Phase 1 Report
National and Provincial
HIV Acquisition and Transmission
Estimates and Patterns in Zimbabwe

A Mathematical Modelling Analysis

JULY 2018

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Medical Research, Practical Action.

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Phase 1 Report

National and Provincial HIV Acquisition and Transmission Estimates and Patterns in Zimbabwe

A Mathematical Modelling Analysis

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### Abbreviations

<table>
<thead>
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<th>Description</th>
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</thead>
<tbody>
<tr>
<td>AE</td>
<td>Allocative efficiency</td>
</tr>
<tr>
<td>AIDS</td>
<td>Acquired immune deficiency syndrome</td>
</tr>
<tr>
<td>ART</td>
<td>Antiretroviral therapy</td>
</tr>
<tr>
<td>Clients</td>
<td>Clients of sex workers</td>
</tr>
<tr>
<td>DALY</td>
<td>Disability-adjusted life year</td>
</tr>
<tr>
<td>DHS</td>
<td>Demographic and Health Survey</td>
</tr>
<tr>
<td>FSW</td>
<td>Female sex workers</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>Global Fund</td>
<td>The Global Fund to Fight AIDS, Tuberculosis and Malaria</td>
</tr>
<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
</tr>
<tr>
<td>HTS</td>
<td>HIV Testing Services</td>
</tr>
<tr>
<td>MSM</td>
<td>Men who have sex with men</td>
</tr>
<tr>
<td>M&amp;E</td>
<td>Monitoring and Evaluation</td>
</tr>
<tr>
<td>PLHIV</td>
<td>People living with HIV</td>
</tr>
<tr>
<td>PMTCT</td>
<td>Prevention of Mother-To-Child Transmission</td>
</tr>
<tr>
<td>YLL</td>
<td>Years of life lost</td>
</tr>
<tr>
<td>ZIMPHIA</td>
<td>Zimbabwe Population-based HIV Impact Assessment</td>
</tr>
</tbody>
</table>
Executive summary

This report summarizes findings from a mathematical modelling study to examine the patterns of HIV acquisition and transmission in Zimbabwe during the period from 2000 to 2017 and to predict future trends to 2030. This study was conducted in preparation for the planned analyses to identify opportunities for optimizing HIV resource allocation and improving implementation efficiency of core components as part of the HIV response in Zimbabwe. These analyses were carried out using the Optima HIV model.

Model alignment

The following key findings emerged from the analysis of data, epidemic estimates and projections:

- HIV estimates produced by the Optima HIV model are, broadly, in line with other epidemic trend estimates produced by Spectrum and other models. HIV estimates produced by Optima HIV are in line with the measured HIV prevalence and incidence as measured through two population-based surveys, Demographic and Health Survey (DHS) and the Zimbabwe Population based HIV Impact Assessment (ZIMPHIA).

Figure ES1. Estimated HIV incidence rates from different sources

![HIV incidence rates from different sources](image)

Sources: Populated Optima-HIV model, Hontelez et al (2017, in draft), UNAIDS 2017 estimates, ZIMPHIA

Upper and lower 95% confidence intervals

HIV prevalence trends

- Despite an overall decline in HIV prevalence there is substantial subnational variation in HIV prevalence levels and trends. Optima HIV estimates suggest that HIV prevalence among 15-49 declined from 22% in 2000 to 14% in 2015 and is projected to decline further to less than 10% by 2030. The decline in HIV prevalence is more pronounced in the northern and eastern provinces (Harare, Manicaland, Mashonaland Central, East and West) while in the southern and western provinces (Bulawayo, Matabeleland South & North, Midlands, Masvingo) HIV prevalence has only moderately declined or has stabilized.
• Declines in risk behavior recorded between the 1990s and 2010 may have begun to be reversed by 2015 (DHS) and risk behaviors remain higher in the south-western provinces, where HIV prevalence is higher. The 2015 DHS recorded an increase in risk behaviors after 2010 including increases in non-regular partnerships, multiple partnerships, and paid sex. There are also major geographical differences in the prevalence of non-regular partnerships, which are more common in Bulawayo and Matabeleland South & North.

• In contrast to large geographical variation in reported risk practices, HIV service coverage and outcomes are relatively uniform in Zimbabwe. Rates of self-reported condom use are similar across provinces (77.7% – 90.1% among men and 54.4% – 73.3% among women in DHS 2015) but lower in the two Matabeleland provinces (77.7% – 78.4% among men and 54.4% and 63.3% among women). There are no significant differences between provinces in levels of HIV testing, treatment and viral suppression, which are only non-significantly higher in the three south-western provinces.

• The high HIV prevalence in southern provinces despite similar HIV service coverage requires further analysis and programmatic attention. People residing in the three south-western provinces of Zimbabwe encounter a combination of several risk factors. In addition to an already high prevalence of HIV and higher frequency of non-regular partnerships, sex work is relatively more frequent in Bulawayo (3.3% of females aged 15-49 years report being sex workers versus 1.3% nationally and 1.9% in Harare). There is also a large amount of temporary seasonal labor migration. Strategies to address the three mentioned factors (higher prevalence of HIV, higher sexual risk behavior, and a relatively higher number of sex workers and paid commercial sex), must be further explored for the respective provinces.

• If the most recent epidemic patterns and program coverage are maintained, findings from the Optima HIV model suggest a continued decline in HIV incidence; however, this decline will not be sufficient to reach global 2020 and 2030 targets. Additional efforts and innovations will be required to reach 90% reduction by 2030 compared with 2010 levels.

• The HIV epidemic in Zimbabwe is projected to continue aging. In 2000, approximately two-thirds of people living with HIV (PLHIV) were younger than 35 years of age. In 2015 this group increased to approximately 50% and it is projected that by 2030 two-thirds of PLHIV will be 35 and older. This suggests that in addition to integration of HIV services within reproductive health services for youth, HIV care will increasingly need to be integrated with prevention and care for non-communicable diseases among aging adults.

HIV incidence patterns

• Around half of new HIV infections are acquired among the general population aged 25 years and older. The pattern of new HIV infections acquired in Zimbabwe represents a mix of several different groups and transmission settings. An estimated 56% of new adult HIV infections were shown to have been acquired by females and 44% among males. 16% of new HIV infections acquired were estimated to have occurred
among key populations, the vast majority (14% of all new infections) in sex work settings, 1.3% among men who have sex with men (MSM) and 0.7% among prisoners. 14% of new infections were estimated to have been acquired in children through vertical transmission and 20% among young people 15 to 24 years old. Broadly in line with ZIMPHIA data, Optima HIV estimates suggest that HIV incidence among females is particularly high in 20-34 year olds and remains high among 35-49 year olds. Among males, HIV incidence among 15-24 year olds was estimated to be low and most new infections occurred among 25-49 year old men.

**Figure ES2. Trends and projections of new HIV infections acquired and transmitted from 2017 to 2030**

A. New HIV infections acquired, 2017-2030

B. New HIV infections transmitted, 2017-2030

**Source:** Populated Optima HIV model

- **A large proportion of new HIV infections from 2017 to 2030 are estimated to be transmitted by those aged 25 years and older.** 31% of HIV is modeled to be transmitted by women 25-49 years of age from the general population including vertical transmission. 26% of HIV is transmitted by men 25-49 years old from the general population. There are specific differences by age and sex between new infections acquired and transmitted. While young people 15-24 years of age (excluding young people from key population groups) were estimated to account for 20% of new infections acquired, they were estimated to account for having transmitted only 12% of new HIV infections. Although males aged 50 years and older were estimated to have acquired less than 2% of new HIV infections, it was estimated that they transmitted 9% of all new infections over this period.

- **Among key populations, the largest share of HIV infections is attributable to sex workers and their clients, but it was estimated that all four key populations included in the model (FSW, clients, MSM, and prisoners) will experience a high incidence of HIV.** It is projected that around 1 in 5 of all HIV infections that will be transmitted in Zimbabwe will be among sex workers and their clients. The impact of sex work-related transmission on the epidemic is likely even higher that shown in this model exercise since clients and sex workers may continue transmitting HIV even after
they are sex workers or clients and transition back into the general population. The role of sex workers in the epidemic is particularly impactful in the urban settings of Bulawayo and Harare.

- **Model projections suggest that under most recent conditions, the number of people living with HIV will moderately decline and levels of HIV diagnosis in 2017 already exceeded the 90% target set for 2020.** With a projected further decline in the number of PLHIV who are not aware of their status, it will become increasingly challenging to detect undiagnosed PLHIV. Therefore, it is particularly important to understand who comprises those remaining to be diagnosed. According to Optima HIV estimates, HIV positive adolescents aged 15 to 19 years are least likely to be diagnosed. However, since HIV prevalence and the absolute number of people living with HIV is much higher among those aged 25 years and older, the majority of those undiagnosed are also among the general population 25+ (56%), despite a smaller proportion being undiagnosed. The remainder of those undiagnosed are distributed as follows: 13% are children, 14% young people aged 20-24 years, and 13% female sex workers and their clients.

