



HIV MATHEMATICAL MODELLING TO SUPPORT SWAZILAND'S DEVELOPMENT OF ITS HIV INVESTMENT CASE

Final Report, 8 October 2014



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1 ACKNOWLEDGEMENTS

This report presents HIV investment modelling results for Swaziland, and was carried out by the World Bank at the request of the Government of Swaziland. This was a collaborative project between the Swaziland Government, National Emergency Response Council on HIV and AIDS (NERCHA), UNAIDS Country Office, Swaziland, and the World Bank. The mathematical model used was Optima and modeling results were generated by Sherrie Kelly, Andrew Shattock, Cliff Kerr, and David Wilson from the Kirby Institute, University of New South Wales Australia (contracted to the World Bank for this purpose), with input from the Government of Swaziland and UNAIDS. We acknowledge the valuable contribution of the following people without whose input this project could not have been completed: Ms. Thembi Gama (Head of Programmes, NERCHA), Mr. Nhlanhla Nhlabatsi (Epidemiologist, MoH), Mr. Guilmerme Zagatti (Economist, MEPD), Mr. Bheki Ndzinisa (MoF), Mr. Edward Mkhathshwa (CANGO), Dr. Welile Sikhondze (MoH-NTLP), Mr. Kshitij Chaudhary (Health Economist, NERCHA, ODI Fellow), Ms. Julia Cocchia (World Food Programme), Mr Tony Ao (PEPFAR/CDC), Dr. Sithembile Dlamini-Nqeketo (World Health Organisation) Mr. Bheki Vilane (Clinton Health Access Initiative), Ms Pepukai Chikukwa (UNAIDS), Ms. Gloria Bille (UNAIDS), Ms Thembisile Dlamini (UNAIDS), Dr. Carel Pretorius (Futures Institute, USA) Mr. Nuha Ceesay (UNAIDS), and Ms. Nokwazi Mathabela (Project Leads, NERCHA) and the World Bank (Marelize Gorgens and Pandu Harimurti).

2 SUMMARY OF MODELLING RESULTS

Background and context: Swaziland is currently developing its HIV investment case and is thus focusing on which high impact interventions to prioritize. As a starting point to this process, the Government of Swaziland and UNAIDS requested the World Bank to estimate, through mathematical modelling, what the impact of the high impact ('game changer') interventions would be. The World Bank contracted the HIV modelling team at UNSW Australia to conduct this work. This report summarizes the outcomes of this modelling effort.

Purpose of the study: At the request of the Government, this modelling study aimed to assess the impact of moderate or high-level scale-up of the following five interventions, separately and jointly:

1. Antiretroviral therapy (ART) for people living with HIV;
2. Voluntary medical male circumcision (VMMC);
3. Implementation of conditional cash transfers (CCT) for girls and young women aged 15–24 years;
4. Prevention of mother-to-child transmission (PMTCT) of HIV;
5. Tuberculosis (TB)/HIV treatment.

Summary of results

a) By 2030 in Swaziland, compared to the situation had current coverage levels been maintained, it is possible to reduce new HIV infections by 27% and AIDS-related deaths by 12%

- By jointly implementing all interventions, it was estimated that by 2030 an additional 27,400 new infections and an additional 7,400 AIDS-related deaths could be averted (Table 1 and Figure 1).

b) The highest marginal impact interventions are ART, VMMC, and CCT

- Rapid scale-up of ART for people living with HIV, VMMC in males aged 10–49 years, and CCT for girls and young women aged 15–24 years showed the greatest impact on reducing more new HIV infections and AIDS-related deaths at population level by 2030. **VMMC** alone accounts for 49% of new HIV infections averted by 2030, **ART** for 27% of all infections averted, and **CCT** for 36% of new infections averted (Table 25 and Figure 9). **ART** alone for over half (57%) of AIDS-related deaths averted.

c) It is possible to reduce new HIV infections amongst girls and young women aged 15–24 years by 23% and at the national level by 10% by implementing the CCT program for girls and young women alone

- Cash transfers have multiple benefits and have also been shown to positively impact school enrollment rates, preventive healthcare, and household consumption in poor and vulnerable populations (not measured in this modelling effort) [1].
- If the CCT program were implemented among 60% of girls and young women aged 15–24 years in Swaziland by 2018, maintained until 2030, it is estimated that there would be 5,100 (23%) fewer new infections in this age group alone, and almost twice as many (9,900) new infections in the total population could be averted (Tables 13 and 14; Figures 5 and 6).

d) PMTCT shows lower marginal impact as the impact of the other game changer interventions – due to already-high coverage of the program – is already highly effective

- Scale-up of PMTCT to 90% coverage by 2018, maintained at 90% until 2030, would result in an estimated 1,200 (1.2%) fewer new HIV infections among infants born to HIV-positive mothers by 2030. As a secondary benefit, there would be 200 (0.3%) fewer deaths among HIV-positive mothers, and over time among their children (Table 19 and Figure 7).
- Since the current PMTCT coverage is already high at 84%, continued funding of this program is required to maintain high coverage and low-levels of new congenital infections. However, decreasing MTCT from 2% to 1%, as well as breastfeeding from 51% to 30% in 2018 and to 20% in 2030, as modeled by the moderate scale-up scenario, will obviously avert even more new infections (1.2%), which has important societal and downstream epidemiological benefits.

e) Moderate scale-up of TB/HIV intervention accounts for 35% of AIDS-related deaths averted by 2020

- By 2030, scale-up of ART coverage among people co-infected with TB/HIV to 75% by 2015, 85% by 2018, and 90% by 2030 would result in an estimated 1,200 (2%) fewer AIDS-related deaths. Moreover, with increased coverage of TB/HIV co-treatment it is estimated that an additional 3,800 people would be cured of TB by 2030 (Tables 22 and 23; Figure 8).

3 MODELLING OBJECTIVES

To assess the impact of the following interventions:

1. Antiretroviral therapy (ART) for people living with human immunodeficiency virus (HIV);
2. Voluntary medical male circumcision (VMMC);
3. Implementation of conditional cash transfers (CCT) for girls and young women aged 15–24 years;
4. Prevention of mother-to-child transmission (PMTCT) of HIV;
5. Tuberculosis (TB)/HIV treatment.

According to two scenarios including moderate or high-level scale-up of each:

1. All five interventions implemented jointly;
2. The five interventions implemented separately.

This study measures the projected impact using the following indicators by 2020 and 2030:

1. Number of new HIV infections averted;
2. Number of AIDS-related deaths averted;
3. Change in HIV incidence;
4. Cost per new infection averted;
5. Cost per AIDS-related death averted.

Note that these scaled-up interventions will lead to fewer new HIV infections and AIDS-related deaths, and as a result HIV prevalence may actually increase as people with HIV live longer. This is a positive outcome.

For the populations

- A. All people in Swaziland;
- B. Boys and men aged 10–49 years in Swaziland, for the VMMC intervention;
- C. Girls and young women aged 15–24 years in Swaziland, for the CCT intervention.

4 MODELLING METHODS, INPUT DATA AND ASSUMPTIONS

4.1 MODELING METHODS

To assess the HIV investment case in Swaziland we used a mathematical model of HIV transmission and disease progression called Optima (formerly known as Prevtool). Optima incorporates HIV transmission and progression in populations partitioned by at-risk group and health state. The model uses best-practice HIV epidemic modeling techniques and incorporates realistic biological transmission processes, detailed infection progression, and sexual mixing patterns.

4.2 INPUT DATA

Model input values from the previous World Bank/UNSW Optima allocative efficiency modeling project for Swaziland were used unless otherwise stated.

4.3 ASSUMPTIONS AND TARGETS

Overall assumptions

- It was assumed that interventions would be implemented beginning in January 2015.
- It was assumed that new HIV infections and AIDS-related deaths averted are discounted by 3% per year.

a) Accelerated scale-up of ART for people living with HIV

Assumptions and current state

- The current ART eligibility for people living with HIV (PLHIV) is CD4 <350 cells/mm³ (Swaziland Government communication).
- It was assumed that as of 2015, ART eligibility for PLHIV will be CD4 <500 cells/mm³ (Swaziland Government communication).
- The current HIV testing rates were taken to be 22.8% for girls 15–19 years and 54.4% for women aged 20–24 years (Swaziland Government communication).
- The current estimated proportion of PLHIV in Swaziland who have been diagnosed with their infection is 63%.
- The model was calibrated to reflect the total number of people on first- and second-line ART.
- The current ART coverage is 70% of PLHIV with CD4 <350 cells/mm³. This corresponds to an ART coverage of 55% once eligibility for treatment becomes CD4 <500 cells/mm³ anticipated to begin January 2015.

