

# Cost-Effectiveness of Repeat HIV Counseling and Testing Strategies in Africa

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## ABSTRACT

**Background.** HIV counseling and testing (HCT) is promoted to increase serostatus awareness and entry into care and treatment. However, in Africa there is little guidance on whether and how often repeat testing should be done for those who test negative. Tanzanian HCT guidelines recommend a single repeat test after 3 months, a policy suited to the concept of a single exposure. In order to inform allocation of HCT resources, we evaluated the cost-effectiveness of alternative repeat testing strategies under various HIV incidence scenarios. **Methods.** 20-year survival, HIV treatment costs, and cost of HCT were modeled for 3 hypothetical cohorts of 10,000 persons each with HIV incidence rates of 0.1% (low), 0.5% (medium), and 2.0% (high) respectively. Estimates of CD4-count decline, treatment failure, mortality, and cost with and without treatment from Tanzania were used. Marginal costs per case identified were compared to first-time testing in a previously untested population. Costs and benefits were discounted at 3% per year. **Results.** Under current Tanzania HCT guidelines with repeat testing after 3 months the cost per case identified from repeat testing ranges from US\$3,008 to \$28,666 in high and low incidence populations, respectively. Changing the repeat testing interval to 1 year reduces the cost per case to \$2,914 at high and \$8,887 at low incidence. An interval of 5 years reduces cost per case to as low as \$2,500 in the high incidence population (Table 1). **Conclusions.** While beneficial relative to one-time testing, the Tanzania strategy of a single repeat test after 3 months is costly, particularly in low-incidence populations. At the population level repeat testing at longer intervals is more cost effective. An extension of repeat testing intervals in low incidence populations results in the greatest absolute reduction in cost per case identified. We suggest that testing policies in countries with generalized epidemics should advocate not only for universal testing, but also for regular repeat testing. Our data demonstrate benefits of tailoring testing intervals to local prevalence and incidence, and resource constraints in various populations.

## INTRODUCTION

- HIV counseling and testing (HCT) is promoted to increase serostatus awareness and entry into care and treatment.
- Although HCT may modify risk for future HIV infection, risk persists suggesting that repeat HCT strategies would be beneficial.
- In Africa there is little guidance on whether and how often repeat testing should be done for those who test negative at their first or subsequent HCT encounter.
- Tanzanian HCT guidelines recommend a single repeat test 3 months after an initial test, a policy suited to the concept of a single exposure where detection of recent infection is the primary goal.
- In order to inform allocation of HCT resources, we evaluated the cost-effectiveness of alternative repeat testing strategies under various HIV incidence scenarios.

## METHODS

- 20-year survival, HIV treatment costs, and cost of HCT were modeled for 3 hypothetical cohorts of 10,000 persons each with HIV incidence rates of 0.1% (low), 0.5% (medium), and 2.0% (high) respectively.
- Estimates of CD4-count decline, treatment failure, mortality, and cost with and without treatment from Tanzania were used.
- Marginal costs per case identified were compared to first-time testing in a previously untested population.
- Number of diagnoses, clients on and off antiretroviral therapy (ART), survival, person-years gained (PYG) and HCT and treatment costs were calculated using the formulas, constants, and cost estimates below:

### FORMULAE

#### Retention and virologic suppression among ART clients

$$ART1_t / ART2_t / ART_t / moART_t$$

Probability of being on ART1, ART2, either, or neither at time t

$$s_{ART1}(t) = ART1_t \times (1 - s_{ART1}(t)) \times s_{ART1}(t)$$

$$s_{ART2}(t) = ART2_t \times (1 - s_{ART2}(t)) \times s_{ART2}(t)$$

$$s_{ART}(t) = ART_t \times (1 - s_{ART}(t)) \times s_{ART}(t)$$

$$s_{moART}(t) = moART_t \times (1 - s_{moART}(t)) \times s_{moART}(t)$$

Failure rate of ART1/2 at after t years

#### Survival as a function of ART retention and virologic suppression

$$s_{surv}(t) = s_{surv}(t-1) \times (1 - m_{surv}(t))$$

$$s_{surv}(t) = s_{surv}(t-1) \times (1 - m_{surv}(t) \times ART_t)$$

$$s_{surv}(t) = s_{surv}(t-1) \times (1 - m_{surv}(t) \times moART_t)$$

#### Cost as a function of ART retention and mortality

$$c_{ART}(t) = ART_t \times c_{ART} + ART2_t \times c_{ART2}$$

$$c_{moART}(t) = [ART_t \times (0 - s_{surv}(t)) + moART_t] \times (0 - s_{surv}(t)) \times (c_{surv} + c_{mortality})$$