These findings will inform subsequent phases of collaborative modelling analysis between the National AIDS Council, Ministry of Health and Child Care, the World Bank and technical partners – as agreed in the scope of work for the analysis including:

- Implementation efficiency: optimization across the HIV treatment and care cascade, and
- Cost-effectiveness analysis of intensive sex worker programs.
1. Introduction

1.1.1. Background – overall disease burden in Zimbabwe

HIV remained the single largest cause of deaths, disability adjusted life years (DALYs) and years of life lost (YLL) in 2016. According to the global burden of disease study 2016, 23.1% of all years of life lost were due to HIV in all age groups.

Among the population of reproductive age (15-49) HIV still accounted for 46.8% of all years of life lost in 2016, which suggests that HIV remains the primary cause of premature mortality in Zimbabwe. Despite a decline in HIV prevalence from an estimated 23.4% in 1997 to 13.5% in 2016 (UNAIDS) and impressive progress in scaling up treatment to 1 million people living with HIV, additional action will be required to further reduce HIV related disease burden.

Figure 1.1. Global burden of disease estimates for Zimbabwe, Years of Life Lost (2016)

1.2. A need for enhanced efficiency

Any resource-constrained effort to improve health outcomes is inevitably faced with the need to achieve the best possible outcomes with a finite set of resources. Current HIV programs are faced with the need to scale up prevention, while providing ongoing treatment to a larger number of people living with HIV than ever before. This makes strategic decisions in prioritization of which programs to fund (allocative efficiency) and efficiency in how they are implemented (implementation efficiency) critical to maximize health outcomes.

In order to enhance the efficiency of the HIV response, the National AIDS Council (NAC), Ministry of Health and Child Care (MOHCC) and the World Bank have agreed on analytical collaboration in four different areas:

1. Mathematical modelling of current and future trends of the HIV epidemic at national and provincial levels
2. Allocative efficiency including geospatial analysis of resource allocation
3. Implementation efficiency: Optimization of the HIV treatment and care cascade
4. Cost-effectiveness of intensive sex worker programs

This report summarizes findings of component 1 of the collaboration and presents an epidemiological model analysis of patterns of transmission and acquisition of HIV in Zimbabwe. This analysis is carried out in preparation of the other allocative and implementation efficiency analyses using modelling techniques in Zimbabwe (components 2 to 4).

The epidemic modelling analysis in this study was carried out using the Optimization & Analysis Tool (Optima HIV). The results can be utilized to inform decision-makers and health planners on patterns and trends in Zimbabwe’s HIV epidemic.
2. Methods

This chapter provides a brief overview on the Optima HIV model with additional technical information being provided in the Annex and in the referenced publications.

2.1. The Optima Model

To assess HIV epidemic trends, we used the Optima HIV epidemic module, which consists of a mathematical model of HIV transmission and disease progression. Optima uses established HIV epidemic modelling techniques and incorporates evidence on biological transmission probabilities, detailed infection progression, sexual behaviours and sexual mixing patterns. Data relating to programs and costs associated with programs are used in an integrated analysis to determine an optimized distribution of investment under defined scenarios.

Optima was calibrated to HIV prevalence data points available from different sub-populations at specific time points, as well as to data points on the number of people on ART. Calibration was performed in consultation with experts on the Zimbabwean epidemic. Section 2 and Appendix 2 provide further details regarding the calibration process.

2.2. Analytical framework

To tailor the model to the local context, analysts selected a number of parameters that describe the country population. Sub-populations, which were chosen in consultation for this study with national experts and included in the model, are listed in Table 2 below.
<table>
<thead>
<tr>
<th>Short name</th>
<th>Long name</th>
<th>Male</th>
<th>Female</th>
<th>Age from (years)</th>
<th>Age to (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSW</td>
<td>Female sex workers</td>
<td>No</td>
<td>Yes</td>
<td>15</td>
<td>49</td>
</tr>
<tr>
<td>Clients</td>
<td>Clients of sex workers</td>
<td>Yes</td>
<td>No</td>
<td>15</td>
<td>99</td>
</tr>
<tr>
<td>MSM</td>
<td>Men who have sex with men</td>
<td>Yes</td>
<td>No</td>
<td>15</td>
<td>99</td>
</tr>
<tr>
<td>Prisoners</td>
<td>Prisoner population</td>
<td>Yes</td>
<td>No</td>
<td>15</td>
<td>99</td>
</tr>
<tr>
<td>F0-14</td>
<td>Girls 0-14</td>
<td>No</td>
<td>Yes</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>M0-14</td>
<td>Boys 0-14</td>
<td>Yes</td>
<td>No</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>F15-19</td>
<td>Young women 15-19</td>
<td>No</td>
<td>Yes</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>M15-19</td>
<td>Young men 15-19</td>
<td>Yes</td>
<td>No</td>
<td>15</td>
<td>19</td>
</tr>
<tr>
<td>F20-24</td>
<td>Young women 20-24</td>
<td>No</td>
<td>Yes</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>M20-24</td>
<td>Young men 20-24</td>
<td>Yes</td>
<td>No</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>F25-34</td>
<td>Adult women 25-34</td>
<td>No</td>
<td>Yes</td>
<td>25</td>
<td>34</td>
</tr>
<tr>
<td>M25-34</td>
<td>Adult men 25-34</td>
<td>Yes</td>
<td>No</td>
<td>25</td>
<td>34</td>
</tr>
<tr>
<td>F35-49</td>
<td>Adult women 35-49</td>
<td>No</td>
<td>Yes</td>
<td>35</td>
<td>49</td>
</tr>
<tr>
<td>M35-49</td>
<td>Adult men 35-49</td>
<td>Yes</td>
<td>No</td>
<td>35</td>
<td>49</td>
</tr>
<tr>
<td>F50+</td>
<td>Older women 50+</td>
<td>No</td>
<td>Yes</td>
<td>50</td>
<td>99</td>
</tr>
<tr>
<td>M50+</td>
<td>Older men 50+</td>
<td>Yes</td>
<td>No</td>
<td>50</td>
<td>99</td>
</tr>
</tbody>
</table>

2.3. Overview of data inputs

For the specified sub-populations, detailed demographic, epidemiological and program data were collated from population-based surveys, population size estimation studies and program records. Table 2 summarizes the types of data included in the analysis. Data tables on selected key data inputs are provided in Annex 3.

Table 2. Types of data included in the model

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population size</td>
<td>Population sizes by sub-population</td>
</tr>
<tr>
<td>HIV prevalence</td>
<td>HIV prevalence by sub-population</td>
</tr>
<tr>
<td>Other epidemiology</td>
<td>Background mortality, STIs, TB prevalence</td>
</tr>
<tr>
<td>Testing &amp; treatment</td>
<td>HIV testing rates, on ART, ART UC, PrEP, PMTCT, birth rate, breastfeeding</td>
</tr>
</tbody>
</table>
| Optional indicators| Tests, diagnosis, modelled estimates (infections, prevalence, PLHIV, deaths),
|                    | initiating ART, PLHIV aware of status, diagnosed in care, on treatment (%),
|                    | on PMTCT (%), on ART with VS (%)                                         |
| Cascade            | Time to be linked to care, lost to follow-up, VL                         |
| Sexual behavior    | Number of regular, casual, commercial acts, condom use, circumcision     |
| Drug injecting behavior | Frequency of injection, needle-syringe sharing, OST                      |
| Partnerships       | Mixing patterns (sexual, drug injections)                                |
| Transitions        | Age- and risk-related movement between populations                       |
| Constants          | Parameters (transmissibility, efficacy, disease progression, mortality...)|

2.4. OPTIMA Model Calibration and Validation

A key stage in the Optima modelling process is the model ‘calibration’, which is also explained in more detail in Annex 1 and referenced academic publications. Calibration aims to align the Optima-projected trends with the historically observed trends in HIV prevalence in different
population groups in a given context. Given the challenges inherent in fitting epidemiological and behavioral data, the calibration for Zimbabwe was performed manually by varying relevant model parameters to attain a best-fit between model-projected and historic HIV prevalence. This process was conducted in close collaboration with in-country stakeholders.

Once the Optima model is calibrated, it can describe future expected trends in the HIV epidemic as described in Chapter 4.

Since the focus of this study is on estimating current patterns of HIV transmission and acquisition and projecting future trends, the model analysis focuses on the period 2000-2030. This is also the period, for which most data on the HIV response are available.

