A Mathematical Model for the Effects of Preventive Education on HIV/AIDS Prevalence in South Korea

21500040 Kwon Hoe-Jun

TABLE OF CONTENTS

01

Introduction

1. HIV Domestic and Foreign Status
2. Difficulty in predicting HIV
3. Characteristics of the HIV/AIDS model currently in use.
4. Domestic Situation on HIV/AIDS Prevention and Treatment
5. The Importance of HIV/AIDS Prevention Education

HIV Domestic and Foreign Status

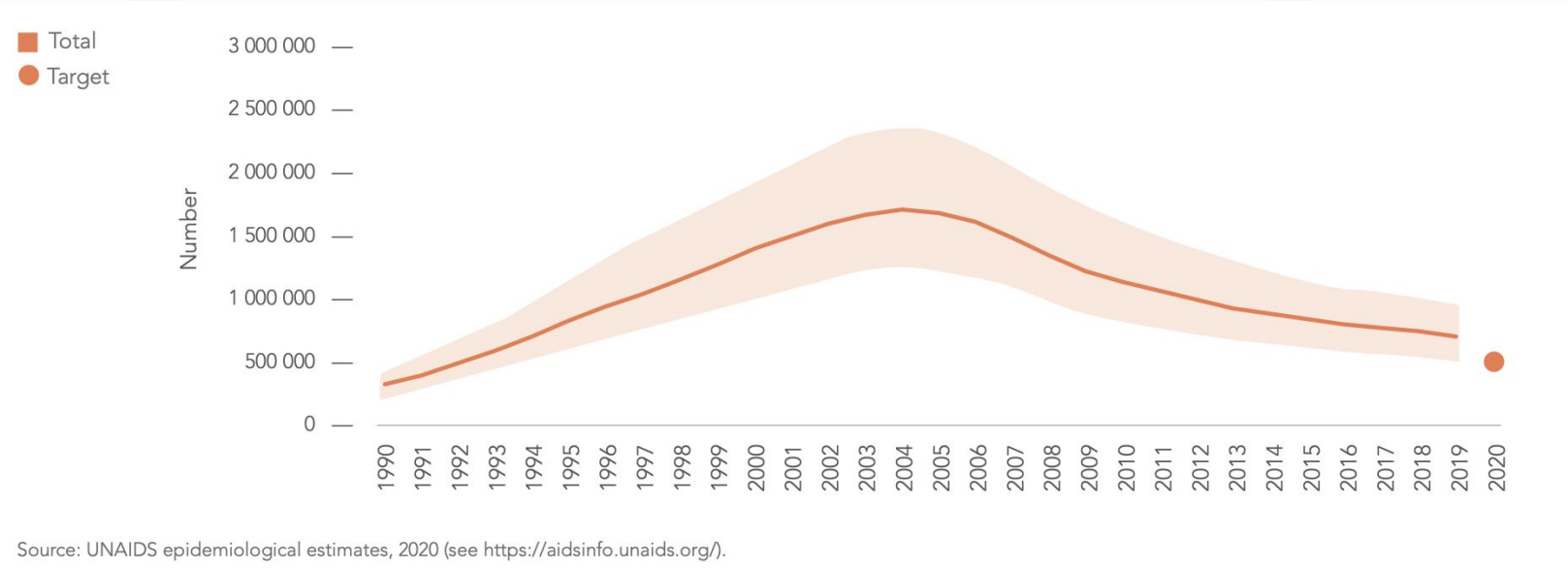


Fig1. Global infected HIV/AIDS Population

HIV Domestic and Foreign Status

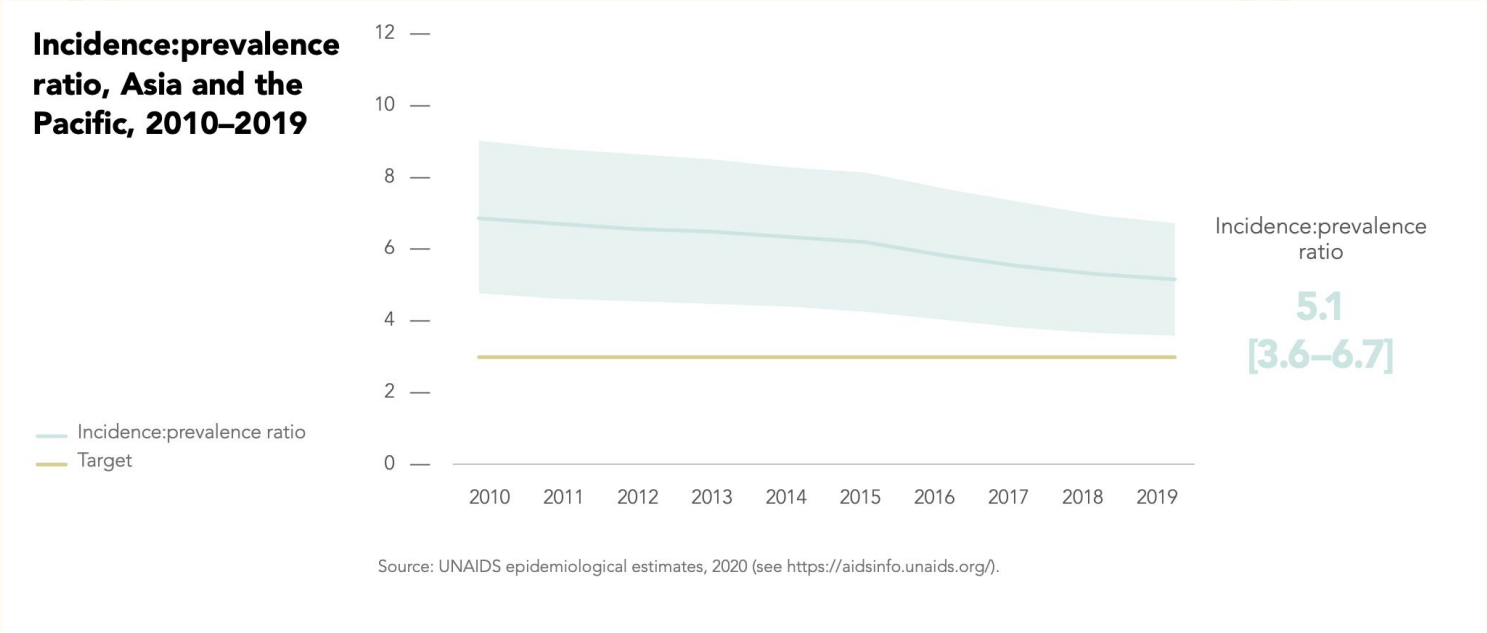


Fig2. Asia & Pacific infected HIV/AIDS Population

HIV Domestic and Foreign Status

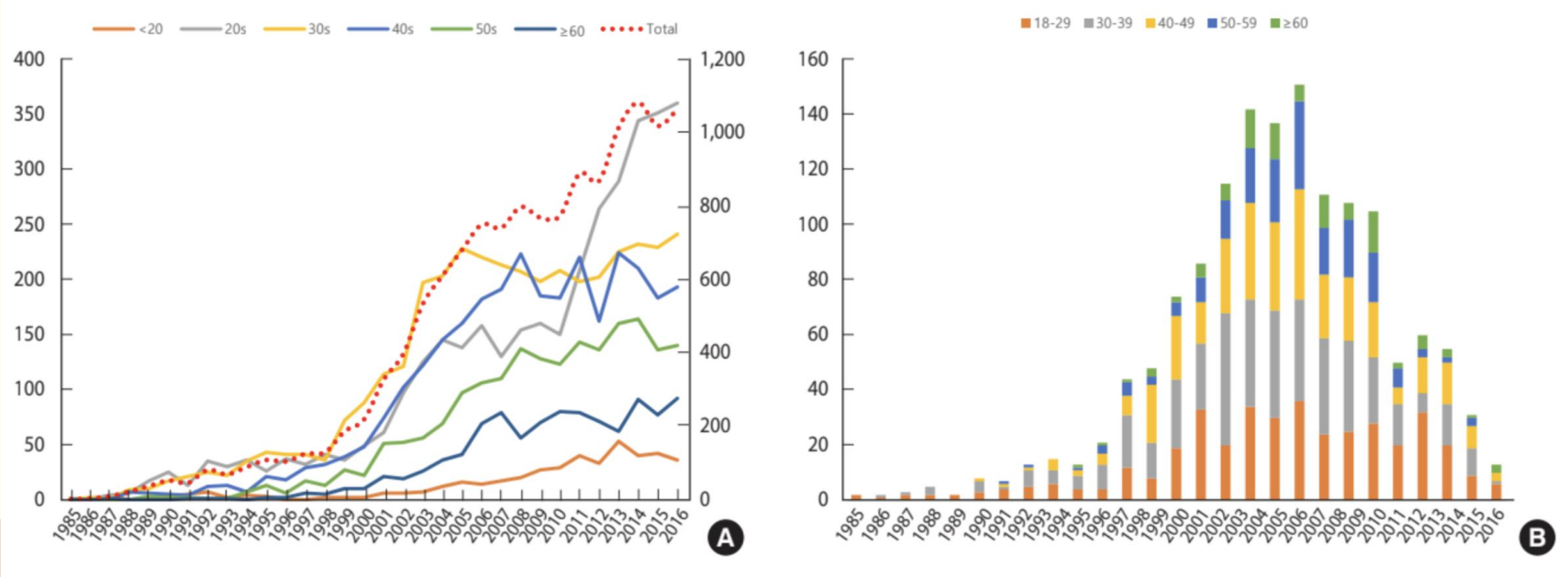


Fig3. Annual HIV/AIDS Report in South Korea

Difficulty in predicting HIV

01

Long Incubation Period

02

Sexual Transmitted Disease

03

Unstable Epidemiological Survey

Long Incubation Period

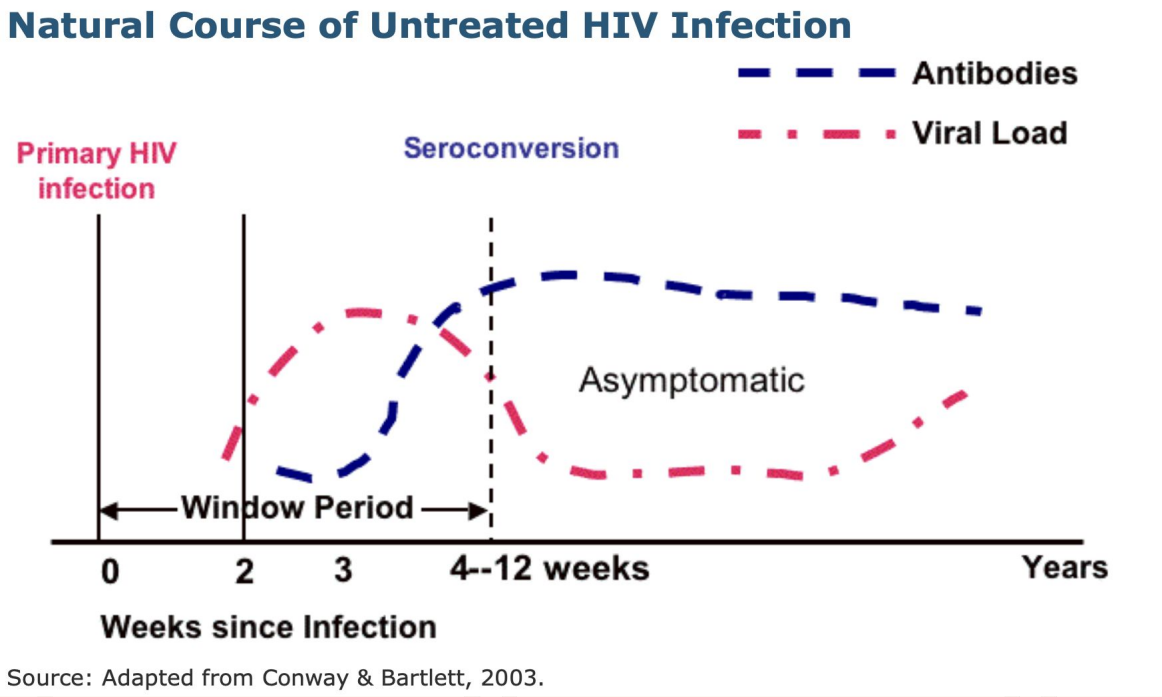


Fig4. HIV Incubation Period

Sexual Transmitted Disease

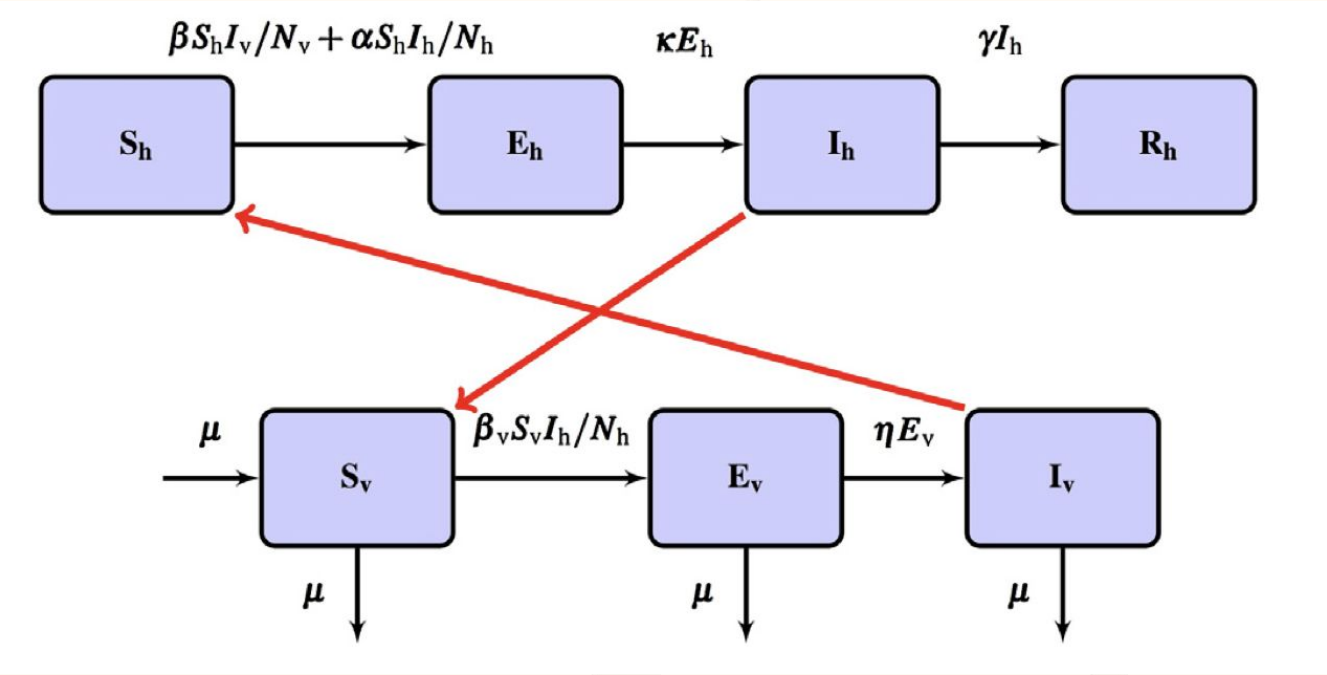


Fig5. Gender dependant mathematical model

Unstable Epidemiological Survey

[표 5] 연도별 HIV/AIDS 내국인 감염경로* 분포, 1985-2019 (남자)

-계속-
(단위 : 명)

연도	계	성 접촉			남자 수직 감염	마약주사 공동사용	수혈/혈액제제‡	무응답
		소계	이성	동성†				
1985	1	1	1	0	0	0	0	0
1986	0	0	0	0	0	0	0	0
1987	4	1	1	0	0	0	3	0
1988	17	15	13	2	0	0	2	0
1989	35	33	26	7	0	0	2	0
1990	48	47	43	4	0	0	1	0
1991	42	32	26	6	0	0	9	1
1992	77	62	34	28	0	1	10	4
1993	62	56	43	13	0	0	5	1
1994	78	72	50	22	0	0	3	3
1995	89	84	63	21	1	0	1	3
1996	93	80	59	21	0	0	0	13
1997	107	97	56	41	0	0	0	10
1998	111	92	58	34	0	0	0	19
1999	160	135	84	51	0	0	0	25
2000	194	168	108	60	0	1	0	25
