

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



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Introduction

1. **HIV Domestic and Foreign Status**
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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

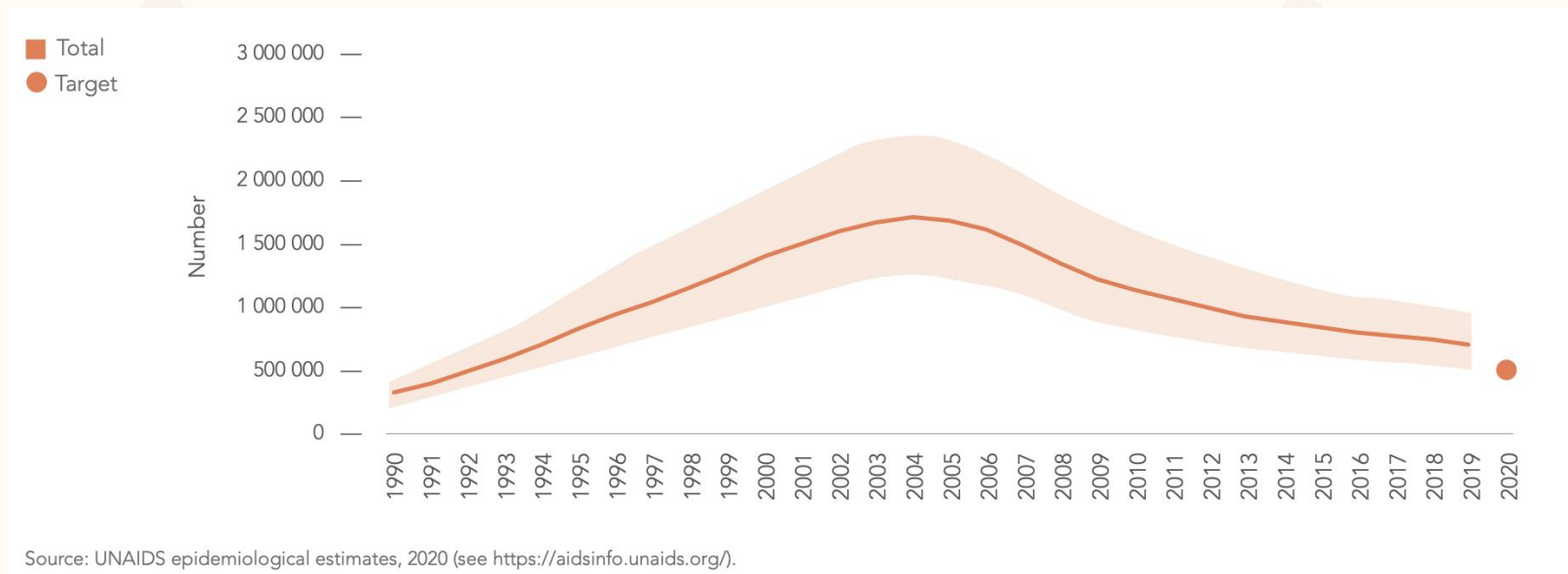
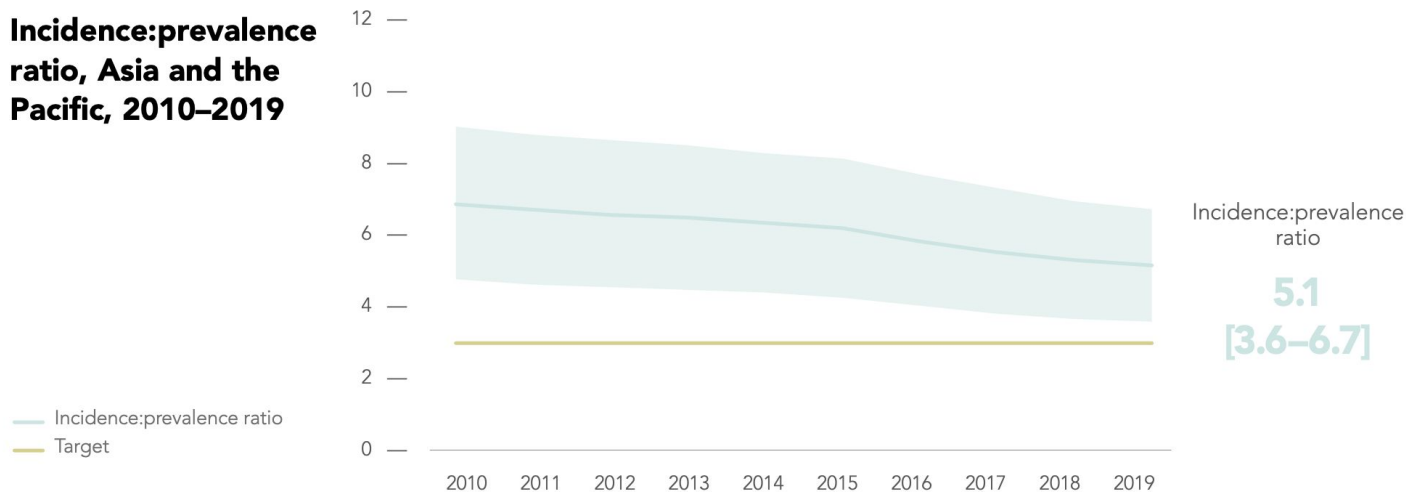


Fig1. Global infected HIV/AIDS Population

HIV Domestic and Foreign Status

**Incidence:prevalence
ratio, Asia and the
Pacific, 2010–2019**



Source: UNAIDS epidemiological estimates, 2020 (see <https://aidsinfo.unaids.org/>).