Targets

- The ART coverage targets are:
 - Moderate: 65% of PLHIV with CD4 <500 cells/mm³ by 2020 and 75% by 2030.
 - High: 85% of PLHIV with CD4 <500 cells/mm³ by 2020 and 90% by 2030.

b) Scale-up voluntary medical male circumcision

Assumptions and current state

- The current VMMC coverage in males aged 15–49 years is 19%.

Targets

- The VMMC targets are:
 - Moderate: to 55% by 2018 for males 10–49 years and maintained at 55% until 2030.
 - High: to 45% by 2015 for males 10–49 years, 70% by 2018, and maintained at 70% until 2030 [2].

c) Conditional cash transfers (CCT) for girls and young women 15–24 years

Assumptions and current state

- The current coverage of CCT for girls and young women aged 15–24 years is 0%. This program has yet to be implemented.
- It was assumed that a \$20 monthly CCT benefit would be applied [3].
- It was assumed that these CCTs would result in a 43% reduction in the number of sexual interactions girls and young women aged 15–24 years had with any partners [4].
- It was assumed that there would be a 17% reduction in sexual interactions with men 25 years of age or older with females aged 15–24 receiving CCTs [4].

Targets

- The CCT coverage targets are:
 - Moderate: to 60% by 2018 for females aged 15–24 years and maintained at 60% until 2030.
 - High: to 95% by 2018 for females aged 15–24 years and maintained at 95% until 2030.

d) Prevention of mother-to-child transmission of HIV

Assumptions and current state

- The current PMTCT coverage is 84% (corresponding to 2% transmission) [5].
- It was assumed that there would be lifelong treatment for HIV-positive mothers in accordance with option B+ [6].
- The current exclusive breastfeeding is 51% of infants up to 6 months of age (Swaziland Government communication).

Targets

- The targets for PMTCT coverage are:
 - Moderate: 90% coverage by 2018 and maintained until 2030 (reduce MTCT to 1%).
 - High: 95% coverage by 2018 and maintained until 2030.
- The targets for breastfeeding in HIV-positive mothers are:

- Moderate: 30% by 2020 and 20% by 2030.
- High: 0% by 2020 and maintained until 2030.

e) Intensifying TB/HIV co-treatment

Assumptions and current state

- The current ART uptake for TB patients who are also living with HIV is 73% [5].
- The current prevalence of TB among people living with HIV is 6.5% (calculated as an estimated 13,000 people co-infected with TB/HIV out of an estimated 200,000 people living with HIV) [7, 8].
- It was assumed that the TB/HIV co-infection rate was 79.6% [9].
- It was assumed that the percentage of HIV-positive TB patients on co-trimoxazole preventive therapy was 98% [7].
- It was assumed that 48% of people with new-smear positive cases of TB that are treated for TB would be cured [7]. It was also assumed for this modeling project that people with TB/HIV would all be new-smear positive cases of TB.

Targets

- The target for TB/HIV co-treatment coverage are:
 - Moderate: ART coverage among TB/HIV-co-infected people to 75% by 2015, 85% by 2018, and 90% by 2030.
 - High: ART coverage among TB/HIV-co-infected people to 75% by 2015, 85% by 2018, and 95% by 2030.

4.4 PAST SPENDING AND UNIT COST ASSUMPTIONS

Assumptions and current state

Spending and costs in this report are reported in United States dollars (USD).

a) Past HIV spending, USD [5]

Program	2012–2013
Prevention	\$20,333,000
Care and treatment	\$51,363,000
Other programs	\$25,235,000
Total	\$96,931,000

b) Past TB/HIV spending, USD

Program	2013
TB/HIV diagnosis and treatment	\$3,208,541

Source: Swaziland Government Communication

c) Unit costs, USD

Intervention	Unit cost (per person per year)	Source
ART, first line drugs	\$131.70	[10]
VMMC	\$130.00 (per male 10–49 per year)	[10]
CCT (\$20 monthly)	\$76.56 ^(a) (per female 15–24 per year)	[3]
PMTCT	\$186.00 (per mother-infant pair)	[11]
TB/HIV	\$247.00 ^(b)	Cost of TB/HIV program in 2013 (shown in above table) divided by the estimated HIV-positive incident TB cases in 2012 [7]

^(a) It was assumed that only 29% of the costs for the conditional cash transfer program would be allocated to the HIV program as there are multiple benefits to this intervention; therefore, the HIV program would not be expected to fund the full cost of the program at \$264 per girl or young woman aged 15–24 years per year (see Remme AIDS 2014, Table 3).

^(b) It was assumed that the cost of the TB/HIV program would increase proportionally to the increased TB/HIV coverage over time to meet targets. As well, since it was reported that, “The prevalence of HIV among TB patients is 79.6%, therefore 79.6% of total expenditure on TB was captured as TB/HIV treatment expenditure.”[12], it follows that only 80% of the TB/HIV spending was allocated to the HIV program.

- It was assumed that unit costs are discounted by 3% per year to present values.

5 RESULTS

5.1 COMBINED IMPACT OF MODERATE SCALE-UP OF ALL INTERVENTIONS

1. ART for people living with HIV;
2. Voluntary medical male circumcision;
3. Implementation of conditional cash transfers for girls and young women aged 15–24 years;
4. Prevention of mother-to-child transmission of HIV ;
5. TB/HIV co-treatment.

Table 1: Projected impact of moderate scale-up of all interventions combined by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio ^(a)
New HIV infections	by 2020	37,464	6,503	17.4%	\$41,441,559	\$6,373
	by 2030	99,855	27,355	27.4%	\$74,205,074	\$2,713
AIDS-related deaths	by 2020	25,526	1,351	5.3%	\$41,441,559	\$30,686
	by 2030	64,007	7,413	11.6%	\$74,205,074	\$10,010

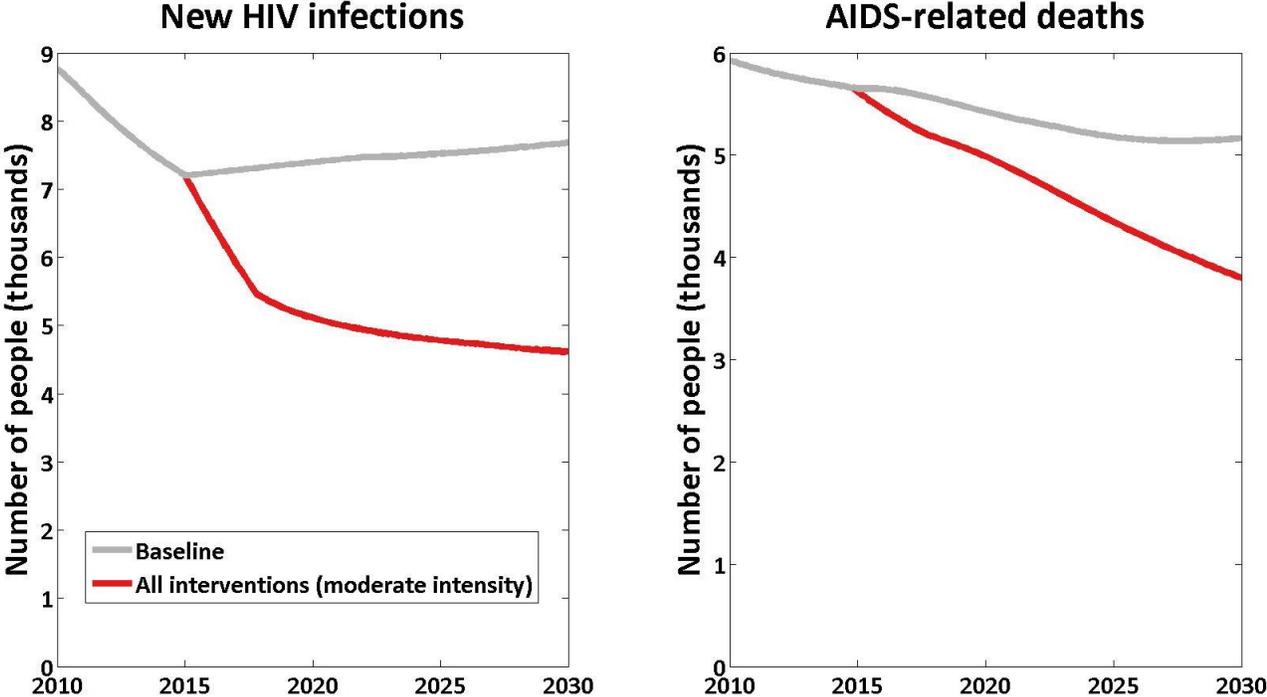
^(a)Incremental cost-effectiveness ratio is cost per infection or death averted.

- HIV incidence would change from 2.4% in 2014 to 2.2% by 2020 and 2.0% by 2030.