2001	292	248	153	95	0	0	0	44
2002	363	321	174	147	1	0	0	41
2003	502	443	211	232	0	0	4	55
2004	557	491	235	256	0	0	0	66
2005	640	574	293	281	0	0	0	66
2006	687	606	322	284	0	0	0	81
2007	698	595	375	220	0	0	0	103
2008	743	549	305	244	0	1	0	193
2009	710	528	305	223	0	0	0	182
2010	723	538	315	223	1	1	0	183
2011	827	602	312	290	0	0	0	225
2012	808	504	284	220	1	0	0	303
2013	946	561	319	242	0	0	0	385
2014	1,016	619	335	284	0	0	0	397
2015	974	624	336	288	0	0	0	350
2016	1,000	680	355	325	0	0	0	320
2017	958	714	356	358	0	1	0	243
2018	945	766	392	374	0	0	0	179
2019	952	777	335	442	0	2	0	173

* 본인 응답에 의한 자료임
† 동성 및 양성과 성 접촉 모두 포함함
‡ 혈액제제에 의한 감염은 1995년, 수혈로 인한 감염은 2006년 이후 보고 사례 없음

[표 5] 연도별 HIV/AIDS 내국인 감염경로* 분포, 1985-2019 (여자)

-계속-
(단위 : 명)

연도	계	성 접촉			여자 수직 감염	마약주사 공동사용	수혈/혈액제제‡	무응답
		소계	이성	동성†				
1985	0	0	0	0	0	0	0	0
1986	3	3	3	0	0	0	0	0
1987	5	5	5	0	0	0	0	0
1988	5	5	5	0	0	0	0	0
1989	2	1	1	0	0	0	1	0
1990	4	4	4	0	0	0	0	0
1991	4	3	3	0	0	0	0	1
1992	4	4	4	0	0	0	0	0
1993	7	7	7	0	0	0	0	0
1994	11	11	11	0	0	0	0	0
1995	19	17	17	0	0	0	1	1
1996	11	10	10	0	0	0	0	1
1997	18	17	17	0	0	0	0	1
1998	18	15	15	0	0	0	0	3
1999	26	21	21	0	1	0	0	4
2000	25	22	22	0	0	0	0	3
2001	35	35	35	0	0	0	0	0
2002	34	31	31	0	0	0	2	1
2003	31	27	27	0	2	0	0	2
2004	53	44	44	0	0	0	1	8
2005	40	35	35	0	0	0	1	4
2006	62	53	53	0	1	0	0	8
2007	42	31	31	0	0	0	0	11
2008	54	44	44	0	0	0	0	10
2009	58	34	34	0	0	0	0	24
2010	50	39	39	0	0	0	0	11
2011	61	47	47	0	0	0	0	14
2012	60	37	37	0	0	0	0	23
2013	67	38	38	0	0	0	0	29
2014	65	33	33	0	1	0	0	31
2015	44	28	28	0	0	0	0	16
2016	60	32	32	0	0	0	0	28
2017	50	38	38	0	0	0	0	12
2018	44	33	33	0	0	0	0	11
2019	53	44	44	0	0	0	0	9