Fig2. Asia & Pacific infected HIV/AIDS Population

HIV Domestic and Foreign Status

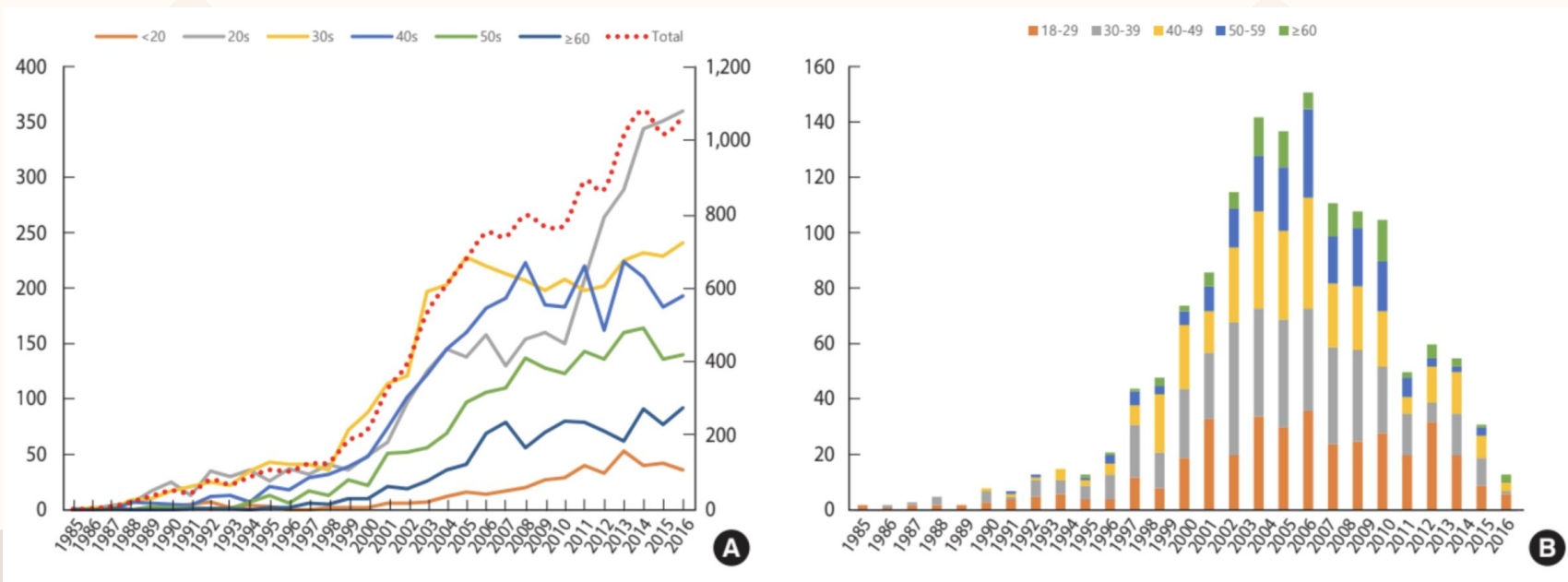


Fig3. Annual HIV/AIDS Report in South Korea



Difficulty in predicting HIV



01


**Long
Incubation
Period**

02

**Sexual
Transmitted
Disease**

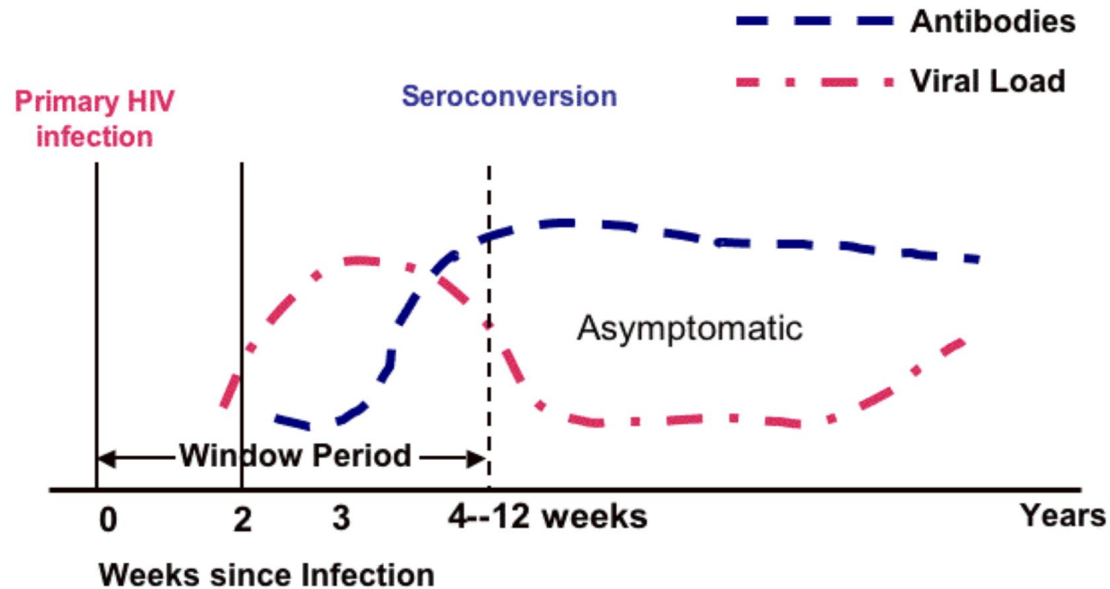
03

**Unstable
Epidemiological
Survey**



Long Incubation Period

Natural Course of Untreated HIV Infection



Source: Adapted from Conway & Bartlett, 2003.

Fig4. HIV Incubation Period

Sexual Transmitted Disease

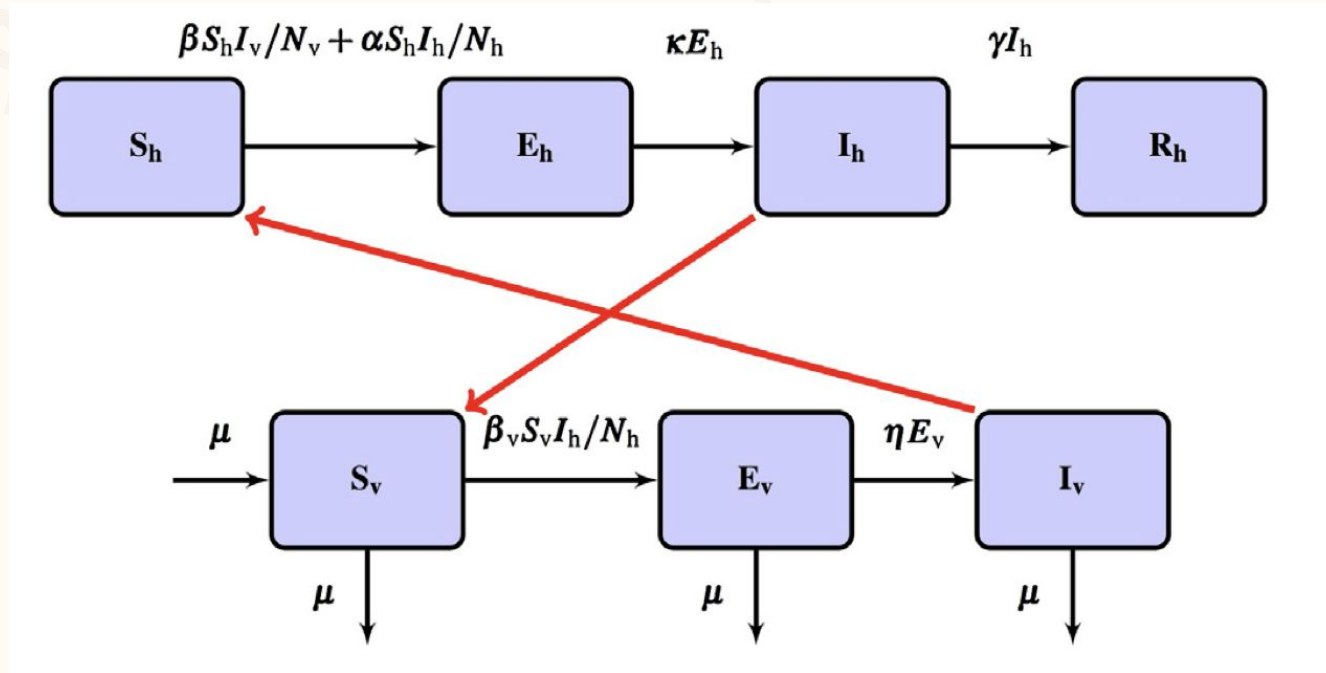


Fig5. Gender dependant mathematical model

Unstable Epidemiological Survey

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

(단위: 명)

연도	계	소계	성 접촉 이성	동성†	남자 수직 감염	마약주사 공동사용	수혈/ 혈액제제‡	무응답
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 양성상 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)

(단위: 명)

연도	계	소계	성 접촉 이성	동성†	여자 수직 감염	마약주사 공동사용	수혈/ 혈액제제‡	무응답
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 양성상 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