Of note, results are reported as cumulative values throughout, i.e. ‘by 2020’ represents additive values from the start of the scaled-up interventions from 2015 to 2020 (5 years of values) and ‘by 2030’ represents additive values from 2015 to 2030 (15 years of values).

Costing values are also reported cumulatively. These costs, estimated for meeting scale-up targets, are over and above the current program costs.

Figure 1: Epidemic trajectories for moderate scale-up of all interventions combined compared to current trends of new HIV infections and AIDS-related deaths in Swaziland, 2010–2030



All interventions

- Implementing moderate scale-up of all interventions would lead to 27,400 (27%) fewer new infections and 7,400 (12%) fewer AIDS-related deaths by 2030 (Table 1 and Figure 1).

5.2 IMPACT OF ACCELERATED SCALE-UP OF ART FOR PEOPLE LIVING WITH HIV

MODERATE SCALE-UP

Table 2: Projected number of people on ART and costs associated with moderate scale-up of ART by 2020 and 2030, Swaziland

Year (Cumulative)	Number of PLHIV on ART in baseline	ART intervention coverage targets	Additional number of PLHIV on ART in intervention	Unit cost (USD)	Discounted cost of program
by 2020	340,405	65%	56,019	\$131.70	\$6,664,259
by 2030	1,189,254	75%	125,107	\$131.70	\$13,654,653

Table 3: Projected impact of moderate scale-up of ART on new HIV infections and AIDS-related deaths by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	1,980	5.3%	\$6,664,259	\$3,366
	by 2030	99,855	7,452	7.5%	\$13,654,653	\$1,832
AIDS-related deaths	by 2020	25,526	860	3.4%	\$6,664,259	\$7,750
	by 2030	64,007	4,254	6.6%	\$13,654,653	\$3,210

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and by 2030.

HIGH-LEVEL SCALE-UP

Table 4: Projected number of people on ART and costs associated with high-level scale-up of ART by 2020 and 2030, Swaziland

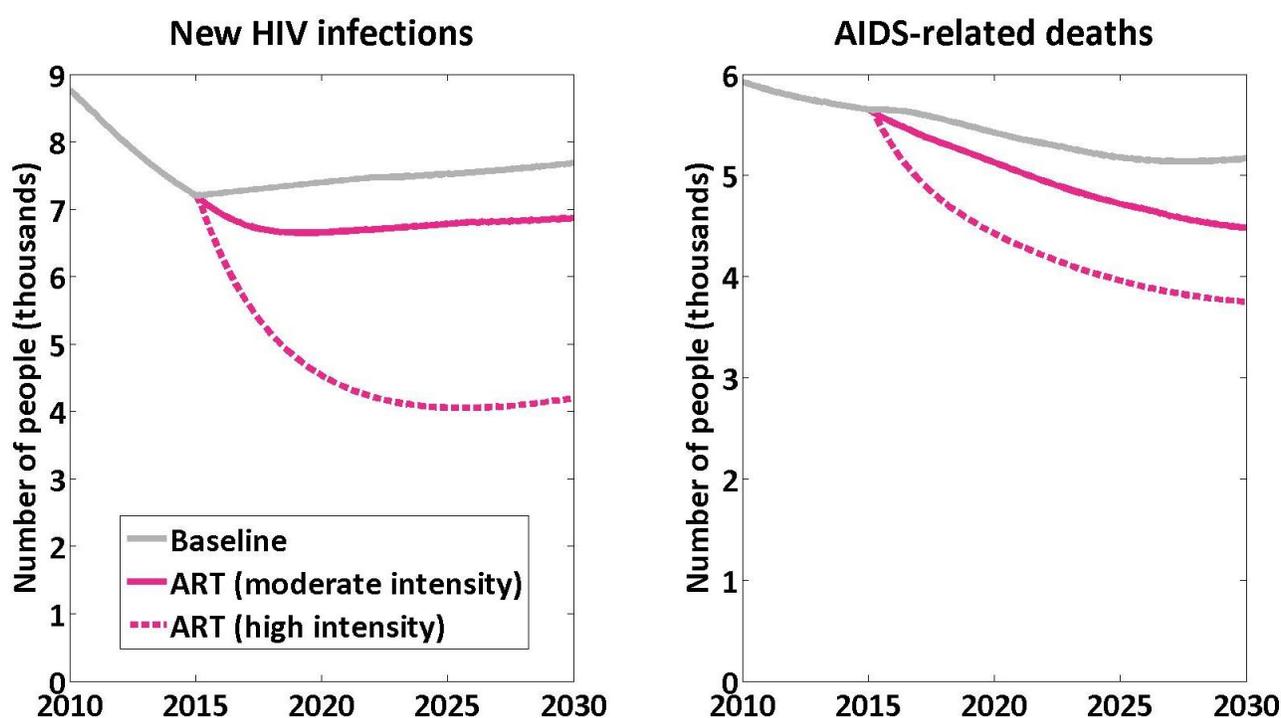
Year (Cumulative)	Number of PLHIV on ART in baseline	ART intervention coverage targets	Additional number of PLHIV on ART in intervention	Unit cost (USD)	Discounted cost of program
by 2020	340,405	85%	267,289	\$131.70	\$31,620,577
by 2030	1,189,254	90%	1,338,379	\$131.70	\$134,908,884

Table 5: Projected impact of high-level scale-up of ART on new HIV infections and AIDS-related deaths by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	6,536	17.4%	\$31,620,577	\$4,838
	by 2030	99,855	28,137	28.2%	\$134,908,884	\$4,795
AIDS-related deaths	by 2020	25,526	2,845	11.1%	\$31,620,577	\$11,114
	by 2030	64,007	11,718	18.3%	\$134,908,884	\$11,513

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and by 2030.

Figure 2: Epidemic trajectories for moderate and high-level scale-up of ART compared to current trends of new HIV infections and AIDS-related deaths in Swaziland, 2010–2030



- Moderate scale-up of ART coverage to 65% by 2020 and 75% by 2030 would result in an estimated 7,500 (8%) fewer new HIV infections and 4,300 (7%) fewer AIDS-related deaths by 2030 (Table 3 and Figure 2).
- High-level scale-up of ART coverage to 85% by 2020 and 90% by 2030 would result in an estimated 37,400 (29%) fewer new HIV infections and 15,600 (19%) fewer AIDS-related deaths (Table 5 and Figure 2).

5.3 IMPACT OF SCALE-UP VOLUNTARY MEDICAL MALE CIRCUMCISION (VMMC)

MODERATE SCALE-UP

Total population

Table 6: Projected number of VMMCs and costs associated with moderate scale-up of VMMC by 2020 and 2030, Swaziland

Year (Cumulative)	Number of VMMCs in baseline	VMMC intervention coverage targets	Additional number of VMMCs in intervention	Unit cost (USD)	Discounted cost of program
by 2020	10,560	55% by 2018	18,700	\$130	\$2,281,432
by 2030	30,578		20,690	\$130	\$2,475,488

Table 7: Projected impact of moderate scale-up of VMMC on new HIV infections and AIDS-related deaths in the total population of Swaziland by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	2,546	6.8%	\$2,281,432	\$896
	by 2030	99,855	13,291	13.3%	\$2,475,488	\$186
AIDS-related deaths	by 2020	25,526	12	NA	\$2,281,432	NA
	by 2030	64,007	1,334	2.1%	\$2,475,488	\$1,856

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and by 2030.

Males 10–49 years

Table 8: Projected impact of moderate scale-up of VMMC in males 10–49 years on new HIV infections and AIDS-related deaths by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	9,811	1,672	17.0%	\$2,281,432	\$1,364
	by 2030	26,097	6,440	24.7%	\$2,475,488	\$384
AIDS-related deaths	by 2020	6,546	9	0.1%	\$2,281,432	\$266,027
	by 2030	16,310	644	3.9%	\$2,475,488	\$3,843

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.2% by 2020 and by 2030.