* 본인 응답에 의한 자료임
† 동성 및 양성과 성 접촉 모두 포함함
‡ 혈액제제에 의한 감염은 1995년, 수혈로 인한 감염은 2006년 이후 보고 사례 없음

Fig6. Infection Route Survey in South Korea

Characteristics of the HIV/AIDS model in use

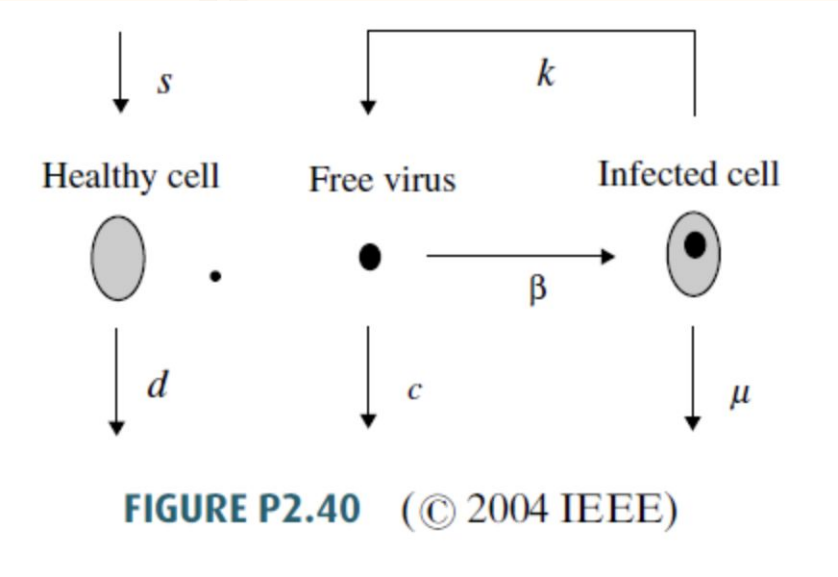


FIGURE P2.40 (© 2004 IEEE)

Fig7. Virus infection model

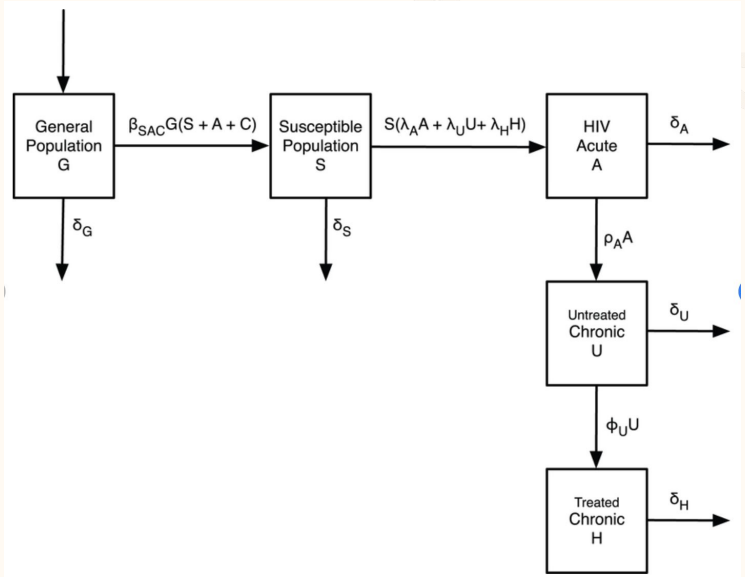


Fig8. Population infection model

Domestic Situation on HIV/AIDS Prevention and Treatment

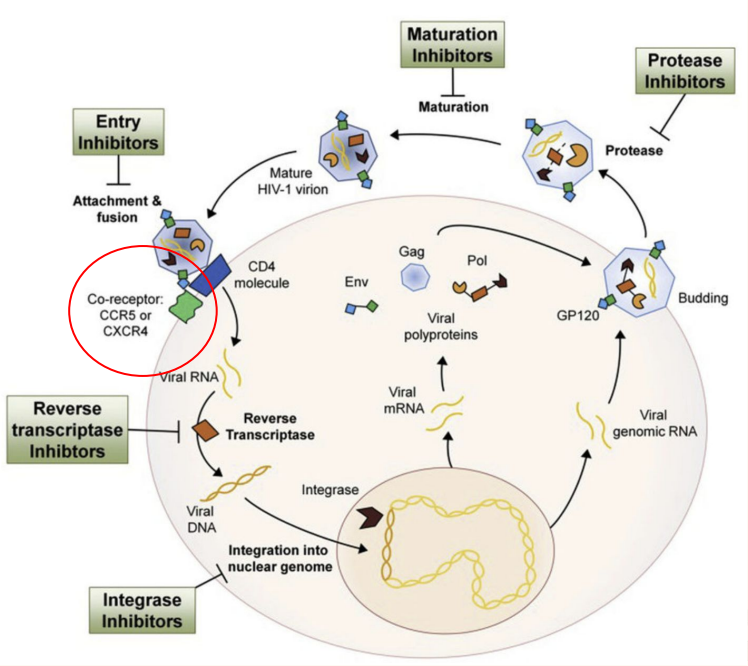


Fig9. Targets for antiretroviral therapy

Fig10. Cocktail Therapy

Domestic Situation on HIV/AIDS Prevention and Treatment

01

Condoms

02

High risk Behavior X

03

PrEP

04

Education

Condoms

Fig11. Condoms in the Nurse's Office

Don’t do High Risk Behavior

Type of Exposure	Risk per 10,000 Exposures
Parenteral	
Blood Transfusion	9,250
Needle-Sharing During Injection Drug Use	63
Percutaneous (Needle-Stick)	23
Sexual	
Receptive Anal Intercourse	138
Insertive Anal Intercourse	11
Receptive Penile-Vaginal Intercourse	8
Insertive Penile-Vaginal Intercourse	4
Receptive Oral Intercourse	Low
Insertive Oral Intercourse	Low

Fig12. Fact sheet for HIV/AIDS transmission risk

PrEP(Pre-exposure prophylxis)

