Gender-related effects of expanded adult male circumcision programs in Southern Africa: The impact of relationship dynamics and potential risk compensation on heterosexual HIV transmission

Kyeen M Andersson[1], Douglas K Owens[2], & A David Paltiel[1]

(1) Yale University School of Medicine, Dept. of Epidemiology & Public Health, New Haven, United States
(2) VA Palo Alto Health Care System & Stanford University Dept. of Medicine, Palo Alto, United States

BACKGROUND

Adult male circumcision has been found in three randomized controlled trials conducted in African populations to reduce female-to-male HIV transmission by approximately 60%.

The potential for post-intervention risk-taking behavior to increase poses a significant threat to the successful use of any partially effective HIV prevention program, including adult male circumcision.

Male circumcision benefits women only indirectly because their sexual partners are less likely to be HIV-infected. Whether this benefit may be offset by increased risk-taking in men, particularly in settings where women are less able to negotiate safe sex, has not been examined.

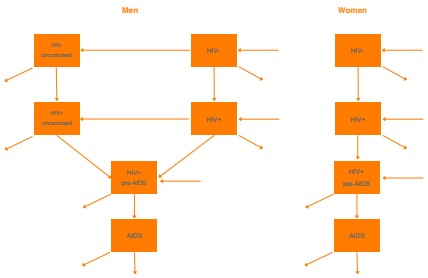
METHODS

We developed a dynamic, compartmental epidemic model (see diagram below) for heterosexual HIV transmission and disease progression to simulate the population-level impact of expanded adult male circumcision programs in Southern Africa.

We incorporated gender-specific negotiation of condom use to capture the dominant role played by the male partner in these decisions.

We calculated annual rates of movement between population groups defined by gender (male/female), disease stage (HIV-, HIV+, AIDS, and death) and male circumcision status (uncircumcised/circumcised). We simulated various program scenarios and explored the effects of subsequent changes in sexual risk behavior, using input parameters and estimates for the population of Soweto, South Africa as an example.

We used the model to predict the number of HIV infections averted over a 20-year period following 5-year expanded male circumcision programs, using varying assumptions regarding changes in post-intervention condom use for circumcised men.

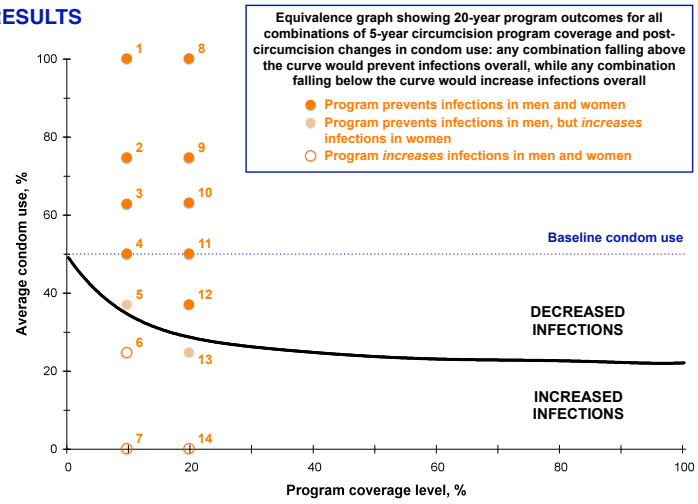


Input data included (see parameter table below):
(1) A sexually-active, anti-retroviral-naïve population of 823,000 men and women
(2) Varying contact rates and per-partner infectivity rates, depending upon disease stage
(3) Exclusive male negotiation of condom use in heterosexual partnerships
(4) Circumcision efficacy of 61% in reducing FTM transmission
(5) Baseline circumcision levels of 35%
(6) Varying program coverage levels (0-100%) for the percentage of additional eligible uncircumcised men who were circumcised annually in the expanded program
(7) Gender differences in post-circumcision risk compensation: varying condom use in circumcised men from 0-100%