HIGH-LEVEL SCALE-UP

Total population

Table 9: Projected number of VMMCs and costs associated with high-level scale-up of VMMC by 2020 and 2030, Swaziland

Year (Cumulative)	Number of VMMCs in baseline	VMMC intervention coverage targets	Additional number of VMMCs in intervention	Unit cost (USD)	Discounted cost of program
by 2020	10,560	45% by 2015 and 70% by 2018	26,479	\$130.00	\$3,280,570
by 2030	30,578		29,101	\$130.00	\$3,536,632

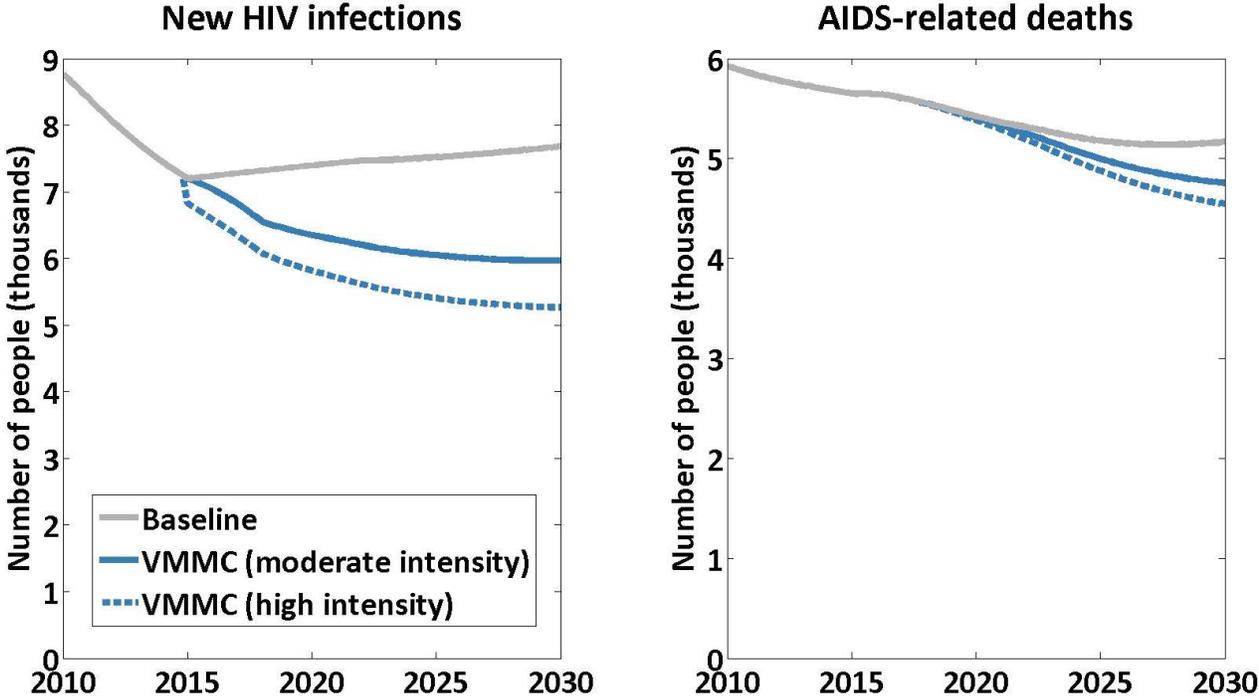
Table 10: Projected impact of high-level scale-up of VMMC on new HIV infections and AIDS-related deaths in the total population of Swaziland by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	4,686	12.5%	\$3,280,570	\$700
	by 2030	99,855	20,187	20.2%	\$3,536,632	\$175
AIDS-related deaths	by 2020	25,526	37	NA	\$3,280,570	NA
	by 2030	64,007	2,193	3.4%	\$3,536,632	\$1,612

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.2% by 2020 and by 2030.

Figure 3: Epidemic trajectories for moderate and high-level scale-up of VMMC compared to current trends of new HIV infections and AIDS-related deaths in Swaziland, 2010–2030



- Moderate scale-up of VMMC in males aged 10–49 years to 55% by 2018, maintained at 55% until 2030, would result in an estimated 13,300 (13%) fewer new HIV infections and 1,300 (2%) fewer AIDS-related deaths by 2030 in the total population (Table 7 and Figure 3).
- High-level scale-up of VMMC in males aged 10–49 years to 45% by 2015, 70% by 2018, maintained at 70% until 2030, would result in an estimated 20,200 (20%) fewer new HIV infections and 2,200 (3%) fewer AIDS-related deaths by 2030 in the total population (Table 10 and Figure 3).

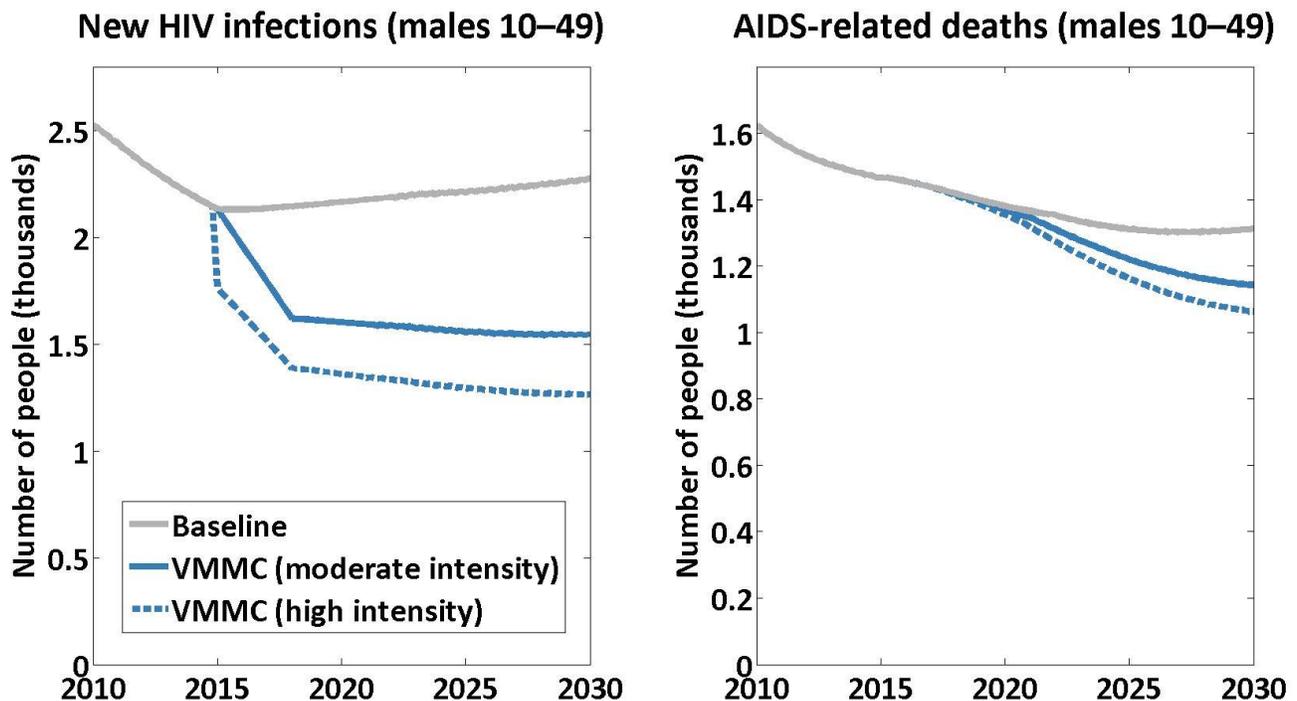
Males 10–49 years

Table 11: Projected impact of high-level scale-up of VMMC in males 10–49 years on new HIV infections and AIDS-related deaths by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	9,811	2,934	29.9%	\$3,280,570	\$1,118
	by 2030	26,097	9,629	36.9%	\$3,536,632	\$367
AIDS-related deaths	by 2020	6,546	26	0.4%	\$3,280,570	\$125,183
	by 2030	16,310	1,044	6.4%	\$3,536,632	\$3,386

- HIV incidence would change from 2.4% in 2014 to 2.1% by 2020 and by 2030.

Figure 4: Epidemic trajectories for moderate and high-level scale-up of VMMC compared to current trends of new HIV infections and AIDS-related deaths in Swaziland males aged 10–49 years, 2010–2030



- Moderate scale-up of VMMC in males aged 10–49 years to 55% by 2018, and maintained at 55% until 2030, would result in an estimated 6,400 (25%) fewer new HIV infections and 600 (4%) fewer AIDS-related deaths by 2030 among males aged 10–49 years alone (Table 8 and Figure 4).

- High-level scale-up of VMMC in males aged 10–49 years to 45% by 2015, 70% by 2018, and maintained at 70% until 2030, would result in an estimated 9,600 (37%) fewer new HIV infections among these males alone and 1,000 (6%) fewer AIDS-related deaths by 2030 (Table 11 and Figure 4).

IMPACT OF IMPLEMENTING A CONDITIONAL CASH TRANSFER (CCT) PROGRAM FOR GIRLS AND YOUNG WOMEN 15–24 YEARS

MODERATE SCALE-UP

Total population

Table 12: Projected number of females aged 15–24 years receiving CCTs with moderate coverage and associated costs by 2020 and 2030, Swaziland

Year (Cumulative)	Number of females 15–24 years eligible for CCTs	CCT intervention coverage targets	Additional number of CCTs in intervention	Unit cost (USD)	Discounted cost of program
by 2020	383,319	60% by 2018	229,991	\$76.56	\$16,113,664
by 2030	1,241,999		745,199	\$76.56	\$45,031,793

Table 13: Projected impact of implementing moderate coverage of the CCT program on new HIV infections and AIDS-related deaths in the total Swaziland population by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	2,185	5.8%	\$16,113,664	\$7,375
	by 2030	99,855	9,895	9.9%	\$45,031,793	\$4,551
AIDS-related deaths	by 2020	25,526	11	NA	\$16,113,664	NA
	by 2030	64,007	1,033	1.6%	\$45,031,793	\$43,608

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and by 2030.