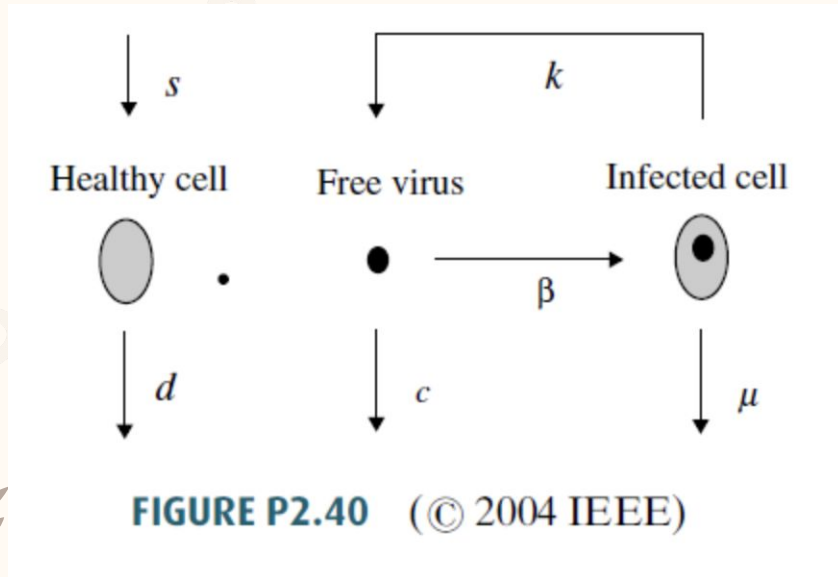


Fig7. Virus infection model

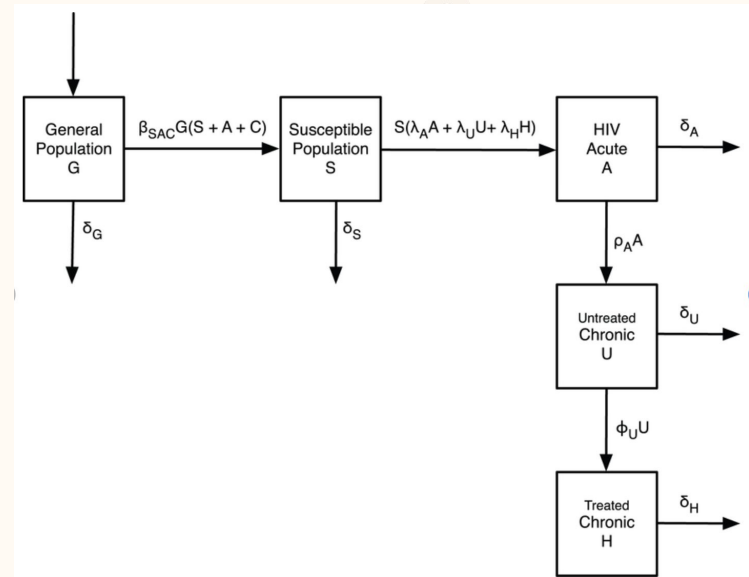


Fig8. Population infection model

Domestic Situation on HIV/AIDS Prevention and Treatment

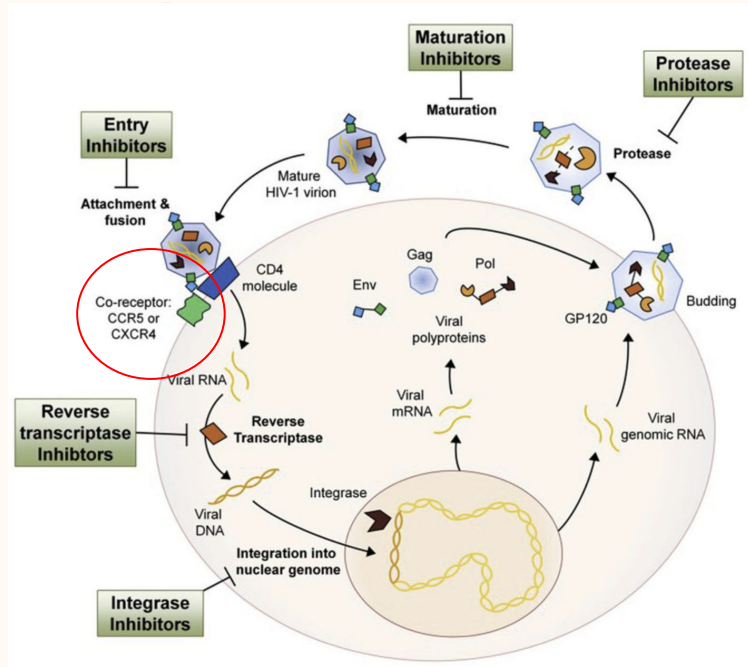


Fig9. Targets for antiretroviral therapy



Fig10. Cocktail Therapy

Domestic Situation on HIV/AIDS Prevention and Treatment

01

Condoms

02

High risk
Behavior X

03

PrEP

04

Education

Condoms



Credit: UNAIDS

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 prophylaxis)



Fig13. tenofovir/emtricitabine

Status of PrEP availability in Asia and the Pacific, 2019

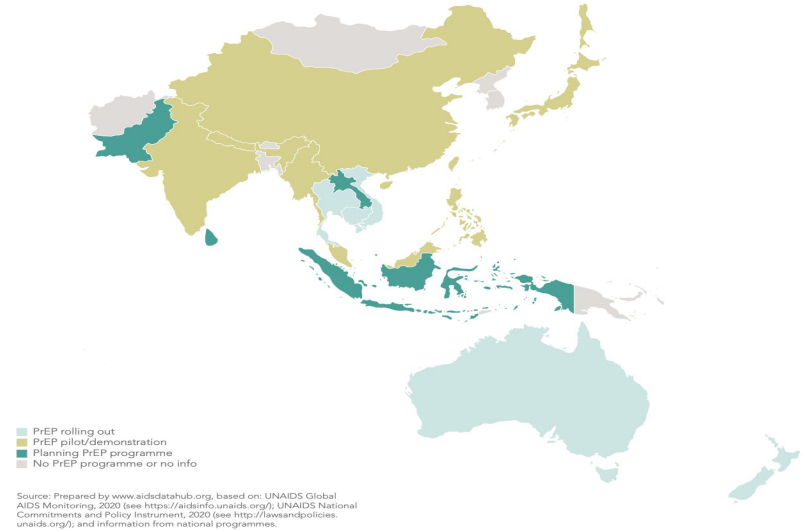


Fig14. PrEP implementation Country

Education

www.cdc.go.kr

에이즈 백 번의 검색보다 한 번의 검사!

전국 가까운 보건소에서 **무료** 하게 무료로 익명검사 받으세요.

에이즈가 의심되면 **꼭** 하자!

왜 검사가 필요 한가요?
- 에이즈 감염 후 사산, 중아 및 뇌사까지 일어 때때로 감지해 줄때, 감염 여부를 확인할 수 있습니다.

언제 검사해야 하나요?
- HIV 감염이 의심되는 행위를 했다면 그 후 2주가 지나서 3개월 안에 정확한 결과를 알 수 있습니다.

어디서 검사해야 하나요?
- 가까운 보건소, 병·의원에서 검사 받으세요. * 전국 보건소에서는 무료검사가 가능합니다.

에이즈 예방 방법 3가지
1. 콘돔 사용 2. 안전한 성관계 3. 정기적인 HIV 검사

에이즈 상담센터
1599-8105

1339 보건복지부
보건복지부 질병관리본부

에이즈, 얼마나 알고 있나요?

○에이즈 잘 알고 잘 대처하기!

‘에이즈’란?
에이즈는 인간면역결핍바이러스가 몸속에 잠입하여 면역력을 저하시킴으로써 바이러스 및 세균성 질환, 결핵 등 각종 감염성 질병이 나타나는 경우를 말합니다.

에이즈 ‘증상’은?
초기에는 감기, 발열 등의 일반적인 증상이 나타나므로 증상만으로는 에이즈 감염 여부를 확인할 수 없습니다.
반드시 검사가 필요합니다.

HIV와 AIDS란?
HIV는 ‘Human Immunodeficiency Virus’의 약자로 에이즈를 일으키는 원인 바이러스를 말하며, AIDS는 ‘Acquired Immune Deficiency Syndrome’의 약자로 HIV 감염 후 질병이 진행되어 나타나는 면역결핍증후군을 말합니다.

에이즈의 치료, ‘락테일 요법’!
3가지 이상의 약을 함께 복용하는 것으로, 약효를 높여 HIV를 효과적으로 억제하고 내성(항원제거)억제가 대역이 나타나는 저항성을 방지하는 것을 말합니다.

* 락테일요법(LART) : 고전도 항바이러스제 병행요법 (High Active Antiretroviral Therapy) 이라고 함

○어떻게 감염되나요?

감염된 피의 교환, 감염된 주사기 사용, 감염된 혈액, 감염된 모유, 감염된 타액, 감염된 눈물, 감염된 땀, 감염된 침, 감염된 타액, 감염된 눈물, 감염된 땀, 감염된 침

* 우리 나라의 경우, 90% 이상이 성관계로 감염됨.

○에이즈 검사는 왜 받아야 하나요?

검사를 통해 초기에 감염 사실을 확인하였다면 보다 빠른 치료로 건강한 삶을 살 수 있습니다. 또한 배우자 등 다인에게 전파하는 것을 예방할 수 있으며, 안전한 불임진과 공포심을 해소할 수 있습니다.