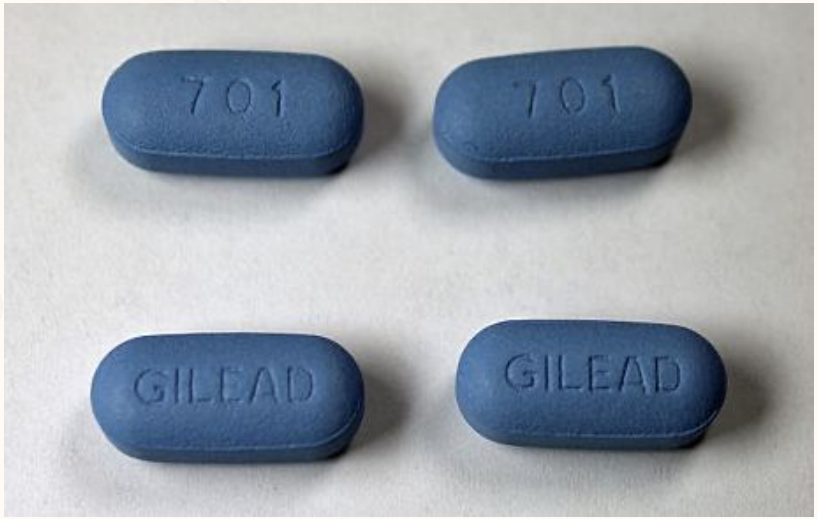


Fig13. tenofovir/emtricitabine

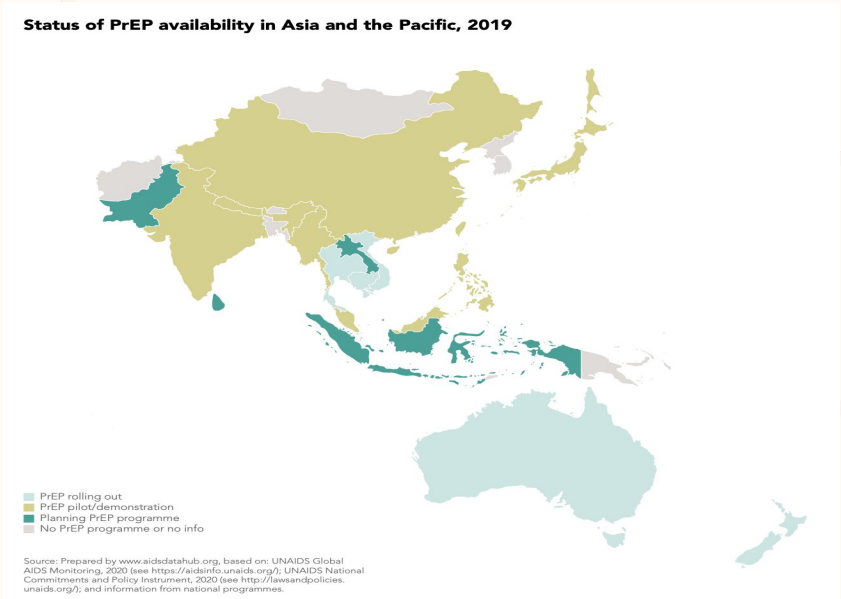


Fig14. PrEP implementation Country

Education

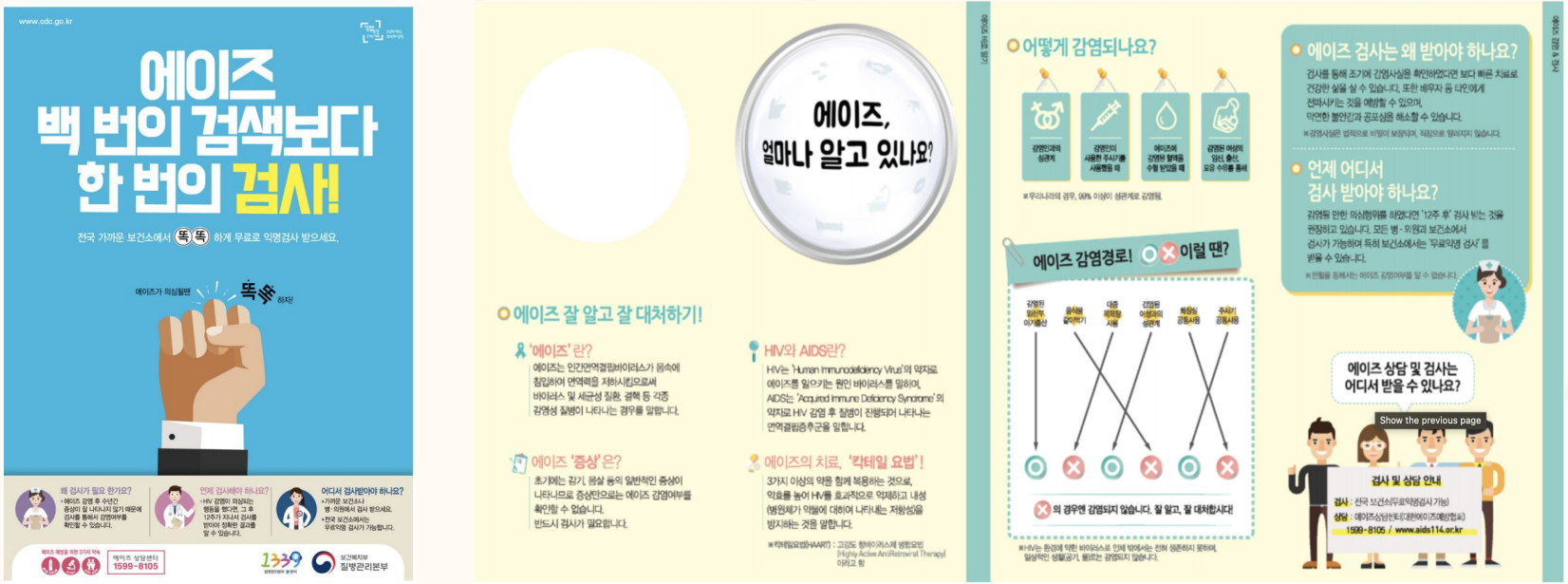


Fig15. HIV/AIDS Campaigns and Educational Materials in Korea

The Importance of HIV/AIDS Prevention Education

Fig5. HIV Education

1. Help learners to not only develop and maintain safer behaviours

2. Reduce stigma and discrimination towards people affected by, and living with, HIV

02

Material & Methods

1. Study Design
2. Interventions Scenarios
3. Data Sources
4. Model and Parameters description

Study Design

- To know the extent to which preventive education influences compared to PrEP, which is the most recommended prevention method in developed country
- Estimate parameters that make up a mathematical model

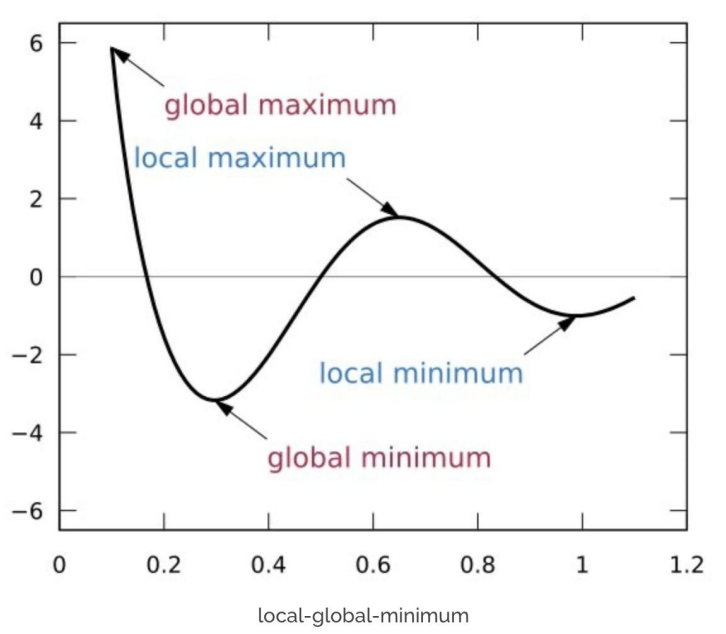


Fig16. Simulated Annealing

Intervention Scenarios

Measures / Case	PrEP	Education
Case1	50%	
Case 2	60%	
Case3	70%	
Case 4	80%	

Data Sources

질병관리청
Korea Disease Control and Prevention Agency

2019 HIV/AIDS Annual Reports

통계청
Statistics Korea

Estimation of future population

건강보험심사평가원
HEALTH INSURANCE REVIEW & ASSESSMENT SERVICE

Allowance of medical care for people infected with HIV/AIDS

DEPARTMENT OF HEALTH & HUMAN SERVICES · USA
CDC

HIV Education Program budget

Model & Parameters Description

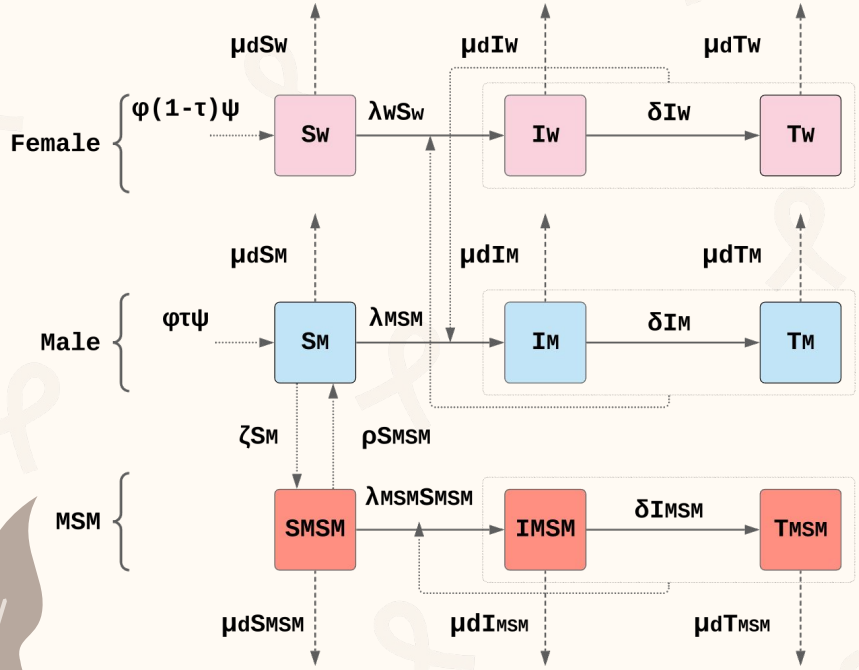


Fig17. Schematic diagram of HIV model

Parameter	Meaning	Value	Reference
π	Total Population	47612748	(39)
τ	Women Proportion in Korea	0.499246%	(39)
$\psi 1$	Annual Men Population Growth	0.13%	(39)
$\psi 2$	Annual Women Population Growth	0.098%	(39)
ζ	Annual Sex-Oriented change rate	0.00804%	(40)
μ_d	Natural Death Rate	0.005825%	(39)
β_1	Insertive Penile-vaginal intercourse	0.7%	(39)
β_2	Receptive penile - vaginal intercourse	1.7%	(41)
β_3	Receptive Anal Intercourse	4.5%	(42)
γ_1	Men Sex Partner Shift	3	(43)
γ_2	Women Sex Partner Shift sex	3	(43)
γ_3	MSM Sex Partner Shift	6	(43)
ω_1	Condom usage Education effectiveness	77%	(32)
ω_2	UAIC prevention Education effectiveness	33%	(26)
ρ	Sexual Identity Education effectiveness	2%	(44)
κ_1	Heterosexual PrEP	62.22%	(17)
κ_2	Homosexual PrEP	44%	(17)
δ_a	annual treatment rate	11%	(41)
θ_1	Men Modifying Factor	0.13	Derived
θ_2	Women Modifying Factor	0.39	Derived
θ_3	MSM Modifying Factor	0.3	Derived

Model & Parameters Description

$$N(t) = N_M(t) + N_W(t) + N_{MSM}(t)$$

$$N_M(t) = S_M + I_M + T_M$$

$$N_W(t) = S_W + I_W + T_W$$

$$N_{MSM}(t) = S_{MSM} + I_{MSM} + T_{MSM}$$

Fig18. Total Population for Time

Model & Parameters Description

$$\lambda_M = \frac{\beta_1 \gamma_1 (1-\omega_1)(1-\kappa_1)(I_W + \theta_1 T_W)}{N_M}$$

$$\lambda_{MSM} = \frac{\beta_3 \gamma_3 (1-\omega_1)(1-\omega_2)(1-\kappa_2)(I_{MSM} + \theta_3 T_{MSM})}{N_{MSM}}$$

$$\lambda_{MSM} = \frac{\beta_3 \gamma_3 (1-\omega_1)(1-\omega_2)(1-\kappa_2)(I_{MSM} + \theta_3 T_{MSM})}{N_{MSM}}$$

Fig19. Transmission rate for sex orientation

Model & Parameters Description

$$\frac{S_M}{dt} = \pi(1-\tau)\psi_1 + \rho S_{MSM} - \lambda_M S_M - (\mu_d + \zeta)S_M$$

$$\frac{S_W}{dt} = \pi(\tau)\psi_2 - \lambda_W S_W - (\mu_d)S_W$$

$$\frac{S_{MSM}}{dt} = \zeta S_M - \lambda_{MSM} S_{MSM} - (\mu_d + \rho)S_{MSM}$$

