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The Effect of Expanded Antiretroviral Treatment (ART) Strategies on the MSM HIV Epidemic in San Francisco

Contact:
Edwin Charlebois, MPH, PhD
50 Beale St., Suite 1300
San Francisco, CA 94105
Telephone: 415-597-9301
Fax: 415-597-9213
Email: Edwin.Charlebois@ucsf.edu

Edwin Charlebois, MPH, PhD[1,3], Travis Porco, PhD[4], Moupali Das, MD[2,3], Diane V. Havlir, MD[3]

[1]University of California, San Francisco, Center for AIDS Prevention Studies; [2]San Francisco City Department of Public Health; University of California, San Francisco, Departments of [3]Medicine, [4]Epidemiology and Biostatistics

Introduction

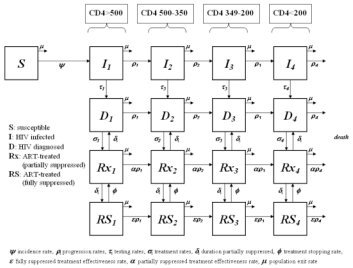
- Expanded use of ART may reduce HIV incidence and eventually HIV prevalence at the population level, assuming significant behavioral HIV risk disinhibition does not occur.
- In San Francisco, where HIV prevalence among Men-who-have-Sex-with-Men (MSM) is 23% and the majority are aware of their HIV serostatus, we sought to estimate the effects of expanded ART treatment strategies on the SF MSM HIV epidemic.

Methods

- We used a mathematical model to quantify the effect of 3 expanded ART treatment strategies on the MSM HIV epidemic in San Francisco:
- Modeling was done in ***R*** using ordinary differential equations structured as a compartment model with uninfected persons and 4 stages of HIV disease and 4 subcategories and high and low behavioral risk populations.
- Model input parameters, population sizes, and progression rates were taken from observed epidemiologic data collected in San Francisco and published data.
- Infections averted were calculated by subtracting incident case totals between models with the standard of care as the referent.

Model

Deterministic Compartment Model of HIV



ART Strategy Scenarios

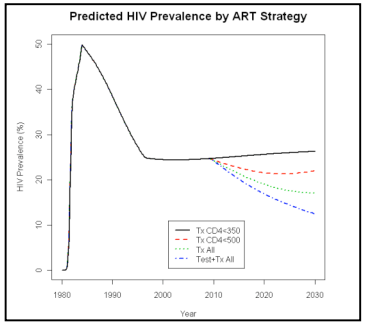
Evaluate 3 Expanded ART scenarios versus
Standard of care arm:
(Treat MSM with CD4<350)

1. **Treat all MSM with CD4<500 cells/mm^3**
2. **Treat all MSM**
3. **Treat all MSM and perform annual HIV testing to detect new infections**

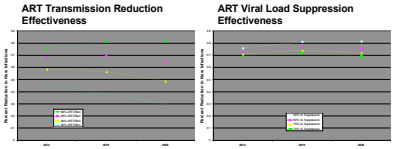
Model Inputs

	Description	Value	Source
S	SF MSM Population Size	67000	SF-DPH
β	Transmission probability per contact	0.1	Winkelstein '87 Porco 2004
μ	Duration in sexually Active population	30 years	Blower & McLean 1994
$\rho 1$	Progression rate (CD4>500)	0.3264	Schecter 1995
$\rho 2$	Progression rate (CD4 500-350)	0.2268	Schecter 1995
$\rho 3$	Progression rate (CD4 349-200)	0.4632	Schecter 1995
$\rho 4$	Progression rate (CD4<200)	0.606	Schecter 1995
$\tau 1$	Testing rate (CD4>500)	Q 3 years	estimate
$\tau 2$	Testing rate (CD4 500-350)	Q 3 years	estimate
$\tau 3$	Testing rate (CD4 349-200)	Q 3 years	estimate
$\tau 4$	Testing rate (CD4<200)	Q 3 mons	estimate
$\alpha_{1,2,3}$	Treatment rate (CD4>500-200)	Varied by scenario	set by design
α_4	Treatment rate (CD4<200)	Within 3 months	historical data
δ_i	Duration of partial suppression (on↔off Tx / resistant virus)	3 months / indefinite	estimates
ε	Relative infectiousness (fully suppressed)	1%	Havlir
α	Relative infectiousness (partially suppressed)	20%	Havlir
ϕ	Treatment cessation rate	1%	SFGH HIV Clinic
f,h	Proportion of MSM high risk	20%	Stop AIDS Project Data
ω_1,h ω_1,l	Pre '84 risky partnerships - hi Pre '84 risky partnerships - lo	6.3 6	Model fit
ω_0,h ω_0,l	Post '84 risky partnerships - hi Post '84 risky partnerships - lo	7 0.101	Model fit

Results



Sensitivity Analysis



HIV Infections Averted*

Infections Averted	Tx<500	Tx All	Test & Tx All
2014	1,554	2,169	2,810
2019	3,102	4,550	6,040
2029	4,940	8,221	12,189

* Cumulative from 2009 (model: 99% ART effectiveness 80% VL suppression)

Percent Reduction in New Infections	Tx<500	Tx All	Test & Tx All
2014	42%	59%	76%
2019	42%	61%	81%
2029	33%	55%	81%

- All 3 treatment strategies resulted in reduction of new HIV infections post implementation compared to current practice.
- The percent reduction in incident infections seen with the 3 strategies was 49%, 71%, and 91% over the first 10 years for strategies 1, 2, & 3 respectively (100% ART effect, 80% VL suppression).

Conclusions

In a city with a mature HIV epidemic where the majority of individuals have known HIV status, the successful application of widespread ART would prevent large numbers of HIV incident cases and produce a decline in HIV prevalence when combined with annual HIV testing to detect new cases.

University of California San Francisco
UCSF
AIDS Research Institute