Females 15–24 years

Table 14: Projected impact of implementing moderate coverage of the CCT program in Swaziland females 15–24 years alone by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	8,384	1,335	15.9%	\$16,113,664	\$12,071
	by 2030	22,509	5,109	22.7%	\$45,031,793	\$8,814
AIDS-related deaths	by 2020	2,094	5	NA	\$16,113,664	NA
	by 2030	5,220	244	4.7%	\$45,031,793	\$184,264

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2030.

HIGH-LEVEL SCALE-UP

Total population

Table 15: Projected number of females aged 15–24 years receiving CCTs with high-level coverage and associated costs by 2020 and 2030, Swaziland

Year (Cumulative)	Number of females 15–24 years eligible for CCTs	CCT intervention coverage targets	Additional number of CCTs in intervention	Unit cost (USD)	Discounted cost of program
by 2020	383,324	95% by 2018	364,158	\$76.56	\$25,513,620
by 2030	1,241,763		1,179,674	\$76.56	\$71,289,221

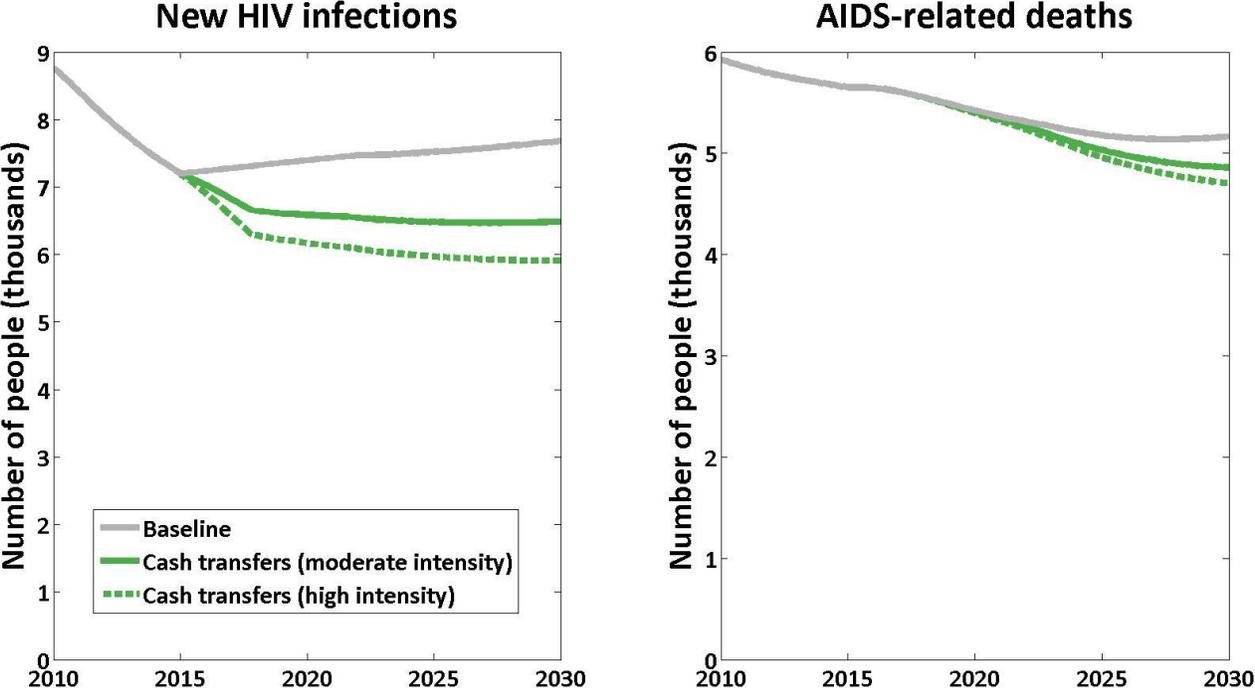
Table 16: Projected impact of implementing high-level coverage of the CCT program on new HIV infections and AIDS-related deaths in the total population of Swaziland by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	3,365	9.0%	\$25,513,620	\$7,583
	by 2030	99,855	14,901	14.9%	\$71,289,221	\$4,784
AIDS-related deaths	by 2020	25,526	17	NA	\$25,513,620	NA
	by 2030	64,007	1,548	2.4%	\$71,289,221	\$46,065

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and 2.2% by 2030.

Figure 5: Epidemic trajectories of moderate and high-level implementation of the CCT program compared to not implementing this program on new HIV infections and AIDS-related deaths in the total population of Swaziland, 2010–2030



- Moderate implementation of a CCT program with a \$20 monthly benefit for girls and young women aged 15–24 years in 2015 with 60% coverage by 2018, maintained until 2030, would result in an estimated 9,900 (10%) fewer new HIV infections and 1,000 (2%) fewer AIDS-related deaths in the total population of Swaziland by 2030 (Table 13 and Figure 5).
- High-level implementation of the CCT program described above, but with 95% coverage of females aged 15–24 years by 2018, maintained until 2030, would result in an estimated 14,900 (15%) fewer new HIV infections and 1,500 (2%) fewer AIDS-related deaths in the total population of Swaziland by 2030 (Table 16 and Figure 5).

Females 15–24 years

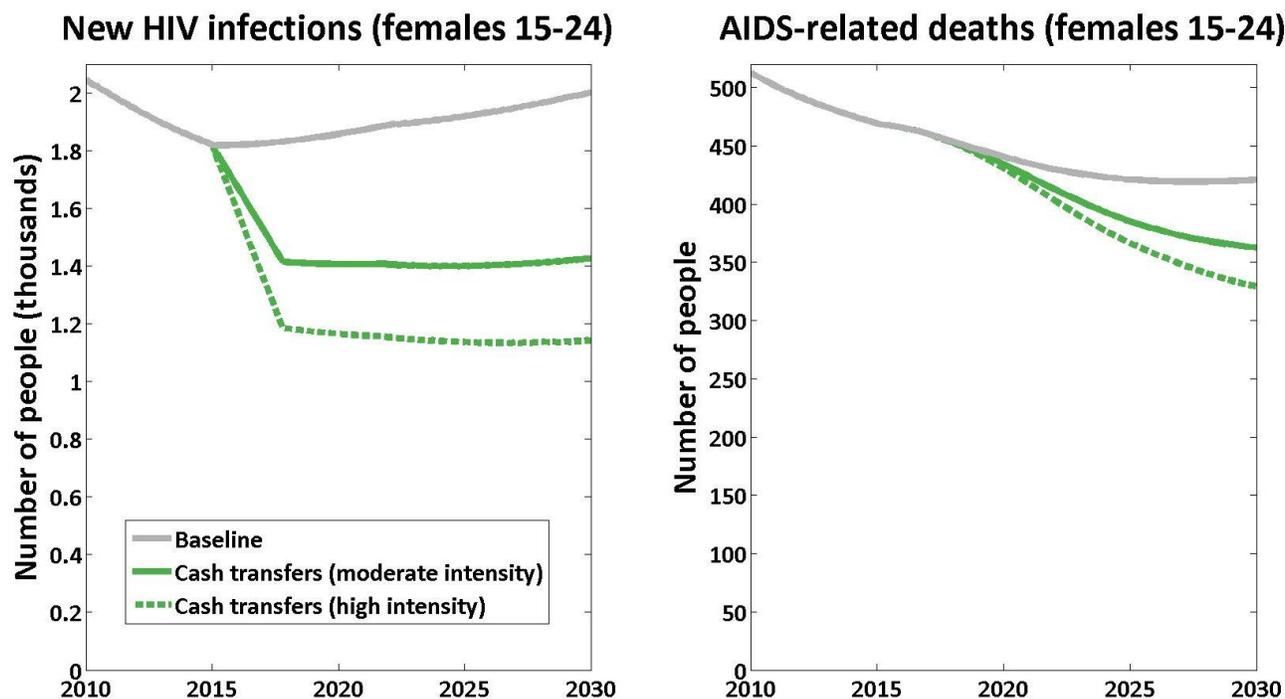
Table 17: Projected impact of implementing high-level coverage of the CCT program in Swaziland females 15–24 by 2020 and 2030

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	8,384	2,072	24.7%	\$25,513,620	\$12,316
	by 2030	22,509	7,779	34.6%	\$71,289,221	\$9,164
AIDS-related deaths	by 2020	2,094	8	0.4%	\$25,513,620	\$3,092,325
	by 2030	5,220	376	7.2%	\$71,289,221	\$189,448

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

- HIV incidence would change from 2.4% in 2014 to 2.3% by 2020 and by 2030.

