Cost of the roll-out of male circumcision in sub-Saharan Africa

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Objectives

Key health economics estimates of the roll-out of MAMC* in sub-Saharan Africa:

a) Number of circumcisers needed

b) Cost of the roll-out (Discounted to present 3% annually)

c) Net cost (after adjustment for averted HIV medical costs)

d) Cost per HIV infection averted (cost-effectiveness)

e) Number of circumcisions to avoid one HIV infection

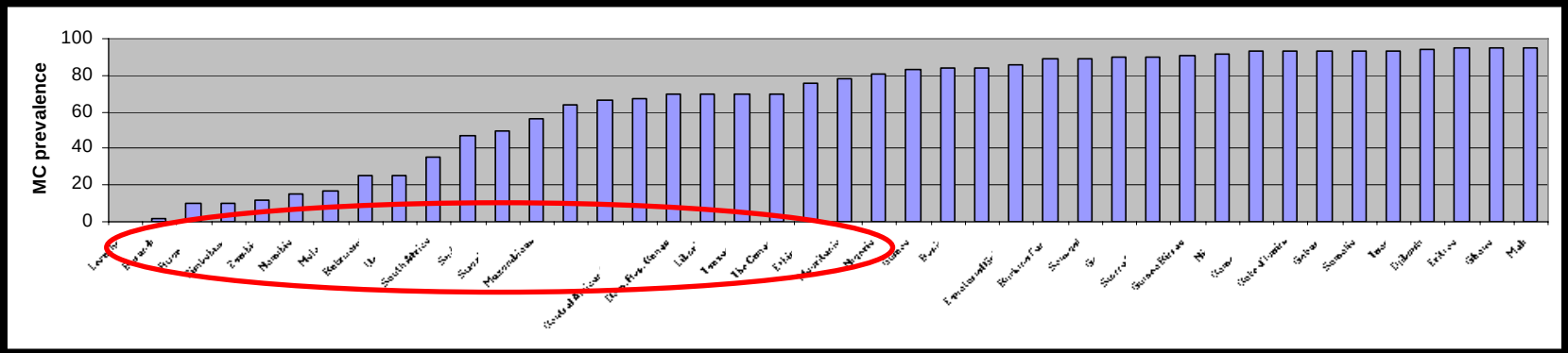
*MAMC=medicalized adult male circumcision

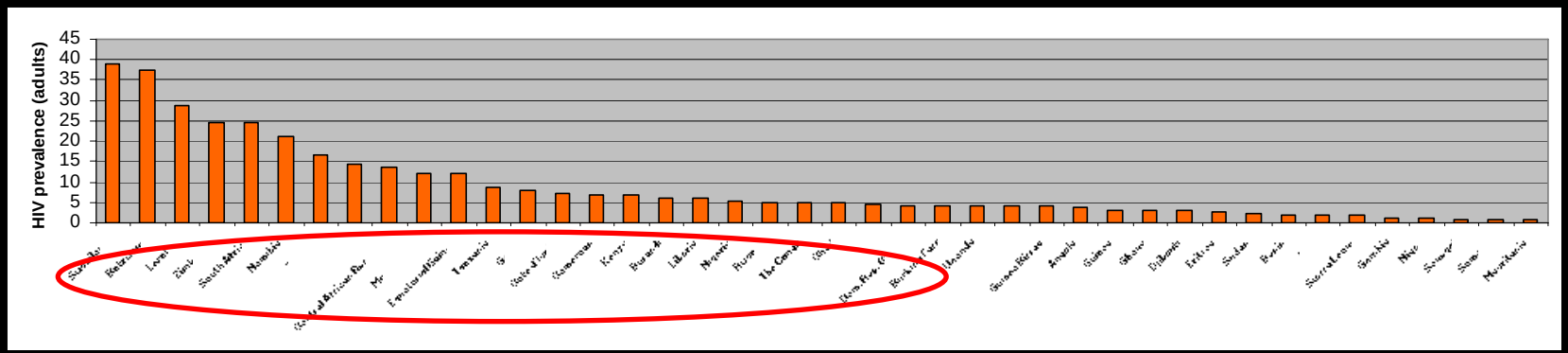
Where in sub-Saharan Africa ?