* 감염자로는 법적으로 비밀이 보장되며, 직장으로 통지하지 않습니다.

○언제 어디서 검사 받아야 하나요?

간단하고 안전한 익명검사를 하려면 ‘2주 후’ 검사 받는 것을 권장하고 있습니다. 모든 병·의원 및 보건소에서 검사가 가능하며 특히 보건소에서는 ‘무료·익명 검사’를 받을 수 있습니다.

* 헌혈을 할 때는 에이즈, 감염 여부를 알 수 없습니다.

에이즈 상담 및 검사는 어디서 받을 수 있나요?

Show the previous page

검사 및 상담 안내
검사: 전국 보건소/지역별검사기관
상담: 에이즈상담전화(국립중앙의료원) 1599-8105 / www.aids114.or.kr

* HIV는 한번에 약 100만 개로 인해 감염되는 전의 위험하지 않으며, 일상에서 생활하기, 통치는 가능합니다.

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

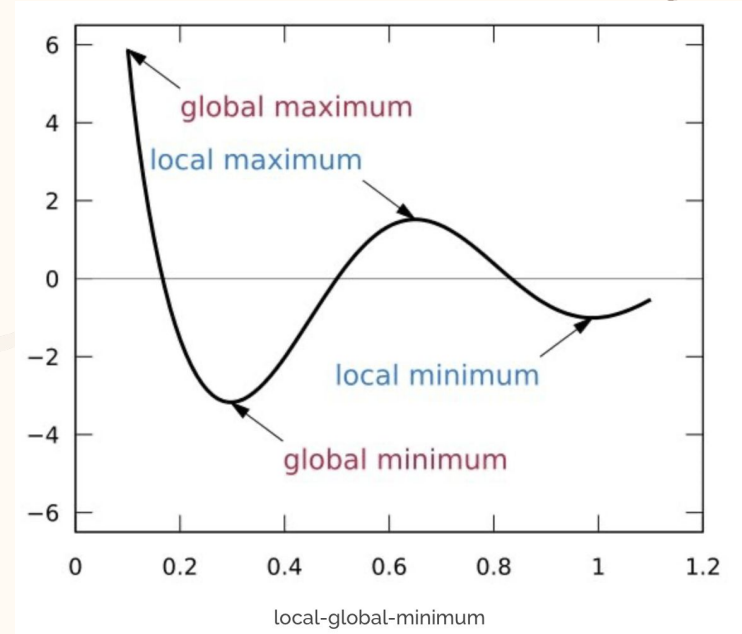


Fig16. Simulated Annealing

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



HIV Education Program budget

Model & Parameters Description

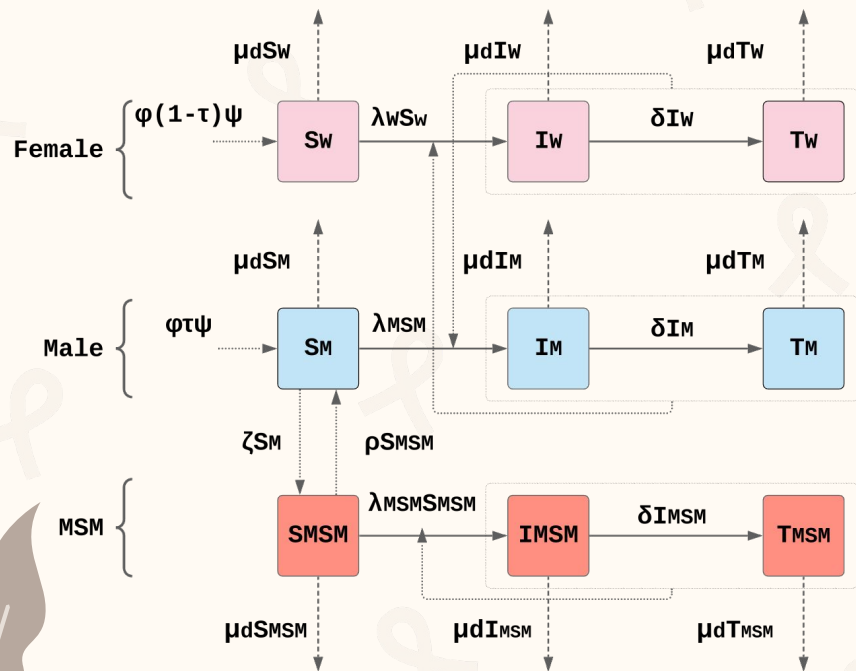


Fig17. Schematic diagram of HIV model

Parameter	Meaning	Value	Reference
π	Total Population	47612748	(39)
τ	Women Proportion in Korea	0.499246%	(39)
ψ_1	Annual Men Population Growth	0.13%	(39)
ψ_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

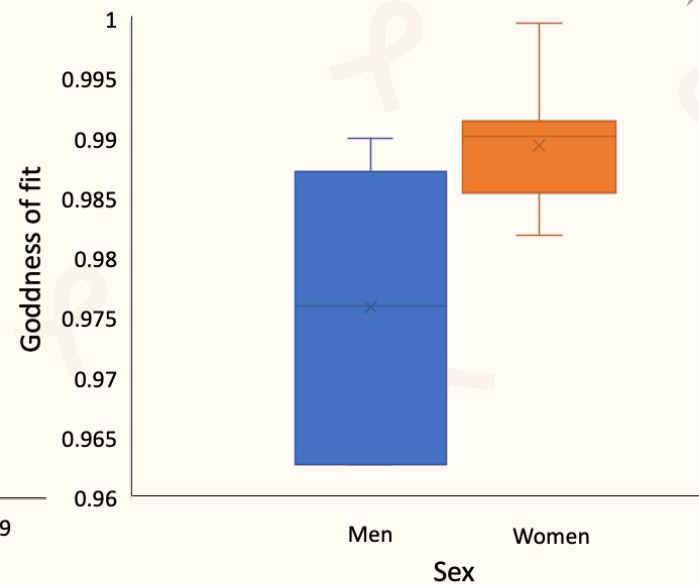
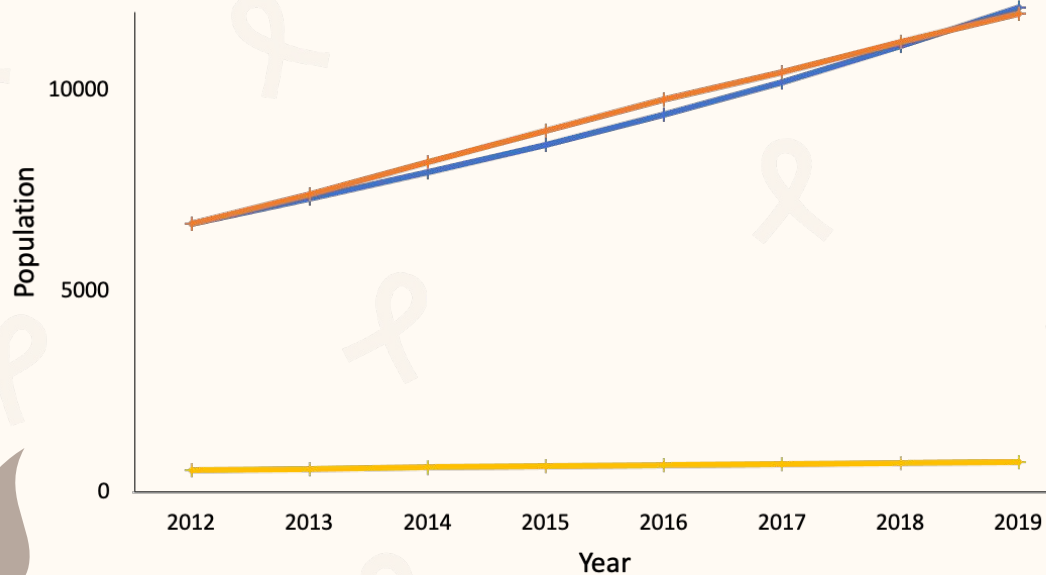
03