2.5. Limitations of the analysis

All mathematical models have their strengths and limitations. Results should therefore be interpreted in light of the assumptions made. In particular, it is important to note that:

- All model forecasts are subject to uncertainty. Therefore, point-estimates are indicative of trends rather than exact figures.
- Model calibration depends as much on the quality of input data as on the quality of the model itself. The country and study teams did everything possible to ensure the best possible data quality but it is never possible to have a complete, or completely certain dataset. The best model calibration will rarely achieve an exact match of historical data, but will mirror as closely as possible the key trends of them.
- Limited data was available for some important parameters in this study:
  - National HIV prevalence among sex work clients
  - Men who have sex with men (no data on population size and HIV prevalence)
  - Prisoners (only one data point for HIV prevalence)
  - Populations aged 50+ (only one data point for HIV prevalence 50-64)
  - Children (only one population-based data point for HIV prevalence)
  - However, relatively good data was available for the population 15-49 among which the majority of new infections occur
- Transmission represented on annual basis does not show dynamic long-term effects (onward transmission), which is higher among groups with greater partner change (sex workers, their clients, people with multiple partners) than populations who are unlikely to transmit to others (such as individuals long-term sero-discordant couples).
- Other models may produce different projections than those produced by Optima. This is an underlying property when using theoretical mathematical frameworks. Different designs of the framework may generate different outcome projections. However, the projections presented in this report are not significantly different from the UNAIDS estimates based on the Spectrum model. In addition, the analyses presented in this report made use of the best available country data, experience gained from applying the Optima model in over 30 countries, and comparisons within the eastern and southern Africa (ESA) region for the validation and contextualization of inputs and findings wherever possible.
3. Key trends emerging from model input data analysis

This chapter summarizes some key HIV data trends that emerged during the process of collating and analyzing data.

3.1. HIV prevalence data

Population-based HIV prevalence data were available from Demographic and Health Surveys (DHS) 2005-6, 2010-1 and 2015 as well as from the Zimbabwe Population-based HIV Impact Assessment (ZIMPHIA) study 2015-16. In addition, a population-based Young Adult Survey collected HIV bio-marker information in 2001-2. Trend data from consecutive DHSs represented in Figure 3.1. shows that HIV prevalence declined in Zimbabwe between 2005 and 2015. Data from antenatal clinics and a population-based cohort in Manicaland suggest that HIV prevalence already started to decline in the late 1990s (Gregson 2010). Figure 3.2. shows HIV prevalence by age in Zimbabwe in 2015-6 with a peak in HIV prevalence among females aged 40-44 and males aged 45-49.

Figure 3.1. HIV prevalence by sex, 2005-2015

![HIV prevalence by sex, 2005-2015](chart1)

Figure 3.2. HIV prevalence by age and sex, Zimbabwe 2015-6

![HIV prevalence by age and sex, Zimbabwe 2015-6](chart2)

Source: ZIMPHIA 2015-6
Figure 3.3 illustrates HIV prevalence by sex and province in Zimbabwe in 2015-16. HIV prevalence is highest in the three south-western provinces of Bulawayo, Matabeleland North and Matabeleland South.

*Figure 3.3. HIV prevalence by province*

Source: ZIMPHIA 2015-6
3.2. Sexual behavior data

Sexual behaviour data from Demographic and Health Surveys was used to calibrate the epidemic model. Consistently defined sexual behaviour indicators were available from 1999. As illustrated in Figure 3.4, trend data on non-regular (non-cohabiting and non-marital) partnerships suggests that these partnerships declined between 1999 and 2005 and increased between 2010 and 2015. Data from the same DHS on multiple partnerships and paid sex follow a similar pattern of early declines and moderate increases in risk after 2010. There is substantial variation in the level of non-regular partnerships in Zimbabwe (Figure 3.5). Non-regular partnerships among both males and females were highest in the three south-western provinces of Bulawayo, Matabeleland North and Matabeleland South. Non-regular partnerships were also relatively high in Harare, which may partially reflect the relatively large proportion of young adults who are not yet married within the population of the capital city. Differences in levels of non-regular partnerships reported by males and females likely reflect a combination of desirability bias and representation of partner numbers in the sexual mixing pattern.

Figure 3.5. Trend in the percentage of the population who had higher risk sex (with a non-regular partner) in the past 2 months

![Figure 3.5](image)

Source: DHS 2015

---

1 The relatively small number of female sex workers with a very large number of partners is likely to be under-presented, while the larger number of their sexual partners is likely to be represented more widely among respondents. In other words, if the ratio of sex workers to clients is 1 to 10, the sexual activity involving this sex worker and her clients would reflect once in the female sample and 10 times in the male sample.
DHS data on self-reported condom use with non-regular partners suggests that condom use increased among males and females from 70% in 1999 to 85% in 2015, and 43% to 67% respectively (Figure 3.6). Data from ZIMPHIA 2015-16, which was conducted only a few months after DHS suggested that condom use with non-regular partners was substantially lower, but the reasons for the difference in those estimates are not clear.

As shown in Figure 3.7, there is some variation in condom use between males and females between provinces, but differences are not as large as for non-regular partnerships. Condom use is lowest in Matabeleland North and South. Within urban areas condom use is higher in Harare than Bulawayo.

**Figure 3.6. Condom use at last higher risk sex (with a non-regular partner)**

**Figure 3.7. Condom use at last sex with a non-regular partner by province (DHS 2015)**
3.3. HIV service uptake data patterns

HIV testing was scaled up rapidly between 2005 and 2015 in Zimbabwe like in the majority of countries in eastern and southern Africa. As shown in Figure 3.8, the difference in HIV testing uptake between males and females remains substantial in all provinces. Differences in HIV testing uptake between provinces, however, are relatively small and unlike sexual behaviour indicators do not follow a clear geographical pattern. HIV testing in the major urban areas of Harare and Bulawayo is below the national average for females and near the average for males. HIV testing among females is relatively high in the two south-western Matabeleland provinces, where HIV prevalence and risk behaviours were found to be highest.

*Figure 3.8. Population receiving an HIV test and receiving test results in the last 12 months*

Source: DHS 2015
The ZIMPHIA study provided the first population-level assessment of progress against the 90-90-90 targets, which is summarized in Figure 3.9. The first 90 represents the proportion of all people living with HIV who know their HIV status. The second 90 represents the proportion of all diagnosed people living with HIV who are on treatment. The third 90 represents the proportion of all people on HIV treatment who are virally suppressed.

**Figure 3.9. Progress towards 90-90-90 HIV treatment targets**

![Graph showing progress towards 90-90-90 targets across provinces.](image)

Source: ZIMPHIA 2015-16

ZIMPHIA data suggest that across all provinces the largest gap in the treatment and care cascade is initial diagnosis, which ranges from 70% in Mashonaland East to 78% in Matabeleland North (Figure 3.9). Treatment initiation and retention ranges from 82% in Mashonaland East to 92% in Matabeleland South, while viral suppression among people on treatment varies from 83% in Midlands to 97% in Mashonaland East.

**Figure 3.10. Viral load suppression (%) in Zimbabwe, 2015-16**

![Graph showing viral load suppression by province.](image)

Source: ZIMPHIA 2015-16

Figure 3.10 shows the population-level viral suppression according to ZIMPHIA. There are no significant differences between provinces. Viral load suppression is non-significantly higher in the three south-western provinces of Bulawayo, Matabeleland North and Matabeleland South, the provinces with higher levels of HIV prevalence and higher levels of risk behaviours.
4. HIV epidemic projections: Patterns of HIV acquisition and transmission

This chapter summarizes the model estimates and future projections made in Optima HIV on new HIV infections acquired, new infections transmitted, estimated HIV incidence rates, prevalence and the number of people living with HIV including their diagnosis status.

4.1. New HIV infections acquired

Figure 4.1 shows the projected trend in new HIV infections acquired in Zimbabwe between 2010 and 2030. Findings from the Optima HIV model suggest that new HIV infections declined from 88,000 in 2010 to 33,000 in 2016. In terms of absolute numbers, new HIV infections were estimated to have declined in all sub-populations considered in the model.

**Figure 4.1. Estimated new HIV infections acquired 2010-2030**

Source: Populated Optima HIV model
Figure 4.2 shows the projected number of new HIV infections acquired in different age groups and key populations in the year 2017, when an estimated 27,000 new HIV infections occured. Model estimates suggest that among females a large number of new infections is acquired among females 20-34 years old. Approximately 800 new infections were projected to be acquired by female sex workers in 2017. Among male populations, the vast majority of new HIV infections will be acquired among males 25-49 and clients of female sex workers. Model estimates suggest that very few new infections are acquired by men 15-24. This is supported by HIV prevalence and incidence data from DHS and ZIMPHIA. In ZIMPHIA, HIV prevalence among men aged 20-24 was lower than among males 15-19 (see Figure 3.2). Survival patterns of HIV positive children in the model – in line with these HIV prevalence patterns among young men - suggest that a proportion of HIV positive males 15-24 are long-term survivors of vertical transmission.

**Figure 4.2. Estimated number of new HIV infections acquired in Zimbabwe, 2017**

![Bar chart showing the estimated number of new HIV infections acquired in different age groups and key populations in Zimbabwe in 2017.](image)

Source: Populated Optima HIV model

**Note:** In order to reflect the large difference in behaviours within certain age groups, in particular younger populations, it was decided to disaggregate younger populations into 5-year age cohorts (15-19, 20-24), while – in line with DHS and PHIA practice – 25-34 year olds and 35-49 year olds were grouped. In the interpretation of results, it should be noted that numbers for 15-24 year olds would need to be added up to be comparable to 25-34 year olds.

### 4.2. New HIV infections transmitted

Since every HIV transmission event involves two partners, it is important to analyse HIV epidemic dynamics both from the perspective of acquisition and transmission. However, identifying groups involved in HIV transmission should not be interpreted as blaming specific
groups, but rather be seen as a step to better support both partners in relationships in preventing HIV.