42 countries
Adult population = 331 million
Uncircumcised adult men= 54 million (33% of adult men)

To estimate the economic and human resources required for this roll-out :

Countries with “high” HIV prevalence (CEA criterion): > 5%
And
Countries with “low” MC prevalence < 80%



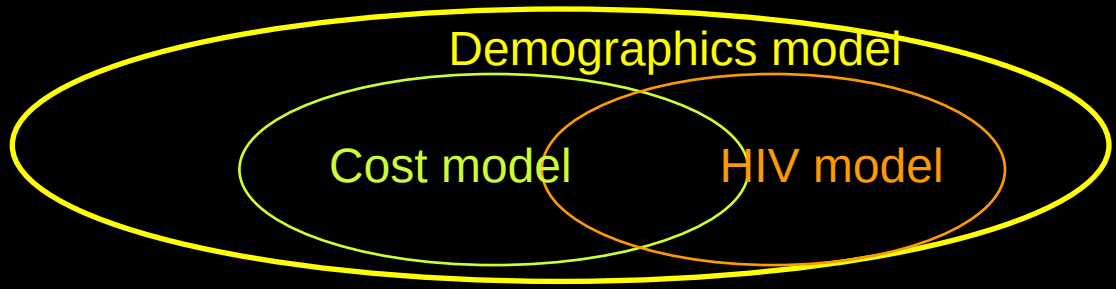


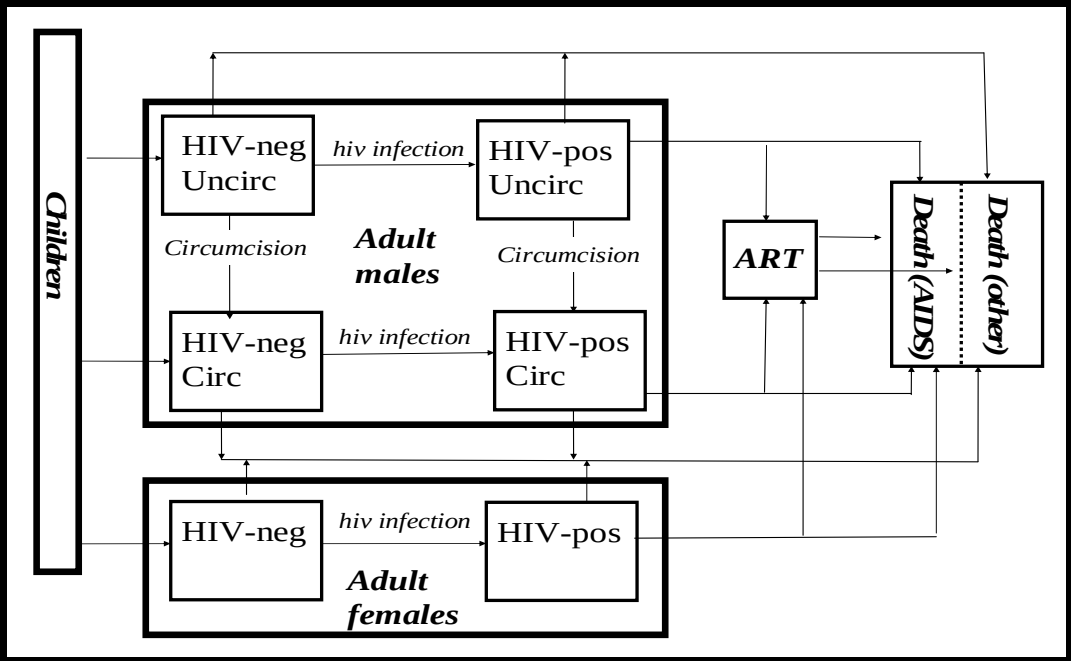
Where in sub-Saharan Africa ?

