV services created through stigma reduction, leaving PrEP as a lower priority at this budget level. As budgets increase over 300% of 2021 spending ($438,000), additional spending on both stigma reduction and PrEP is included in the optimised allocation of resources.

As the optimisable HIV budget increases from 200% to 500% ($292,000 to $730,000) of current targeted spending, the priority is to expand the HIV self-testing to capture a significant proportion of people living with HIV outside of currently active key populations. A large number of tests would need to be conducted to reach these individuals, and targeted HIV self-testing provides a more cost-efficient means than conventional testing strategies. Assisted HIV self-testing was introduced in Bhutan as a trial through SKPA activities with key populations and is conducted at government clinics with health

worker counselling and support and made available through the community-based key population organizations. To date no additional positive HIV tests have been reported through HIV self-testing, likely because it is only reaching those people who were already receiving traditional HIV testing services during the trial phase. Many, especially those visiting health centres, have opted for a dual rapid diagnostic test given the advantage of getting tested for two diseases at a time. Although not modelled, additional focused outreach may also be achieved through index or network testing for key populations.

At budgets of 300% of 2021 spending and above, a substantial proportion of spending is allocated to HIV self-testing. Self-testing is prioritised after saturation program coverage is achieved for outreach to active key populations. In combination with reduced stigma, discrimination, and other barriers to accessing HIV services, self-testing is assumed to have the potential to engage all currently active key populations as well as people with historic risks – in total estimated to be approximately 20% of the adult population (Table H1). However, there is considerable uncertainty over whether stigma reduction activities can sufficiently increase demand for self-testing (Appendix H.5), as well as uncertainty in the implementation and impact of HIV self-testing (Appendix H.6). Additionally, there are substantial opportunities for the unit cost of self-testing to be reduced through procurement of cheaper self-test kits, more access through private purchase, and reduced staff time/overheads. As a result, spending allocations for HIV self-testing capture the need for well-resourced innovative strategies to reach people who have experienced historic risk in addition to preventing new HIV infections among people with current risk, but the impact of this spending allocation may be achievable with lower investment through implementation efficiencies.

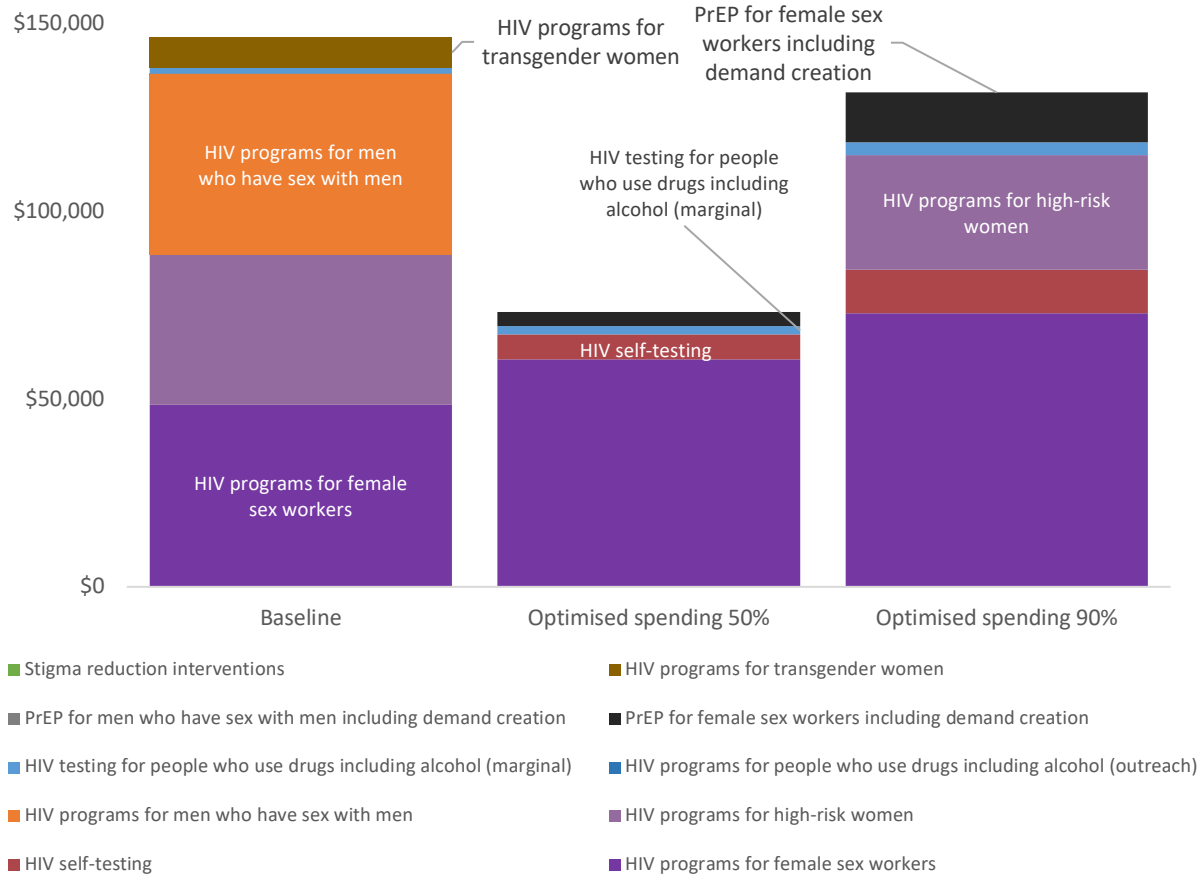
Figure 9. Optimised allocations under 200% to 500% budget levels of annual HIV budgets for 2023 to 2030.



3.4 Optimised spending with reduced budgets for HIV prevention and testing programs

Compared with the baseline scenario, if less spending were available for direct HIV programs for prevention and testing, the highest priority is to reach as many female sex workers and high-risk women as possible. The second priority with reduced resources is to scale-up HIV self-testing for key populations and expand PrEP for female sex workers (Figure 10). This is considered most important to maintain coverage of existing outreach of female sex workers and high-risk women and to enhance the prevention aspects including PrEP for those populations, however, reduced spending on programs for men who have sex with men and transgender women may come with significant risks, as outlined in Appendix H.2.

Figure 10. Optimised allocations with reduced budget of annual HIV budgets for prevention and testing from 2023 to 2030.



3.5 Impact of the optimisation on the HIV epidemic

If funding for Global Fund-supported HIV prevention and testing programs were phased out from 2024 to 2025 after the current grant commitments conclude, an additional 93 (20%) new HIV infections and 5 (1%) HIV-related deaths could occur over the 2023 to 2030 period compared with the baseline scenario (Table 3). Optimised spending 100% is projected to have limited gains, averting an estimated nine cumulative new HIV infections (2%) compared with the baseline from 2023 to 2030. Optimised spending 150% (an additional US$73,000 per annum) on HIV prevention and testing is projected to result in 56 (12%) fewer cumulative new infections over the 2023 to 2030 period compared to the

baseline. Optimised spending 300% and 500% over the 2023 to 2030 period could reduce cumulative new infections by 23% and 32% relative to baseline, respectively (Figure 11).

Impact on the cumulative HIV-related deaths in presented in Figure 12. Optimised spending 150% is projected to result in five (1%) fewer cumulative HIV-related deaths over the 2023 to 2030 period. Optimised spending 300% and 500% is projected to reduce cumulative HIV-related deaths by 13% and 18% over the 2023 to 2030 period relative to baseline, respectively.

Projected epidemic impacts of less than 100% spending should be interpreted with caution, as there may be negative consequences of fully defunding programs in unconstrained optimisations due to lack of surveillance as well as equity implications, and these are not captured in the projected epidemic impacts. These reduced budget optimisations did not include constraints and are thus not directly comparable to higher budget optimisations where only 10% of the budget could be reallocated from year to year.

Table 3. Cumulative new HIV infections and HIV-related deaths between 2023-2030 under different scenarios, and differences in impacts compared to the baseline scenario of fixed 2021 spending on programs modelled.

	Cumulative new HIV infections 2023-2030	Cumulative HIV-related deaths 2023-2030	Difference in infections from baseline	Difference in deaths from baseline
Phaseout prevention spending by 2025	554	363	93 (20%)	5 (1%)
50% optimised*	459	358	-2 (-0.5%)	-1 (-0.2%)
90% optimised*	424	355	-37 (-8%)	-3 (-1%)
Baseline	461	358		
100% optimised	453	357	-9 (-2%)	-2 (-0.6%)
150% optimised	406	353	-56 (-12%)	-5 (-1%)
200% optimised†	399	335	-62 (-13%)	-23 (-7%)
300% optimised†	354	311	-108 (-23%)	-48 (-13%)
400% optimised†	328	298	-134 (-29%)	-60 (-17%)
500% optimised†	312	292	-150 (-32%)	-66 (-18%)

*Optimisations below 100% spending included no constraints. Epidemic impacts are not directly comparable to optimisations at 100% spending and higher which were constrained to not reduce spending by more than 10% on any one program

†Optimisations with the stigma reduction interventions modelled

Figure 11. Annual new HIV infections at varying budget levels (2020 to 2030) and projected change in cumulative new HIV infections from 2023 to 2030.

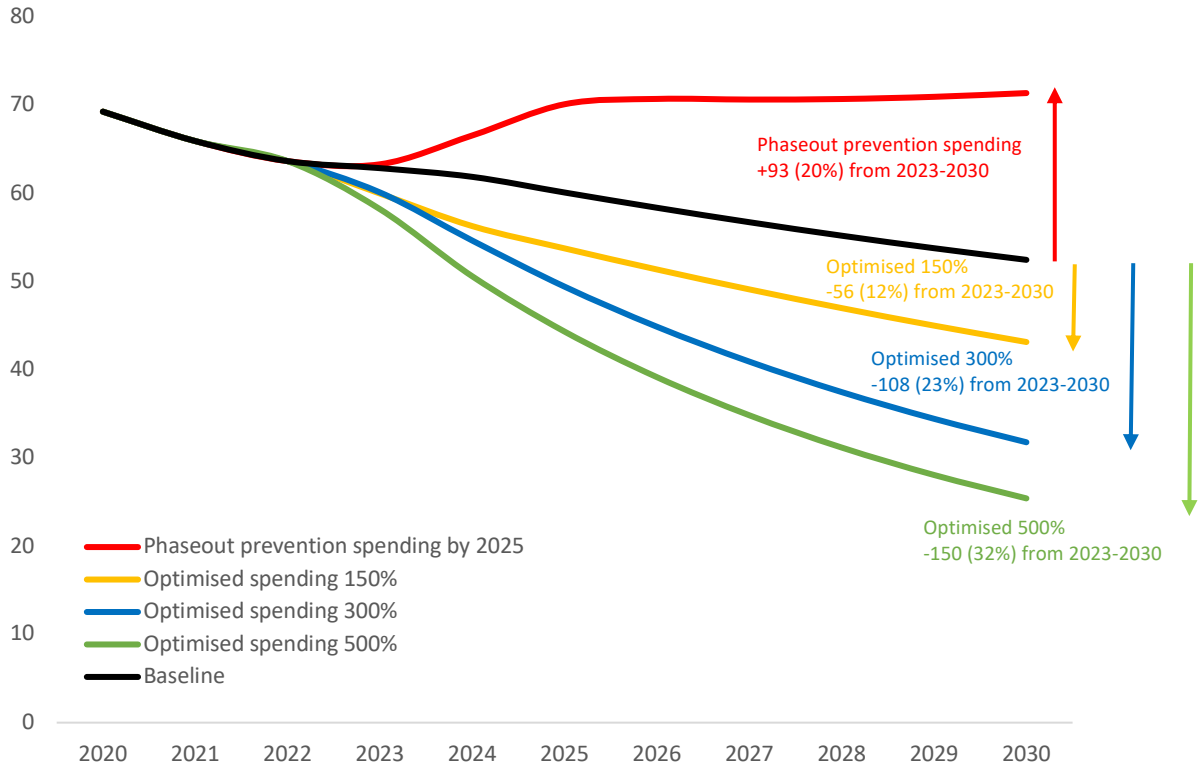
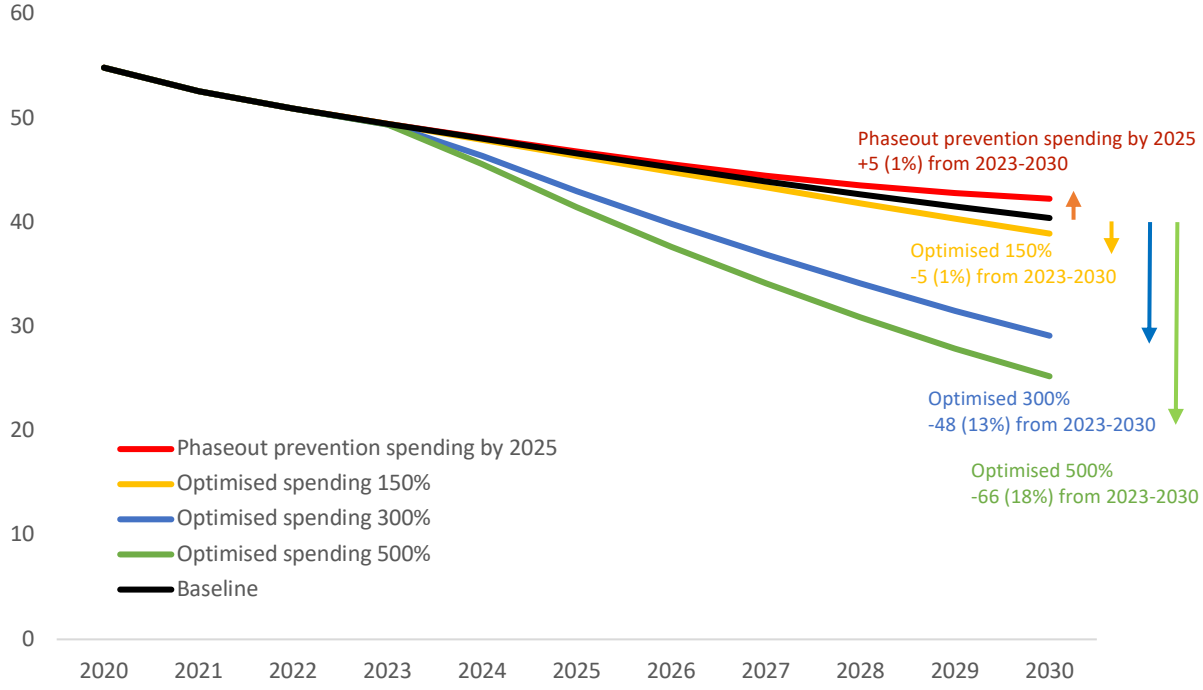