The pattern of new HIV infections transmitted is summarized in Figure 4.3. Since HIV transmissions to children are included, the relatively largest number of new HIV infections are transmitted by females 25-34. 20-24 year old women and female sex workers – relative to small population size – as well as women 35-49 contribute substantially to HIV transmission. Among males the majority of new infections are transmitted by males aged 25+ as well as clients of female sex workers.

**Figure 4.3. Projected new HIV infections transmitted in 2017, Zimbabwe**

![Graph showing projected new HIV infections transmitted by gender and age group in 2017, Zimbabwe.](image)

Source: Populated Optima HIV model
4.3. New HIV infections acquired versus transmitted

Figure 4.4 offers a comparison of patterns of HIV acquisition and transmission in Zimbabwe.

Figure 4.4. Patterns of new HIV infections acquired and transmitted in 2017

A. New HIV infections acquired, 2017
B. New HIV infections transmitted, 2017

An estimated 56% of new HIV infections are acquired by females and 44% by males. An estimated 48% of new HIV infections are transmitted by females including vertical transmission. Although nearly exactly 50% of all new infections are transmitted by males and females when including vertical transmission, when excluding vertical transmission, 42% of new infections are transmitted by females and 58% by males.

There are specific differences by age and sex between new infections acquired and transmitted. While young people 15-24 (excluding young key populations) were estimated to account for 20% of new infections acquired, they were estimated to account for only 12% of new HIV infections transmitted. Although males 50+ were estimated to account for less than 2% of new HIV infections acquired, it was estimated that they contributed 9% of new infections transmitted.

Sex workers and their clients were estimated to account for 14% of all new infections acquired and 17% of new infections transmitted. This excludes HIV infections transmitted by former clients of sex workers who have stopped being clients (defined as having paid for sex in the past 12 months). Therefore, the actual contribution of sex work to transmission is likely to substantially exceed 17% in the long-term.
Figure 4.5 provides illustrates how patterns of HIV acquisition and transmission are projected to change between 2017 and 2030 to provide insights on potential future shifts of HIV response priorities. Model estimates suggest that the contribution of key populations to HIV acquisition is projected to increase between 2017 and 2030 and will exceed 20% of new infections by 2030. Relatively fewer HIV infections are projected to be acquired and transmitted by younger populations in the general population, while the role of populations 25+ is increasing, in particular in relation to transmission.

Figure 4.5. Trends in new HIV infections acquired and transmitted, 2017-2030

Source: Populated Optima HIV model
4.4. HIV incidence rates

Understanding HIV incidence rates is important to understand patterns of HIV acquisition independent from population size. According to Optima HIV model estimates HIV incidence was estimated at 4.0 in 100 person years (PY) in 2017 among female sex workers, which represents by far the highest HIV incidence rate among all sub-populations. Very high HIV incidence of 9.6 per 100 person /years among sex workers between 2009 and 2014 was also found in an analysis of HIV testing data from the country’s largest female sex worker program (Hargreaves 2016). The Optima HIV model suggests that in the same period HIV incidence among female sex workers declined from 13.8 to 7.3 per 100 person /years, which is consistent with estimates by Hargreaves.

HIV incidence rates among clients of sex workers (1.5 in 100 PY in 2017), men who have sex with men (1.0) and prisoners (1.5) were also estimated to be higher than in the general population. It is important to note that estimated HIV incidence rates for these three populations were based on limited data including HIV prevalence estimates from other countries in the region in the case of men who have sex with men.

Figure 4.6. HIV incidence rates by sub-populations, Zimbabwe 2017

Source: Populated Optima HIV model

4.5. HIV incidence estimates in Optima HIV in comparison to other data sources and models

As most countries do not have population-based primary HIV incidence data over the full course of the HIV epidemic, Optima HIV does not use HIV incidence data as a data input, but produces HIV incidence estimates and projections as model outputs. Since Zimbabwe has conducted its first national population-based survey collecting primary HIV incidence data, it is useful to compare HIV incidence estimates from Optima HIV to primary HIV incidence data from ZIMPHIA. For this purpose we are also presenting HIV incidence rates in 2016, the year in which the majority of ZIMPHIA field work was conducted. HIV incidence rates for key populations and the general population by age (excluding key populations) in 2016 are represented in Figure 4.7, which shows that HIV incidence is estimated to be highest among females 20-49 and males 25-49. ZIMPHIA suggested a peak in HIV incidence among females 25-34. There is no pronounced peak among females 25-34 in the Optima model, but this different could be explained by sex workers, many of whom are 25-34, being treated as a separate population in the Optima HIV model.
Figure 4.7. Estimated HIV incidence rates by sub-population, Zimbabwe 2016

a. Key populations

- FSW: 4.90
- Clients: 1.91
- MSM: 1.20
- Prisoners: 1.85

b. General populations (excluding key populations)

- F15-19: 0.26
- M15-19: 0.04
- F20-24: 0.67
- M20-24: 0.09
- F25-34: 0.59
- M25-34: 0.42
- F35-49: 0.64
- M35-49: 0.71
- F50+: 0.02
- M50+: 0.10

Source: Populated Optima HIV model

Figure 4.8. HIV incidence rates by age from a population-based survey using HIV incidence assays (ZIMPHIA 2015-16)

Source: ZIMPHIA 2015-16
Figures 4.7 and 4.8 suggest that HIV incidence estimates for 2016 in Optima HIV are within the confidence bounds of ZIMPHIA data for all age groups. It is important to note that the age-specific HIV incidence estimates from ZIMPHIA cannot be directly compared to Optima HIV estimates for different age groups, because the general population age cohorts in Optima HIV do not include key populations. Therefore in most age groups (except men 35-49), HIV incidence rates in Optima HIV are moderately lower than HIV incidence rates in ZIMPHIA, but when considering all populations 15-49 including key populations, HIV incidence rates in Optima HIV are very similar to ZIMPHIA (Figure 4.9).

Figure 4.9 compares HIV incidence rates among adults 15-49 in Optima HIV to a modelling analysis carried out by Hontelez (World Bank, NAC, MOHCC 2017) for a combination prevention evaluation and UNAIDS 2017 HIV estimates for Zimbabwe.

**Figure 4.9.** HIV incidence rates among people 15-49 from three models and ZIMPHIA

![](image)

Sources: Populated Optima-HIV model, Hontelez et al (2017, in draft), UNAIDS 2017 estimates, ZIMPHIA

All three model estimates are within the confidence bounds of ZIMPHIA primary HIV incidence data. Optima HIV estimated HIV incidence of 0.53 in 100 person years (PY) against 0.50 in 100 PY in ZIMPHIA. The estimate by Hontelez et al is slightly lower at 0.40 in 100 PY, while UNAIDS estimates obtained from the Spectrum model are very close to the ZIMPHIA data point and Optima HIV.
Figure 4.10 presents a comparison of estimated HIV incidence trends between 2000 and 2016.

**Figure 4.10. HIV incidence trends among people 15-49 from three models and ZIMPHIA**

The different models are fairly well aligned to each other. While in the early 2000s, Optima HIV and Hontelez’ model estimated slightly higher levels of HIV incidence than Spectrum, after 2010 the two models estimate lower levels of HIV incidence than Spectrum, but they are close to ZIMPHIA data.

Figure 4.11 illustrates that all three models are also aligned to each other in estimating and projecting HIV prevalence trends. Both Optima HIV and Hontelez’ estimates remain within confidence bounds of Spectrum estimates from 2000 through 2016.

Figure 4.11. HIV prevalence among people 15-49 from three models, DHS and ZIMPHIA

Source: Populated Optima HIV model, Hontelez et al (2017, in draft), UNAIDS 2017 estimates, ZIMPHIA, DHS
4.6. New HIV infections against global targets

The 2016 Political Declaration on HIV and AIDS was adopted by the United Nations General Assembly global fast-track targets to reduce HIV incidence by 75% by 2020 and 90% by 2030. Under current conditions (current coverage of services and current behaviors), it is projected that the 2020 target of an HIV incidence reduction of 75% against 2010 equivalent to a reduction from an estimated 88,000 new infections to 22,000 new infections – could be nearly achieved and only missed by around 1,000 new infections. The 2030 target of less than 8,800 new infections would be missed by approximately 11,000 new infections under current conditions, which suggests that further scale up and optimization of HIV response programs and strategies would be required to achieve those targets.

**Figure 4.12.** Number of new infections acquired projected (2010-2030) under current conditions against global HIV incidence targets

Source: Populated Optima HIV model
4.7. HIV prevalence estimates and trends

As outlined in section 4.5 (Figure 4.11), HIV prevalence estimates generated in Optima HIV are within the confidence bounds of UNAIDS Spectrum estimates. Figure 4.12. provides the model-projected levels of HIV prevalence by sub-population for 2017.

