Assessment of the Potential Cost-Effectiveness of HIV Self-Testing in Resource Limited Settings

Valentina Cambiano[1], Debbie Ford[2], Travor Mabugu[3], Sue Napierala Mavedzenge[4], Alec Miners[5], Owen Mugurungi[6], Fumiyo Nakagawa[1], Paul Revill[7], Andrew Phillips[1]

1.UCL, London, UK; 2. MRC CTU at UCL, London, UK; 3. University of Zimbabwe, Harare, Zimbabwe; 4. RTI International, San Francisco, US; 5. LSHTM, London, UK; 6. Ministry of Health, Harare, Zimbabwe; 7. University of York, York, UK

Correspondence:
e-mail: v.cambiano@ucl.ac.uk
Tel number: +44 (0)2077940500 (Ext: 34570)

Background

Despite the dramatic increase in HIV testing in low and middle income countries in the last few years, over 50% remain unaware of their HIV status.

Implementation studies demonstrated that HIV self-testing (ST) is highly acceptable, could overcome some of the obstacles to testing for HIV and allow savings in costs, given its potentially lower implementation cost compared to provider-delivered HIV testing and counselling (PHTC).

Donors and stakeholders are evaluating whether investments should be made to support product development, promotion and marketing of self-testing in resource limited settings.

The aim of this study is to evaluate the potential benefits of introducing self-testing, in addition to the standard provider delivered HIV testing and counselling over 20 years, using Zimbabwe as an example setting.

Methods

HIV Synthesis Transmission Model

The analysis uses an updated version of the 'HIV Synthesis transmission model', an individual-based stochastic model of heterosexual HIV transmission, progression and treatment of HIV infection (Phillips et al., AIDS 2011, 25(6): 43–850).

Updates for the present analyses include age and gender specific rates of first time and repeat testing, including self-testing, and calibration to reflect HIV prevalence and age and gender specific levels of testing observed in Zimbabwe. A 3-fold reduction in rate of testing for people who never had condom-less sex is incorporated and increased rates of PHTC for women attending antenatal clinics and for subjects experiencing symptoms. A proportion (5%) are assumed to be not willing to be tested for HIV and will only be tested if symptoms occur.

Table 1. Assumptions on PHTC and ST

Parameter		Value	Source
Accuracy of ST		SE = 0.92; SP = 0.99	FDA Approval Oraquick In-Home HIV test
Accuracy of PHTC		SE = 0.98; SP = 1	Pant Pai , Lancet Inf Dis 2012
Probability of PHTC as a direct consequence of a +ve ST (+ve ST is not sufficient to be defined as diagnosed)		0.8 by 1 year since +ve ST	Assumption
Probability of linkage to care after HIV diagnosis (by 1 year since diagnosis)		0.6 (same value whether diagnosis was triggered by +ve ST or not)	Rosen, AIDS 2011
Change in condom-less sex following:	a +ve PHTC	with primary P: -13%, with casual P: -17% in the first 6 ms, -9% after	Kennedy, AIDS Behav 2012; Fonner, Cochrane 2012
	a -ve PHTC	No change	Cremin, Aids Behavior 2010
	a ST	As for PHTC	Assumption
Disability weights		WHO 4 event: 0.55; TB: 0.40; WHO 3 event: 0.22	Salomon, Lancet 2012
Cost PHTC (fully loaded)		Neg US $9; Pos US $25	US $10 overall in Eaton, Lancet Global Health 2014
Cost of ST		US $3	Assumption
CD4 threshold for ART		<500 cells/mm^3	Zimbabwe MoH

SE = sensitivity; SP = specificity;

Methods

Scenarios modelled

The HIV epidemic in Zimbabwe is simulated up to 2015, based on existing data on HIV prevalence and HIV testing (DHS survey 2006 and 2011).

From 2015, we compare the following two scenarios:

- **Reference Scenario (RS)**: ST is not introduced and the rates of 1st time and repeat testing increase linearly by 0.5% per year and the scale up of ART continues at the same rate as before 2015
- **Self-testing scenario (STS - base case):** ST is introduced for the general population aged 15-65 years old and has the following three main effects:
  a. halving of the population not willing to receive an HIV test (from 5 to 2.5%);
  b. substitution of 10% first time and 30% repeat PHTC tests with STs;
  c. an overall increase in the rate of first time and repeat testing by 20%, due to the availability of ST.

Availability of ST is not assumed to affect PHTC testing in antenatal care settings. These assumptions, and those in table 1, are based on limited current evidence available but overall are believed to be conservative in estimating the potential benefits of ST.

Economic Analysis

The two scenarios are compared on the basis of their costs and health outcomes, which are both discounted to present value at 3% per annum, over 20 years. Costs are estimated based upon resource use (e.g. number of tests, number of clinic visits) and associated unit costs:

- ART cost (1st line: TDF+3TC+NVP): US $97 per year (Source: MSF report 2013)
- WHO stage 4: US $200; WHO stage 3: US $20; TB: US $50; Cotrimoxazole (CTX) per year US $5
- Clinic Visit: US $20; CD4 measurement US $10;

Health outcomes are summarised in the form of disability-adjusted life years (DALYs). Expected costs and health outcomes under both scenarios can be compared using incremental cost-effectiveness analysis to establish whether ST is likely to represent good value from available health sector resources.