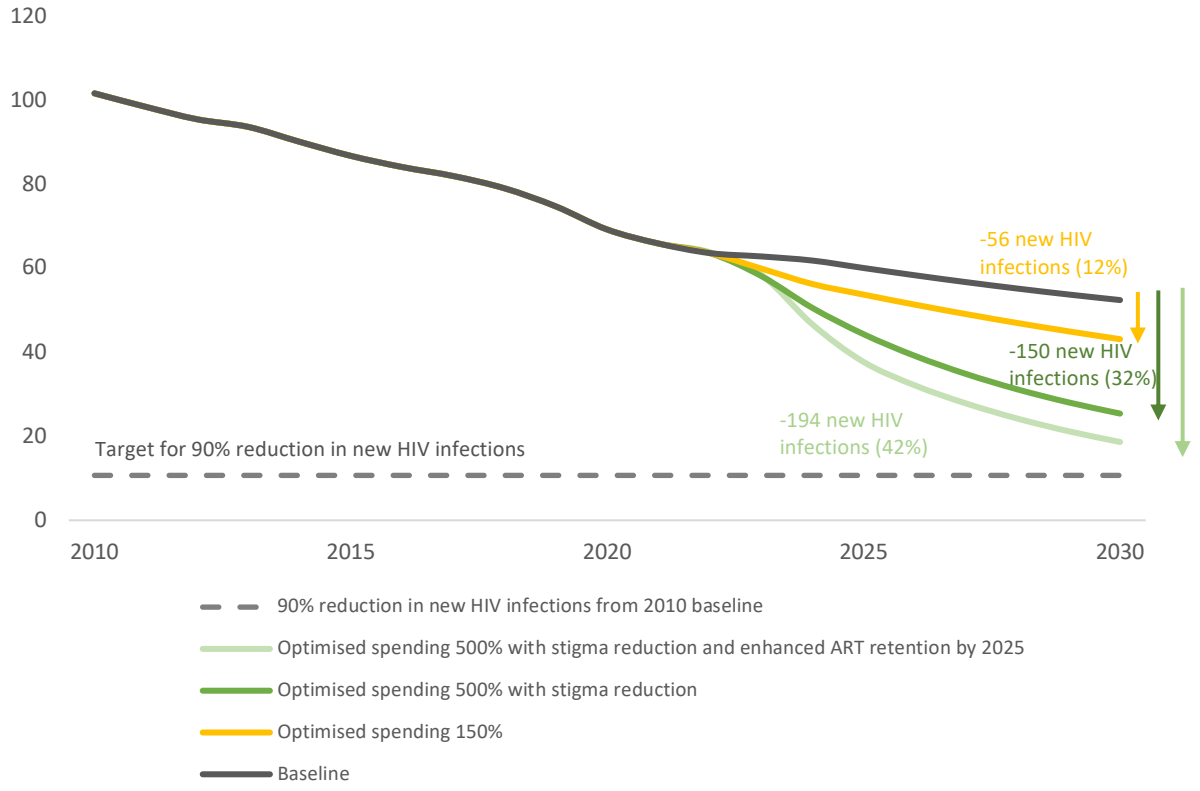
Figure 12. Annual HIV-related deaths at varying budget levels (2020 to 2030) and projected change in cumulative deaths from 2023 to 2030.



3.6 Reaching a 90% reduction in new HIV infections by 2030

Bhutan is committed to scale-up effective HIV services leading to a 90% reduction of new infections from 2010 to 2030 (1). Different scenarios were included to assess the impact of new HIV infections reduction over 2023 to 2030, including expanded HIV program coverage through stigma reduction interventions (as outlined in Appendix E) and enhanced linkage and retention ART by 2025 (Figure 13). Relative to baseline, optimised spending 150% (an investment of US$73,000 additional per year) may result in 56 fewer cumulative new infections over the period 2023 to 2030. Optimised spending 500% (an investment of US$586,000 additional per year) with expanded HIV program coverage through stigma reductions may result in 32% fewer cumulative new HIV infections over the period 2023 to 2030, relative to baseline. If enhanced linkage and retention for ART was added to the stigma reduction scenario at 500% optimised budget, a further reduction by 10% in new HIV infections could be realised over the period 2023 to 2030, relative to baseline.

Figure 13. Impact of cumulative reduction in new HIV infections under different scenarios over the period 2023 to 2030.



3.7 Reaching the 95-95-95 targets

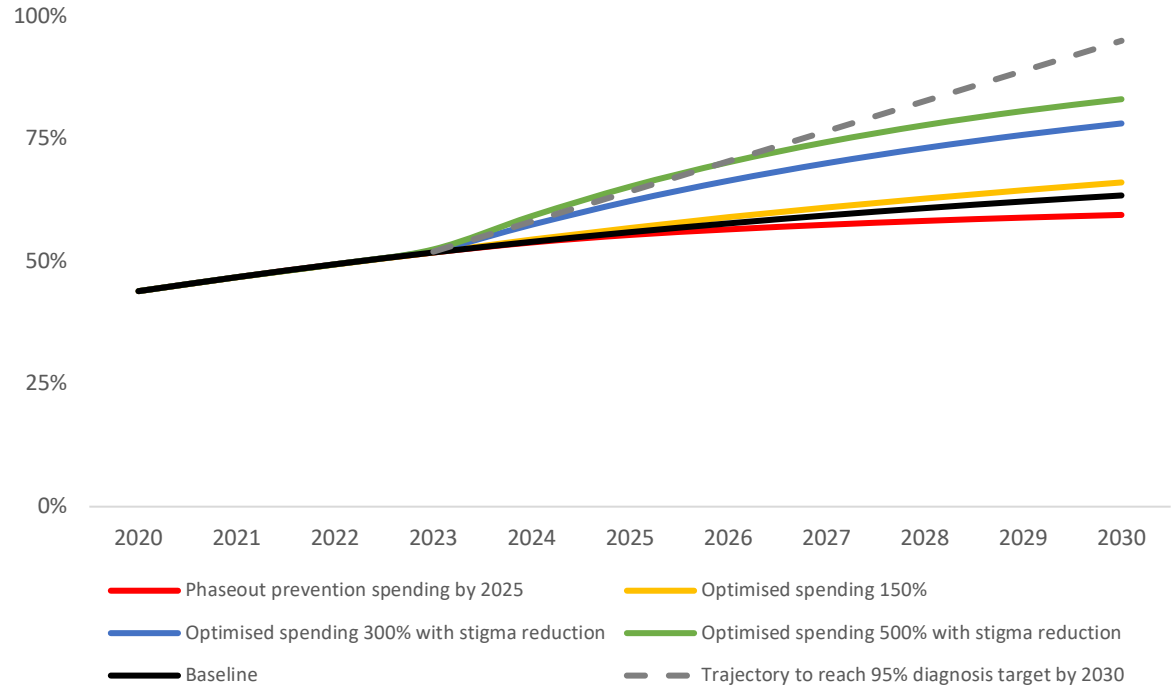
Most recently reported proportion of people living with HIV who are diagnosed is very low (48% in 2021) (4). Optimised allocation of 500% of current targeted HIV prevention and testing spending (an additional US$600,000 per annum) may be able to set Bhutan on a trajectory toward reaching the 95% diagnosis target (Figure 14). However, there are projected to be remaining gaps to reaching the 95% diagnosis target. Further refinement to the HIV programmatic HIV response will be needed as improved evidence becomes available in coming years.

The main challenge of reaching the 95% diagnosis of people living with HIV is due to approximately 90% of an estimated 660 undiagnosed people living with HIV not being currently part of a key or vulnerable population. Because many people within key and vulnerable populations engage in a relatively short duration of risk (see section 3.1), there is limited opportunity to reach them through HIV programs for key populations. Further, these HIV programs are currently not able to effectively reach the partners of key populations and individuals with historic risk. General population testing to reach these groups would be expensive and poorly targeted.

However, more than three quarters of undiagnosed people living with HIV are estimated to have either historically belonged to a key or vulnerable population, including clients of sex workers, or to have been a direct partner or child of a person belonging to a key population. Stakeholders report that stigma reduction interventions that can help reduce barriers to accessing HIV services could engage more people who have experienced historic risk with HIV self-testing services (31-33), through improvements in:

- **Awareness:** Expand through HIV prevention programs for key populations first, however there is a critical gap in contact tracing/partner notification so that partners are aware of the need for HIV testing.
- **Accessibility:** HIV testing, including self-testing, needs to be available how, when, and where people want it.
- **Acceptability:** Reported fear of accessing HIV testing may be addressable through:
    - **Reduced stigma for people living with HIV** to minimize the apprehension of receiving a positive diagnosis, and the subsequent avoidance of testing.
    - **Reduced stigma, discrimination, and legal barriers for key and vulnerable populations** to ensure equitable access to health services including HIV testing and access to treatment thereafter.

Figure 14. Diagnosed people living with HIV (%) at varying budget levels.



The baseline scenario assumed the most recently reported proportion of people diagnosed with HIV treated would remain constant under all HIV prevention and testing scenarios. Additional sensitivity analyses were conducted to assess the impact of enhanced linkage and retention on ART that would meet or exceed the 95% treatment (Figure 15) and 95% viral suppression targets (Figure 16) by either 2025 or 2030. Enhanced linkage and retention on ART was assumed to be feasible without additional spending given the extremely high retention on care already reported and the viral suppression target being within reach. However, stakeholders have reported that this will require continued focus by the HIV program, and additional resources may be required for social support for people living with HIV to maintain at least 95% treatment coverage in the future.

More than 95% of those reported as diagnosed are currently in care in national programmatic data. Despite the high proportion of diagnosed people retained on treatment, there are some people who delay entering care and treatment initiation, and in line with stakeholder concerns about maintaining treatment coverage, it was assumed that an overall treatment coverage of 90% would be maintained in the absence of enhanced linkage and retention on ART (Figure 15).

It is estimated that 92% of people on HIV treatment are virally suppressed (34). It was assumed that this would remain constant under all HIV prevention scenarios, which could prevent treatment targets from being reached without enhanced linkage and retention on ART (Figure 16).

Figure 15. Treatment coverage (%) among diagnosed people living with HIV.

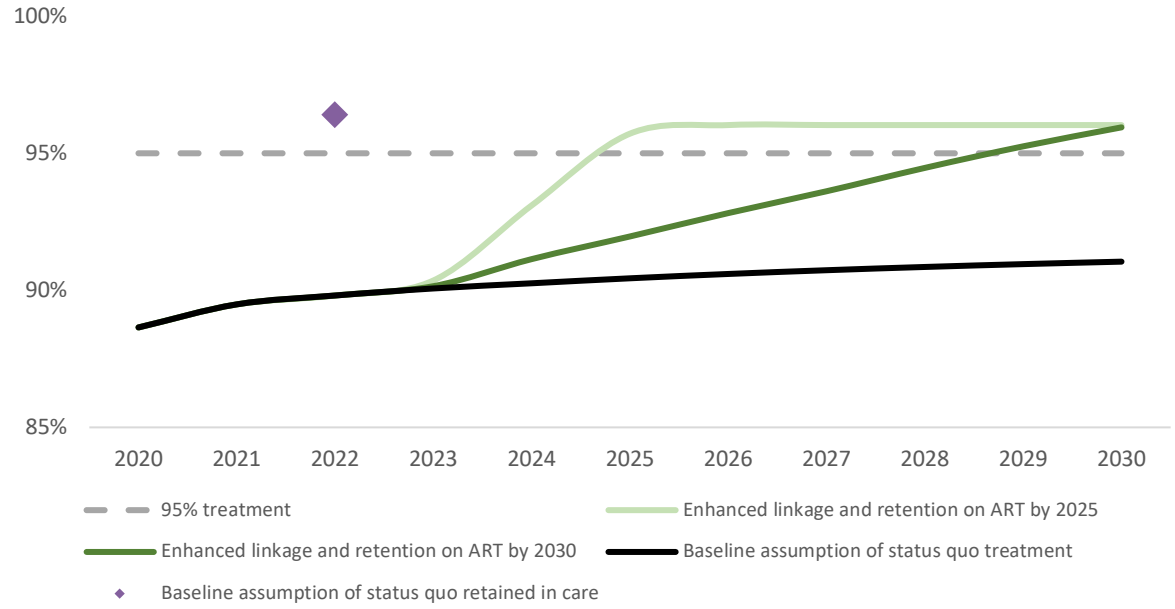
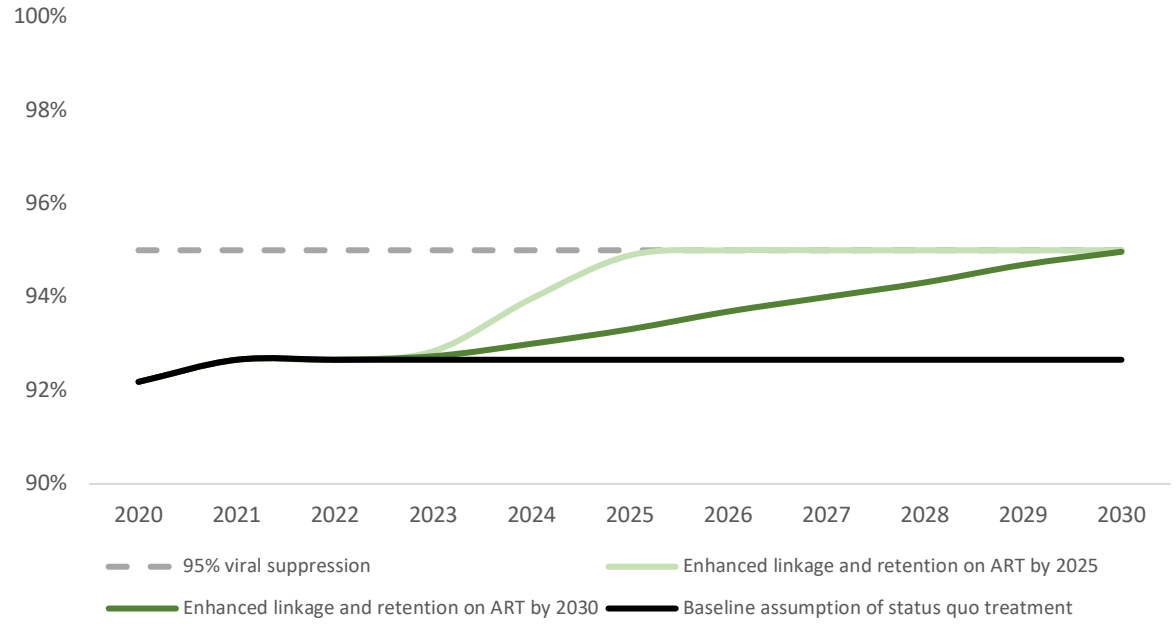


Figure 16. Viral suppression (%) among people living with HIV on treatment.