**Figure 4.12. Projected levels of HIV prevalence in Zimbabwe in 2017 by sub-population**

![Figure 4.12](image)

Source: Populated Optima HIV model

Figure 4.13 shows the trends in HIV prevalence for different sub-populations. Based on data inputs for HIV prevalence, demographics, risk practices and service coverage Optima-HIV projections found substantial declines of HIV prevalence among children and adolescents as well as young adults 20-34. HIV prevalence among men 35-49 is also projected to decline, while HIV prevalence among females 35-49 was estimated to be stable between 2010 and 2020 until moderate declines occur after 2020. Due to ageing and increased survival of people on ART, HIV prevalence among the population 50+ is projected to continue increasing and exceed 25% among both males and females by 2030.
Figure 4.13. *Estimated and projected HIV prevalence trends in Zimbabwe by sub-population, (2005-2030)*

A. Children and adolescents

B. Young adults (15-34)

C. Older adults (35+)

D. Key populations

Source: Populated Optima HIV model

4.8. Estimated number of people living with HIV

Figure 4.14 provides a projected breakdown of the population of people living with HIV in 2018 by sub-population. In 2017, an estimated 23% of people living with HIV will be aged 50+, more than half of PLHIV will be aged 35+ and approximately 4 out of 5 aged 25+.

*Figure 4.14. Estimated distribution of people living with HIV by sub-population, Zimbabwe 2018*
Figure 4.15 provides insights on the change in estimated number of people living with HIV over between 2005 and 2030. Optima-HIV estimates suggest that a substantial change in the age- and population-structure of Zimbabwe’s HIV epidemic has occurred and is projected to continue up to 2030. While the population aged 15-34 accounted for approximately half of all people living with HIV in 2005, they are projected to account for less than a third in 2030. Correspondingly, by 2035, approximately two thirds of PLHIV are projected to be aged 35 years and older.

**Figure 4.15. Estimated trends in the number of people living with HIV by sub-population, Zimbabwe, 2000-2030**

Source: Populated Optima HIV model
4.9. Undiagnosed people living with HIV

Figure 4.16 illustrates the estimated undiagnosed population of people living with HIV.

**Figure 4.16. Number of undiagnosed people living with HIV, Zimbabwe, 2010-2030**

Source: Populated Optima HIV model

Optima-HIV estimates suggest that with current levels of testing, the number of people living with HIV who are undiagnosed have declined substantially between 2010 and 2017 when more than 90% of PLHIV were estimated to be diagnosed. Model-estimated levels of diagnosis are based on annual HIV testing rates. Levels of HIV diagnosis vary between populations and are lowest among adolescents and highest among older adults 35+. However, as shown in Figures 4.17 and 4.18, due to the much larger proportion of people living with HIV who are older than 25 years, undiagnosed people living with HIV continue to be spread across different age groups when considering absolute numbers. Despite high rates of HIV testing, a substantial number of people from key populations remain undiagnosed due to continued high HIV incidence rates in key populations.
**Figure 4.17.** Distribution of undiagnosed people living with HIV by sub-population, Zimbabwe, 2017

Source: Populated Optima HIV model

**Figure 4.18.** Number of undiagnosed people living with HIV by sub-population, Zimbabwe, 2017

Source: Populated Optima HIV model
5. Provincial epidemic patterns

This chapter summarizes the model estimates and future projections made in Optima-HIV on provincial-level patterns and trends in new HIV infections acquired, new infections transmitted, estimated HIV incidence rates and the number of people living with HIV including their diagnosis status.

5.1. Overview: Considerable variation in HIV incidence between the 10 provinces

*Figure 5.1.1 Total estimated HIV incidence rates per 100 person/years in 10 provinces of Zimbabwe in 2017*

![Graph showing estimated HIV incidence rates per 100 person/years in 10 provinces of Zimbabwe in 2017.]

*Figure 5.1.2 Number of new HIV infections acquired by population in 10 provinces of Zimbabwe in 2017*

![Graph showing number of new HIV infections acquired by population in 10 provinces of Zimbabwe in 2017.]

[Graphs and data analysis are included here, but not fully transcribed due to the nature of the visual elements.]
Figure 5.1.3. Proportion of new HIV infections acquired by population in 10 provinces of Zimbabwe in 2017

Figure 5.1.4. Proportion of new HIV infections transmitted by population in 10 provinces of Zimbabwe in 2017
Figure 5.1.5. Estimated number of PLHIV by province by population in Zimbabwe in 2017

Figure 5.1.6. Estimated number of undiagnosed PLHIV by province by population in Zimbabwe in 2017
5.2. Bulawayo

Figure 5.2.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.2.2. Number of new HIV infections acquired by population in 2017
Figure 5.2.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New infections acquired, 2017

New HIV infections transmitted, 2017
Figure 5.2.4. Number of estimated people living with HIV (PLHIV) by population in 2017

Figure 5.2.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.3. Harare

**Figure 5.3.1. Number of new HIV infections acquired by population 2010-2030**

**Figure 5.3.2. Number of new HIV infections acquired by population in 2017**
Figure 5.3.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 0.1%
- Clients: 1.2%
- MSM: 4.2%
- Prisoners: 10.1%
- F0-14: 12.7%
- M0-14: 6.1%
- F15-19: 20.1%
- M15-19: 7.2%
- F20-24: 0.8%
- M20-24: 3.4%
- F25-34: 0.1%
- M25-34: 1.1%
- F35-49: 1.3%
- M35-49: 8.2%
- F50+: 8.2%
- M50+: 15.1%

New HIV infections transmitted, 2017

- FSW: 1.4%
- Clients: 7.1%
- MSM: 9.5%
- Prisoners: 16.2%
- F0-14: 11.3%
- M0-14: 7.2%
- F15-19: 20.4%
- M15-19: 0.8%
- F20-24: 1.6%
- M20-24: 0.2%
- F25-34: 1.1%
- M25-34: 0.0%
- F35-49: 0.0%
- M35-49: 1.6%
- F50+: 0.0%
- M50+: 15.6%
Figure 5.3.4. Number of estimated people living with HIV (PLHIV) by population in 2017

Figure 5.3.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.4. Manicaland

Figure 5.4.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.4.2. Number of new HIV infections acquired by population in 2017
Figure 5.4.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 2.1% 3.5%
- Clients: 8.0%
- MSM: 9.0%
- Prisoners: 1.4%
- F0-14: 8.1%
- M0-14: 8.1%
- F15-19: 6.5%
- M15-19: 0.7%
- F20-24: 11.8%
- M20-24: 2.9%
- F25-34: 2.1%
- M25-34: 16.4%
- F35-49: 0.7%
- M35-49: 0.0%
- F50+: 3.5%
- M50+: 0.0%

New HIV infections transmitted, 2017

- FSW: 2.2% 10.7%
- Clients: 6.6%
- MSM: 9.0%
- Prisoners: 2.3%
- F0-14: 0.0%
- M0-14: 9.0%
- F15-19: 1.4%
- M15-19: 0.6%
- F20-24: 2.7%
- M20-24: 15.8%
- F25-34: 0.0%
- M25-34: 10.0%
- F35-49: 2.2%
- M35-49: 10.5%
- F50+: 7.6%
- M50+: 10.0%
- F50+: 10.0%
- M50+: 19.1%
Figure 5.4.4. Number of estimated people living with HIV (PLHIV) by population in 2017

Figure 5.4.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.5. Mashonaland Central

Figure 5.5.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.5.2. Number of new HIV infections acquired by population in 2017
Figure 5.5.3. Proportion of new HIV infections acquired and transmitted by population in 2017

Figure 5.5.4. Number of estimated people living with HIV (PLHIV) by population in 2017
Figure 5.5.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.6. Mashonaland East

Figure 5.6.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.6.2. Number of new HIV infections acquired by population in 2017
Figure 5.6.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 11.9%
- Clients: 1.1%
- MSM: 6.5%
- Prisoners: 6.5%
- F0-14: 7.5%
- M0-14: 9.8%
- F15-19: 1.1%
- M15-19: 1.3%
- F20-24: 20.3%
- M20-24: 3.9%
- F25-34: 1.9%
- M25-34: 1.9%
- F35-49: 1.9%
- M35-49: 2.0%
- F50+: 0.9%
- M50+: 0.9%
Figure 5.6.4. Number of estimated people living with HIV (PLHIV) by population in 2017

Figure 5.6.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.7. Mashonaland West

Figure 5.7.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.7.2. Number of new HIV infections acquired by population in 2017
Figure 5.7.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 4.0%
- Clients: 2.6%
- MSM: 1.7%
- Prisoners: 1.6%
- F0-14: 8.2%
- M0-14: 8.2%
- F15-19: 5.7%
- M15-19: 0.5%
- F20-24: 12.2%
- M20-24: 1.2%
- F25-34: 19.3%
- M25-34: 7.8%
- F35-49: 4.7%
- M35-49: 4.7%
- F50+: 11.0%
- M50+: 0.5%