Fig20. Susceptible Population

Model & Parameters Description

$$\frac{I_M}{dt} = \lambda_M S_M - (\mu_d + \delta_a) I_M$$

$$\frac{I_W}{dt} = \lambda_W S_W - (\mu_d + \delta_a) I_W$$

$$\frac{I_{MSM}}{dt} = \lambda_{MSM} S_{MSM} - (\mu_d + \delta_a) I_{MSM}$$

Fig21. Infected Population

Model & Parameters Description

$$\frac{T_M}{dt} = \delta I_M - (\mu_d) T_M$$

$$\frac{T_W}{dt} = \delta I_W - (\mu_d) T_W$$

$$\frac{T_{MSM}}{dt} = \delta I_{MSM} - (\mu_d) T_{MSM}$$

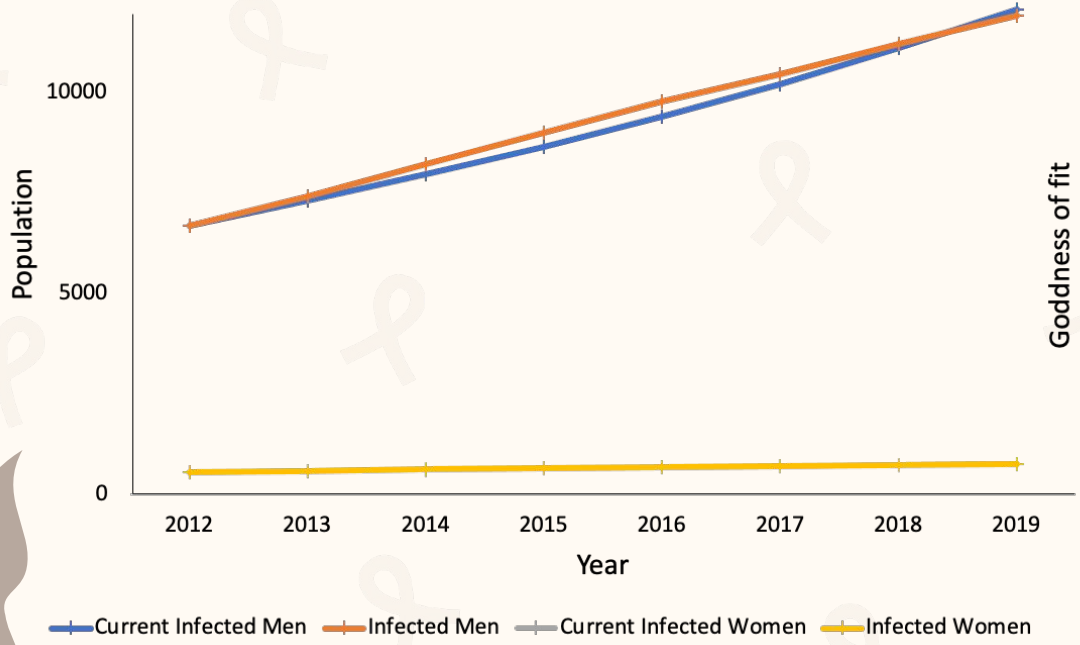
Fig22. Infected but Treatment Population

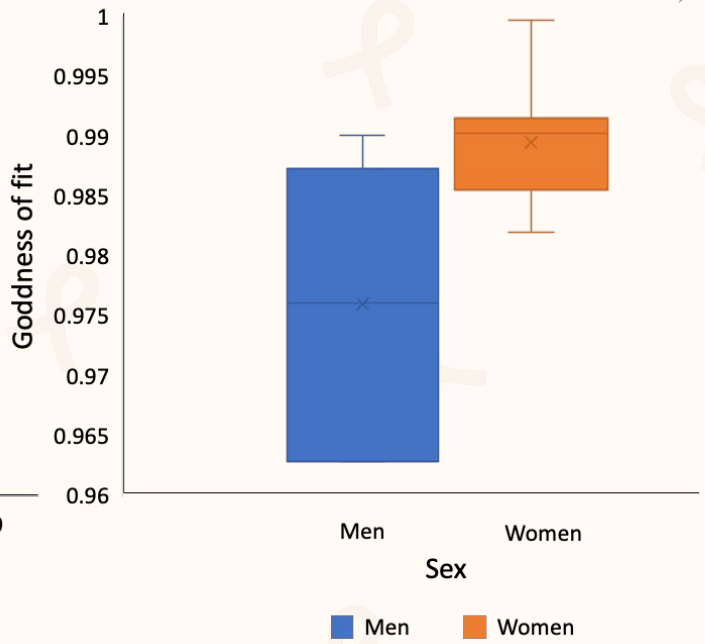
03

Results

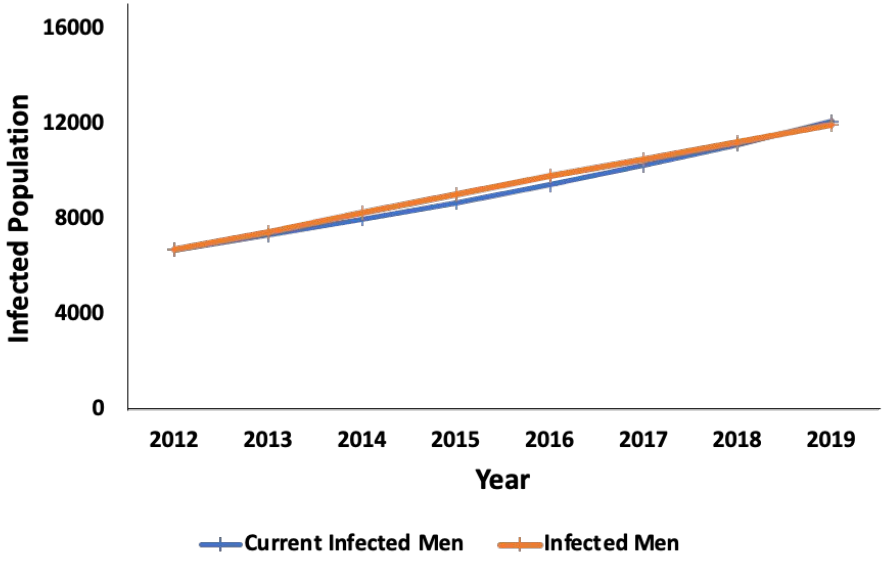
1. Evaluation of model performance.
2. Identify aspects of HIV/AIDS patients without both education and PrEp
3. Identify aspects of HIV/AIDS patients with PrEP.
4. Identify aspects of HIV/AIDS patients with education.
5. Identify aspects of HIV/AIDS patients with both Education and PrEP
6. Economic Impact Analysis