3.8 Resource needs to maintain current ART coverage

According to the Annual Health Bulletin 2021, 539 people were on treatment in 2020, but it was it was assumed that an overall treatment coverage of 90% would be maintained in the baseline and budget optimisation scenarios in the absence of enhanced linkage and retention on ART (see section 3.7). Based on the latest National AIDS Spending Assessment, the estimated ART unit cost was US$749 in 2020. ART resource need projections are shown in Figure 17. Given current epidemic trends and current coverage of other HIV programs and if ART unit costs remain constant (US$749), by 2030 the

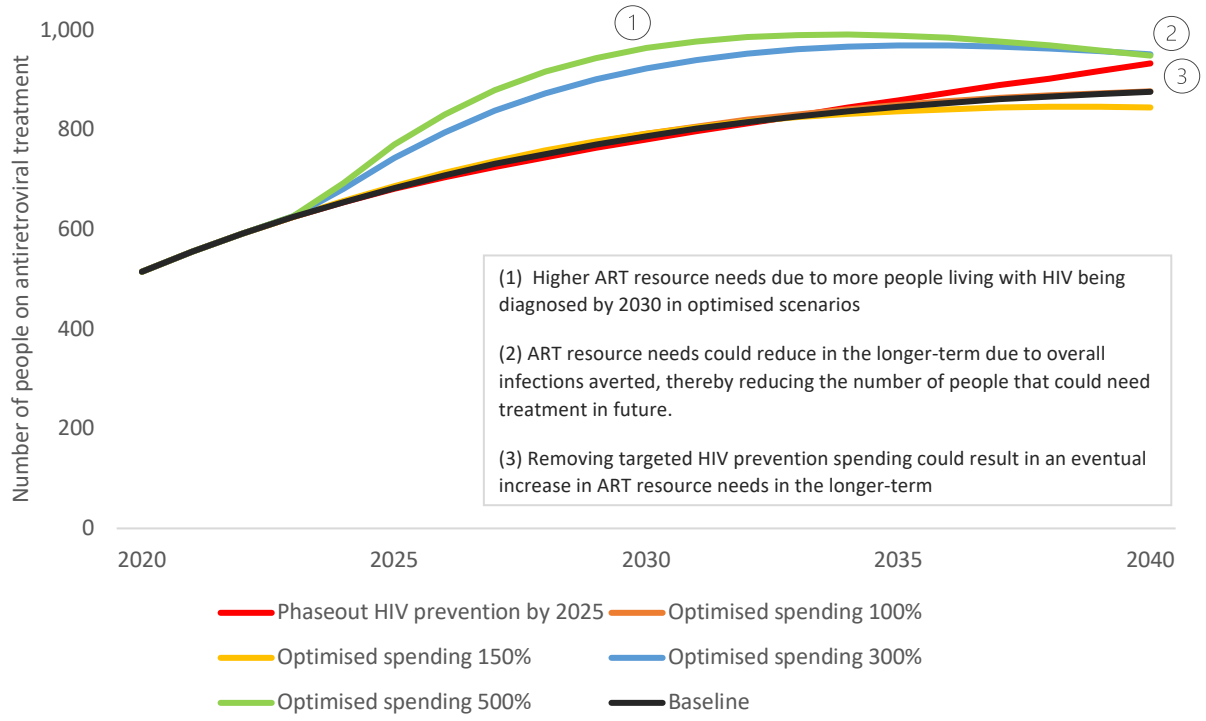
annual resources needs for ART are projected to be $589,000, compared to $416,000 in 2021, in order to maintain 90% of diagnosed people living with HIV on treatment.

The scenario depicting a rapid increase in spending on HIV prevention (optimising spending 500% for key populations), could lead to further increased ART resource needs due to increasing diagnoses. The ART resource needs are projected to increase in line with the number of diagnosed people living with HIV (Figure 17). With 500% spending optimised, annual ART resource needs could increase to $722,000 by 2030, representing:

- An additional US$306,000 in 2030 relative to ART spending in 2021, or
- Additional US$133,000 relative to projected ART spending in 2030 under baseline coverage of HIV prevention and testing programs.

With increased people living with HIV diagnosed over time and more new infections averted, the longer-term projections result in lower ART resource needs. Conversely, phaseout of HIV prevention would lead to more infections and higher ART resource needs in the longer-term.

Figure 17. Resource needs to maintain current ART coverage at varying spending on HIV prevention and testing.



4. Key limitations

As with any modelling study, there are limitations to consider when interpreting results and recommendations:

- **The maximum proportion of a population that could be reached by each program**, particularly for key population programs, was based on assumptions validated by country partners. In practice it may be difficult to reach these populations and achieve these coverage levels.

- **Epidemiological indicators** and **behavioural parameters** come from population surveys and/or programmatic data that have varying degrees and types of biases and may be outdated. Uncertainty in these indicators combined with uncertainty in population sizes can lead to uncertainty in model calibration and projected baseline outcomes.
- **Geographical heterogeneity** is not modelled, and outcomes represent national averages.
- **Effect (i.e. impact) sizes for interventions are informed from global literature**. Actual intervention impacts may vary depending on context or quality of implementation. This may also change over time, as programs are tailored to improve targeting of at-risk individuals, which may affect impact sizes locally.
- **Equity** in program coverage or HIV outcomes was not captured in the model but should be a key consideration in program implementation. Policy makers and funders are encouraged to consider resources required to improve equity, such as through investment in social enablers to remove human rights-based barriers to health, and technical or implementation efficiency gains. In addition, prevention programs may have benefits outside of HIV, such as for sexually transmitted infections and community empowerment. These were not considered in the optimisation but should be factored into programmatic and budgeting decisions.

In addition to these limitations, there is uncertainty in projections and recommendations pertaining to the following areas, described in further detail in Appendix H:

- **The current state of the HIV epidemic has considerable uncertainty** over the number of baseline new HIV infections per year and how many undiagnosed people living with HIV there are in Bhutan. If the number of people living with HIV is lower than the best estimate, then a higher proportion of the undiagnosed could be among key populations. Due to the low-level epidemic in Bhutan and the relative uncertainty around each indicator, there are wide uncertainty bounds for the projections.
- **Behavioural change** may occur over time and alter the risks experienced by key populations and this should be taken into account in prioritization. Although current HIV transmission risks in Bhutan are concentrated around sex work, there are higher regional trends in HIV transmission risks for men who have sex with men and transgender women.
- **Acceptability of PrEP** for key populations and especially for female sex workers is not yet established although surveys and trials are in the planning stage.
- **The time taken to scale up program coverage** is uncertain especially as it relates to reducing barriers to accessing HIV services for key populations. The impact of additional investments may be reduced if people cannot be reached with available services.
- **Stigma reduction interventions** will require careful technical implementation. The combined impact of stigma, discrimination, legal and other barriers on HIV can be quantified because of people not accessing HIV services, but the barriers and experience of stigma can be highly individual and the full impact of stigma reduction may not be reached by 2030.
- **Wider HIV self-testing** availability and acceptability may help to achieve HIV diagnosis targets by 2030 through reaching people who have experienced historic HIV transmission risk, but without targeted implementation, it could result in expensive generalised testing.

5. Conclusions

Although Bhutan has a low prevalence HIV epidemic, this allocative efficiency analysis for HIV prevention and testing programs in Bhutan highlights that maintaining the current prevention and testing is vital to avert a potential rise in HIV incidence. There are opportunities to further accelerate programmatic coverage of key populations and implement flexible innovation to reduce barriers to access and increasing HIV prevention coverage, including reaching people who have experienced historic risk.

Through strong government commitment to public health and stigma reduction for HIV, Bhutan has opportunities to maintain epidemic control of HIV with a modest additional investment (additional US$73,000 per year, 150% of the current HIV prevention budget), or to invest more substantially in bringing the elimination of HIV as a public health concern within reach by 2030 (additional US$586,000 per annum, 500% of current HIV prevention spending or 32% of the total HIV spending). Implementation efficiencies may make achieving HIV targets by 2030 possible at a lower total cost than estimated.

Key recommendations to improve the HIV response in Bhutan include:

1. To minimise future new HIV infections in Bhutan, focusing on the target of HIV elimination, expand:
    - Expand coverage of comprehensive HIV prevention and testing outreach to all reachable female sex workers, high-risk women, men who have sex with men, and transgender persons.
    - Fund HIV testing for accessible people who use drugs including alcohol reached by existing programs.
    - Make HIV pre-exposure prophylaxis (PrEP) available to key populations, including men who have sex with men and transgender women, but with a focus on demand creation among female sex workers.
2. To reach the 95% diagnosis target by 2030 could be challenging and there is a need for novel interventions for female sex workers, their clients, their partners, and others who have experienced historic risk.
    - The innovative package of interventions could include HIV self-testing as part of key population outreach and facility-based healthcare to expand testing of previously unreached populations. However, this will require awareness, access and availability of self-testing, at an acceptable cost and is subject to ongoing refinement in program targeting.
3. To achieve priorities (1) and (2), it will be necessary to focus on reducing stigma, discrimination and other barriers to accessing HIV testing and care, including utilizing innovative testing strategies and targeting such as the adoption and scale-up of HIV self-testing, in line with WHO guidelines.
4. Maintain effective and rapid linkage to treatment and retention on treatment in line with the on-track targets of continued 95% treatment, 95% viral suppression and elimination of mother-to-child transmission.

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Appendix A. Technical summary of the Optima HIV model

This model is informed by the latest evidence on HIV transmission, disease progression, and the impact of HIV programs on both. The following table lists all the assumptions on which this model is based. All references can be found in the Optima HIV Vol. VI. Parameter Data Sources.

The risks of transmitting, acquiring, and dying from HIV depend on a host of different factors that can vary across the population, across partnerships, and over time. In the Optima HIV epidemic model, the population is stratified in three different ways to reflect this variation: by demographic and/or risk group, by health/disease state (stratified by CD4 count category), and by stage of care. Optima HIV defines the different demographic/risk groups as *populations*, the different disease progression stages as *health states*, and the different care and treatment stages as *care states*. For example, a given person might be a female entertainment worker (their population) and be living with HIV with a CD4 count of 350–500 (their health state), and currently be linked to care but not on treatment (their care state).

To perform the optimisation, Optima HIV uses a global parameter search algorithm called adaptive stochastic descent (ASD) (35). Optima HIV version 2.11.3 updated November 2022, available at hiv.optimamodel.com was used for this analysis.

A.1 Model parameters

Three different types of HIV transmission are modelled: transmission between sexual partners, transmission via sharing injecting equipment, and mother-to-child transmission. The input data associated with populations, sexual partnerships, injecting partnerships, and births are outlined in Table A1 and Table A2 (36).

Table A1. Model parameters: transmissibility, disease progression and disutility weights.

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%
Intravenous injection	0.80%
Mother-to-child (breastfeeding)	36.70%
Mother-to-child (non-breastfeeding)	20.50%
Relative disease-related transmissibility	
Acute infection	5.60
CD4 (>500)	1.00
CD4 (500) to CD4 (350-500)	1.00
CD4 (200-350)	1.00
CD4 (50-200)	3.49
CD4 (<50)	7.17
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
Changes in transmissibility (%)	

Condom use	95%
Circumcision	58%
Diagnosis behaviour change	0%
STI cofactor increase	265%
Opioid substitution therapy	54%
PMTCT	90%
ARV-based pre-exposure prophylaxis	95%
ARV-based post-exposure prophylaxis	73%
ART not achieving viral suppression	50%
ART achieving viral suppression	100%
Disutility weights	
Untreated HIV, acute	0.18
Untreated HIV, CD4 (>500)	0.01
Untreated HIV, CD4 (350-500)	0.03
Untreated HIV, CD4 (200-350)	0.08
Untreated HIV, CD4 (50-200)	0.29
Untreated HIV, CD4 (<50)	0.58
Treated HIV	0.08

Source: Optima HIV User Guide Volume VI Parameter Data Sources

Table A2. Model parameters: treatment recovery and CD4 changes due to ART, and death rates.

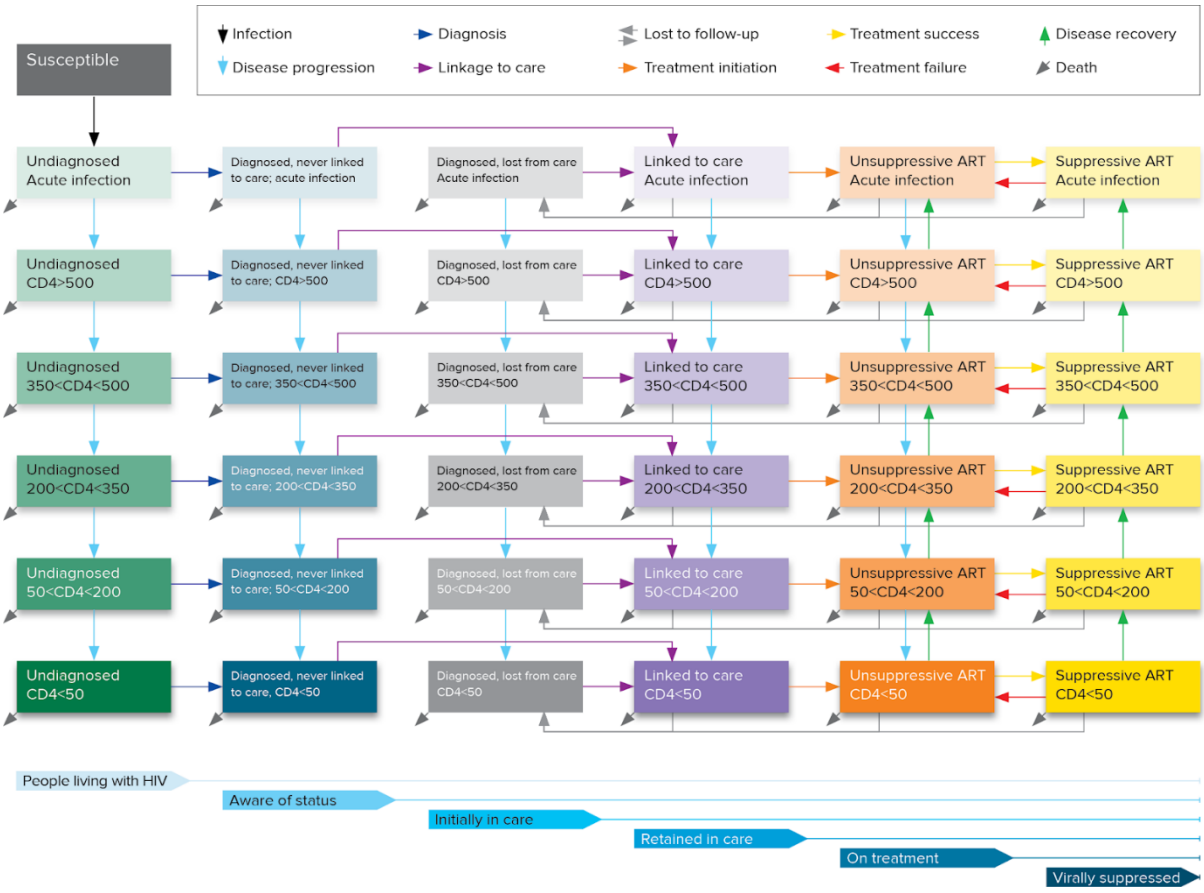
Treatment recovery due to suppressive ART (average years to move)	
CD4 (350-500) to CD4 (>500)	2.20
CD4 (200-350) to CD4 (350-500)	1.42
CD4 (50-200) to CD4 (200-350)	2.14
CD4 (<50) to CD4 (50-200)	0.66
Time after initiating ART to achieve viral suppression (years)	0.20
CD4 change due to non-suppressive ART (%/year)	
CD4 (500) to CD4 (350-500)	3%
CD4 (350-500) to CD4 (>500)	15%
CD4 (350-500) to CD4 (200-350)	10%
CD4 (200-350) to CD4 (350-500)	5%
CD4 (200-350) to CD4 (50-200)	16%
CD4 (50-200) to CD4 (200-350)	12%
CD4 (50-200) to CD4 (<50)	9%
CD4 (<50) to CD4 (50-200)	11%
Death rate (% HIV-related mortality per year)	
Acute infection	0%
CD4 (>500)	0%
CD4 (350-500)	1%
CD4 (200-350)	1%
CD4 (50-200)	6%
CD4 (<50)	32%
Relative death rate on ART achieving viral suppression	23%
Relative death rate on ART not achieving viral suppression	49%
Tuberculosis cofactor	217%

Source: Optima HIV User Guide Volume VI Parameter Data Sources

Optima HIV models seven states related to the care and treatment cascade (susceptible, undiagnosed, diagnosed and never linked to care, in care and not receiving ART, receiving ART and not virally

suppressed, receiving ART and virally suppressed, and lost-to-follow-up). Among male populations, the susceptible compartment is further divided into those who have been circumcised versus those who have not been circumcised. All infected stages are further disaggregated into six CD4-related health states. Taken together, this gives 38 health and care states (Figure A1; circumcised compartments modelled for male populations only and not shown).