New HIV infections transmitted, 2017

- FSW: 10.1%
- Clients: 19.3%
- MSM: 1.7%
- Prisoners: 2.0%
- F0-14: 6.4%
- M0-14: 8.5%
- F15-19: 7.7%
- M15-19: 7.7%
- F20-24: 1.7%
- M20-24: 1.7%
- F25-34: 2.1%
- M25-34: 0.0%
- F35-49: 0.0%
- M35-49: 0.0%
- F50+: 11.1%
- M50+: 0.5%
- F0-14: 15.9%
- M0-14: 11.1%
- F15-19: 22.2%
- M15-19: 2.1%
- F20-24: 2.2%
- M20-24: 7.9%
- F25-34: 6.4%
- M25-34: 7.9%
Figure 5.7.4. Number of estimated people living with HIV (PLHIV) by population in 2017

Figure 5.7.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.8. Masvingo

Figure 5.8.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.8.2. Number of new HIV infections acquired by population in 2017
Figure 5.8.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

New HIV infections transmitted, 2017
Figure 5.8.4. Number of people living with HIV (PLHIV) by population in 2017

Figure 5.8.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.9. Matabeleland North

Figure 5.9.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.9.2. Number of new HIV infections acquired by population in 2017
Figure 5.9.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired, 2017

New HIV infections transmitted, 2017
Figure 5.9.4. Number of people living with HIV (PLHIV) by population in 2017

Figure 5.9.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.10. **Matabeleland South**

*Figure 5.10.1. Number of new HIV infections acquired by population 2010-2030*

*Figure 5.10.2. Number of new HIV infections acquired by population in 2017*
Figure 5.10.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 3.7%
- Clients: 6.3%
- MSM: 14.9%
- Prisoners: 12.8%
- F0-14: 8.9%
- M0-14: 3.1%
- F15-19: 15.5%
- M15-19: 1.1%
- F20-24: 15.0%
- M20-24: 0.9%
- F25-34: 4.3%
- M25-34: 6.0%
- F35-49: 17.0%
- M35-49: 7.3%
- F50+: 18.0%
- M50+: 18.0%

New HIV infections transmitted, 2017

- FSW: 5.5%
- Clients: 0.1%
- MSM: 0.0%
- Prisoners: 11.0%
- F0-14: 5.3%
- M0-14: 0.7%
- F15-19: 6.6%
- M15-19: 0.8%
- F20-24: 15.5%
- M20-24: 11.0%
- F25-34: 0.8%
- M25-34: 0.1%
- F35-49: 5.3%
- M35-49: 0.1%
- F50+: 5.3%
- M50+: 5.3%
Figure 5.10.4. Number of people living with HIV (PLHIV) by population in 2017

Figure 5.10.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
5.11. Midlands

Figure 5.11.1. Number of new HIV infections acquired by population 2010-2030

Figure 5.11.2. Number of new HIV infections acquired by population in 2017
Figure 5.11.3. Proportion of new HIV infections acquired and transmitted by population in 2017

New HIV infections acquired 2017

- FSW: 0.9%
- Clients: 3.5%
- MSM: 2.0%
- Prisoners: 1.2%
- F0-14: 7.0%
- M0-14: 5.7%
- F15-19: 9.0%
- M15-19: 11.7%
- F20-24: 21.1%
- M20-24: 1.1%
- F25-34: 10.2%
- M25-34: 10.2%
- F35-49: 5.8%
- M35-49: 0.9%
- F50+: 3.5%
- M50+: 0.0%

New HIV infections transmitted, 2017

- FSW: 1.9%
- Clients: 9.2%
- MSM: 5.2%
- Prisoners: 7.8%
- F0-14: 15.2%
- M0-14: 9.9%
- F15-19: 22.7%
- M15-19: 1.9%
- F20-24: 1.5%
- M20-24: 0.0%
- F25-34: 8.4%
- M25-34: 0.0%
- F35-49: 2.9%
- M35-49: 0.6%
- F50+: 1.9%
- M50+: 1.5%
Figure 5.11.4. Number of people living with HIV (PLHIV) by population in 2017

Figure 5.11.5. Number of undiagnosed PLHIV by population in Zimbabwe in 2017
6. Key findings and emerging recommendations

The following summary of findings and recommendations synthesizes preliminary insights gained from data analysis and HIV epidemic modelling in preparation for further scenario and optimization analysis. The key findings of this first analysis phase are not meant to be programmatic recommendations in themselves, but identify key issues for consideration in the upcoming components of the modelling. More detailed recommendations on programmatic implications will be provided as part of a second phase of allocative efficiency analysis.

1. **HIV prevalence continued to decline at national level both among males and females, but there is substantial regional variation in HIV prevalence levels and trends.** In line with population-based surveys and other models, Optima HIV estimates suggest that HIV prevalence among the population aged 15-49 declined from 16.2% in 2010 to 13.8% in 2017 and is projected to decline further to less than 10% among 15-49 year olds by 2030. The decline in HIV prevalence is more pronounced in the northern and eastern provinces, while in the southern and western provinces (Bulawayo, Matabeleland South & North, Midlands) HIV prevalence declined moderately or stabilized.

2. **Declines in risk behavior recorded between the 1990s and 2010 may have begun to be reversed by 2015 (DHS). Risk behaviors remain higher in the south-western provinces, where HIV prevalence is higher.** The 2015 DHS recorded an increase in risk behaviors after 2010 including increases in proportion of people reporting having sex with non-regular partners, multiple sexual partnerships and paid sex. There are major geographical differences in the level of non-regular partnerships, which are highest in Bulawayo, Matabeleland South & North.

3. **In contrast to large geographical variation in reported risk practices and HIV prevalence, HIV service coverage is relatively uniform in Zimbabwe.** Coverage of HIV testing has increased substantially among all populations and all provinces, but remains lower among males than females. Rates of self-reported condom use are similar across provinces, but are moderately lower in the south-western provinces. There are no significant differences between provinces in levels of viral suppression, which are non-significantly higher in the three south-western provinces.

4. **The high HIV prevalence and slower decline in HIV prevalence in southern provinces despite similar and partially higher level of HIV service coverage requires further analysis and programmatic attention.** Zimbabwe’s three south-western provinces experience a combination of several risk factors for high HIV transmission. In addition to already high HIV prevalence and higher non-regular partnerships, sex work is relatively more frequent in Bulawayo, the major city of the region. In Bulawayo, 3.3% of female adults are sex workers compared to 1.3% nationally and 1.9% in Harare. Temporary migration to high prevalence areas in Botswana and South Africa is also likely to contribute to elevated HIV incidence. Strategies to address the three potential causes of elevated HIV transmission (higher risk behavior, sex work, temporary migration) need to be explored and can be considered in subnational allocative efficiency analysis.
5. **Optima HIV predicts a continued decline in HIV incidence based on current epidemic patterns and program coverage but not a sufficient decline to reach global 2020 and 2030 targets.** Under current conditions, Optima HIV projections suggest that the 2020 target of a 75% reduction in HIV incidence from 88,000 to 22,000 new HIV infections annually will only be narrowly missed, but 2030 targets of a 90% reduction in HIV incidence to 8,800 new infections will be missed by 11,000 new infections per year. Additional efforts will be required, while further increases in risk behavior as recorded between 2010 and 2015 might offset gains partially or in specific geographical settings.

6. **Zimbabwe’s HIV epidemic is projected to continue ageing.** In the year 2000, approximately two thirds of people living with HIV were younger than 35 years of age, in 2015 around half of all HIV positive persons were younger than 35 years of age and in 2030 approximately two thirds of people living with HIV will be 35 and older. This suggests that in addition to integration of HIV services with young people's reproductive health services, HIV care will increasingly need to be integrated with prevention and care for non-communicable diseases.

7. **Around half of new HIV infections acquired are among the general population aged 25+.** The pattern of new HIV infections acquired in Zimbabwe represents a mix of several different groups and transmission settings. An estimated 56% of new HIV infections are acquired by females and 44% by males. 16% of new HIV infections acquired were estimated to occur among key populations, the vast majority (14% of all new infections) in sex work settings, 1.3% among MSM and 0.7% among prisoners). 14% of new infections were acquired by children through vertical transmission and 20% among young people 15-24. Broadly in line with ZIMPHIA data, Optima HIV estimates suggest that HIV incidence among females is particularly high in 20-34 year olds and remains high among 35-49 year olds. Among males HIV incidence among 15-24 year olds was estimated to be very low and most of the new infections among males were among the 25-49 year olds. There is need to reflect how the adult population 25-49 can best be reached with HIV program communications, demand generation and service delivery.

8. **A large proportion of HIV is transmitted by the population aged 25+.** There are specific differences by age and sex between new infections acquired and transmitted. While young people 15-24 (excluding young key populations) were estimated to account for 20% of new infections acquired, they were estimated to account for only 12% of new HIV infections transmitted. Although males 50+ were estimated to account for less than 3% of new HIV infections acquired, it was estimated that they contribute 11% of new infections transmitted. 30% of HIV is transmitted by general population women aged 25-49 (including vertical transmission). 25% of HIV is transmitted by men 25-49 in the general population.

9. **Among key populations the largest share of HIV infections is attributable to sex workers and their clients, but all four key populations included in the model were estimated to experience high HIV incidence rates above 1 in 100 person years.** Around 1 in 5 of all HIV infections transmitted in Zimbabwe are transmitted by sex workers and their clients. The role of sex work-related transmission in the epidemic is
likely even higher, because clients and sex workers may continue transmitting HIV after they transitioned back into the general population. The role of sex workers in the epidemic is particularly large in the urban settings of Bulawayo and Harare. Men who have sex with men and prisoners were estimated to experience HIV incidence rates that are approximately three times higher than males from the general population.