Figure 6: Epidemic trajectories of moderate and high-level implementation of the CCT program compared to not implementing this program on new HIV infections and AIDS-related deaths in Swaziland females 15–24, 2010–2030



- Moderate implementation of a CCT program would result in an estimated 5,100 fewer new HIV infections, representing a 23% reduction, and 200 fewer AIDS-related deaths, a 5% reduction in girls and young women aged 15–24 years alone by 2030 (Table 14 and Figure 6).

- High-level implementation of the CCT program would result in an estimated 7,800 fewer new HIV infections, representing a 35% reduction, and 400 fewer AIDS-related deaths, an 7% reduction in girls and young women aged 15–24 years alone by 2030 (Table 17 and Figure 6).

IMPACT OF PREVENTION OF MOTHER-TO-CHILD TRANSMISSION (PMTCT) OF HIV

MODERATE SCALE-UP

Table 18: Projected number of HIV-positive mother-infant pairs on PMTCT and costs associated with moderate scale-up of PMTCT by 2020 and 2030, Swaziland

Year (Cumulative)	Number of mother-infant pairs on PMTCT in baseline	PMTCT intervention coverage targets	Additional number of mother-infant pairs on PMTCT in intervention	Unit cost (USD)	Discounted cost of program
by 2020	53,311	90% PMTCT by 2018 and 30% breastfeeding	1,696	\$186	\$288,931
by 2030	168,615	90% PMTCT until 2030 and 20% breastfeeding	5,202	\$186	\$767,735

Table 19: Projected impact of moderate scale-up of PMTCT by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	393	1.0%	\$288,931	\$736
	by 2030	99,855	1,164	1.2%	\$767,735	\$659
AIDS-related deaths	by 2020	25,526	10	NA	\$288,931	NA
	by 2030	64,007	221	0.3%	\$767,735	\$3,480

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

HIGH-LEVEL SCALE-UP

Table 20: Projected number of HIV-positive mother-infant pairs on PMTCT and costs associated with high-level scale-up of PMTCT by 2020 and 2030, Swaziland

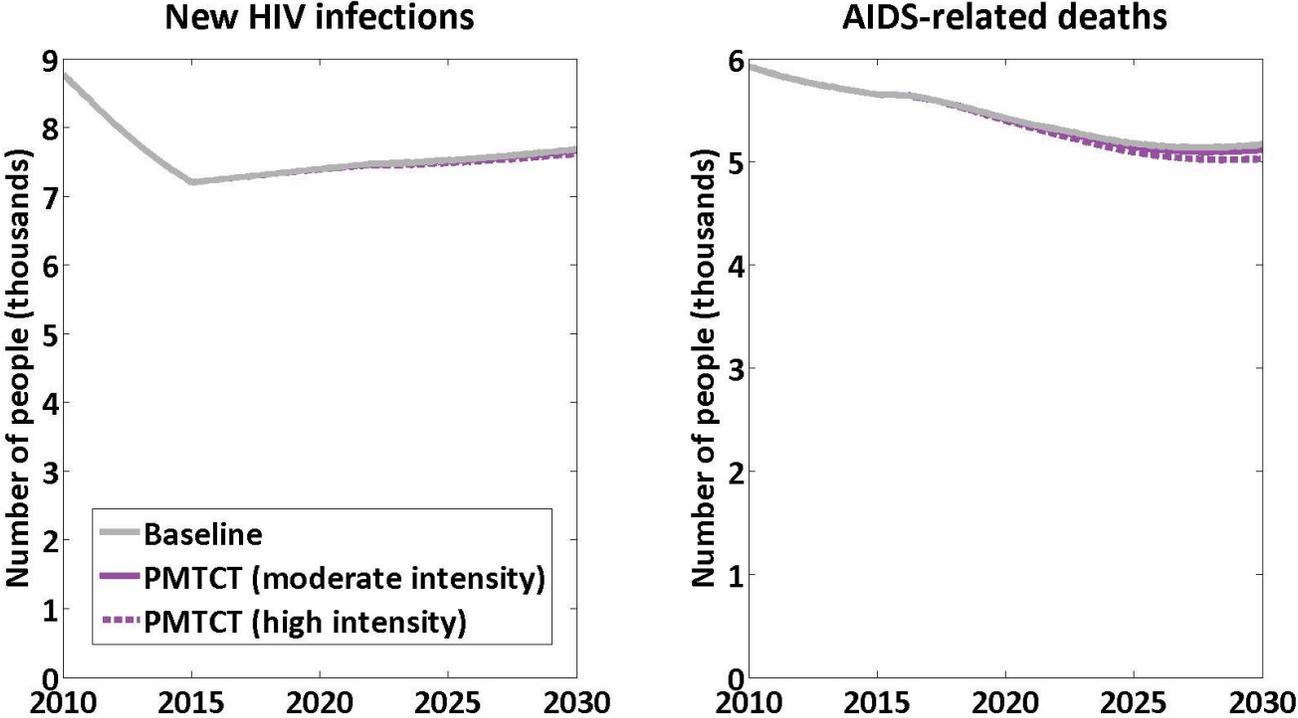
Year (Cumulative)	Number of mother-infant pairs on PMTCT in baseline	PMTCT intervention coverage targets	Additional number of mother-infant pairs on PMTCT in intervention	Unit cost (USD)	Discounted cost of program
by 2020	53,311	95% PMTCT by 2018 and 0% breastfeeding	4,735	\$186	\$806,821
by 2030	168,615	95% PMTCT until 2030 and 0% breastfeeding	14,500	\$186	\$2,140,540

Table 21: Projected impact of high-level scale-up of PMTCT by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	1,096	2.9%	\$806,821	\$736
	by 2030	99,855	3,247	3.3%	\$2,140,540	\$659
AIDS-related deaths	by 2020	25,526	27	NA	\$806,821	NA
	by 2030	64,007	616	1.0%	\$2,140,540	\$3,476

NA = Not applicable as so few AIDS-related deaths were averted over the short-term

Figure 7: Epidemic trajectories for moderate and high-level scale-up of PMTCT compared to current trends of new HIV infections and AIDS-related deaths in Swaziland, 2010–2030



- With current coverage of PMTCT at 84% and less than 2% transmission of HIV to infants born to HIV-positive mothers, the current state is already approaching the intervention PMTCT target of 1% transmission. Therefore, with a relatively small amount of scale-up required to reach the moderate scale-up targets for PMTCT to 90% coverage by 2018, maintained until 2030, as well reaching the breastfeeding in HIV-positive mothers target of 30% by 2020 and 20% by 2030, it is estimated that there would be 1,100 (1%) fewer new HIV infections and as a result, 200 (0.3%) fewer AIDS-related deaths by 2030 (Table 19 and Figure 7).
- With high-level scale-up of PMTCT to 95% by 2018, maintained until 2030, as well as eliminating breastfeeding in HIV-positive mothers by 2020, maintained until 2030, it is estimated that there would be 3,200 (3%) fewer new HIV infections, and as a result, 600 (1%) fewer AIDS-related deaths by 2030 (Table 21 and Figure 7).

IMPACT OF INTENSIFYING TB/HIV CO-TREATMENT

MODERATE SCALE-UP

Table 22: Projected impact of moderate scale-up of TB/HIV co-treatment on the number of people cured of TB by 2020 and 2030, Swaziland

By 2020	Baseline	Intervention
Number of people on ART	340,405	396,424
Number of people on ART co-infected with TB (6.5% prevalence of TB in PLHIV)	22,126	25,768
Number of people on ART co-infected with TB, on TB treatment (98% coverage)	21,684	25,252
Number of people on ART co-infected with TB, on TB treatment that would be cured of TB (TB cure rate of 48% in new smear positive cases)	10,408	12,121
Additional number of people cured of TB in intervention compared to baseline	1,713	
By 2030	Baseline	Intervention
Number of people on ART	1,189,254	1,314,361
Number of people on ART co-infected with TB (6.5% prevalence of TB in PLHIV)	77,302	85,433
Number of people on ART co-infected with TB, on TB treatment (98% coverage)	75,755	83,725
Number of people on ART co-infected with TB, on TB treatment that would be cured of TB (TB cure rate of 48% in new smear positive cases)	36,363	40,188
Additional number of people cured of TB in intervention compared to baseline	3,825	

Moderate intervention targets: ART coverage among TB/HIV-co-infected people to 75% by 2015, 85% by 2018, and 90% by 2030.