Figure A1. Optima HIV model structure.



A.2 Model inputs

Epidemiological, behavioural and programmatic data informing the Optima HIV model for Bhutan were sourced from national records, surveillance surveys, household surveys and other studies supplemented by expert advice from stakeholder consultations.

Table A3. Model inputs and their data sources.

Parameter	Source
Population size*	Age and gender stratified population sizes from the United Nations World Population Prospects 2019 (37). Key population sizes for higher risk populations are estimated from sources including (6, 15).

Parameter	Source
HIV prevalence by population groups*	HIV prevalence data values are used as the primary point of reference during calibration. Values are taken from a combination of primary research including survey data, where available, and expert opinion/assumptions where no data exists. Sources include (5, 14, 17, 23).
Other epidemiology* ▪ Percentage of people who die from non-HIV-related causes per year ▪ Prevalence of any ulcerative STIs ▪ Tuberculosis prevalence	Background mortality is taken from (37), with supplementary comorbidity information from (7, 15, 17, 28, 38-42).
Testing and treatment* ▪ Percentage of population tested for HIV in the last 12 months ▪ Probability of a person with CD4<200 being tested per year ▪ Number of people on treatment ▪ Percentage of people covered by ARV-based prophylaxis ▪ Number of women on PMTCT (Option B/B+) ▪ Birth rate (births per woman per year) ▪ Percentage of HIV-positive women who breastfeed	The percentage of the population tested per year represents the likelihood that someone with an undiagnosed HIV infection will be diagnosed over the course of a year. As such inputs may be adjusted as part of calibration to match the proportion of HIV infections estimated to be diagnosed in each year, while maintaining trends in reported testing percentages. Sources include (15, 17, 22, 23, 43-45).
Optional indicators* • Number of HIV tests per year • Number of HIV diagnoses per year • Modelled estimate of new HIV infections per year • Modelled estimate of HIV prevalence • Modelled estimate of number of people living with HIV • Number of HIV-related deaths • Number of people initiating ART each year • People living with HIV aware of their status (%) • Diagnosed people living with HIV in care (%) • People living with HIV in care on treatment (%) • Pregnant women on PMTCT (%) • People on ART with viral suppression (%)	Data entered in this section of the Optima HIV databook is not used by the model directly to generate output, but rather allows comparison points to be entered from other reliable sources or models in order to ensure consistency. Sources include (2, 4, 18, 22, 23, 46, 47).
Cascade* • Average time taken to be linked to care (years) (by population groups) • Average time taken to be linked to care for people with CD4<200 (years) • Percentage of people in care who are lost to follow-up per year (%/year) • Percentage of people with CD4<200 lost to follow up (%/year) • Viral load monitoring (number/year) • Proportion of those with VL failure who are provided with effective adherence support or a successful new regimen (%/year) • Treatment failure rate	Cascade parameters informed by programmatic data compiled through (2, 34).

Parameter	Source
Sexual behaviour*	
▪ Average number of acts with regular partners per person per year ▪ Average number of acts with casual partners per person per year ▪ Average number of acts with transactional partners per person per year ▪ Percentage of people who used a condom at last act with regular partners ▪ Percentage of people who used a condom at last act with casual partners ▪ Percentage of people who used a condom at last act with transactional partners ▪ Percentage of males who have been circumcised	Sources for sexual behaviour include (7, 14-17, 28) and programmatic data, with circumcision estimate was informed through global prevalence of male circumcision (48).
Injecting behaviours*	
▪ Average number of injections per person per year ▪ Percentage of people who receptively shared a needle/syringe at last injection ▪ Number of people who inject drugs who are on opiate substitution therapy (OST)	Sources for injecting behaviour informed by the expert advice.
Partnerships and transitions	
▪ Interactions between regular partners ▪ Interactions between casual partners ▪ Interactions between transactional partners ▪ Interactions between people who inject drugs ▪ Birth ▪ Aging ▪ Risk-related population transitions (average number of years before movement)	Informed by population definitions, supplemented by details from (14, 15).
Constants	
• Interaction-related transmissibility (% per act) • Relative disease-related transmissibility • Disease progression (average years to move) • Treatment recovery due to suppressive ART (average years to move) • CD4 change due to non-suppressive ART (%/year) • Death rate (% mortality per year) • Changes in transmissibility (%) • Disutility weights	Source for constant values used for Optima HIV are given in the Optima HIV user guide available through the online tool http://hiv.optimamodel.com

*Values can be defined annually from 1990 to 2022

Appendix B. Model calibration

The aim of calibration is to align model outputs to available epidemiological data and official country estimates based on other models (e.g. Estimation and Projection Package of Spectrum) as best as possible given the underlying model structure and assumptions. The main calibration parameters used for Optima HIV are 'initial prevalence' (the percentage of each population with HIV in the first-time step of the model, January 1, 1990), and 'force of infection' which represents all factors which are not modelled explicitly but which impact on the likelihood of each population becoming infected relative to other populations. Individual population prevalence estimates are calibrated to prevalence survey data relating to each population, and secondarily to match existing country estimates including new HIV infections and HIV-related deaths from Spectrum modelling to provide consistency with an agreed baseline.

Calibration outputs in relation to official country estimates based on World Population Prospects, Spectrum model, surveillance surveys, program data and UNAIDS are presented below.

Figure B1. Calibration output for HIV treatment cascade parameters for 2004 to 2022.

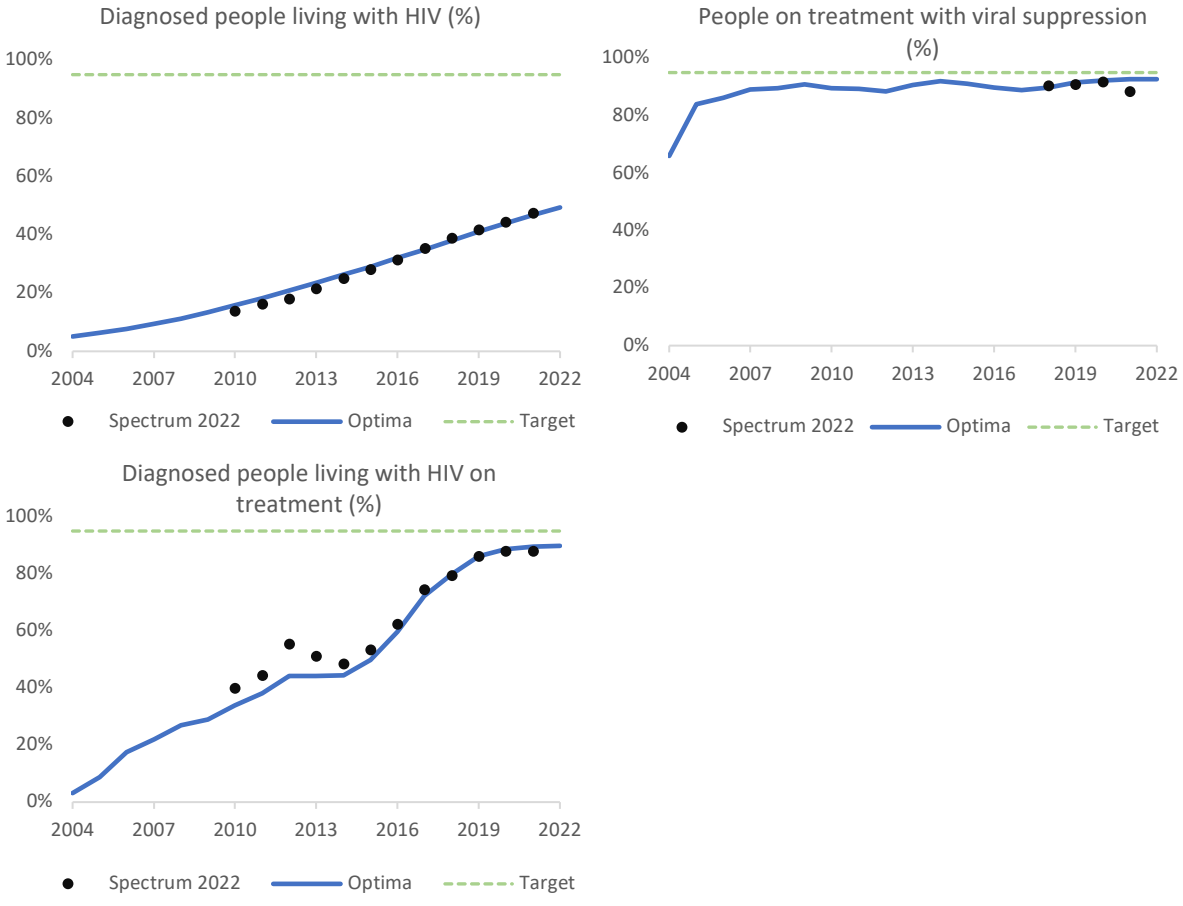
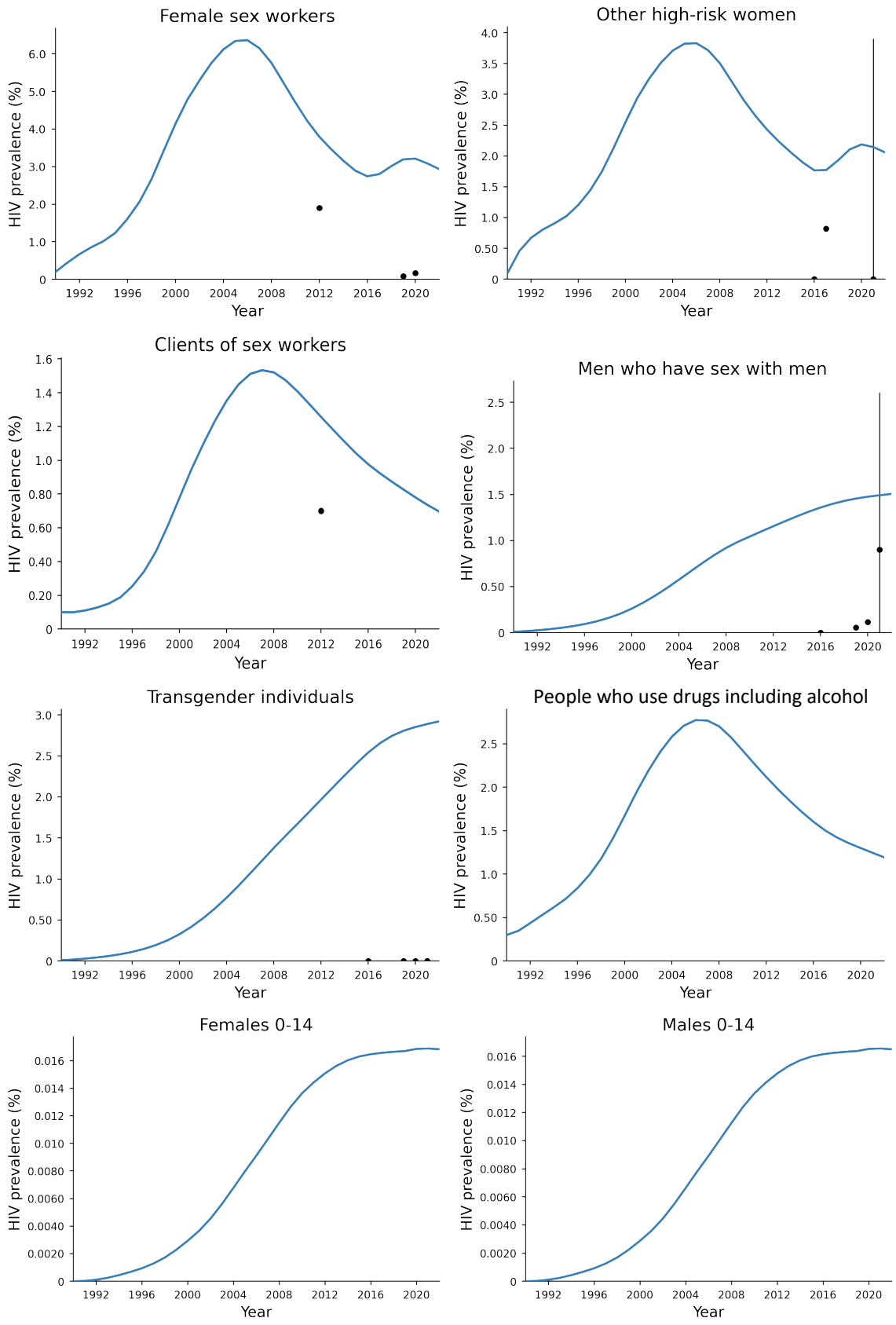
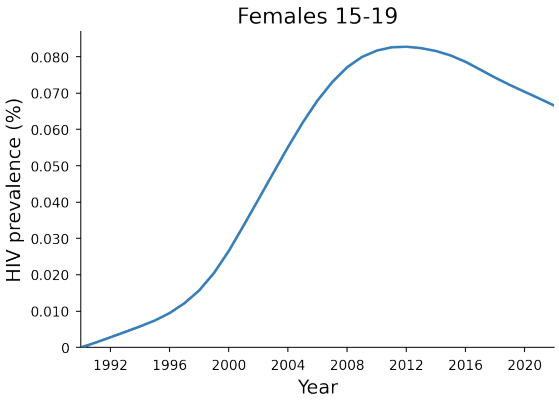
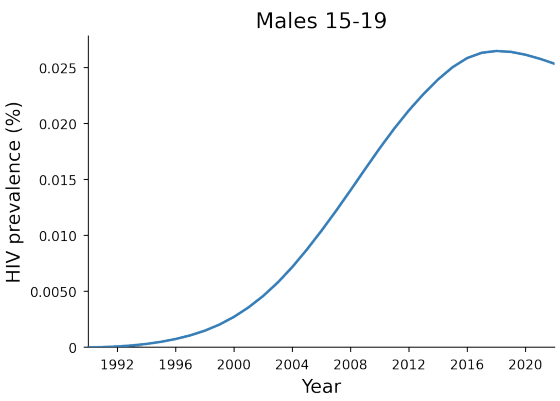
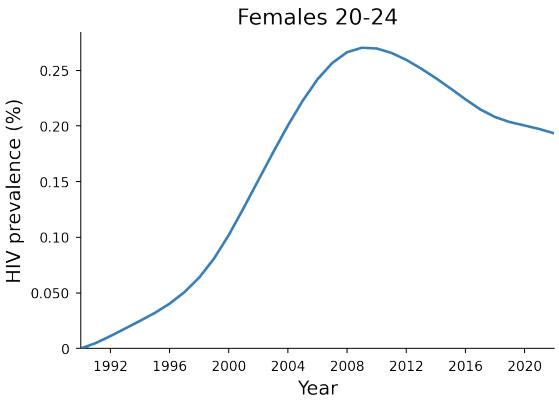


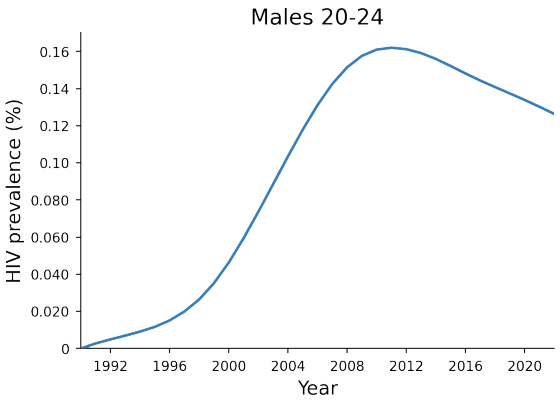
Figure B2. Calibration outputs for HIV prevalence by population for 1990 to 2022.