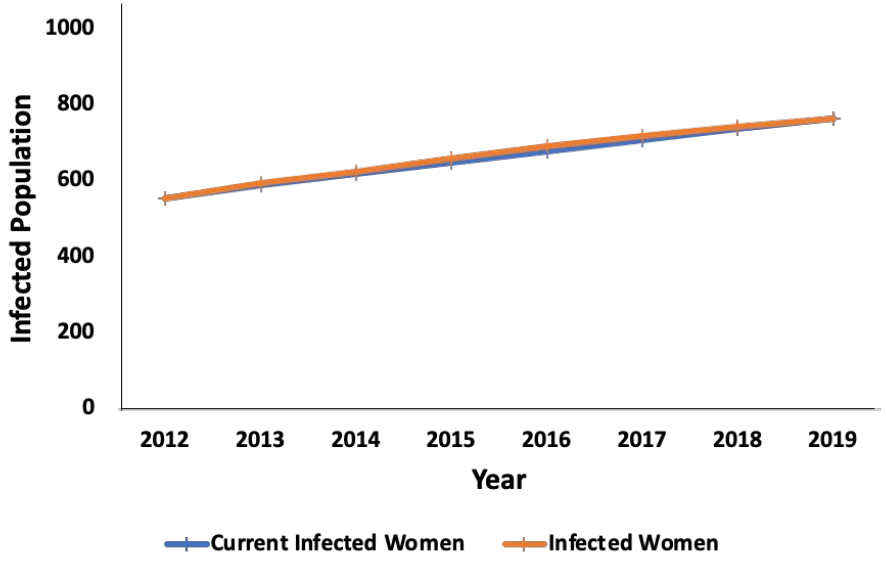
Evaluation of Model Performance



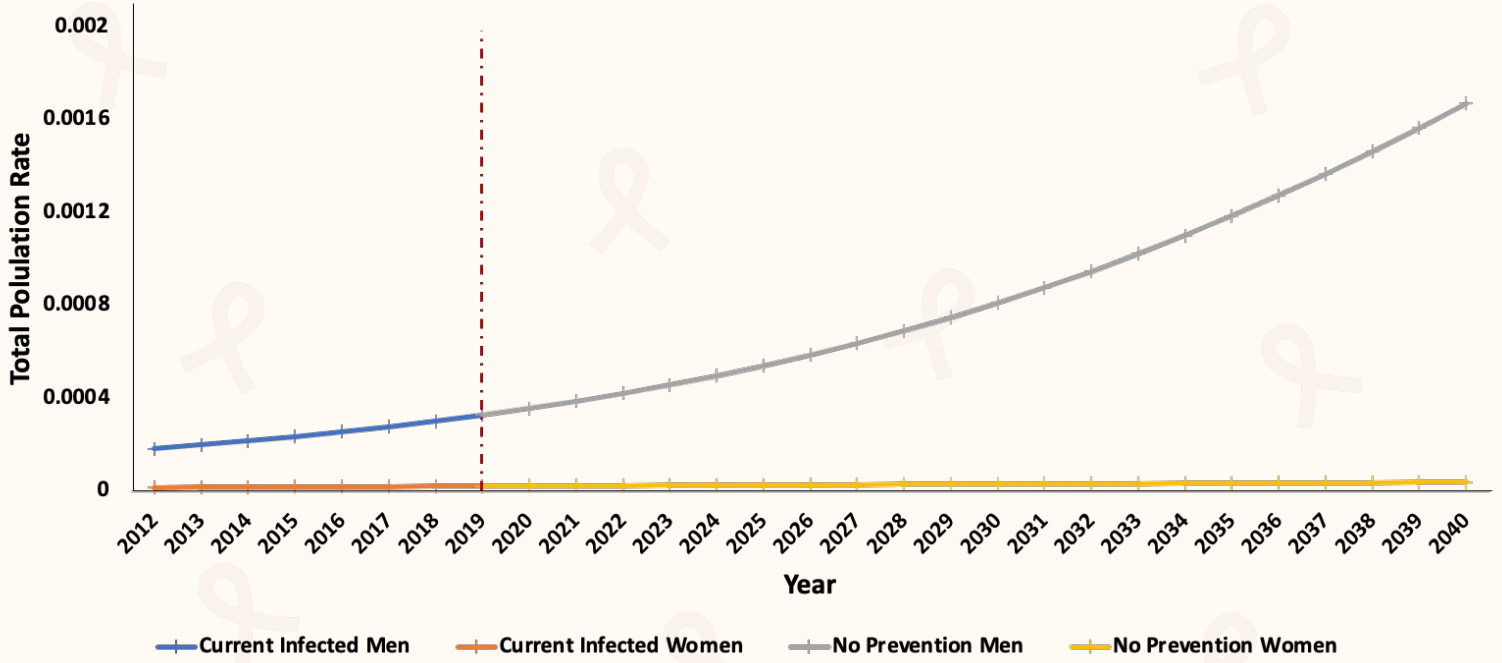


Evaluation of Model Performance

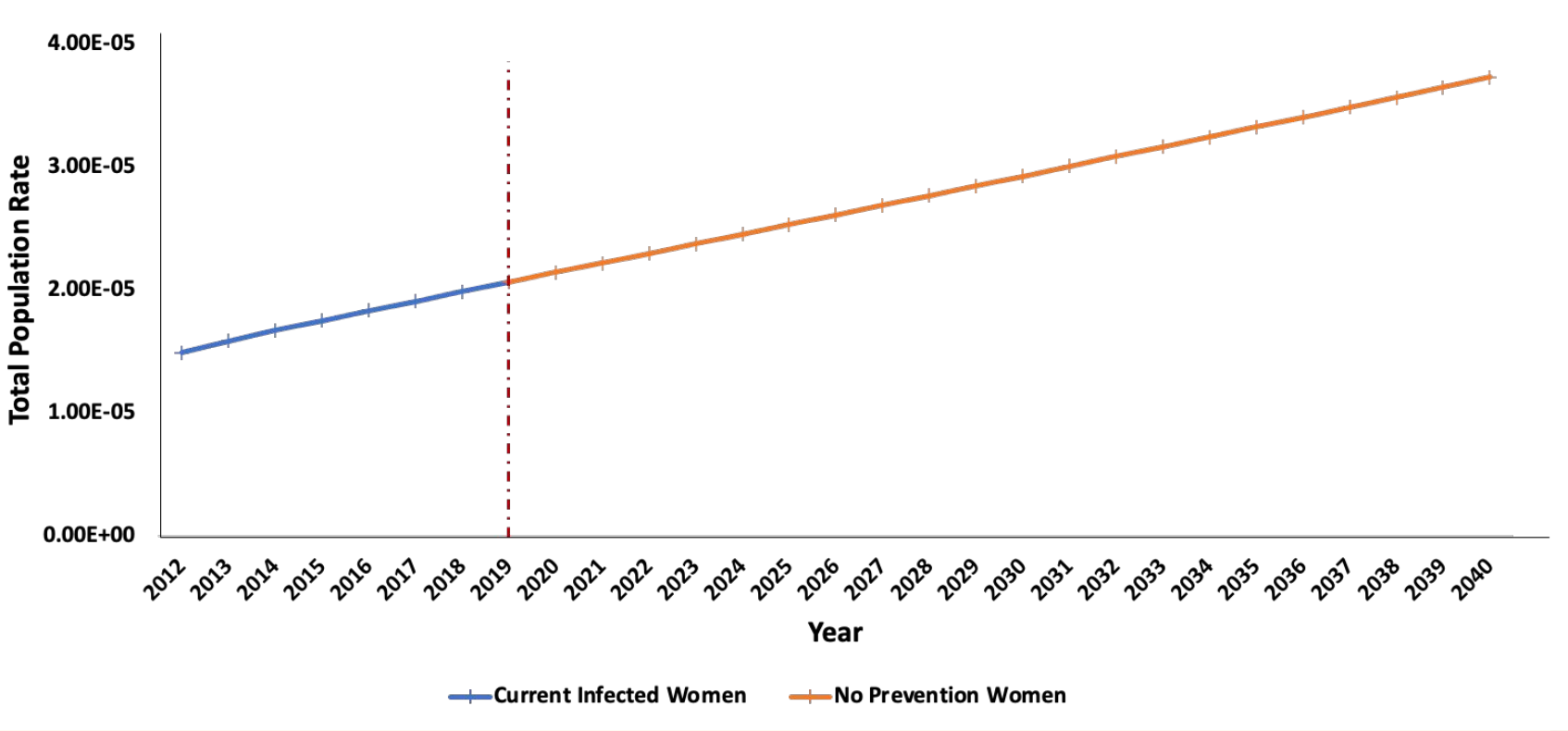




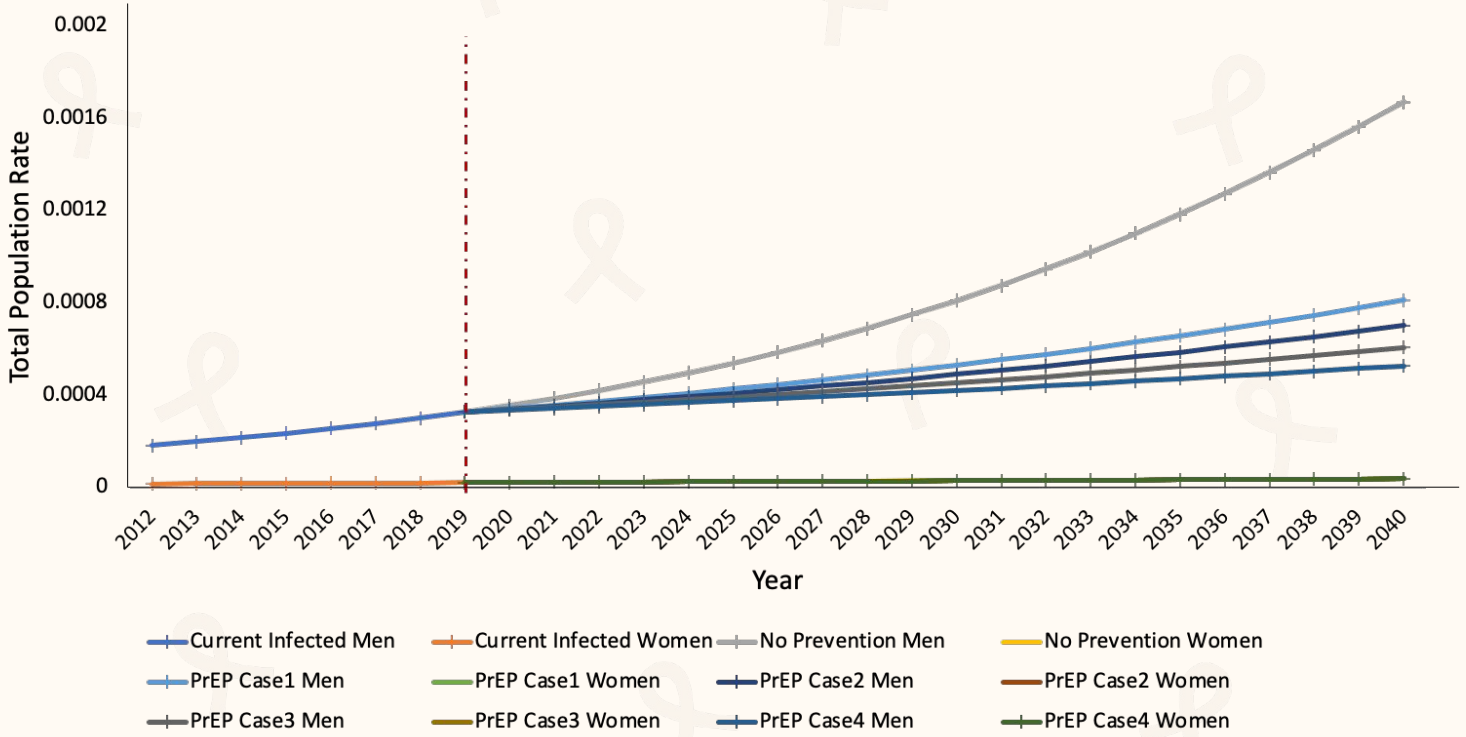
Identify Aspects of HIV/AIDS Patients without both education and PrEP