Table 23: Projected impact of moderate scale-up of TB/HIV co-treatment by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	NA	NA	\$15,558,361	NA
	by 2030	99,855	NA	NA	\$37,669,429	NA
AIDS-related deaths	by 2020	25,526	477	1.9%	\$15,558,361	\$32,592
	by 2030	64,007	1,220	1.9%	\$37,669,429	\$30,883

NA = Not applicable as there were no new HIV infections averted

HIGH-LEVEL SCALE-UP

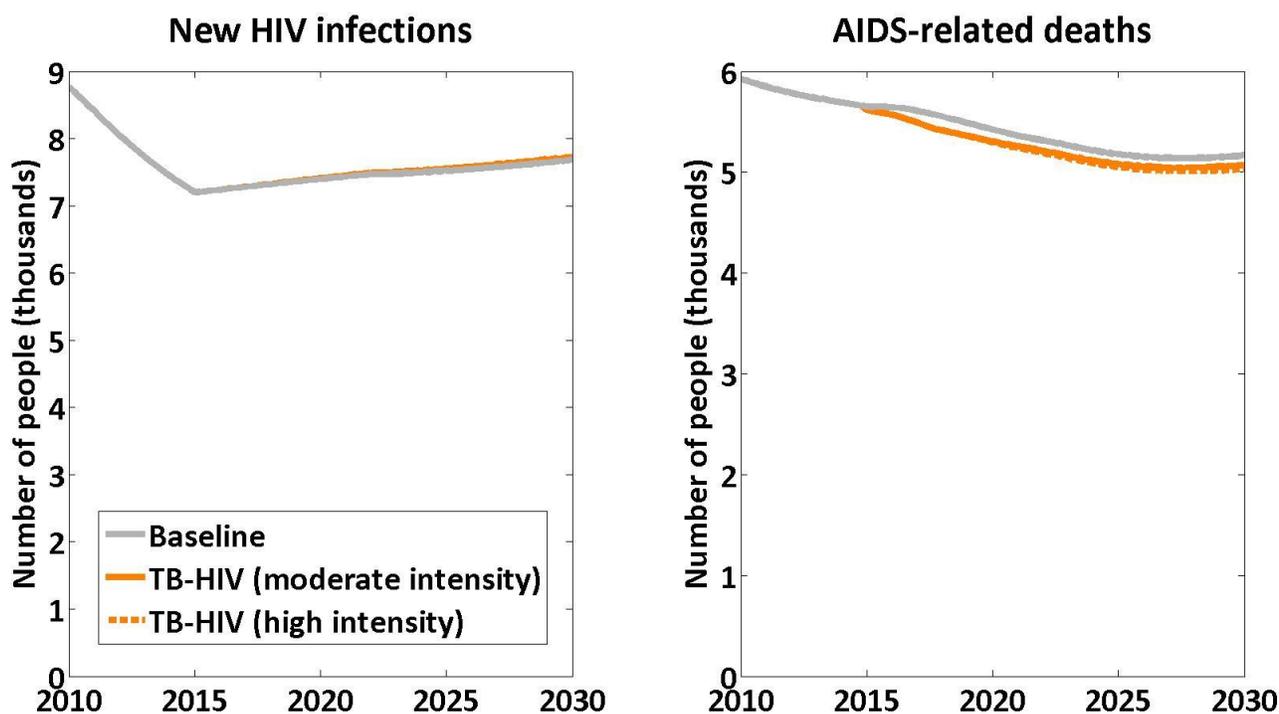
Table 24: Projected impact of high-level scale-up of TB/HIV co-treatment by 2020 and 2030, Swaziland

Impact measures	Year (Cumulative)	Number of infections or deaths in baseline	Number of infections or deaths averted in intervention	Percent reduction (%)	Discounted cost of program	Incremental cost-effectiveness ratio
New HIV infections	by 2020	37,464	NA	NA	\$19,494,417	NA
	by 2030	99,855	NA	NA	\$48,082,605	NA
AIDS-related deaths	by 2020	25,526	486	1.9%	\$19,494,417	\$40,077
	by 2030	64,007	1,423	2.2%	\$48,082,605	\$33,797

NA = Not applicable as there were no new HIV infections averted

High-level intervention targets: ART coverage among TB/HIV-co-infected people to 75% by 2015, 85% by 2018, and 95% by 2030.

Figure 8: Epidemic trajectories for moderate or high-level scale-up TB/HIV co-treatment compared to current trends of new HIV infections and AIDS-related deaths in Swaziland, 2010–2030



- In 2013, in Swaziland, it was estimated that 80% of people infected with TB were also living with HIV [9]. With an estimated 13,000 HIV-positive incident TB cases reported in 2012 [7], the 6.5% prevalence of TB among people living with HIV is relatively low compared to the 27.4% prevalence of HIV alone (reported for 2013) [8].

- Moderate scale-up of ART coverage of people co-infected with TB/HIV from the current 73% to 74% by 2015, 85% by 2018, and 90% by 2030 would result in an estimated 1,200 (2%) fewer AIDS-related. In addition, an estimated 3,800 more people would be cured of TB by 2030 (Tables 22 and 23; Figure 8) [7].
- High-level scale-up of ART coverage of people co-infected with TB/HIV from the current 73% to 74% by 2015, 85% by 2018, and 95% by 2030 would result in 1,400 (2%) fewer AIDS-related deaths. (Table 24 and Figure 8) [7].

CONTRIBUTION OF EACH INTERVENTION

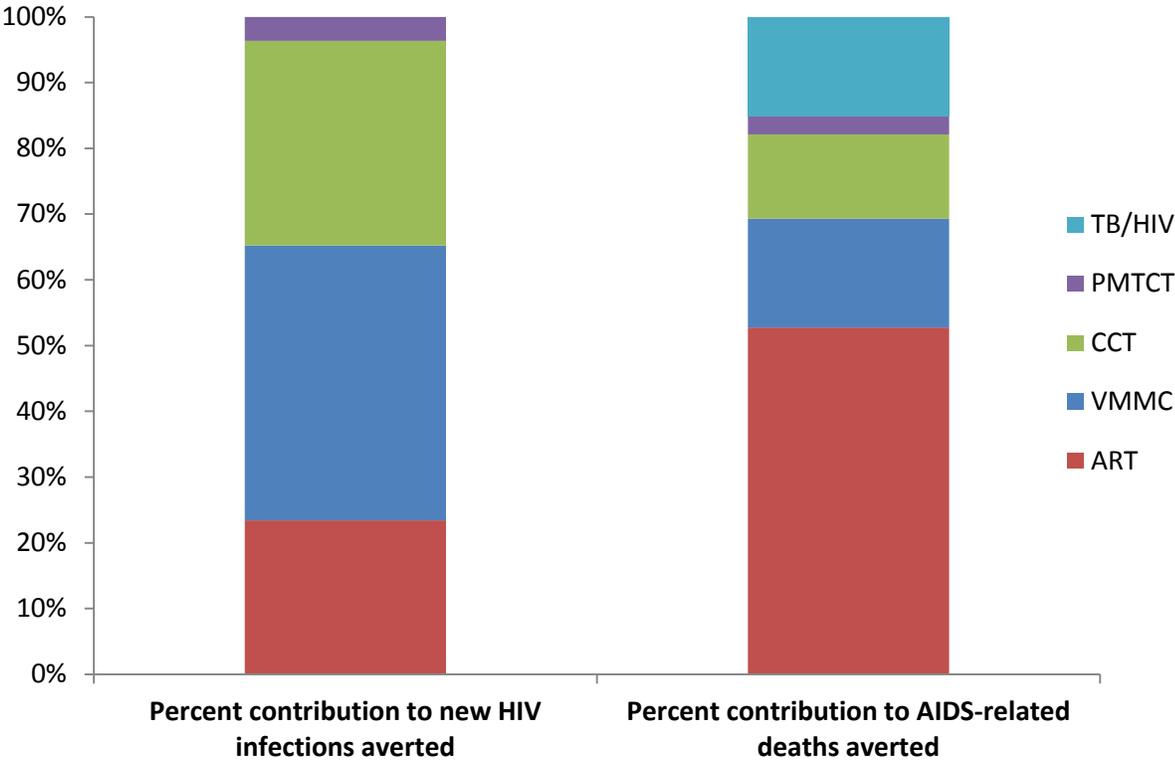
Table 25: Projected percent contribution of each moderate scale-up intervention to the total reduction in new HIV infections and AIDS-related deaths by 2020 and 2030, Swaziland

Year (Cumulative)	Intervention	New HIV infections		AIDS-related deaths	
		Number of infections averted*	Percent contribution to infections averted (%)	Number of deaths averted*	Percent contribution to deaths averted (%)
by 2020	All interventions	6,503	-	1,351	-
	ART	1,980	30%	860	64%
	VMMC	2,546	39%	12	1%
	CCT	2,185	34%	11	1%
	PMTCT	393	6%	10	1%
	TB/HIV	NA	NA	477	35%
by 2030	All interventions	27,355	-	7,413	-
	ART	7,452	27%	4,254	57%
	VMMC	13,291	49%	1,334	18%
	CCT	9,895	36%	1,033	14%
	PMTCT	1,164	4%	221	3%
	TB/HIV	NA	NA	1,220	16%

NA = Not applicable as there were no new HIV infections averted

* The sum of new infections averted for separate interventions is not equal to total number of new infections averted for 'All interventions', as when the five interventions are modeled jointly, there is overlap in infections that would be averted when interventions are modeled separately. The same holds true for the number of AIDS-related deaths averted. Lastly, the sum of the percent contribution to the total reduction values from the separate interventions is greater than 100% due to the aforementioned consideration.