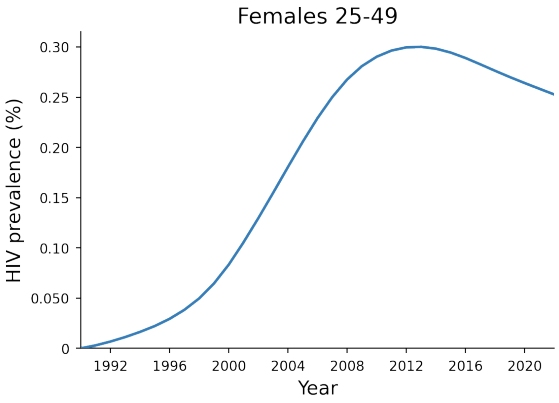


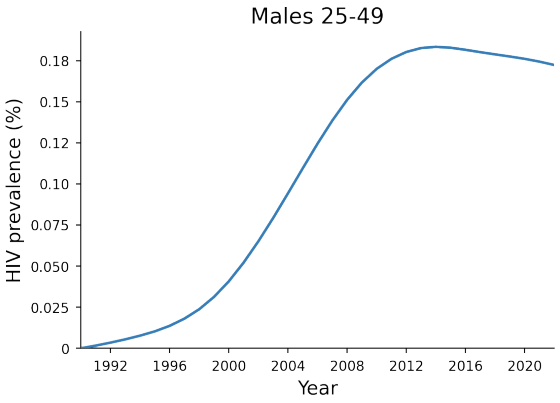

Females 15-19
HIV prevalence (%)
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0
1992
1996
2000
2004
2008
2012
2016
2020
Year

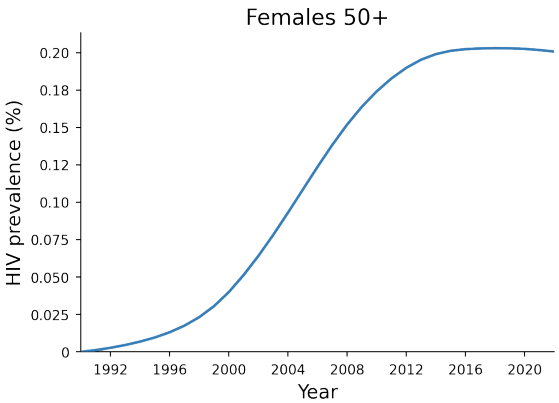

Males 15-19
HIV prevalence (%)
0.025
0.020
0.015
0.010
0.0050
0
1992
1996
2000
2004
2008
2012
2016
2020
Year

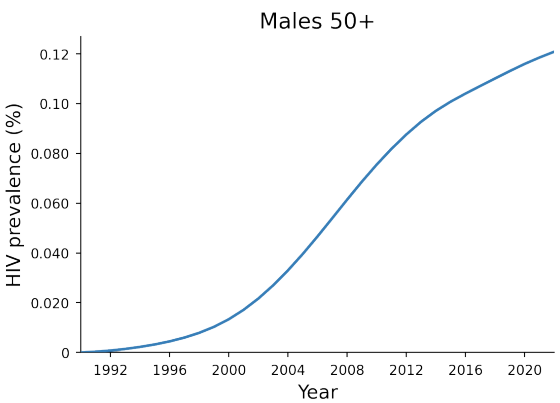

Females 20-24
HIV prevalence (%)
0.25
0.20
0.15
0.10
0.050
0
1992
1996
2000
2004
2008
2012
2016
2020
Year


Males 20-24
HIV prevalence (%)
0.16
0.14
0.12
0.10
0.080
0.060
0.040
0.020
0
1992
1996
2000
2004
2008
2012
2016
2020
Year


Females 25-49
HIV prevalence (%)
0.30
0.25
0.20
0.15
0.10
0.050
0
1992
1996
2000
2004
2008
2012
2016
2020
Year


Males 25-49
HIV prevalence (%)
0.18
0.15
0.12
0.10
0.075
0.050
0.025
0
1992
1996
2000
2004
2008
2012
2016
2020
Year


Females 50+
HIV prevalence (%)
0.20
0.18
0.15
0.12
0.10
0.075
0.050
0.025
0
1992
1996
2000
2004
2008
2012
2016
2020
Year


Males 50+
HIV prevalence (%)
0.12
0.10
0.080
0.060
0.040
0.020
0
1992
1996
2000
2004
2008
2012
2016
2020
Year

Appendix C. Stakeholder consultations

To meet stakeholder needs, the flexibility of Optima HIV to model context-specific subpopulations and programs was leveraged to answer policy questions through scenario and optimisation analyses. This study was conducted in consultation with stakeholder groups through a series of technical group meetings with leadership and coordination from the National HIV/AIDS and STIs Control Program (Table C1) and individual discussions that were held from 8th of April 2022 to 5th April 2023 as listed in Table C2.

Table C1. Membership of Technical Working Group, Bhutan.

Sl.No	Name	Designation & organisation
01	Mr. Lekey Khandu	Officiating Chief Program Officer National HIV AIDS Control Programme Communicable Disease Division Ministry of Health
02	Mr. Sonam Wangdi	Sr. Planning Officer Policy & Planning Division[1] Ministry of Health
02	Ms. Sangay Choden	Finance Officer Directorate Services Ministry of Health
04	Mr. Jurmi Drukpa	Sr. HIV Counsellor Care Support and Treatment Unit Jigme Dorji Wangchuck National Referral Hospital Thimphu
05	Mr. Yoenten Choki Norbu	Counsellor Health Information Service Centre Thimphu
06	Mr. Wangda Dorji	Executive Director Lhak-Sam Bhutan Network of People Living with HIV & AIDS Thimphu
07	Mr. Tenzin Gyeltshen	Executive Director Pride Bhutan (LGBT+) Thimphu
08	Mr. Tshewang Tenzin	Executive Director Chithuen Phendey Association (Substance abuse/alcohol) Thimphu Bhutan
12	Mr. Jamyang Norbu	Project Officer

[1] PPD oversees health planning, monitoring, evaluation, research/epidemiology, health care financing & health information system.

		Save the Children Thimphu
13	Dr. Tashi Dendup	Sr. Program Manager Save the Children Thimphu
14	Miss. Choki Dolkar	Program Officer National HIV AIDS Control Programme Communicable Disease Division Ministry of Health

Table C2. Stakeholder consultation discussions.

Stakeholder	Key topics
Technical Working Group 1 (April 2022)	▪ Provided introduction to Optima, reviewed key analysis inputs, discussed key policy questions, program and population inclusion, and discussed analysis timelines and TWG membership.
GFATM, MoH	▪ HIV funding landscape; and prioritisation of funds for key population programs.
Multi-Sector Task Force, MoH	▪ Health awareness programs; and barriers in expanding HIV prevention-related programs.
Policy and Planning Division, MoH	▪ HIV testing, monitoring, reporting systems.
Care, Support and Treatment Unit	▪ HIV treatment, care and support pathways, ART drug regimen; adherence programs; impact of COVID-19 pandemic on ART; and training for service providers.
Health Information Service Centre	▪ HIV testing and treatment programs; outreach activities; and barriers in accessing HIV services.
Bhutan Narcotics Control Authority	▪ Review estimates for the number of people who use alcohol and other drugs, and risk-taking behaviour among people who use alcohol and other drugs; and treatment and rehabilitation programs for people who use alcohol and other drugs.
Lhaksam	▪ HIV prevention programs; stigma and discrimination towards people living with HIV; and potential of income generation programs.
Pride Bhutan	▪ Population size estimation of transgender people; and HIV prevention services for transgender people.
Red Purse Network	▪ Population size estimation of female sex workers and other high-risk women; HIV prevention services for

Stakeholder	Key topics
	female sex workers and other high-risk women; outreach costs for female sex workers and other high-risk women; and implications of Drayang closures on reaching female sex workers and other high-risk women.
Chithuen Phendey Association	▪ Risk-taking behaviour among people who use alcohol and other drugs/people who inject drugs; prevention programs and rehabilitation services for people who use alcohol and other drugs; and barriers in increasing the program coverage.
Technical Working Group 2 (June 2022)	▪ Reviewed key policy questions and discussed the inclusion of stigma reduction intervention in the model.
Dissemination (August 2022)	▪ Results of the allocative efficiency analysis, including pathways to HIV infection in Bhutan, recommendations to reach 2030 HIV elimination targets, and policy implications.
Follow-up consultations with CSOs	▪ Additional programmatic cost and coverage data and estimation of maximum coverage with stigma reduction programs.
Technical Working Group 3 (April 2023)	▪ Reviewed updated program definitions and updated optimisation results.

Appendix D. Populations

Population definitions are consistent with the population size estimation study in Bhutan (15) with further age stratification in the non-key population males and females (Table D1). Additionally, a key population of people who use drugs including alcohol was included due to stakeholder concerns on the potential significance of the population to the HIV epidemic given risk-related behaviours, and due to the accessibility of this population to interventions through existing civil society outreach outside of the HIV program.

Key assumptions: Data for people who use drugs including alcohol are limited and this is a varied risk group with heterogenous risks, however they are included here using behavioural assumptions and separate population estimate based on the study on the National Baseline Assessment of Drugs and Controlled Substance Use in Bhutan (6).

Table D1. Population groups modelled in this analysis.

Population group	Definition
Female sex workers	Biological females, 15 to 49 years old, who have had transactional sex in the last 12 months.
High-risk women	Biological females, 15 to 49 years old, who work at or visit hotspots defined as environments where high risk sexual behaviours are frequently initiated (e.g., commercial sex networking within and between key populations).
Clients of female sex workers	Clients of female sex workers, who have paid money or goods in exchange for sex in the last 12 months.
Men who have sex with men	Biological males, 15 to 49 years old, who have had anal sex with another male in the last 12 months including those who find and meet male sex partners through online applications.
People who use drugs including alcohol	Biological males, 15 to 49 years old, who have used drugs including use of cannabis, brown sugar, solvent/glue (sniffing), pharmaceuticals for pleasure and injecting.
Transgender women	Biological males at birth, 15-49 years old, self-identified as female or third gender.
Females (0-14) Males (0-14) Females (15-19) Males (15-19) Females (20-24) Males (20-24) Females (25-49) Males (25-49) Females (50+) Males (50+)	Age stratified general population 0-14, 15-19, 20-24, 25-49, and 50 years and older, analogous to non-key population males and females in Spectrum.

Appendix E. HIV Program definitions

The key assumptions of resource optimisation are the relationships between (1) the cost of HIV programs for specific target populations, (2) the resulting coverage levels of targeted populations with these HIV programs, and (3) how these coverage levels of HIV programs for targeted populations influence behavioural and clinical outcomes. The data to inform these relationships are listed in Table E1, with saturation coverage estimates highlighted in Table E1..

E.1 Overview of HIV program inputs

Treatment, care, and support programs including ART, treatment adherence, viral load monitoring, and PMTCT were not considered in terms of allocative efficiency but were assumed to continue at most recently reported coverage levels based on the number of people diagnosed and available to treat. Similarly, likelihood of diagnosis through clinic-based testing services and counselling (including routine tests as part of antenatal care) was assumed to continue at the most recently reported levels to capture the continuation of these government services.

The following HIV prevention programs in key populations were considered for optimisation and scenarios.

Table E1. HIV programs included in the model; budget and unit costs US dollars.

Program	Estimated budget 2021 (derived from unit cost and number covered)	Unit cost 2021	Number covered (percentage of target population) 2021	Target population and saturation based on stakeholder consultations with currently implementing civil society organizations
HIV prevention programs for sex workers	$48,450	$160.00 – $180.00 [a]	285 (48%)	48% – 80% of female sex workers. Coverage in 2020 was estimated at 490 female sex workers (81%) while sex work was more concentrated in Thimphu and accessible to programs as a result, but it was estimated that maintaining this coverage would not be feasible in future years without substantial reduction in barriers to accessing services.
HIV prevention programs for high-risk women	$40,000	$130.10 – $150.10 [b]	246 (39%)	39% – 80% of other high-risk women working in entertainment venues based on reported limited potential for expansion and the risk of decreasing access through legal changes including the closure of Drayangs. Most recent proportion covered (39%) estimated based on survey results through the population size estimate (15) as this population is reached through venues and is less likely to be over-sampled in survey results.