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**

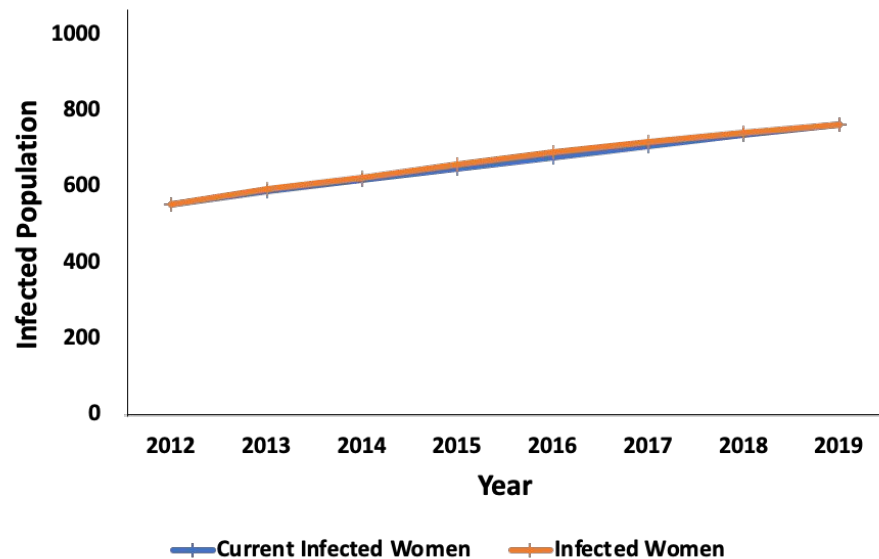
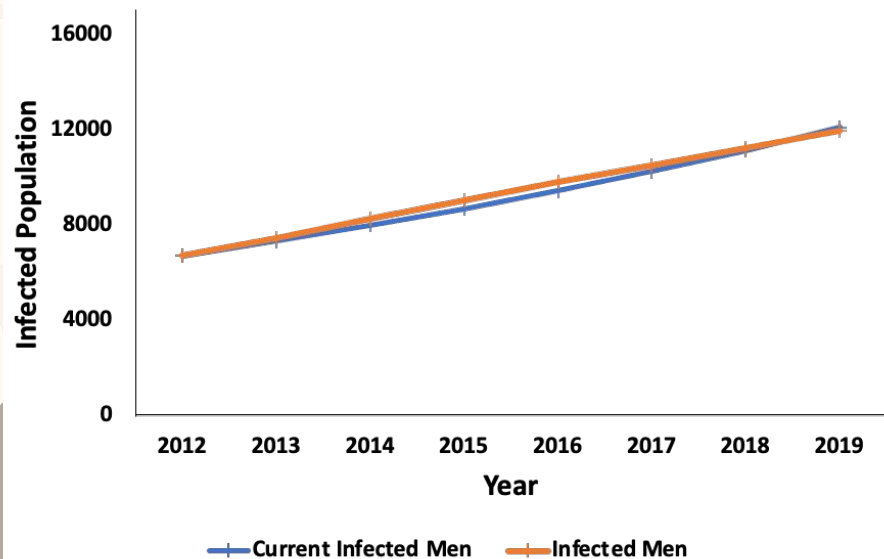
Evaluation of Model Performance



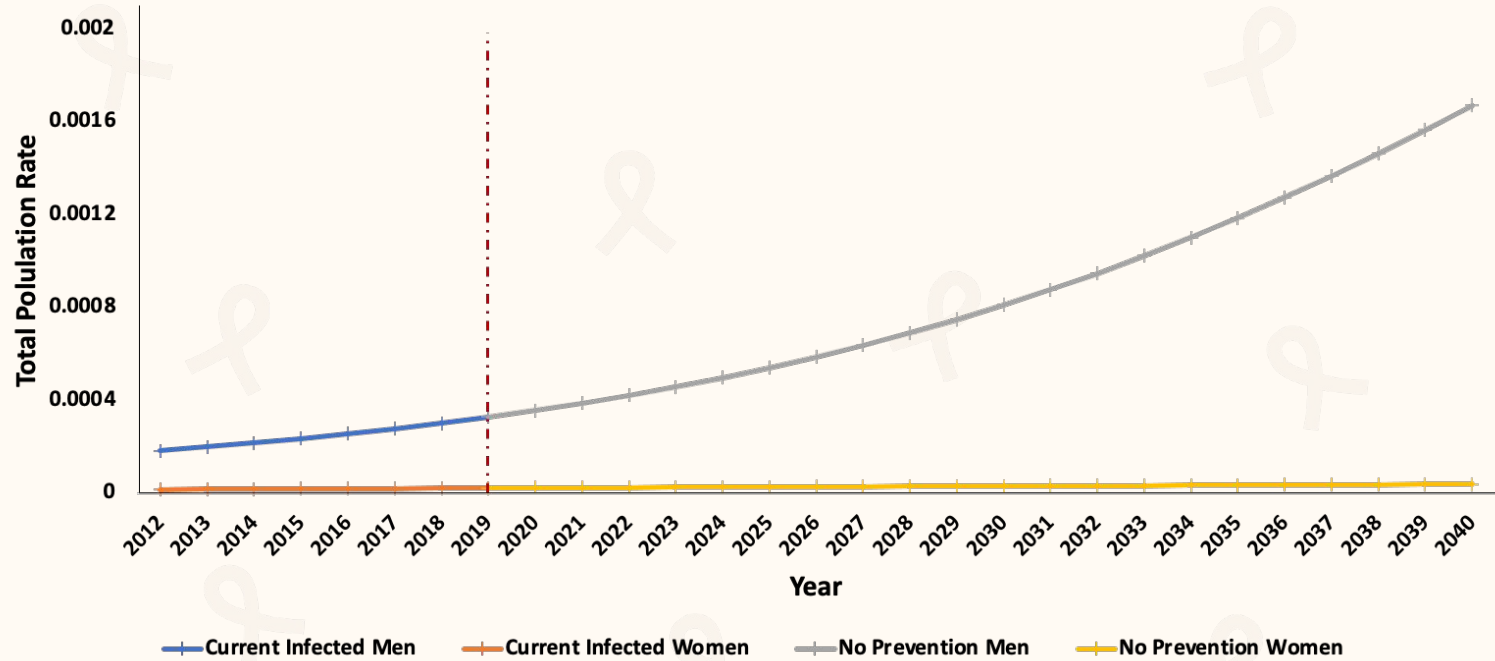
— Current Infected Men — Infected Men — Current Infected Women — Infected Women