Countries:	**42 countries**	**→ 16 setting (33%)**
Adult population:	**331 million**	**→ 96 million (29%)**
HIV positive:	**24 million**	**→ 14 million (60%)**

	HIV (%)	MC (%)	Uncirc (millions)	% total uncirc
Botswana	37	25	0.3	1%
Burundi	6	2	1.7	5%
Central African Republic	14	67	0.3	1%
Kenya (Nyanza)	24	10	1.0	3%
Lesotho	29	0	0.4	1%
Liberia	6	70	0.2	1%
Malawi	14	17	2.3	7%
Mozambique	12	56	2.0	7%
Namibia	21	15	0.4	1%
Rwanda	5	10	1.8	6%
South Africa	25	35	8.0	26%
Swaziland	39	50	0.1	0%
Tanzania	9	70	2.7	9%
Uganda	4	25	4.4	14%
Zambia	17	12	2.2	7%
Zimbabwe	25	10	2.8	9%
Total			30.5	100%

Methods





HIV and demographics models

$$\frac{dn_1}{dt} = U\frac{(n_1+n_2+n_3)}{2}(1-P_c) - Kn_1 - a_1 - x$$

$$\frac{dn_{1,no}}{dt} = U\frac{(n_1+n_2+n_3)}{2}P_{no} - Kn_{1,no} - a_{1,no}$$

$$\frac{dn_2}{dt} = U\frac{(n_1+n_2+n_3)}{2}P_c - Kn_2 - a_2 + x$$

$$\frac{dn_3}{dt} = U\frac{(n_1+n_2+n_3)}{2} - Kn_3 - a_3$$

$$\frac{dn_1^+}{dt} = z_1 - (n_1^+ - n_{1,no}^+)\frac{x}{n_1 - n_{1,no}} - Kn_1^+ - a_1$$

$$\frac{dn_{1,no}^+}{dt} = z_{1,no} - Kn_{1,no}^+ - a_{1,no}$$

$$\frac{dn_2^+}{dt} = z_2 + (n_1^+ - n_{1,no}^+)\frac{x}{n_1 - n_{1,no}} - Kn_2^+ - a_2$$

$$\frac{dn_3^+}{dt} = z_3 - Kn_3^+ - a_3$$

$$z_1 = K_1(e^{\beta\frac{n_1^+}{n_1}} - 1)(n_1 - n_1^+)e^{-\alpha\frac{n_1^+}{n_1}}$$

$$z_{1,no} = K_1(e^{\beta\frac{n_1^+}{n_1}} - 1)(n_{1,no} - n_{1,no}^+)e^{-\alpha\frac{n_{1,no}^+}{n_{1,no}}}$$

$$z_2 = K_2(e^{\beta\frac{n_2^+}{n_2}} - 1)(n_2 - n_2^+)e^{-\alpha\frac{n_2^+}{n_2}}$$

$$z_3 = K_3(e^{\beta\frac{n_1^+}{n_1}} - 1)(n_3 - n_3^+)\frac{n_1}{n_1+n_2}e^{-\alpha\frac{n_1^+}{n_1}} + K_4(e^{\beta\frac{n_2^+}{n_2}} - 1)(n_3 - n_3^+)\frac{n_2}{n_1+n_2}e^{-\alpha\frac{n_2^+}{n_2}}$$