HIV prevention programs for men who have sex with men	$48,261	$162.00– $205.00 [a]	263 (13%)	13% - 40% of men who have sex with men, equating to 26% – 80% of HIV transmission risk among men who have sex with men. This reflects the significant behavioural change achieved despite low programmatic coverage, suggesting that the men who have sex with men reached by HIV services may represent a larger portion of casual partnerships, consistent with other countries.
HIV prevention programs for people who use drugs including alcohol (outreach)	$0	$117.89 – $142.90 [c]	0	10% – 55% of males who use drugs including alcohol. This prospective program would have impacts estimated to be in line with high-risk women as similar venue-based outreach.
HIV prevention programs for people who use drugs including alcohol (marginal)	$1,673	$12.44 – $ 16,00 [d]	118 (3%)	3% – 15% of people who use drugs including alcohol based on the potential to provide HIV testing in addition to existing outreach to this key population with other health services and social support. Current coverage based on civil society data for people who use drugs including alcohol seeking healthcare services.
HIV prevention programs for transgender women	$8,050	$180.00 – $212.70 [a]	41 (55%)	35% – 70% of transgender women based on a reported higher capacity to reach and engage with transgender populations. As the full impact of other health interventions and social support including transgender men could not be modelled, total estimated spending in 2020 ($14,251) and unit costs were adjusted to reflect only the proportion of transgender women reached (28 out of 67).
PrEP for female sex workers with demand creation	$0	$155 – $238 [e]	0	10% – 20% of female sex workers, equating to 20% to 40% of HIV transmission risk among female sex workers. This assumption reflects self-selection of highest risk individuals for PrEP initiation (49),
PrEP for men who have sex with men with demand creation	$0	$155 – $238 [e]	0	10% – 20% of men who have sex with men and transgender women, equating to 40% to 80% of HIV transmission risk among men who have sex with men and transgender women. This assumption reflects self-selection of highest risk individuals for PrEP initiation (49), combined with effective program targeting through HIV prevention programs for men who have sex with men for a population with highly heterogenous risk.
HIV self-testing (scenarios without stigma reduction)	$0	$12.44 – $16.00 [f]	0	0% – 10% who would not otherwise have received HIV testing, among active key populations including female sex workers, high-risk women, transgender women, men who have sex with men, and people who use drugs including alcohol. This reflects HIV self-testing implemented as a pilot program through SKPA activities but believed to be reaching primarily individuals already tested through other means through key population HIV services but increasing the proportion of people who are reached that have HIV testing within that population.
HIV self-testing (scenarios	$0	$12.44 – $16.00 [f]	0	0% – 15% who would not otherwise have received HIV testing, among all populations

with stigma reduction)				with either active or historic risk (those who have ever previously been part of a key or vulnerable population), including female sex workers, high-risk women, transgender women, men who have sex with men, people who use drugs including alcohol, and clients of female sex workers. This reflects high levels of population awareness of HIV self-testing that is widely acceptable and accessible following reduction of barriers to accessing HIV services including stigma and discrimination.

PrEP, Pre-exposure prophylaxis

a Triangulated from (i) Top-down Global Fund disbursement including SKPA activities targeting specified population group 2020-2021, (ii) Bottom-up costing for March 2022 through SKPA costing study (REF), and (iii) Comprehensive 2018 NASA cost estimates.

b Cost based on comprehensive prevention programs for sex workers and adjusted for other high-risk women to reflect lower levels of outreach and modelled behavioural change.

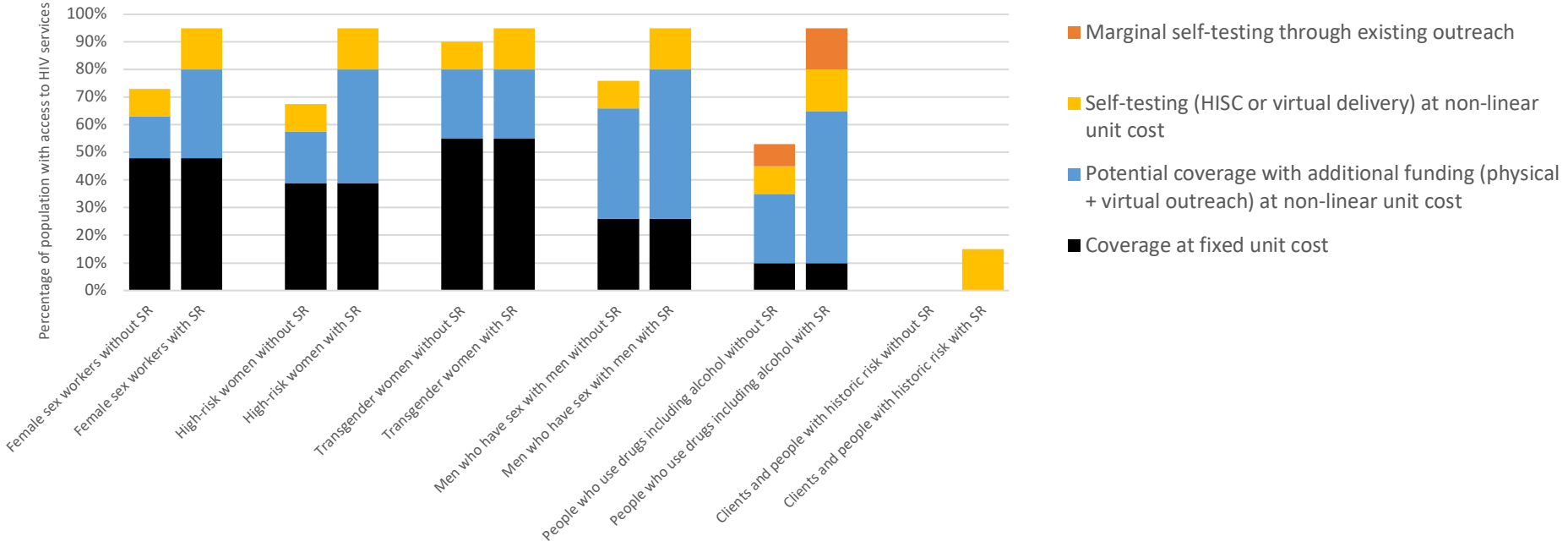
c Cost includes outreach and overheads, informed by program costs for reaching men who have sex with men and adjusted to reflect lower levels of outreach and modelled behavioural change.

d Aligned with HIV-self testing costs, assuming the outreach, training and other overheads would be funded outside of the HIV budget.

e Range based on PrEP unit cost in Nepal and average PrEP unit cost in Asia (49), combined with estimated regional PrEP demand creation costs through CSOs in Cambodia and Thailand (50, 51).

f Range based on bottom-up costs for HIV self-tests including pre-test counselling delivered through HISCs, with between 10% and 30% of tests conducted through private purchase at pharmacies at no cost to the HIV program.

Figure E1. Maximum saturation coverage achievable by key population programs with and without stigma reduction (SR)



E.2 Program impacts

For each HIV program, it is necessary to derive one set of logistic curves that relate funding to program coverage levels and another set of curves (generally linear relationships) between coverage levels and clinical or behavioural outcomes (i.e., the impacts that HIV strategies aim to achieve). Outcomes expected from changes in program funding are assumed by interpolating and extrapolating available data using a fitted logistic curve. A limitation of this approach is that all changes in behaviour are assumed to be because of changes in program funding.

Where no specific source is given, values were reconciled based on available evidence to align with the most recently reported behavioural data.

- "Baseline value": The proportion of people who would be tested or use condoms without any HIV interventions, determined by early behavioural surveys before interventions or typically through reported general population values (e.g., those who might be tested through clinic-based testing services and counselling).
- "Individual value with outreach": The proportion of people who would be tested or use condoms when reached with the specific HIV interventions (the difference between this value and the baseline value represents the *behavioural change.*
- "2020 Value": The behaviour in 2020 taken from behavioural surveys where available.
- "Maximum achievable value at program saturation": Across the whole population, if the saturation coverage was achieved given the limitations primarily due to stigma and discrimination, the modelled value for this parameter.
- "Maximum achievable value at program saturation with reduced barriers to healthcare": Across the whole population, the modelled maximum program coverage achievable if stigma and discrimination barriers were reduced. It was assumed that 95% of key populations could have access to an HIV prevention and testing service with stigma reduction in place.

HIV testing is given with two values: reported HIV testing rate and adjusted HIV testing rate. The number of reported diagnoses is low relative to the number of tests, and this can be interpreted alongside 'hidden' populations of people such as home-based sex workers who are both more likely to have been exposed to HIV transmission risk and more likely to avoid testing due to barriers to accessing HIV services. Conversely, some key populations most aware of their risk may be tested more regularly, with testing as part of HIV prevention outreach. The modelled likelihood that an undiagnosed person would be diagnosed within 12 months shown in the second row was calibrated to align with reported national diagnosis rates relative to the reported testing rates by population, and this is significantly lower under current conditions. If barriers to accessing HIV services were removed, it is estimated that additional HIV testing may become representative of the population, resulting in higher diagnosis rates among previously unreached and undiagnosed key populations.

Table E2. HIV prevention programs for key populations impacts.

Program	Parameter	Baseline value	Individual value with outreach	2020 average value	Maximum achievable value at program saturation, including HIV self-testing		Notes
					Without stigma reduction	With stigma reduction	
HIV prevention programs for sex workers	Reported HIV testing (proportion of population tested)	23% [a]	81% [b]	70% [c]			Assumed lower maximum values for condom use for female sex workers than for men who have sex with men as female sex workers may be less likely to be able to negotiate condom use. The higher value for HIV testing in 2020 than the maximum achievable value at saturation reflects the program reports that sex work was more concentrated in Thimphu in 2020 and accessible by programs and it would not be possible to maintain the same level of program coverage and testing in future years.
	Adjusted HIV testing (proportion of undiagnosed people living with HIV tested)			14%	24%	79%	
	Casual condom use	23%	63%	55% [a]	50%	57%	
	Commercial condom use	45%	85%	69% [a]	72%	79%	
HIV prevention programs for high-risk women	Reported HIV testing (proportion of population tested)	23% [a]	65%	46% [c]			Lower values for casual condom use as perceived risk is likely lower for high-risk women who are not female sex workers and challenges in negotiating condom use with partners especially including people who use drugs including alcohol.
	Adjusted HIV testing (proportion of undiagnosed people living with HIV tested)			9%	17%	66%	
	Casual condom use	18%	35%	24% [a]	28%	31%	
	Commercial condom use	55%	90%	69% [a]	75%	83%	
HIV prevention programs for men who have sex with men	Reported HIV testing (proportion of population tested)	23%	78% [b]	31% [c]			Based on high levels of behavioural change observed in men who have sex with men through surveys since the introduction of HIV prevention programs, assumed that the program is able to reach people at disproportionately higher risk, e.g. 14% of men who have sex with men reached equates to 28% of casual and commercial acts between men who have sex with men, and saturation coverage of 15% to 25% of men who have sex with men would represents 30% to 50% of acts.
	Adjusted HIV testing (proportion of undiagnosed people living with HIV tested)			7%	19%	82%	
	Casual condom use	27%	85%	43% [a]	50%	68%	
	Commercial condom use	50%	95%	63% [a]	68%	82%	
HIV prevention programs for people who use	Reported HIV testing (proportion of population tested)	18%	39%	19%			As this is a prospective program with limited direct evidence and there is not recent survey data on risks including condom use, values are largely assumptions based on non-key population estimates and other programs.
	Adjusted HIV testing (proportion of undiagnosed people living with HIV tested)			4%	17%	54%	

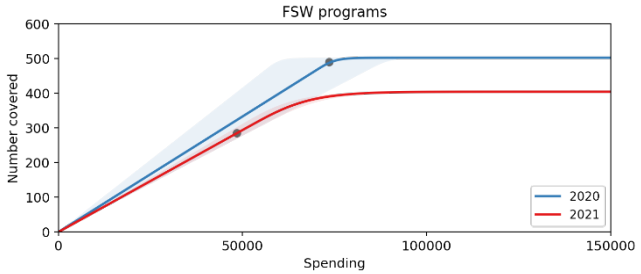
Program	Parameter	Baseline value	Individual value with outreach	2020 average value	Maximum achievable value at program saturation, including HIV self-testing		Notes
					Without stigma reduction	With stigma reduction	
drugs including alcohol	Casual condom use	18%	45%	20%	29%	37%	
	Commercial condom use	23%	60%	25%	38%	49%	
HIV prevention programs for transgender women	Reported HIV testing (proportion of population tested)	23%	78% [b]	43% [c]			Assumed lower maximum values for condom use for transgender women than for men who have sex with men as transgender women may be less likely to be able to negotiate condom use.
	Adjusted HIV testing (proportion of undiagnosed people living with HIV tested)			8%	17%	77%	
	Casual condom use	18%	46%	27% [a]	33%	39%	
	Commercial condom use	57%	85%	67% [a]	72%	78%	

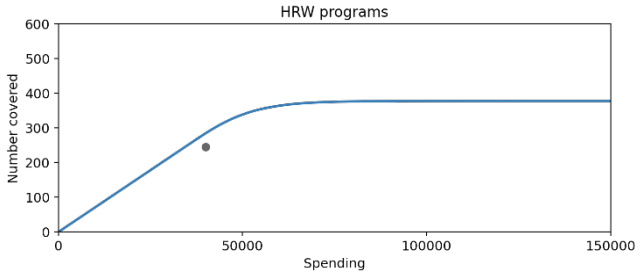
a, PSE; b, Program data; c, Global Fund disbursement report 2021

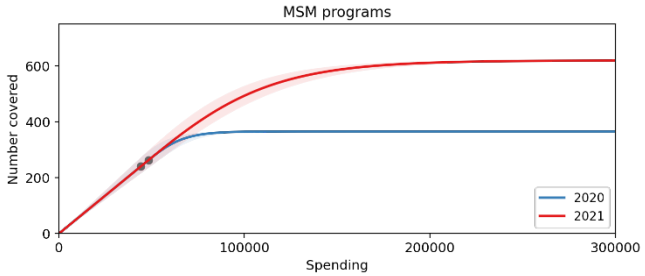
E.3 Cost functions

The following figures show the relationship between total spending and number of individuals covered among targeting population(s) of each program. For programs where estimated saturation coverage changed from 2020 to 2021 due to changed circumstances, the 2021 curve was used for optimisation.

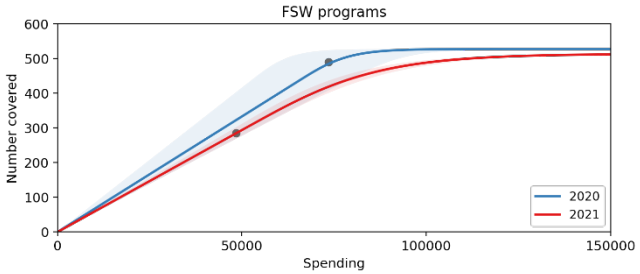
Cost functions without stigma reduction interventions.