Parameter name	Value	Source
Preventive circumcision program parameters		
Proportion of uncircumcised uninfected or uncircumcised asymptomatic HIV+ males circumcised annually	0.10-0.20, ts5 0, t>5	Assumption
Circumcision protective effect (probability a partnership is protected from infection)	0.61 (Range 0 to 1.0)	1
Change in probability of (male-negotiated) condom use following circumcision	0 (Range -1.0 to 1.0)	Assumption
HIV transmission parameters		
Male infectivity (per-partner probability of transmission to a female)	0.0684-0.1657	2
Female infectivity (per-partner probability of transmission to a male)	0.1112-0.2697	2
Contact rate (number of new partners per year) of males or females		
Uninfected or HIV infected, asymptomatic period	3	3
HIV infected, symptomatic period	1	Assumption
HIV infected, AIDS	0	Assumption
Baseline (male-negotiated) condom use for all partnerships (without implementation of an adult male circumcision program)	0.5	3-7
Condom failure rate for all partnerships	0.14	8
HIV disease duration parameters		
Asymptomatic HIV infection (years)	6.8	9-11
Symptomatic HIV infection (years)	2.6	9-11
AIDS (years)	0.8	11
Population parameters, heterosexual men/women > 16 years		
Mean age (years)	25.1	12
Non-AIDS life expectancy (years)	60.8	13
Initial population size	823,000	4-7, 14
Initial HIV prevalence, male population (%)	11.6	6
Initial HIV prevalence, female population (%)	20.0	6
Initial circumcision rate, baseline male population (%)	0.35	15
Arriving male population HIV prevalence (%)	0.03	4-6, 16
Arriving female population HIV prevalence (%)	0.10	4-6, 16
Arriving male population circumcision rate (%)	0.35	4

1. Auvert PLoS Med 2005; 2. Gray Lancet 2001; 3. Andersson Int J STD AIDS 2008; 4. Pettifor AIDS 2005; 5. Pettifor RHRU 2004; 6. Shisana HSRC Survey 2002; 7. Similayi AIDS Care 2004; 8. NIAID Workshop 2005; 9. Edwards Interfaces 1998; 10. Owens AIDS 1998; 11. Morgan AIDS 2002; 12. Statistics SA 2004; 13. ASSA 2007; 14. SA census 2007; 15. Shisana HSCR Survey 2002; 16. CADRE Survey 2005

RESULTS



Sensitivity analysis on potential risk behavior change and protective circumcision effect: total infections prevented after 20 years by various 5-year expanded circumcision programs

	Infections prevented by expanded circumcision program[a]			
Change in condom use post-circumcision[b]	Male	Female	Total	Graph Reference
Programs with 10% coverage goals				
Condom use increases by 100%	63,000	42,000	106,000	1
Condom use increases by 50%	44,000	29,000	74,000	2
Condom use increases by 25%	33,000	21,000	54,000	3
No change in condom use	**22,000**	**11,000**	**32,000**	**4**
Condom use decreases by 25%	9,000	[1,000]	8,000	5
Condom use decreases by 50%	[5,000]	[14,000]	[20,000]	6
Condom use decreases by 100%	[37,000]	[44,000]	[81,000]	7
Programs with 20% coverage goals				
Condom use increases by 100%	82,000	56,000	138,000	8
Condom use increases by 50%	61,000	40,000	101,000	9
Condom use increases by 25%	49,000	30,000	79,000	10
No change in condom use	**36,000**	**18,000**	**53,000**	**11**
Condom use decreases by 25%	20,000	4,000	24,000	12
Condom use decreases by 50%	4,000	[12,000]	[8,000]	13
Condom use decreases by 100%	[34,000]	[49,000]	[83,000]	14

[a] Total expected infections over 20 years for various circumcision protective effects in the *absence* of expanded circumcision programs: 244,000 (142,000 male and 102,000 female). Numbers in brackets represent negative values, which indicate the number and percentage of *additional infections* caused by a particular program.
[b] *Considering an increase or decrease in baseline condom use levels of 50%.* A 25% difference implies an absolute increase to 62.5% or decrease to 37.5% in condom use levels. A 50% difference implies an absolute increase to 75% or decrease to 25% in condom use levels. A 100% difference implies an absolute increase to 100% or decrease to 0% in condom use levels.

CONCLUSIONS

- **Programs offering male circumcision in Southern Africa may confer substantial health benefits in terms of HIV infections prevented, even for short-term programs with modest coverage goals.**
- **However, changes in sexual risk behaviors could greatly impact program outcomes and the consequences may be more severe for women. In certain scenarios, male circumcision programs could even result in increased transmission of HIV for women and men.**
- **In societies where women have less power to negotiate safe sex, decreased condom use by circumcised men could make women more susceptible to HIV infection. Women do not receive direct protection from male circumcision and they are therefore more vulnerable to risk compensation in men.**
- **Power in sexual negotiation of condom use may be an important factor when predicting outcomes of HIV prevention programs that do not provide benefits for women.**
- **As circumcision programs are implemented in Southern Africa, gender-specific risk reduction counseling and female-controlled methods for HIV prevention are urgently needed.**

CONTACT INFORMATION: kyeen.andersson@yale.edu

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