Differential equations

Input parameters

32 input parameters: One set per setting

Sources: WHO, The Global Fund, OF, publications, opinion of experts

Input parameters		
Initial population size of adults in the geographic setting	6 260 000	
Birthrate	4.0	% per year
Percent of newborns reaching adulthood	70	%
Life expectancy when becoming adult (without HIV)	35	years
Adult males circumcised (in traditional setting)	10	%
Percent of males who will not accept circumcision	15	%
Duration to reach maximum male circumcision prevalence	5	years
Initial number of circumcisers	235	
Number of circumcisions per day per circumciser	10	
Number of working days per year	230	
MC effect (reduction of female to male transmission)	60	%
MC effect (reduction of male to female transmission)	10	%
Initial HIV prevalence among adults	24.6	%
Uncirc.male-to-female/f-to-uncirc.m ratio of transmissibility	1.5	
Percent of HIV(+) receiving treatment before ARV-eligible	30	%
Cost of this treatment (total)	799	US$
Percent of HIV(+)s eligible for ARVs who receive ARVs	30	%
Life expectancy on ARVs	13	years
Cost of ART (annual)	639	US$
Percent of HIV(+) eligible for ARVs who receive non-ARV treatment	30	%
Cost of this treatment (total)	1 764	US$
Discount rate (annual)	3.0	% per year
Cost model (1=Public 0=Private)	1	
Private: Geographic setting level (communication, management, M&E)	10	%
Private: Circumcision cost (inclusive)	22.0	US$
Public: Geographic setting level (communication, management, M&E)	20	%
Public: Initial investment per circumcision unit	7 482	US$ for year #1
Public: Number of circumcisers per circumcision unit	2	
Public: Initial training per circumciser	674	US$
Public: Salary of each circumciser	169	US$ per month
Public: Circumcision cost (variable)	10.4	US$

Output parameters

a) Number of circumcisers needed

b) Cost of the roll-out (Discounted to present 3% annually)

c) Net cost (after adjustment for averted HIV medical costs)

d) Cost per HIV infection averted (cost-effectiveness)

e) Number of circumcisions to avoid one HIV infection

Model

Range for each output

Monte Carlo simulation (aggregate uncertainty from all inputs)

Each input → range

random samples of input parameters → random samples of outputs

Range = 2.5 – 97.5 percentile

Input parameters: Demographics, HIV transmission, discounting

Initial population size of adults in the geographic setting	6 260 000	
Birthrate	4.0	% per year
Percent of newborns reaching adulthood	70	%
Life expectancy when becoming adult (without HIV)	35	years
Number of working days per year	230	
→ MC effect (reduction of female to male transmission)	60	%
MC effect (reduction of male to female transmission)	10	%
Initial HIV prevalence among adults	24.6	%
Uncirc.male-to-female/f-to-uncirc.m ratio of transmissibility	1.5	
Discount rate (annual)	3.0	% per year

Input parameters: Intervention

Adult males circumcised (in traditional setting)	10	%
→ Percent of males who will not accept circumcision	15	%
Duration to reach maximum male circumcision prevalence	5	years
Initial number of circumcisers	235	
Number of circumcisions per day per circumciser	10	
Number of working days per year	230	

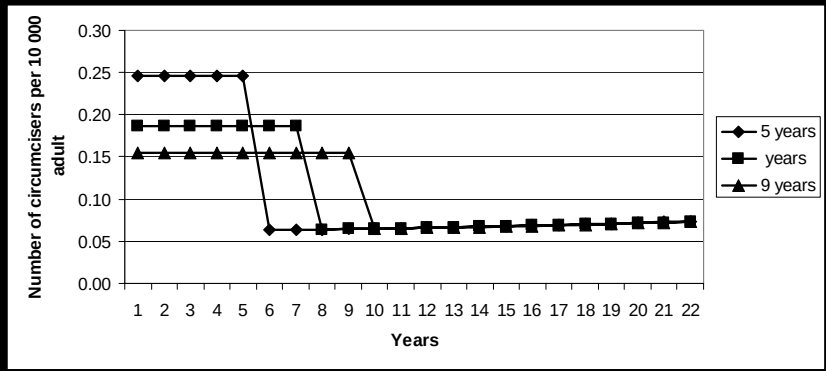
Input parameters: Cost of the intervention

Private: Geographic setting level (communication, management, M&E)	10	%
→ Private: Circumcision cost (inclusive)	22.0	US$
Public: Facility and program overhead	110	% of all costs
Public: Initial investment per circumcision unit	7 482	US$ for year #1
Public: Number of circumcisers per circumcision unit	2	
Public: Initial training per circumciser	674	US$
→ Public: Salary of each circumciser	169	US$ per month
Public: Increase of last salary due to other salary	59.0	%
Public: Circumcision cost	11.0	US$