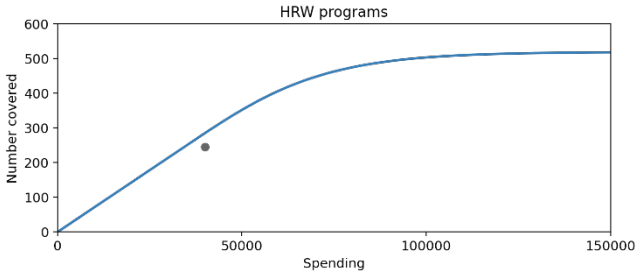


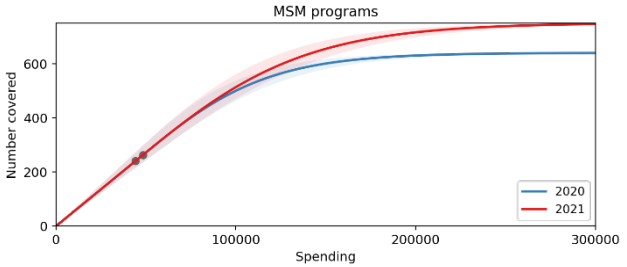


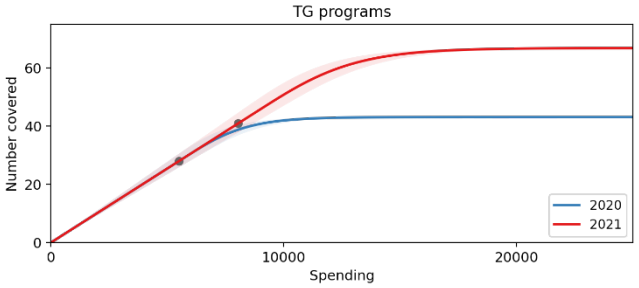


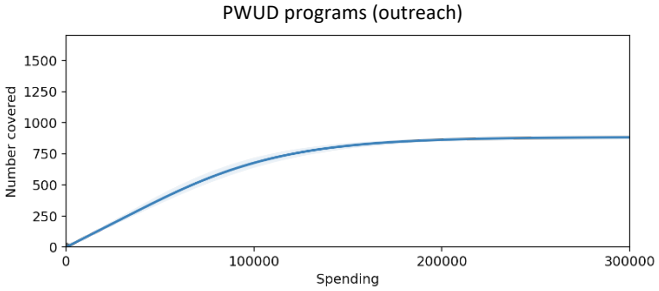
Cost functions with stigma reduction interventions.

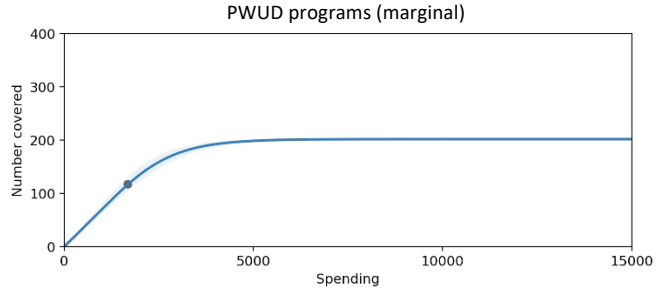


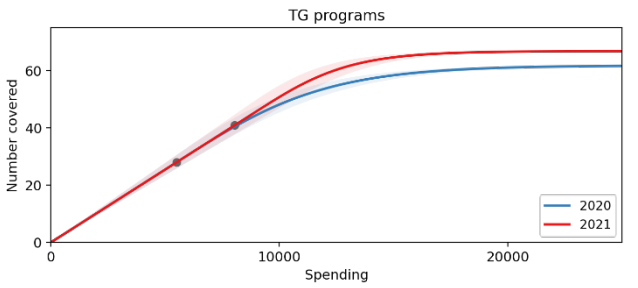


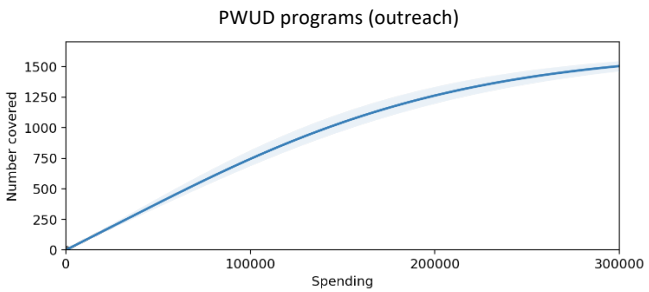


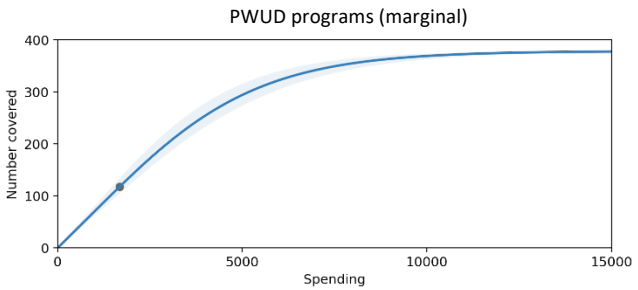

TG programs
Number covered
Spending
2020
2021

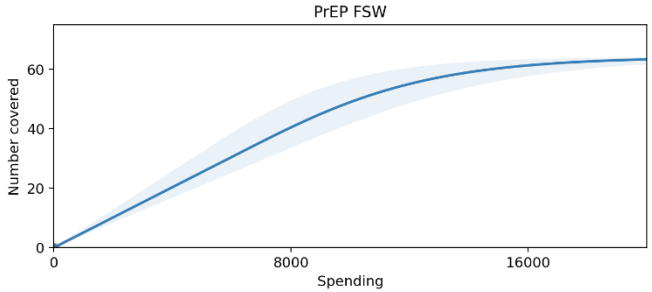

PWUD programs (outreach)
Number covered
Spending

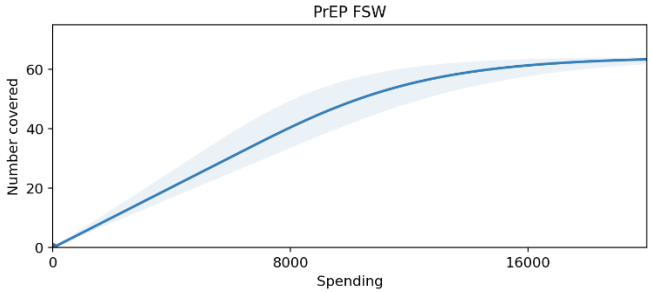

PWUD programs (marginal)
Number covered
Spending

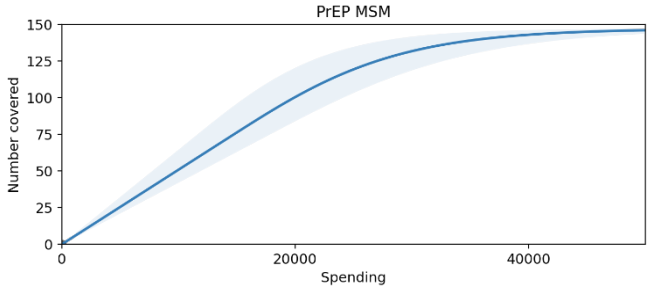

TG programs
Number covered
Spending
2020
2021

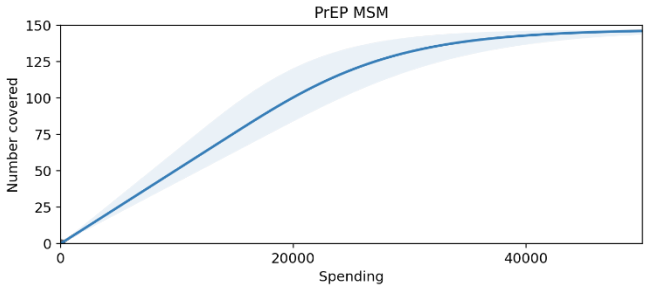

PWUD programs (outreach)
Number covered
Spending

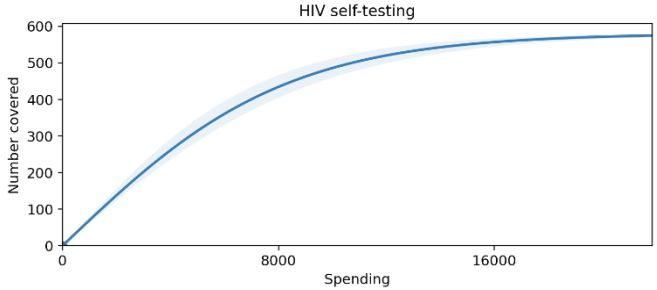

PWUD programs (marginal)
Number covered
Spending

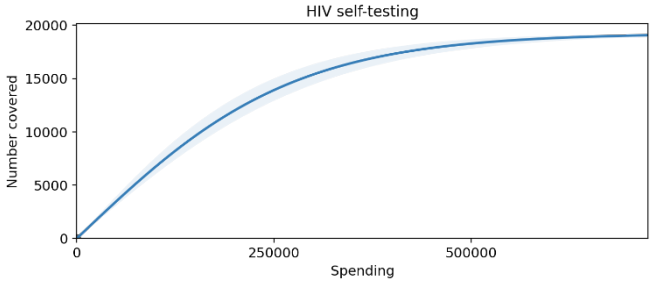

PrEP FSW
Number covered
0
20
40
60
0
8000
16000
Spending


PrEP FSW
Number covered
0
20
40
60
0
8000
16000
Spending


PrEP MSM
Number covered
0
25
50
75
100
125
150
0
20000
40000
Spending


PrEP MSM
Number covered
0
25
50
75
100
125
150
0
20000
40000
Spending


HIV self-testing
Number covered
0
100
200
300
400
500
600
0
8000
16000
Spending


HIV self-testing
Number covered
0
5000
10000
15000
20000
0
250000
500000
Spending

Appendix F. Estimation of cost of stigma reduction interventions

Table F1. Stigma reduction interventions implemented and estimation of intervention costs.

	Cost (Bhutan Nu) 2021	Cost (USD)* 2021
KP-friendly health services to ensure increasing uptake of STIs including HIV services		
Facilitate online and face to face dialogue forums	150,000	$1,899
IEC materials targeting health workers developed and distributed	100,000	$1,266
Community based monitoring support for KPs	800,000	$10,127
Social media messages/publicity	100,000	$1,266
Two ToT on STI among KPs	300,000	$3,797
Availability of knowledgeable and specialised health personnel to provide KP-friendly services by 2021		
Online Survey to gauge health workers' understanding of SOGIESC/ health needs of KPs	200,000	$2,532
Adaptation/ development of SOGIESC related training materials/ modules	350,000	$4,430
Training for health workers on Revised Service package/ SOGIESC/health needs of KPs	300,000	$3,797
Schools and workplaces support LGBTQI community to excel and provide equal opportunities		
Sensitisation workshop for schools/education institutes and organisations to raise awareness and prevent discrimination, abuse, and violence	0	$0
Development of IEC materials for schools, educational institutes, workplaces	150,000	$1,899
Enabling legal and policy environment for LGBTQI community members to receive equal rights before law and in society		
Sensitisation workshop with lawmakers and enforcers on legal/policy/socio-economic barriers faced by KPs	500,000	$6,329
Sensitisation workshop on legal literacy for KPs	150,000	$1,899
IEC materials	500,000	$6,329
Promote and ensure humane, health & social rights of drug users and reduce stigma and discrimination in the society		
IEC materials for schools/ parents and family members	500,000	$6,329
Essay/quiz competition	100,000	$1,266

KP networks, CSOs, and members flourish in a socially nurturing environment		
Sensitisation programme for KPs on human rights and equality	100,000	$1,266
Training for media professionals on reporting KP issues and media award	250,000	$3,165
Mobile application for accessing information on SOGIESC, HIV, KP, legal provisions, and reporting on S&D	400,000	$5,063
Media advertisement, IEC and communication materials	200,000	$2,532
Total	5,150,000	$65,190

*Bhutan ngultrum was converted to USD based on an exchange rate (79 Nu:US$1)

CSO, civil society organisation; IEC, information, education and communication; KP, key population; LGBTQI, Lesbian, Gay, Bisexual, Transgender, Queer and Intersex; S&D, stigma and discrimination; SOGIESC, sexual orientation, gender identity, gender expression and sex characteristics; STI, sexually transmitted infection ; ToT, training of trainers

Appendix G. Optimisation results

The following tables list estimated optimised resource allocations for each program by spending level both without stigma reduction (Table G1) and with stigma reduction activities (Table G2). These outputs are not suggested future budgets, as they assume changes can be made immediately in 2023 and do not take into account external factors that are not modelled, such as workforce mobilisation, adequate time for scale-up of the program, procurement of commodities and adaptation of facilities.

Table G1. Optimised spending allocation with varying resource availability without stigma reduction activities.

Programs	Baseline	Optimised spending 50%	Optimised spending 90%	Optimised spending 100%	Optimised spending 150%	Optimised spending 200%	Optimised spending 300%	Optimised spending 400%	Optimised spending 500%
HIV programs for female sex workers	$48,450	$60,700	$72,900	$53,300	$79,900	$84,300	$89,900	$98,600	$109,900
HIV programs for high-risk women	$40,000	$0	$30,600	$36,000	$54,300	$59,200	$65,500	$75,300	$86,600
HIV programs for men who have sex with men	$48,261	$0	$0	$43,400	$43,400	$71,500	$104,400	$154,600	$199,100
HIV programs for people who use drugs including alcohol (outreach)	$0	$0	$0	$0	$0	$31,800	$105,500	$157,900	$214,500
HIV testing for people who use drugs including alcohol (marginal)	$1,673	$2,200	$3,400	$1,900	$4,200	$4,500	$5,200	$6,100	$7,200
HIV programs for transgender women	$8,050	$0	$0	$7,200	$7,200	$7,200	$7,200	$13,500	$16,600
PrEP for female sex workers including demand creation	$0	$3,700	$13,300	$0	$16,000	$17,700	$19,900	$23,100	$27,200
PrEP for men who have sex with men including demand creation	$0	$0	$0	$0	$0	$0	$22,600	$32,800	$42,300
HIV self-testing	$0	$6,600	$116,400	$4,600	$14,600	$16,600	$19,000	$23,800	$28,700
Stigma reduction activities (N/A)	$0	$0	$0	$0	$0	$0	$0	$0	$0

Total HIV prevention and testing	**$146,434**	**$73,200**	**$131,800**	**$146,400**	**$219,700**	**$292,900**	**$439,300**	**$585,700**	**$732,200**

Except for baseline spending, all values rounded to nearest 100

Table G2. Optimised spending allocation with varying resource availability with stigma reduction activities.