Results are presented across a range of cost-effectiveness thresholds; from US $0 (an extreme case, implying a health system would only be concerned with reducing costs) to US $10,000 (a relatively high threshold only likely to be relevant in well financed health systems with full coverage of interventions offering health gains at less than this amount). Costs and health outcomes are rescaled to provide figures relevant to the entire adult population (15-65 years old) of Zimbabwe. Due to the stochastic variation inherent in the model a high number of simulations are required so figures representing multivariate sensitivity analyses are presented on a discrete rather than a continuous scale.

Table 2. Predictions over time in the two main scenarios (median over simulations)

	Data -DHS	Model				
		Baseline	Reference		Self-testing	
	2011	2015	2025	2035	2025	2035
HIV prevalence (%)	15	14	11	7	11	7
% ever tested for HIV	50	65	77	79	80	83
% tested for HIV in the last year	28	37	46	50	53	56
% on ART (of those HIV+)	-	53	71	76	71	76

Acknowledgements
Thanks to UCL Computing Services for use of Legion high performance cluster computing. This work was funded by the Bill and Melinda Gates Foundation (Global Health Grant Number OPP1064862).

Results

Figure 1. Total discounted cost over 20 years in US $ billions

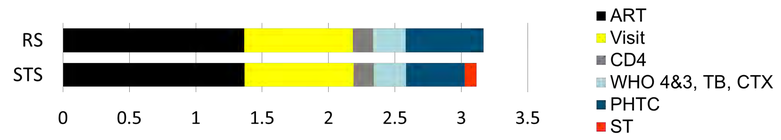
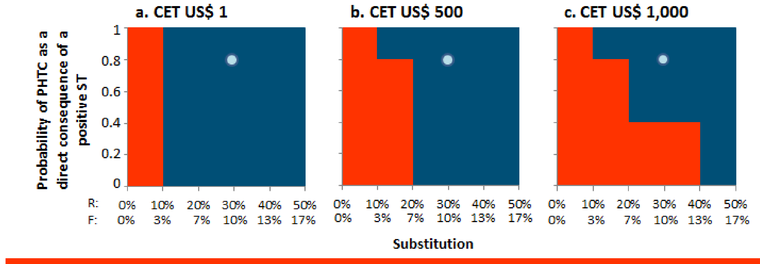


Figure 2a. Cost-effective scenario (STS or RS) under base case and alternative assumptions and according to cost effectiveness threshold (CET)

		CET in US $ thousands					Δ discounted costs* in US$ million (95%CI)	Discounted DALYs averted* in thousands (95%CI)
		0	0.5	1	5	10		
Base case (See section "Scenario modelled" in methods)							-53 (-58;-49)	102 (62;142)
Cost of ST = US $9 (B: US $3)							123 (119;127)	102 (62;142)
Sensitivity of ST = 0.55 (B: 0.92)							-77 (-81;-74)	-157 (-193;120)
Probability of PHTC as a direct consequence of a pos ST = 0.37 (B: 0.8)							-79 (-83;-75)	-166 (-203;-130)
Linkage to care following diagnosis for those who had a ST 0.4 by 1 year (B: 0.6)							-93 (-98;-88)	-166 (-211;-122)
ART initiation at CD4 < 350 cells/mm^3 (B: CD4 < 500 cells/mm^3)							-159 (-163;-155)	-252 (-293;-211)
No reduction in condom-less sex following a pos ST (B: as PHTC)							-75 (-79;-70)	-129 (-173;-86)
Increase in rate of 1st test due to ST (B: 20%)	2.5%						-86 (-92;-79)	-141 (-206;-76)
	7.5%						-85 (-91;-77)	-138 (-202;-75)
Increase in rate of repeat test due to ST (B: 20%)	2.5%						-100 (-106;-94)	-117 (-176;-57)
	7.5%						-93 (-98;-88)	-96 (-144;-47)
Substitution (B: 30% repeat, 10% 1st test)	5% of repeat, 2% 1st test						47 (42;53)	209 (163;255)
	15% of repeat, 5% 1st test						-2 (-11;8)	139 (55;223)
	25% of repeat, 8% 1st test						-35 (-43;-26)	118 (36;198)

*Compared to the RS [Total discounted life-years 120.5 million]; B: base case assumption
ST not cost-effective ST cost-effective base case

Figure 2b. Two-way sensitivity analysis under three different cost-effectiveness thresholds



Conclusions

Under our base case assumptions, our results suggest that the introduction of ST is not only cost-effective but cost-saving, with an estimated saving of around US $53 million over 20 years in Zimbabwe and a small (100,000) number of DALYs averted.
However, the population costs and health effects of ST depend upon a range of complex and interacting factors, many of which are currently uncertain due to limited data. In particular, while most scenarios may lead to cost-savings, a number of plausible scenarios do not result in DALYs averted. It will therefore be important to update these predictions as more data become available.