### LEGEND

Switching rate to ART2 after failure of ART1

Survival/mortality without ART at time t

Survival/mortality rate with ART at time t

Cost of ART1 / ART2 per year

Cost of opportunistic infections and mortality at time t

STRATEGY	DIAGNOSES	PYG	LEGEND
1. 1 test after 3 months	$d_{i,t} = \frac{d_i}{4}$	$PYG_{i,t} = \frac{PYG2}{4}$	$d_{i,t}$ Diagnoses for each HCT strategy
2. 1 test after 1 year	$d_{i,t} = s_i(1)$	$PYG_{i,t} = \sum_{j=0}^{t-1} a_i(j) \times s_i(j)$	Person-years gained for each HCT strategy
3. 1 test after 5 years	$d_{i,t} = s_i(5)$	$PYG_{i,t} = \sum_{j=0}^{t-5} a_i(j) \times s_i(j)$	Survival of year x infections in year y, without ART
4. 5 annual tests	$d_{i,t} = \sum_{j=0}^{t-1} s_i(j)$	$PYG_{i,t} = \sum_{j=0}^{t-1} \frac{(a_i(j) \times s_i(j))}{(0.97)^j}$	$a_i(j) / a_i(5, j)$ Survival rate for year y of infections in year x for annual/cumulative testing with ART
<b>CONSTANTS</b>			
Time horizon	20 years (discount rate 3%)	<b>HCT cost (USD)</b>	
Mortality off ART (4)	0.01 in t=0; increasing to 0.08 by year 5	<b>HCT cost (1)</b>	
Mortality on ART (5)	0.01 in t=0,1; 0.027 in t=1	$c_{HCT} = \$6.45$ per test	
Cumulative mortality by year 10	52% off ART; 29.8% on ART	<b>Treatment cost (2, 3)</b>	
Infections averted (6)	0.142 per PY w/ virologic suppression	$c_{ART1} = \$490$	
ART1/ART2 failure rates	0.15 in t=0; 0.10 in t=1; 0.05 in t=1	$c_{ART2} = \$1,248$	
ART1 to ART2 switching rate	0.67	$c_{moART} = \$104$	
Mean CD4 (sd) at diagnosis (7)	600 (302)	$c_{surv} = \$375$ in last year of life	
Mean CD4 decline (sd) per year (8)	-20.7 (158)		

## RESULTS

- Under current Tanzania HCT guidelines with repeat testing after 3 months the cost per case identified from repeat testing ranges from US\$3,008 to \$28,666 in high and low incidence populations, respectively.
- Changing the repeat testing interval to 1 year reduces the cost per case to \$2,914 at high and \$8,887 at low incidence.
- An interval of 5 years reduces cost per case to as low as \$2,500 in the high incidence population (Table 1).
- The cost per infection averted ranges from \$3,557 to \$39,272.

TABLE 1. MARGINAL CASES AND COSTS PER CASE FOR ALTERNATIVE REPEAT TESTING STRATEGIES

Annual incidence	One test after 3 months			One test after 1 year			One test after 5 years			Annually for 5 years		
	Cases	HCT	Total	Cases	HCT	Total	Cases	HCT	Total	Cases	HCT	Total
0.10%	2.5	\$26,061	\$28,666	10	\$6,281	\$8,887	46	\$1,179	\$3,620	49	\$5,928	\$8,712
0.50%	12.4	\$5,212	\$7,818	50	\$1,251	\$3,857	228	\$256	\$2,676	244	\$1,181	\$3,966
2.00%	49.5	\$1,303	\$3,908	198	\$308	\$2,914	900	\$59	\$2,500	963	\$291	\$3,077

TABLE 2. INFECTIONS AVERTED AND COSTS PER INFECTION AVERTED FOR ALTERNATIVE REPEAT TESTING STRATEGIES

Annual incidence	One test after 3 months		One test after 1 year		One test after 5 years		Annually for 5 years	
	Infections averted	Cost per infection averted	Infections averted	Cost per infection averted	Infections averted	Cost per infection averted	Infections averted	Cost per infection averted
0.10%	1.8	\$39,272	7	\$12,175	32	\$5,151	39	\$10,948
0.50%	9.0	\$10,710	36	\$5,284	160	\$3,808	194	\$4,983
2.00%	36.1	\$5,355	145	\$3,991	633	\$3,557	766	\$3,864

## LIMITATIONS

- Input data may not be representative of all settings or were based on expert opinion in some cases.
- Behavior change associated with HCT would affect estimated cost-effectiveness.
- Lack of detailed modeling of morbidity, mortality, and cost differentials associated with ART as well as alternative testing strategies should be addressed.

## CONCLUSIONS

- While beneficial, the Tanzania strategy of a single repeat test after 3 months is costly, particularly in low-incidence populations.
- At the population level repeat testing at longer intervals is more cost effective. An extension of repeat testing intervals in low incidence populations results in the greatest absolute reduction in cost per case identified.
- Our results demonstrate the value of HCT as a tool for prevention and linkage to treatment and care services.
- We suggest that testing policies in countries with generalized epidemics should advocate not only for universal testing, but also for regular repeat testing. Our data demonstrate benefits of tailoring testing intervals to local prevalence and incidence, and resource constraints in different populations.

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