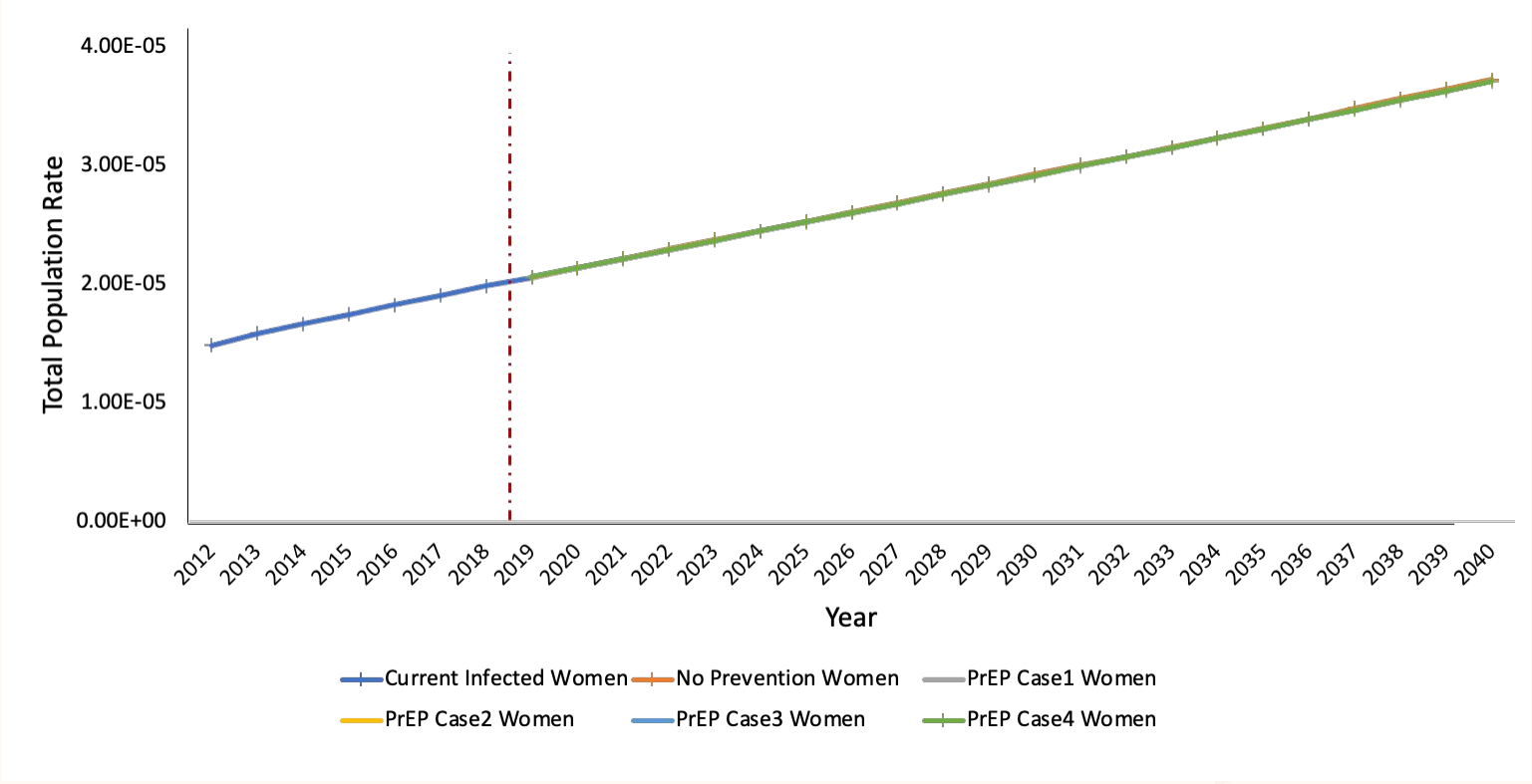
Identify Aspects of HIV/AIDS Patients without both education and PrEP



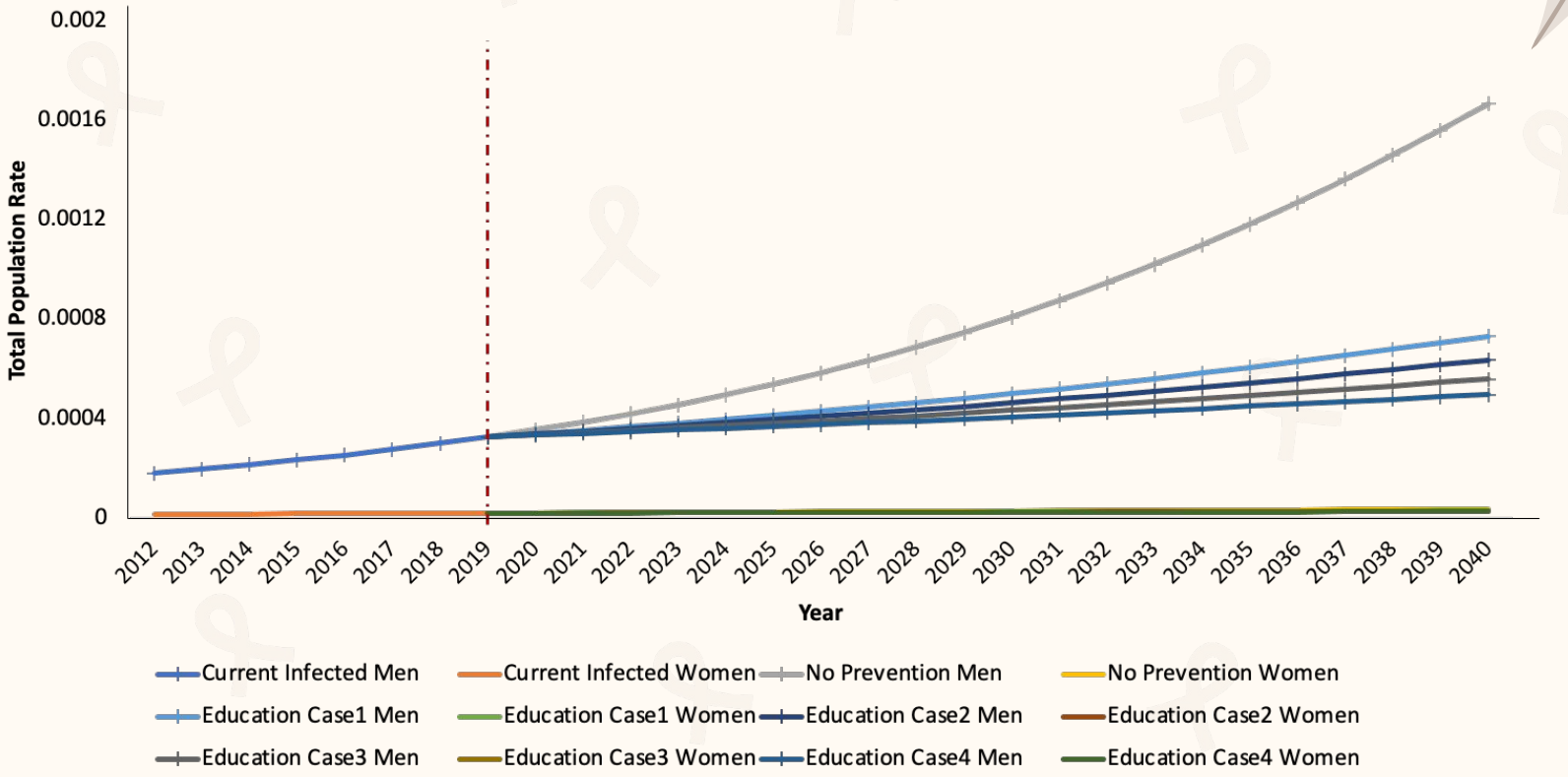
Identify Aspects of HIV/AIDS Patients with PrEP



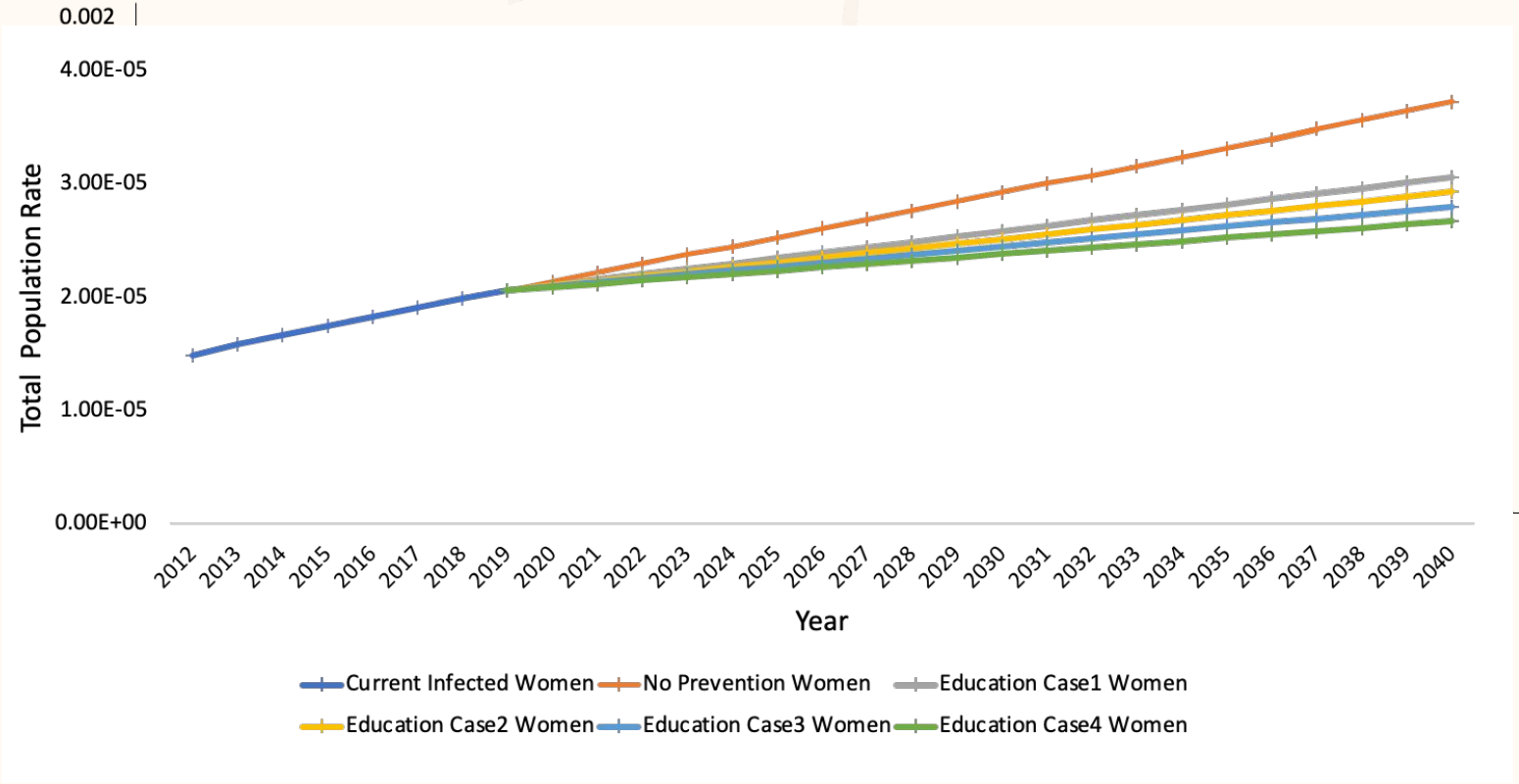
Identify Aspects of HIV/AIDS Patients with PrEP