Programs	Baseline	Optimised spending 50%	Optimised spending 90%	Optimised spending 100%	Optimised spending 150%	Optimised spending 200%	Optimised spending 300%	Optimised spending 400%	Optimised spending 500%
HIV programs for female sex workers	$48,450	$4,600	$60,000	$26,900	$60,100	$68,100	$77,900	$91,500	$102,800
HIV programs for high-risk women	$40,000	$0	$0	$22,200	$36,000	$36,000	$36,000	$51,400	$69,700
HIV programs for men who have sex with men	$48,261	$0	$0	$26,800	$43,400	$43,400	$43,400	$43,400	$67,100
HIV programs for people who use drugs including alcohol (outreach)	$0	$0	$0	$0	$0	$0	$0	$0	$0
HIV testing for people who use drugs including alcohol (marginal)	$1,673	$3,600	$5,000	$900	$5,000	$5,200	$7,000	$8,400	$69,600
HIV programs for transgender women	$8,050	$0	$0	$4,500	$7,200	$7,200	$7,200	$7,200	$7,200
PrEP for female sex workers including demand creation	$0	$0	$0	$0	$0	$0	$9,300	$12,200	$14,400
PrEP for men who have sex with men including demand creation	$0	$0	$0	$0	$0	$0	$0	$0	$0
HIV self-testing	$0	$0	$0	$0	$2,900	$67,900	$193,400	$306,600	$396,400
Stigma reduction activities	$0	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000
Total HIV prevention and testing	**$146,434**	**$73,200**	**$131,800**	**$146,400**	**$219,700**	**$292,900**	**$439,300**	**$585,700**	**$732,200**

Except for baseline spending, all values rounded to nearest 100

Appendix H. Uncertainty in projections and recommendations

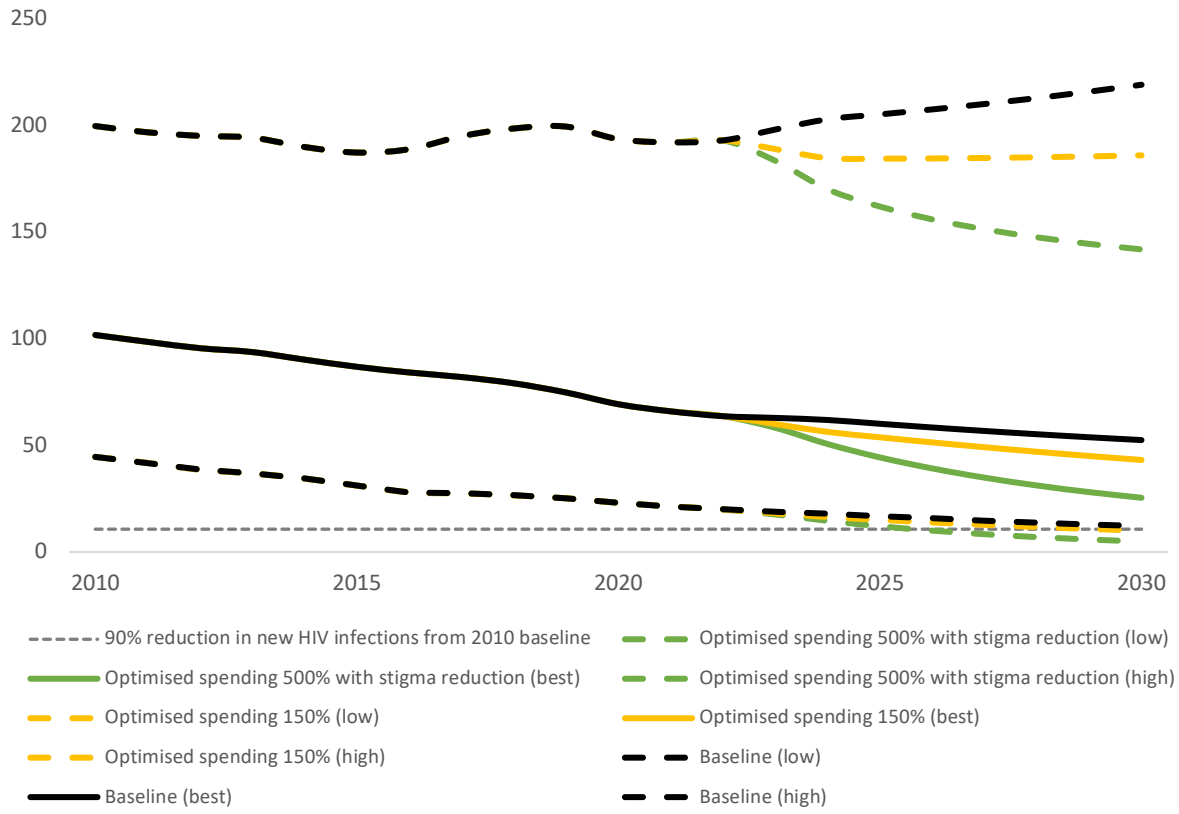
H.1 Uncertainty over future HIV infections

If the HIV epidemic is lower than the 'best' estimate of new HIV infections (65 new infections per year in 2021), then the impact of additional spending may avert few total new HIV infections (Figure H1).

However, if the epidemic is toward the upper bound of estimates (nearly 200 new HIV infections per year in 2021), then:

- The impact of investments will be greater in terms of infections averted.
- Significant additional investment will be needed to avert a rising trend.

Figure H1. Uncertainty in future new HIV infections.



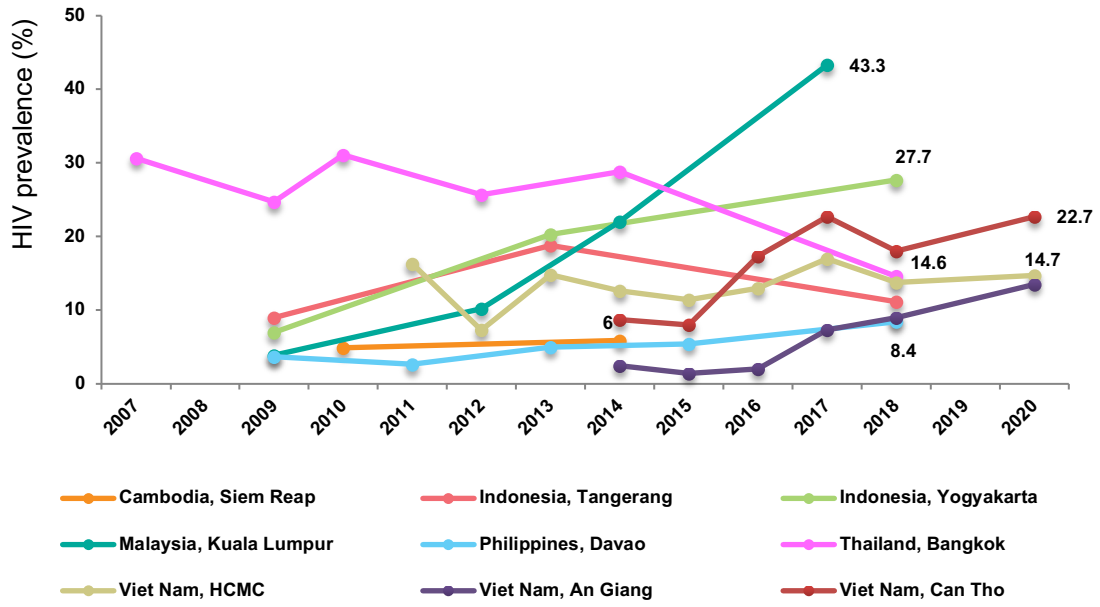
H.2 Uncertainty over behavioural change/risks in the future

Maintenance and expansion of HIV prevention programs for men who have sex with men and transgender populations is a high priority. Model estimates of HIV prevalence among men who have sex with men (1.5%) and transgender women (3%) is relatively low but rising.

In the South-East Asia region, increasing risks are reported to be related to sexualized drug use among men who have sex with men, and there are increasing trends in HIV prevalence in many contexts (Figure H2).

If regional trends for risk emerge in Bhutan, HIV prevention programs for men who sex with men including PrEP will become a more critical priority.

Figure H2. Trends in HIV prevalence among men who have sex with men in South-East Asian cities, 2007 to 2020.



Source: Prepared by www.aidsdatahub.org based on HIV Sentinel Surveillance Surveys and Integrated Biological and Surveillance Surveys; GARPR Reporting and Global AIDS Monitoring

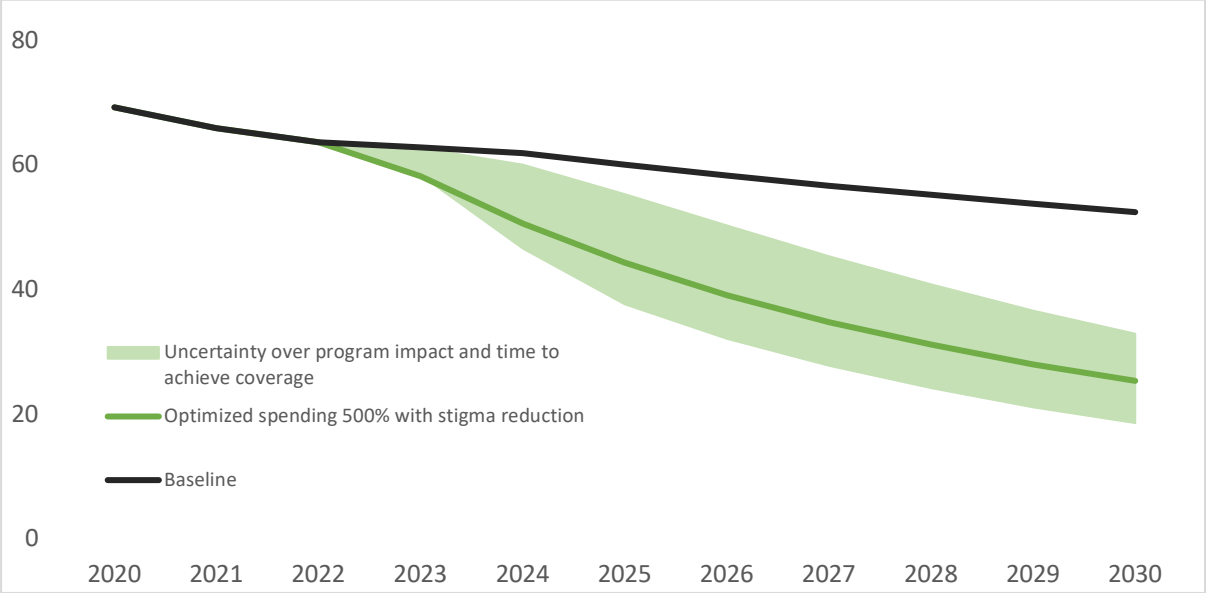
H.3 Uncertainty over acceptability of pre-exposure prophylaxis

Model outputs suggest PrEP for female sex workers including demand creation may be cost-efficient as part of the HIV response. However, there is low awareness of PrEP in Bhutan as indicated during the stakeholders consultations which may impact the uptake of PrEP, even with demand creation (52). Ongoing/planned trialling of PrEP may better inform achievable coverage levels by key population.

H.4 Uncertainty over program impacts and time to achieve increased coverage

Additional investments of up to 500% current targeted HIV prevention and testing spending may maximise projected impacts on reducing new HIV infections by further improving the linkage to care, ART retention, and viral suppression. However, the optimisation assumes that changes to allocations of spending are applied immediately, whereas in practice there may be delays in reaching full coverage. These lead to uncertainty in impact on epidemic projections (Figure H3). Technical efficiencies of the intervention design will be critical to achieve the full potential of the modelled impact.

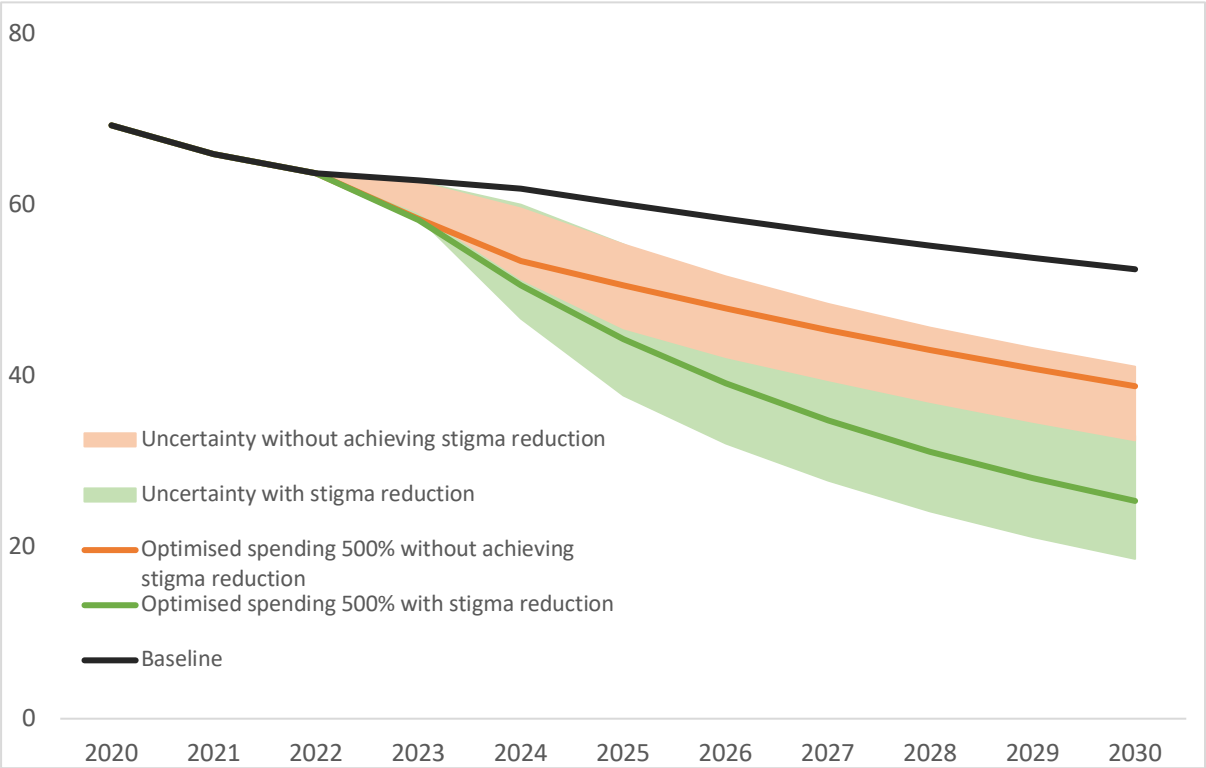
Figure H3. Uncertainty in impact of optimised spending 500% with stigma reduction scenario on annual new HIV infections.



H.5 Uncertainty over stigma reduction interventions

If stigma reduction interventions are not included as part of additional investment or if they are not successful in reducing stigma, discrimination, and other structural barriers to accessing HIV services, investing in alternative programs would have substantially lower impact (Figure H4).

Figure H4. Uncertainty in impact of stigma reduction interventions on projected new HIV infections.



H.6 Uncertainty over the uptake of HIV self-testing

HIV self-testing in the context of reduced stigma, discrimination and other barriers to accessing HIV services is assumed to have the potential to engage all currently active key populations as well as people with historic risks, up to a total estimated 20% of the adult population (Table H1). This includes primarily males who have ever been clients of female sex workers, as well as females who have ever worked in high-risk venues, and is calculated based on the estimated key population sizes and the average duration within key populations.

Table H1. Target population size to be reached by HIV self-testing

Estimated 2020 key population sizes	
Clients of female sex workers	29,130
People who use drugs including alcohol	2,352
Female sex workers	603
High-risk women	631
Men who have sex with men	1,751
Transgender women	77
Estimated 2020 target population size for increased self-testing	
Males who were previously in a high-risk population	66,667
Females who were previously in a high-risk population	20,105

We estimated that 10-30% of self-testing could be through private purchase, and 70-90% provided through health information service centres, at a cost of $17.78 per test.

There are opportunities for self-testing to be more targeted, reducing overall cost per diagnosis, if used by people with higher historic risks. Reducing unit costs for HIV self-testing is also achievable through: procurement of cheaper self-test kits; more access through private purchase; and reduced staff time/overheads.

Alternatively, there are risks that self-testing could be less targeted, and thus have higher overall costs, if used by people without high historic risks. There is considerable uncertainty over uptake of HIV self-testing, as this is primarily demand based.