■ Men ■ Women

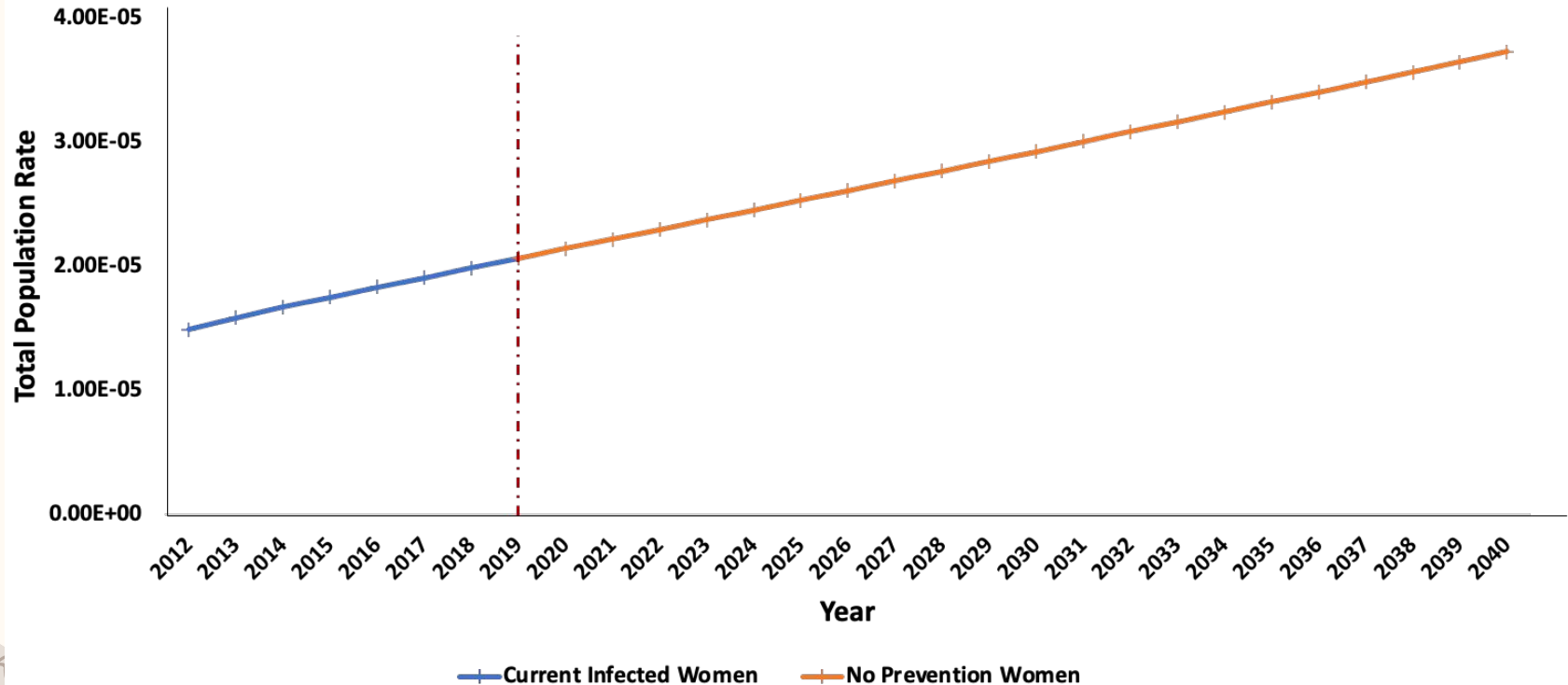
Evaluation of Model Performance



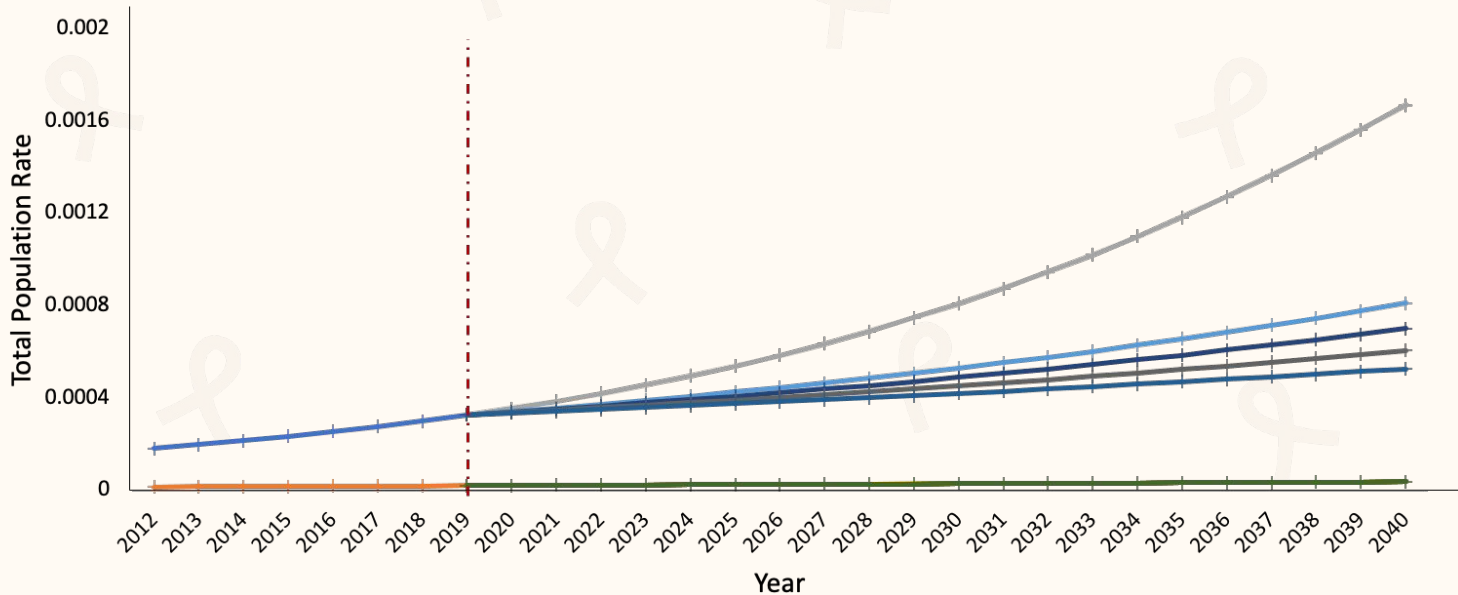
Identify Aspects of HIV/AIDS Patients without both education and PrEP



