Sawubona

Cost Benefit Analysis
10 April 2013

Introduction

Sawubona aims to use automated SMS to improve HIV treatment outcomes in a sustainable manner. To do this, we must demonstrate a positive net benefit. The cost-effectiveness of HIV treatment has been extensively studied. Thus, a body of evidence exists with which we can make projections on Sawubona's costs and benefits through the future.

The **costs** incurred by the clinic due to operating Sawubona include:

1. Medication cost for patients retained on treatment
2. Sawubona program subscription, including support and SMS fees.

The most salient **benefits** of HIV treatment are considered:

1. Decreased risk of transmission to others due to suppression of viral load [3]
2. Reduced risk of opportunistic infections (such as tuberculosis) in the patient [8,9]
3. Improved productivity of the patient [6].

Studies have found that the annual default rate is around 5% [1,2] and the average time of default is around one year [prototype data]. Thus, we set D = 0.05. Preliminary results from the prototype showed that Sawubona can decrease the default rate by 0.5, to 2.5% per year. We define the relative decrease in D as the Sawubona effect size, E.

Costs

The per-clinic operational cost for the Sawubona service is an estimated 3302 USD in the first year and 3102 USD in each subsequent one. Our business model will subsidize the subscription fee for the first year, but for the purposes of the cost benefit analysis, we consider true cost. The retention of patients on treatment would also increase expenditures for each clinic.

Benefits

Limiting the epidemic growth of HIV

The increased retention will also affect the HIV infection rate in the surrounding area, based on a study in South Africa [3]. Because HIV treatment suppresses the amount of virus circulating in the body, it reduces the risk of the treated person infecting someone else. For every increase of 1% in treatment coverage, C = (number of HIV+ persons on treatment / number of HIV+ persons), there was a 1.4% decrease in rate of HIV infection, or incidence, in the surrounding area [3]. Based on the exponential growth of epidemics, we use a simple model:

$$R = \alpha * I$$

Where R is the HIV infection rate per person-year, α is a synthetic infectivity variable reflecting the treatment coverage of the community, and I is the infection frequency, or prevalence. We find α_0 given the baseline statistics of I_0 = 0.24 and R_0 = 0.0263 [3], thus α_0 = 0.1096 at standard treatment coverage, C = 0.37. Here, we note that the true coverage C differs from the enrolled fraction $C_{enr} = \frac{C}{1-D} = 0.39$.

For mathematical simplicity, we use a discrete annual model:

$$\frac{\Delta\alpha}{\alpha} = -1.4 * \Delta\mathrm{C} = -1.4 * \left(\frac{C}{1-D}\right) * D * E$$

$$\alpha_S = \alpha_0 + \Delta\alpha = \alpha_0 * \left[1 - 1.4 * \left(\frac{C}{1-D}\right) * D * E\right]$$

Where α_S is the infectivity value in the presence of Sawubona's effect of E.

To compute I over time, we note that persons are infected at rate R and HIV+ persons die at rate $I*F$, where $F = 0.10$ [4]. We assume that post-infection life expectancy experiences only a negligible change due to Sawubona. Thus,

$$I_n = I_{n-1} + R - F * I_{n-1} = I_{n-1} * (1 + \alpha - F)$$

$$I_n = I_{n-1} * (1 + \alpha - F)^n$$

Where n is the year number. The number of HIV+ persons in the area surrounding the clinic during each year is determined with the above formula, using $\alpha=\alpha_0$ or α_S depending on the presence of Sawubona. The cumulative number of HIV infections averted due to Sawubona is shown in **Figure 1**. We include the lifetime costs of treatment for 37% of the persons newly infected with HIV per year, based on current enrollment and default rates. The true costs were determined by considering treatment for would-be defaulters under Sawubona (adjustment for actual D and E). The decreased infection rate lowers costs in the long run.