10. **Model projections suggest that the number of people living with HIV will moderately decline and levels of HIV diagnosis increase sufficiently to achieve 90% diagnosis by 2020.** With relatively few undiagnosed PLHIV, it is particularly important to understand how to find the remaining undiagnosed populations. HIV positive adolescents (15-19) are least likely to be diagnosed. At the same time, since HIV prevalence and the absolute number of people living with HIV is much higher in the population 25+ the majority of undiagnosed people is aged 25+, 13% are children, 14% young people 15-24, and 13% sex workers and their clients.

7. **Conclusion**

The epidemiological modelling analyses summarized in this report have identified a number of key trends, which could potentially have substantial programmatic implications. Key issues include ageing of the HIV epidemic, recent increases in risk behavior, geographical variation in HIV prevalence and risk, increased risk practices in three south-western provinces. The core issues identified need to be further explored in a subsequent stage of the efficiency analysis.

This report will form the basis for allocative and implementation efficiency analysis in Zimbabwe including subnational analysis.
Annexes


This Annex provides a brief technical overview of Optima. A more detailed summary of the model and methods is provided elsewhere. Optima is based on a dynamic, population-based HIV model. Figure A1 shows the disease progression implemented in the model. Optima tracks the entire population of people living with HIV (PLHIV) across 5 stages of CD4 count. These CD4 count stages are aligned to the progression of WHO treatment guidelines, namely, acute HIV infection, >500, 350–500, 200–350, 50–200, and, 50 cells per microliter. Key aspects of the antiretroviral therapy (ART) service delivery cascade are included: from infection to diagnosis, ART initiation on first-line therapy, treatment failure, subsequent lines of therapy, and HIV/AIDS-related or other death. Figure A2 provides a summary of the populations and mixing patterns used in Optima.

Figure A1. Schematic diagram of the health state structure of the model. Each compartment represents a single population group with the specified health state while each arrow represents the movement of numbers of individuals between health states. All compartments except for “susceptible” represent individuals living with HIV. Death includes all causes of death.

Figure A2. Example population groups and HIV transmission-related interactions in Optima

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The model uses a linked system of ordinary differential equations to track the movement of PLHIV between HIV health states; the full set of equations is provided in the supplementary material to a summary paper on the Optima model. The overall population is partitioned in 2 ways: by population group and by HIV health state. Individuals are assigned to a given population group based on their dominant risk. ^3 HIV infections occur through the interaction between different populations by regular, casual, or commercial (including transactional) sexual partnerships, through sharing of injecting equipment or through mother-to-child transmission. The force-of-infection is the rate at which uninfected individuals become infected, and it depends on the number and type of risk events to which individuals are exposed in a given period (either within their population groups or through interaction with other population groups) and the infection probability of each event. Mathematically, the force of infection has the general form:

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

where $\lambda$ is the force-of-infection, $\beta$ is the transmission probability of each event, and $n$ is the effective number of at-risk events (ie, $n$ gives the average number of interaction events with HIV-infected people where HIV transmission may occur). The value of the transmission probability $\beta$ varies across CD4 count compartments (indirectly reflecting the high viral load at early and late stages of infection), differs for different modes of transmission (intravenous drug injection with a contaminated needle–syringe, penile–vaginal or penile–anal intercourse, and mother-to-child), and maybe reduced by behavioral interventions (eg, condom use), biological interventions (eg, male circumcision), or ART.

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^3 However, to capture important cross-modal types of transmission, relevant behavioral parameters can be set to non-zero values (eg, males who inject drugs may engage in commercial sex; some MSM may have female sexual partners).
There is one force-of-infection term for each type of interaction [e.g., casual sexual relationships between male sex workers and female sex workers (FSW)]; the force-of-infection for a given population will be the sum of all interaction types. In addition to the force-of-infection rate, which is the number of individuals who become infected with HIV per year, there are 7 other ways individuals may change health states. The change in the number of people in each compartment is determined by the sum over the relevant rates described above, multiplied by the population size of the compartments on which they act.

4 For sexual transmission, the force-of-infection is determined by:

- The HIV prevalence (weighted by viral load) in partner populations;
- The average number of casual, regular, and commercial homosexual and heterosexual acts per person per year;
- The proportion of these acts in which condoms are used;
- The proportion of men who are circumcised;
- The prevalence of sexually transmissible infections (which can increase HIV transmission probability);
- The proportion of acts that are covered by pre-exposure prophylaxis and post-exposure prophylaxis;
- The proportion of partners on antiretroviral treatment (ART); and
- The efficacies of condoms, male circumcision, post-exposure prophylaxis, pre-exposure prophylaxis, and ART at preventing HIV transmission.

For injecting-related transmission, the force-of-infection is determined by:

- The HIV prevalence (weighted by viral load) in populations of people who use a syringe and then share it;
- The number of injections per person per year;
- The proportion of injections that use shared equipment;
- The fraction of people who inject drugs on opioid substitution therapy and its efficacy in reducing injecting behavior.

For mother-to-child transmission, the number of infections is determined by:

- The birth rate among women living with HIV;
- The proportion of women with HIV who breastfeed;
- The probability of perinatal HIV transmission in the absence of intervention; and
- The proportion of women receiving prevention of mother-to-child transmission (PMTCT), including ART.

5 First, individuals may die, either because of an average background death rate for that population (which is greater for older populations or for people who inject drugs) or because of HIV/AIDS (which depends on CD4 count). Second, in the absence of treatment, individuals progress from higher to lower CD4 counts. Third, individuals can move from undiagnosed to diagnosed states based on their HIV testing rate, which depends on CD4 count (e.g., people with AIDS symptoms or primary HIV infection may have a higher testing rate) and population type (e.g., FSW may test more frequently than males in the general population). Fourth, diagnosed individuals may commence ART, at a rate depending on CD4 count. Fifth, individuals may experience treatment failure because of lack of adherence to therapy or development of drug resistance, and sixth, people may initiate second and subsequent lines of treatment from treatment failure. Finally, while on successful first- or second-line treatment (i.e., effective viral suppressive therapy), individuals may progress from lower to higher CD4 counts.

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

\[
\frac{dU_{FSW_{200-350}}}{dt} = \frac{dU_{FSW_{350-500}}}{dt} \times \frac{1}{2} - \frac{dU_{FSW_{150-200}}}{dt} \times (\mu_{200-350} + \tau_{200-350} + \eta_{FSW_{350-500}}) \times U_{FSW_{200-350}} \times U_{FSW_{350-500}} - U_{FSW_{150-200}} \times \frac{dU_{FSW_{150-200}}}{dt},
\]

where \(U_{FSW_{200-350}}\) is the current number of undiagnosed HIV-positive FSW with a CD4 count between 200 and 350 cells per microliter, \(U_{FSW_{350-500}}\) is the same population but with higher CD4 count (350–500 cells/mL), \(t\) is the disease progression rate for the given CD4 count (where \(1/t\) is the average time to lose 150 CD4 cells/mL), \(m\) is the death rate, and \(h\) is the HIV testing rate. (Note: this example does not consider movement between populations, such as FSW returning to the general female population and vice versa—something which is also included in Optima.)
Each compartment (Figure B, boxes) corresponds to a single differential equation in the model, and each rate (Fig. 1B, arrows) corresponds to a single term in that equation. Table 1 lists the parameters used in Optima; most of these are for calculating the force-of-infection. We interpret empirical estimates for model parameter values in Bayesian terms as previous distributions. The model must then be calibrated, which is the process of finding posterior distributions of the model parameter values such that the model generates accurate estimates of HIV prevalence, the number of people on treatment, and any other epidemiological data that are available (e.g., HIV-related deaths). The calibration can be performed automatically, manually, or a combination of both. This process of model calibration and validation should normally be performed in consultation with governments in the countries in which the model is being applied.

Note: Parameters relating to injecting drug use were not applied in Zimbabwe.
HIV Resource Optimization and Program Coverage Targets

A novel component of Optima is its ability to calculate allocations of resources that optimally address one or more HIV-related objectives (e.g., impact-level targets in a country’s HIV national strategic plan). Because Optima also calculates the coverage levels required to achieve these targets, it can be used to inform HIV strategic planning and the determination of program coverage levels. The key assumptions of resource optimization 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 behavioral and clinical outcomes. Such relationships are required to understand how incremental changes in spending (marginal costs) affect HIV epidemics. Logistc functions can incorporate initial start-up costs and allow changes in behavior to saturate at high spending levels, thus better reflecting program reality. The logistic function has the form:

\[ L(x) = A + \frac{B - A}{1 + e^{-(x-C)/D}} \]

where \( L(x) \) relates spending to coverage, \( x \) is the amount of funding for the program, \( A \) is the lower asymptote value (adjusted to match the value of \( L \) when there is no spending on a program), \( B \) is the upper asymptote value (for very high spending), \( C \) is the midpoint, and \( D \) is the steepness of the transition from \( A \) to \( B \). For our fits, we typically choose saturation values of the coverage to match behavioral data in countries with heavily funded HIV responses.