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

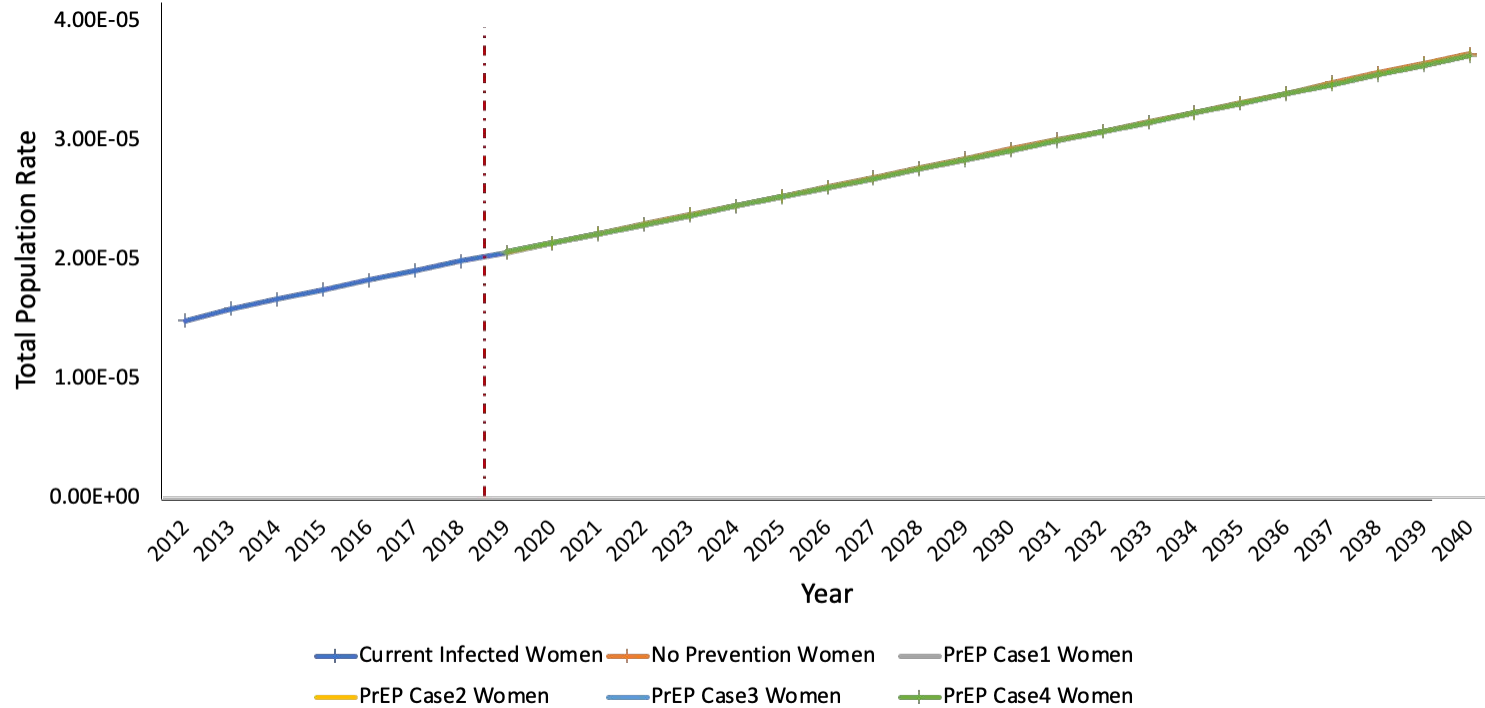


Identify Aspects of HIV/AIDS Patients with PrEP

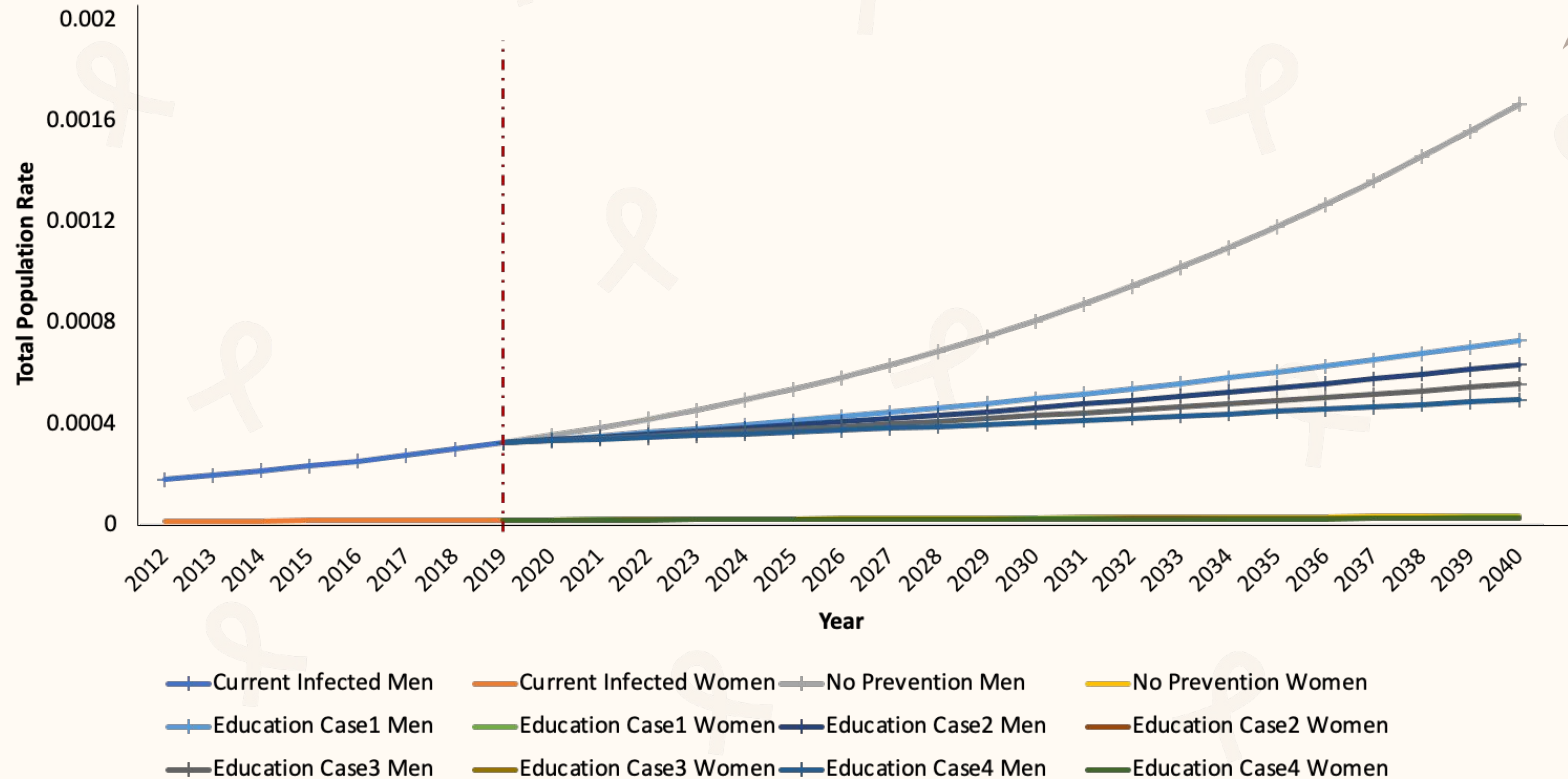


— Current Infected Men — Current Infected Women — No Prevention Men — No Prevention Women
— PrEP Case1 Men — PrEP Case1 Women — PrEP Case2 Men — PrEP Case2 Women
— PrEP Case3 Men — PrEP Case3 Women — PrEP Case4 Men — PrEP Case4 Women

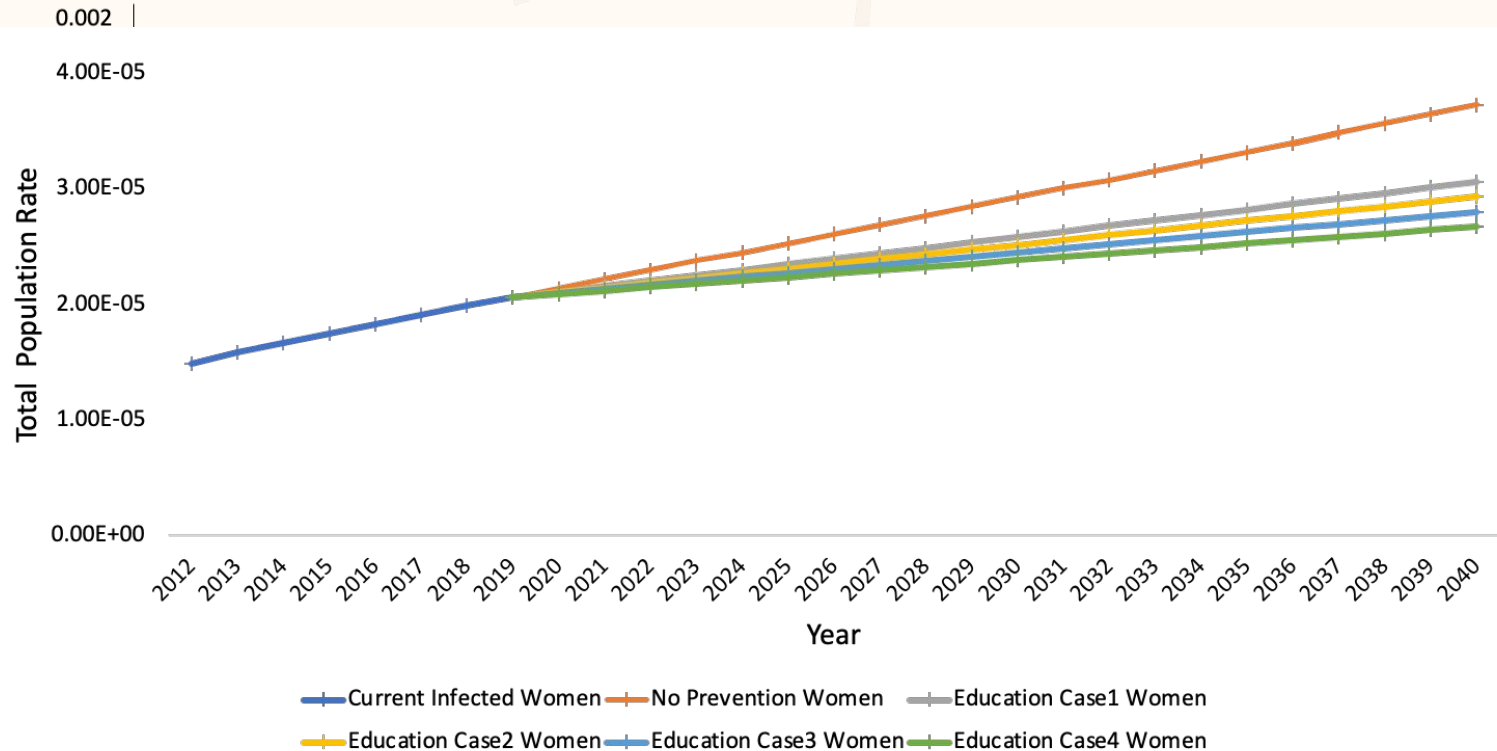
Identify Aspects of HIV/AIDS Patients with PrEP