Input parameters: Cost HIV treatment

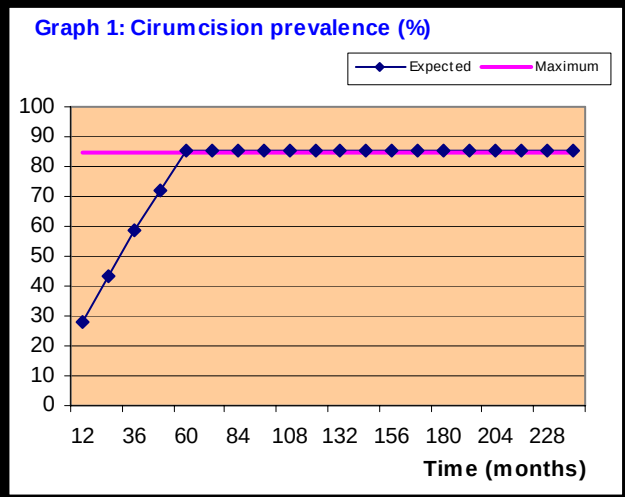
Percent of HIV(+) receiving treatment before ARV-eligible	30	%
Cost of this treatment (total)	799	US$
Percent of HIV(+)s eligible for ARVs who receive ARVs	30	%
Life expectancy on ARVs	13	years
→ Cost of ART (annual)	639	US$
Percent of HIV(+) eligible for ARVs who receive non-ARV treatment	30	%
Cost of this treatment (total)	1 764	US$

a) Number of circumcisers



High number in the first 5-year (initial period)
Lower number afterwards

# circumcisers 1-5 (per year)	**2 357 (2070 – 3 061)**
per 10 000 adults*	**0.25 (0.22 – 0.32)**
# circumcisers 6-10	**626 (533 – 861)**
per 10 000 adults	**0.07 (0.06 – 0.09)**



* Total adult population = 96 million

b) Cost of the roll-out

Total :

	Private	Public
Cost in years 1-5*	1 036 (748 – 1 319)	965 (763 – 1 301)
Cost in years 6-10*	235 (165 – 330)	208 (155 – 290)
Cost 1-10*	**1 271** (911 – 1 644)	**1 173** (924 – 1 590)

* in millions of US$

→ bUS$ **0.9 – 1.6** in the first 10 years

Per adult per year:

	Private	Public
Cost per adult per year**	1.3 (0.9 – 1.7)	1.2 (0.9 – 1.7)

** in US$

→ US$ **0.9 – 1.7** per adult per year

c) Net cost

After adjustment for averted HIV medical costs
>0 → expenses **<0 → saving**

	Private	Public
Cumulative net cost* at 10 years	+ 634 (286 – 990)	+ 536 (253 – 901)
Cumulative net cost* at 20 years	- 3 736 (-5 328 – -2 530)	- 3 879 (-5 396 – -2 584)

* in millions of US$

→ saving!

Per adult per year (over the first 20 years):

	Private	Public
Saving per adult per year**	1.9 (1.3 – 2.7)	2.0 (1.3 – 2.8)

** in US$

Saving US$ 1.3 – 2.8 per adult per year

d) Cost per HIV infection averted (cost-effectiveness)

	Private	Public
Cost* per HIV infection averted in 10 years	295 (220–375)	272 (212–356)
Cost* per HIV infection averted in 20 years	157 (123 - 205)	144 (113–187)

* in US$

→ US$ **113 – 375** per HIV infection averted adult in the first 10-20 years

e) Number of circumcisions to avoid one HIV infection

Number of MAMC to avert 1 HIV infection (in 10 years)	**8.0 (7.2 – 8.9)**
Number of MAMC to avert 1 HIV infection (in 20 years)	**4.7 (4.3 – 5.2)**

* in US$

→ **4 – 9 circumcisions to avoid 1 HIV infection in the first 10-20 years**

Conclusion

Expensive but reasonable in view of favorable cost-effectiveness and saving

Implementation model (private, public, both…) ?
(local context, availability…)

Is cost the main issue ?