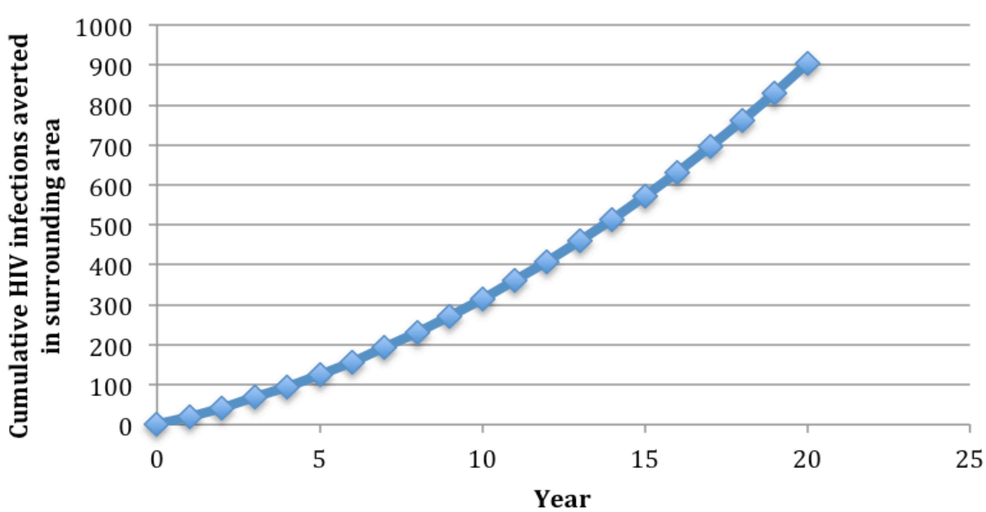

Figure 1. Estimated cumulative number of HIV infections averted per clinic due to Sawubona with $E = 0.5$.

Limiting the frequency of tuberculosis infection

Because HIV suppresses the immune system, people on HIV treatment are less susceptible to so-called opportunistic infections, such as tuberculosis (TB) (see **Table 1**) [7,8]. For each person newly infected with HIV per year, we include the costs of treating their lifetime expected number of TB cases (assuming no future Sawubona).

Because Sawubona retains new and existing patients on HIV treatment, fewer TB infections will occur among the persons enrolled at the clinic as well (adjustment for actual *D* and *E*). Thus, Sawubona has a two-fold effect on TB incidence: it reduces the number of new HIV infections up front, thus reducing the more-susceptible pool, and also reduces TB incidence among those HIV-infected persons who enroll at the clinic by improving HIV treatment retention. The estimate for cumulative number of TB infections averted can be found in **Figure 2**.

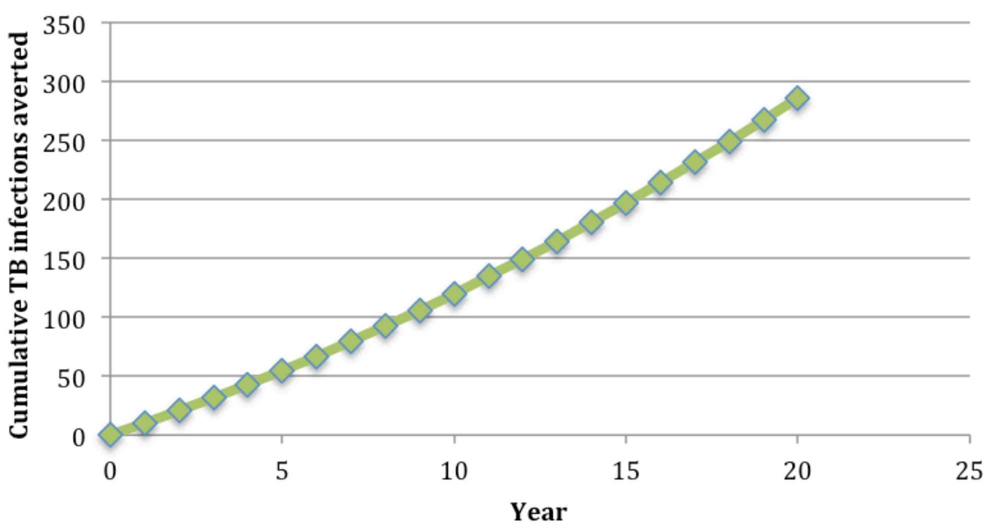

Figure 2. Estimated cumulative number of TB infections averted per clinic due to Sawubona with E = 0.5.