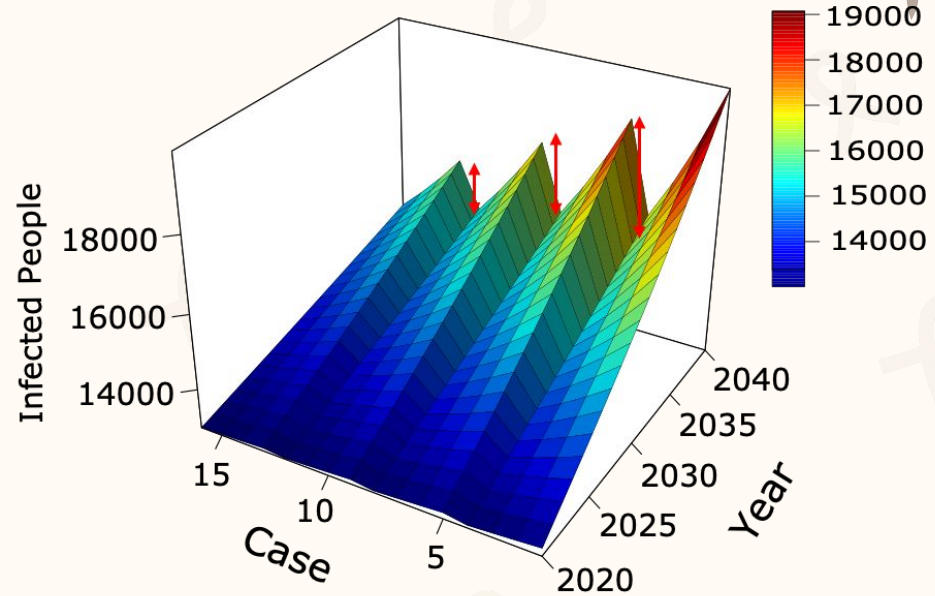
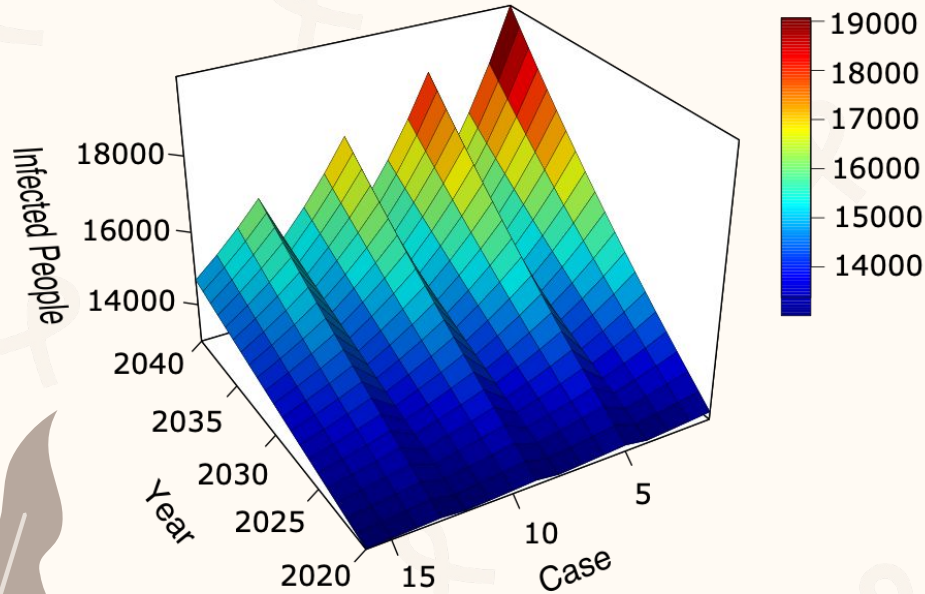
Identify Aspects of HIV/AIDS Patients with Education



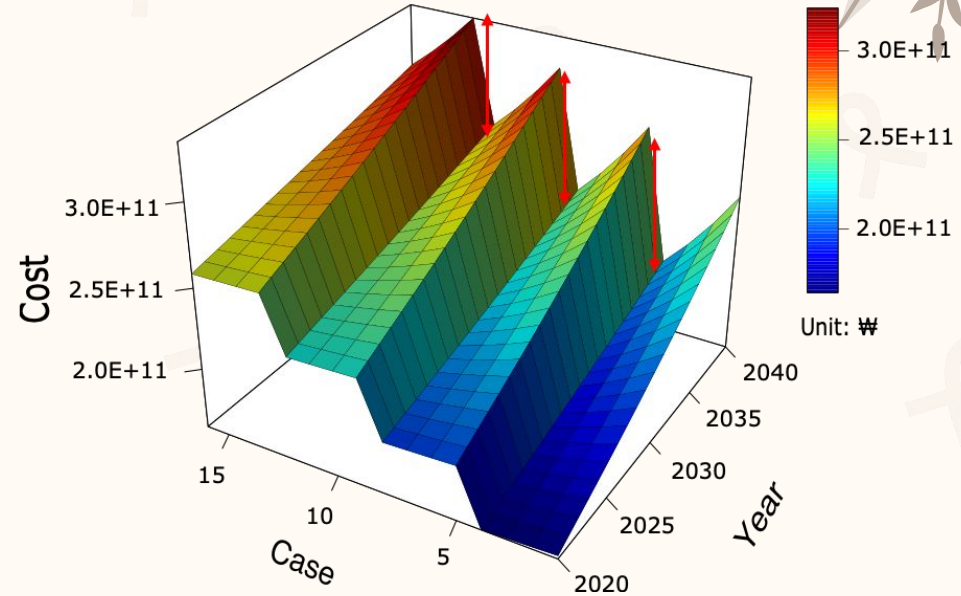
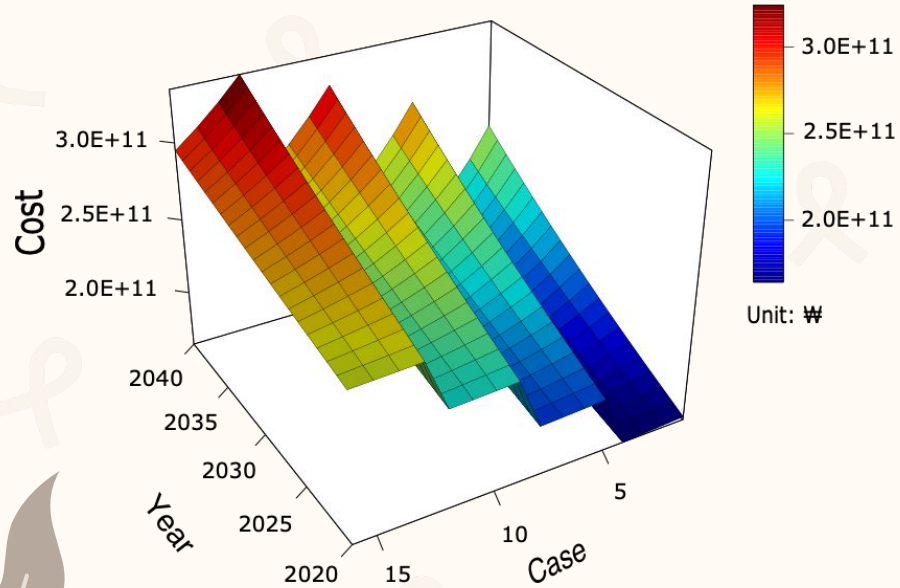
Identify Aspects of HIV/AIDS Patients with Education



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!