Figure 9: Estimated percent contribution of moderate scale-up interventions in reducing new HIV infections and AIDS-related deaths in Swaziland by 2030



The highest-impact interventions are ART, VMMC, and CCT

- Moderate scale-up of ART for people living with HIV, VMMC in males aged 10–49 years, and CCT for girls and young women aged 15–24 years showed the greatest impact in reducing new HIV infections and AIDS-related deaths by 2030. **VMMC** alone accounted for almost half (49%) of new HIV infections averted by 2030; **CCT** alone for 36%. **ART** alone accounted for over half (57%) of AIDS-related deaths averted by 2030 and (Table 25 and Figure 9).

6 Costing

Table 26: Projected program costs of moderate scale-up interventions, number of new infections and deaths averted, and the resulting incremental cost-effectiveness ratios by 2030, Swaziland

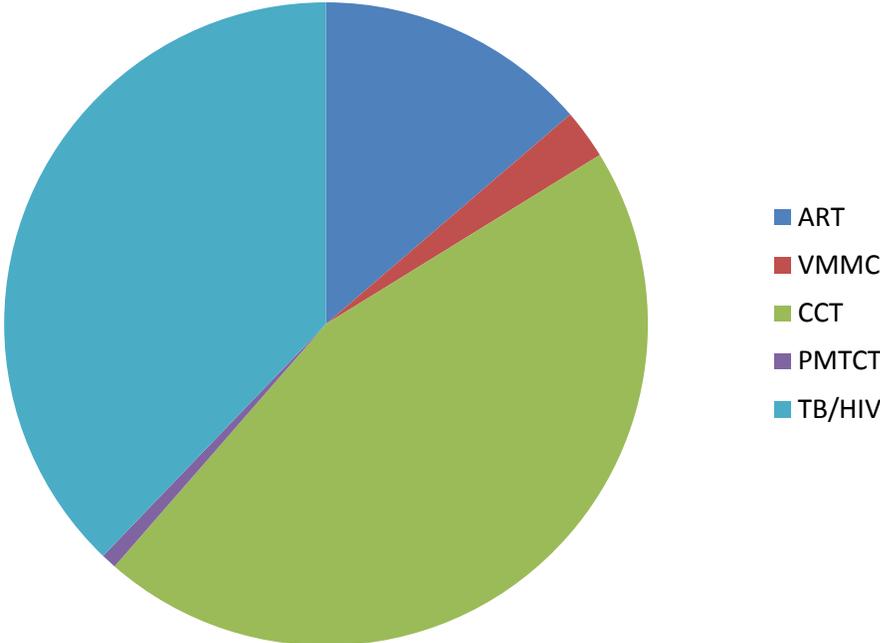
Moderate scale-up interventions	Unit costs (USD, per person per year)	Discounted cost of program	Number of infections averted	Incremental cost-effectiveness ratio for infections	Number of AIDS-related deaths averted	Incremental cost-effectiveness ratio for deaths
by 2030						
All interventions	NA	\$74,205,074	27,355	\$2,713	7,413	\$10,010
ART	\$131.70	\$13,654,653	7,452	\$1,832	4,254	\$3,210
VMMC	\$130.00 (per male 10–49 per year)	\$2,475,488	13,291	\$186	1,334	\$1,856
CCT	\$76.56 ^(a) (per female 15–24 per year)	\$45,031,793	9,895	\$4,551	1,033	\$43,608
PMTCT	\$186.00 (per pregnant woman)	\$767,735	1,164	\$659	221	\$3,480
TB/HIV	\$247.00 ^(b)	\$37,669,429	NA	NA	1,220	\$30,883

NA = Not applicable as there were no new HIV infections averted

^(a) It was assumed that only 29% of the costs for the conditional cash transfer program would be allocated to the HIV program as there are multiple benefits to this intervention (see Remme AIDS 2014, Table 3); therefore, the HIV program would not be expected to fund the full cost of the program at \$264 per girl or young woman aged 15–24 years per year.

^(b) It was assumed that the cost of the TB/HIV program would increase proportionally to the increased TB/HIV coverage over time to meet targets. As well, since it was reported that, “The prevalence of HIV among TB patients is 79.6%, therefore 79.6% of total expenditure on TB was captured as TB/HIV treatment expenditure.”[12], it follows that only 80% of the TB/HIV spending was allocated to the HIV program.

Figure 10: Estimated proportion of cost contribution from moderate scale-up interventions in Swaziland by 2030



All interventions

- The estimated cost of moderate scale-up of all interventions combined by 2030 is **\$74.2 million** (Tables 1 and 26). This would result in an estimated 27,400 (27%) fewer new HIV infections and 7,400 (12%) fewer AIDS-related deaths.

ART

- Moderate scale-up of ART alone would result in an estimated additional 125,000 people living with HIV being put on ART by 2030, with an associated cost of **\$13.7 million** (Table 2). This would result in an estimated 7,500 (8%) fewer new infections with a cost of **\$1,800 per infection averted** and 4,300 (7%) fewer AIDS-related deaths, representing 57% of the total reduction in deaths, at **\$3,200 per death averted** (Tables 3 and 25; Figures 2 and 9).

VMMC

- Moderate scale-up of VMMC alone in males aged 10–49 years would result in 20,700 more VMMCs by 2030 (Table 6). This would result in 13,300 (13%) fewer new HIV infections (Table 7). The total estimated cost of moderate scale-up of the VMMC program by 2030 is **\$2.5 million**.
- This intervention has the best incremental cost-effectiveness ratios per new infection (**\$186**) and death averted (**\$1,856**) (Table 26).

CCT

- Moderate implementation of the CCT program with coverage of 60% among girls and young women aged 15–24 years in Swaziland would cost an estimated **\$4,600** per new infection averted (Tables 13 and 26). This is below the estimated range for a similar study conducted in Malawi; there the estimated cost per infection averted ranged from USD \$5,000 to 12,500 [4].
- The moderate CCT intervention would result in an estimated 9,900 (10%) fewer new infections in the total population by 2030, representing **36%** of the total reduction of new infections predicted (Tables 13 and 25). As well, **5,100 (23%)** new infections would be averted in girls and young women aged 15–24 years alone (Table 14).
- The HIV program willingness to pay for CCT program costs was assumed to be 29%. To conditionally transfer \$20 each month to 750,000 girls and young women aged 15–24 years in Swaziland, representing 60% coverage shown for the moderate implementation scenario from 2015 to 2030, is estimated to cost **\$45 million** (Table 12). This represents almost half of all estimated intervention costs (Figure 10). The total CCT program cost with 60% coverage is estimated at **\$155 million**, for which 71% of program cost would be covered by budget(s) external to the HIV program.

PMTCT

- With current coverage of PMTCT already high at 84% with less than 2% transmission to infants born to HIV-positive mothers, reaching the moderate 90% coverage target by 2018, maintained until 2030, suggests that scale-up efforts should be attainable, with costs for this program estimate at **\$770,000** by 2030 (Table 18). This is a relatively low program cost, representing only 1% of the total scale-up intervention costs (Figure 10).
- The estimated 1,200 (1%) new infections averted by 2030 from moderate PMTCT scale-up have a cost-effectiveness ratio of **\$700** (Tables 19 and 26; Figure 7).

TB/HIV

- While moderate scale-up of the TB/HIV program resulted in an estimated cost per AIDS-related death averted by 2030 that was higher than the other interventions at **\$31,000**, moderate intensification of the TB/HIV program has the added benefit of diagnosing and treating additional people co-infected with TB (Tables 22, 23, and 26). The total program cost by 2030 is estimated at **\$38 million** (Table 23). This represents a large proportion of the overall intervention cost (Figure 10); however, it also accounts for **16%** of all AIDS-related deaths averted by 2030 (Table 25).
- Assuming that all TB/HIV cases in the model were new smear positive cases and that 48% of new smear positive cases treated for TB would be cured [7], it was estimated that an additional **3,800** people would be cured of TB by 2030 as a result of moderate scale-up of the TB/HIV intervention (Table 22).

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