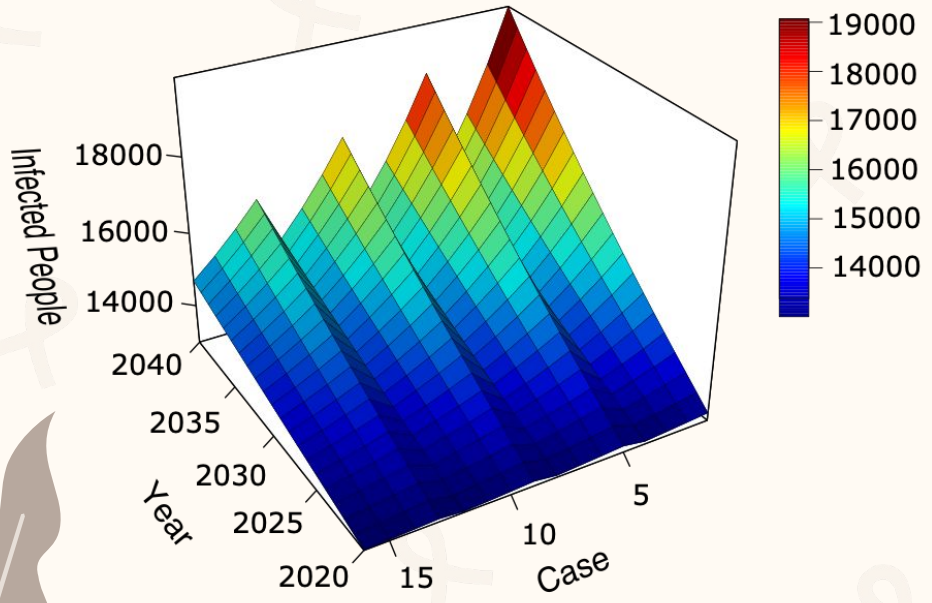
Identify Aspects of HIV/AIDS Patients with Education

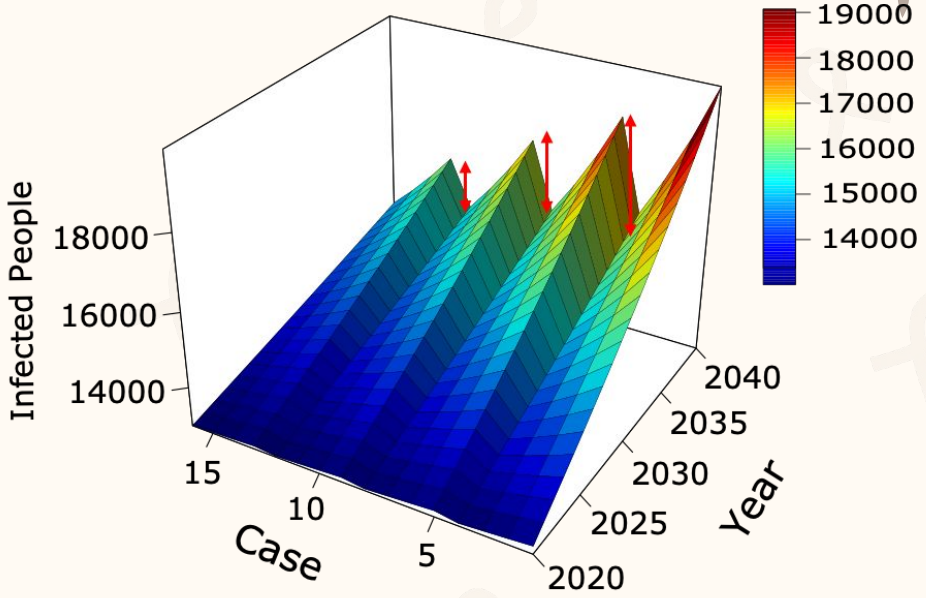


Identify Aspects of HIV/AIDS Patients with Education

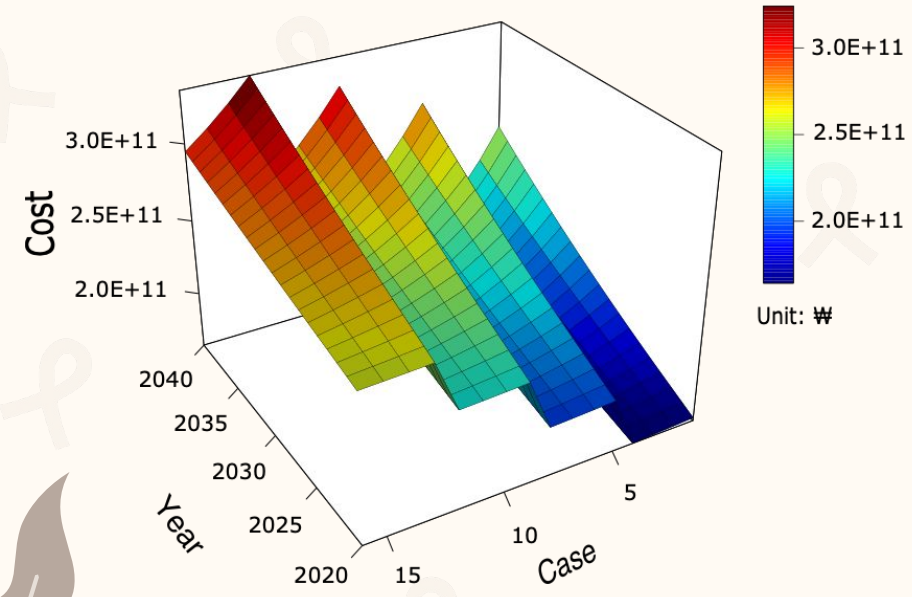


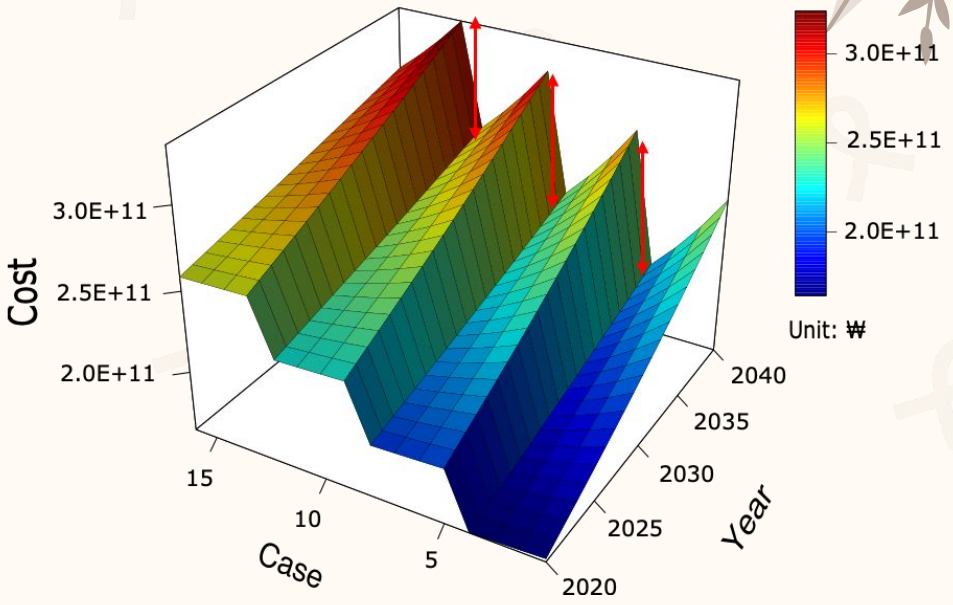
Identify Aspects of HIV/AIDS Patients with both education and PrEP





Economic Impact Analysis





04

Conclusions

Conclusions

- The need for education that has far-reaching preventive effects is highlighted
- When the effectiveness of preventive education increases, an effective reduction in HIV/AIDS prevalence can be expected and cost-effectiveness can also be improved

- Each preventive effect by age was not measured
- Restriction on HIV/AIDS infection routes
- Estimates of results are somewhat biased
- Haven’t verified the validity
- Not everyone may apply equally to the effectiveness of preventive education

THANKS!