To perform the optimization, Optima uses a global parameter search algorithm called Bayesian adaptive locally linear stochastic descent (BALLSD). BALLSD is similar to simulated annealing in that it makes stochastic downhill steps in parameter space from an initial starting point. However, unlike simulated annealing, BALLSD chooses future step sizes and directions based on the outcome of previous steps. For certain classes of optimization problems, we have shown that BALLSD can determine optimal solutions with fewer function evaluations than traditional optimization methods, including gradient descent and simulated annealing.

While all HIV interventions have some direct or indirect non-HIV benefits, some programs like Opiate Substitution Therapy (OST) or conditional cash transfers have multiple substantial proven benefits across different sectors. Such additional benefits were reflected by using the approach of a cross-sector financing model in order to effectively distribute the costs in accordance with the benefits.

Uncertainty Analyses

A traditional approach is to apply unit cost values to inform a linear relationship between money spent and coverage attained. This is a reasonable assumption for programs like an established ART program that no longer incurs start-up or initiation costs, but less appropriate for condom promotion and behavior change communication programs. Most HIV programs typically have initial setup costs, followed by a more effective scale-up with increased funding. However, there are saturation effects for very high coverage levels because these require increased incremental costs because of demand generation and related activities for the most difficult-to-reach groups. Optima uses a logistic function fitted to available input data to model cost–coverage curves (See Annex 2).

Program coverage for zero spending, or behavioral outcomes for zero coverage of formal programs, is inferred using data from early on in the epidemic or just before significant investment in HIV programs. Practically, we also discussed the zero and high spending cases with local experts who can advise on private sector HIV service delivery outside the governments’ expenditure tracking systems. For each HIV program, we 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 behavioral outcomes (i.e., the impacts that HIV strategies aim to achieve).
Optima uses a Markov chain Monte Carlo (MCMC) algorithm for performing automatic calibration and for computing uncertainties in the model fit to epidemiological data. With this algorithm, the model is run many (typically 1000–10,000) times to generate a range of epidemic projections; their differences represent uncertainty in the expected epidemiological trajectories. The most important assumptions in the optimization analysis are associated with the cost–coverage and coverage–outcome curves. To incorporate uncertainty in these curves, users define upper and lower limits for both coverage and behavior for no spending and for very high spending.⁹

⁹ All available historical spending data and achieved outcomes of spending, data from comparable settings, experience, and extensive discussion with stakeholders in the country of application can be used to inform these ranges. All logistic curves within these ranges are then allowable and are incorporated into uncertainty analyses of Optima. These cost–coverage and coverage–outcome curves are thus reconciled with the epidemiological, behavioral, and biological data in a Bayesian optimal way, thereby allowing the calculation of unified uncertainty estimates.
7.2. Annex 2: Calibration figures

7.3.

The following figures illustrate the model calibration process. Black dots represent available data for HIV prevalence – or in some cases proxy estimates for similar populations. Lines attached to these discs represent uncertainty bounds. The solid curve in blue is the best fitting simulation of HIV prevalence.

In some cases projected epidemic trends are not passing through the data points, which is the case if the data points are not exactly representative of the population group included in the model.

Figure A3. Calibration – Part 1
Additional notes on the calibration

- Female sex workers: Data and context suggest continued high prevalence and incidence (reported from SW program and Hargreaves et al 2016).

- Clients: DHS data suggests relatively low HIV prevalence among men who report paying for sex in the past 12 months, but bias is likely and contextual information suggests that prevalence was higher in the 1990s as it was higher for men in the general population – DHS data was seen as an underestimate by experts.

- Men who have sex with men: No data available, data points in the calibration chart represents data for general population males; this data was just included as indicative, but the calibration was not expected to fit this data; data from neighboring countries suggests that HIV prevalence among MSM is higher than general population males – this was reflected in the calibration.
- Prisons: There is only one data point; therefore the epidemic trend is dependent on interactions with other populations in the model.

- Children: Initial HIV prevalence is not known but given MTCT patterns of the late 1990s paired with high mortality, it was assumed to be around 1.5-2.5%, i.e., moderately higher than current values.

- General population HIV prevalence data points represent the 2001 Young adult survey (15-29, national values), 2005, 2010 and 2015 DHS, 2016 ZIMPHIA.

- For young men 15-19 and 20-24 a relatively large share of HIV prevalence is driven by aging of children infected through vertical transmission (long-term survivors). Since there is virtually no increase in HIV prevalence during the ages 15-19 and 20-24 in recent DHS (and HIV prevalence in ZIMPHIA was lower for 20-24 than 15-19), calibration to exact data values was not possible. Model calibration therefore follows lower confidence bounds for 15-19 and higher confidence bounds for 20-24.

- Populations aged 50+: The 2016 data point from ZIMPHIA covers 50-64 year olds, which due to the age pyramid account for the majority of the 50+ population – therefore this data point was deemed more reliable than DHS and calibration was done to the ZIMPHIA data points while considering trend patterns from DHS data for population 45+. A relatively large share of HIV prevalence is driven by ageing of PLHIV, which implies continued flow of HIV positive persons into these groups; it was therefore deemed plausible that HIV prevalence still increases in this population.
### 7.4. Annex 3: Selected data tables

#### Population sizes

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Sources: Census 2002 and 2012, ZimStat projections, population size estimates for female sex workers, World Prison Brief
## HIV prevalence

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Sexual behaviour

**Average number of sexual acts with casual partners per year**

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**Condom use with casual partners**

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<td>52.8%</td>
<td>81.6%</td>
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### Annex 4: Glossary of terms

<table>
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<tr>
<th>Term</th>
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<tr>
<td>Allocative Efficiency</td>
<td>Within a defined resource envelope, allocative efficiency of health or HIV specific interventions is about the right intervention being provided to the right people at the right place in the correct way that targeted health outcomes are maximized.</td>
</tr>
<tr>
<td>Behavioral intervention</td>
<td>Behavioral interventions discourage risky behaviors and reinforce protective ones, typically by addressing knowledge, attitudes, skills, and beliefs.</td>
</tr>
<tr>
<td>Biomedical intervention</td>
<td>Biomedical HIV intervention strategies use medical and public health approaches to block infection, decrease infectiousness, and reduce susceptibility.</td>
</tr>
<tr>
<td>Calibration</td>
<td>The process of fitting parameter estimates to the observed trajectory of the HIV epidemic.</td>
</tr>
<tr>
<td>Cost-effectiveness analysis (CEA)</td>
<td>A form of economic analysis that compares the relative costs and outcomes (effects) of two or more courses of action.</td>
</tr>
<tr>
<td>Effectiveness</td>
<td>Effectiveness can be defined as the degree of achievement of a (health) outcome in a real-world implementation setting.</td>
</tr>
<tr>
<td>Efficiency</td>
<td>Efficiency can be defined as the achievement of an output with the lowest possible input without compromising quality.</td>
</tr>
<tr>
<td>Financial Sustainability</td>
<td>Financial sustainability refers to the ability of government and its partners to continue spending on a health or HIV outcome for the required duration and to meet any cost of borrowing without compromising the financial position of the Government, of household incomes and of other funding partners</td>
</tr>
<tr>
<td>HIV incidence</td>
<td>The estimated total number (or rate) of new (HIV infections in a given period.</td>
</tr>
<tr>
<td>HIV prevalence</td>
<td>The percentage of people who are infected with HIV at a given point in time.</td>
</tr>
<tr>
<td>Implementation efficiency</td>
<td>Implementation efficiency describes a set of measures to ensure that programs are implemented in a way that outputs are achieved with the lowest input of resources. In practical terms improving implementation efficiency means identifying better delivery solutions. This requires improved planning, design of service delivery models as well as assessing and addressing service delivery “roadblocks”. Implementation efficiency will contribute to the improved scale, coverage and quality of programs.</td>
</tr>
<tr>
<td>Model</td>
<td>Computer system designed to demonstrate the probable effect of two or more variables that might be brought to bear on an outcome. Such models can reduce the effort required to manipulate these factors and present the results in an accessible format.</td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
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<tr>
<td>-------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
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<tr>
<td>Opportunistic Infection Prophylaxis (OI Prophylaxis)</td>
<td>Treatment given to PLHIV to prevent either a first episode of an OI (primary prophylaxis) or the recurrence of infection (secondary prophylaxis).</td>
</tr>
<tr>
<td>Pre-exposure prophylaxis (PrEP)</td>
<td>A way for people who do not have HIV but who are at substantial risk of acquiring HIV to prevent HIV infection by taking an antiretroviral drug.</td>
</tr>
<tr>
<td>Program Effectiveness</td>
<td>Program Effectiveness incorporates evaluations to establish what works and provides impact on disease and/or transmission intensity, disseminating proven practice and improve the public health results of programs</td>
</tr>
<tr>
<td>Saturation</td>
<td>Saturation refers here to the maximum level of coverage, which a program can achieve.</td>
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</table>
7.6. Annex 5: References