Improved productivity

We use an economic impact study of HIV on unskilled workers to estimate an average productivity loss parameter (see **Table 1**) [6]. The study found that these costs were primarily due to decreased overall output, lost wages, and retraining costs. The expected lifetime productivity loss for each newly HIV-infected person (assuming no future Sawubona) is included in the projections. Losses for new and previous patients were prorated due to single year defaulting (adjustment for actual D and E).

Conclusion

We recognize that these estimations do not discount future cash flows. However, we note that the current real interest rate in South Africa is quite small, at 0.9% [9]. The most delayed cost will be for the final year of treatment (year 25), attributable to persons infected with HIV in year 10. We considered a synthetic worst-case scenario where all benefits are assumed to occur at year 25 and all costs at year 0. Even combined with the pessimistic estimate of $E = 0.2$ (based on a less robust SMS system from Kenya [10]), Sawubona still achieved a positive cumulative economic benefit by its seventh year of operation.

Thus, for computational simplicity, we assumed the discounting rate to be negligible. Based on this and the optimistic estimate of $E = 0.5$, Sawubona achieves a total net economic benefit of 5829 USD by the end of its first year in a single clinic. **Table 2** summarizes the clinic-specific and economic net effects of Sawubona. The minimum E required to achieve a cumulative positive net benefit over 10 years is $E = 0.058$, which is far below our pessimistic estimate. These projections, firmly grounded in empirical data, provide strong evidence that Sawubona can alleviate human suffering caused by disease while also providing clinics with solid returns on investment.

Table 1. Parameter set used in projections for an average-sized clinic in KwaZulu-Natal, South Africa. Here, Rx is an abbreviation for prescription medicine.

Parameter name (units)	Symbol	Value	Reference(s)
1-year default rate (fraction)	D	0.05	[1,2] and Clinic Data
Sawubona reduction in 1-year default rate (fraction of D)	E	0.5	Prototype
HIV+ persons on treatment		5000	Clinic data
(no. actually on HIV Rx)/(no. HIV+)	C	0.37	[3]
(no. enrolled on HIV Rx)/(no. HIV+)	C_{enr}	0.39	[1,2,3]
(no. HIV+) / (area pop)	I_0	0.24	[3]
Est. area pop.		56306	Clinic Data
Est. post-infection life expectancy (years)	$1/F$	10	[4]
Est. post-infection life expectancy w/ HIV Rx enrollment (years)		15	[4]
Est. post-infection life expectancy w/o HIV Rx enrollment (years)		7	[4]
Est. duration of Rx (years)		10	[4]
Per annum cost of Rx (USD)		300	[5]
Lost productivity per HIV+ person w/o Rx (USD)		3077.45	[6]
Probability that an HIV+ person w/o Rx will cause lost productivity		0.240	[6]
Probability that patient will lose productivity when off Rx for 1 year		0.024	[6]
TB Rx cost (USD)		621	[5]
Effect on HIV incidence per 1% increase in HAART coverage (fraction)		-0.0140	[3]
Baseline HIV incidence (per person-year)	R_0	0.0263	[3]
TB incidence w/o HIV Rx (per HIV+ person-year)		0.0700	[7,8]
TB incidence w/ HIV Rx (per HIV+ person-year)		0.0150	[8]
TB incidence w/o HIV (per HIV- person-year)		0.0020	[7,8]
Real interest rate in South Africa		0.0090	[9]

Table 2. Net benefit (costs w/o Sawubona – costs w/ Sawubona, in USD) assuming negligible discount rate. Economic net benefit refers to gained productivity; clinical net benefit is the sum of all other items.

Sawubona effect (*E*)	Category	Over 1 yr	Over 10 yrs
0.2 (Pessimistic)	Clinical	-7610.52	-25915.96
	Economic	7644.49	99079.09
	Total	33.97	73163.13
0.5 (Optimistic)	Clinical	-14073.31	-17804.15
	Economic	19111.24	246775.04
	Total	5037.93	228970.90

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