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Needling the entitlement balloon: Assumptions, cost projections and flaws in the Centre for Global Development's AIDSCost model

Matthew MacDevette

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Needling the entitlement balloon: Assumptions, cost projections and flaws in the Centre for Global Development's AIDSCost model

Abstract:

The recently developed AIDSCost model was designed to forecast the future financial burden of global antiretroviral treatment (ART) up until 2050, and has been used to claim that ART treatment is too expensive for developing countries. This paper interrogates the structure and outputs of the AIDSCost model. Firstly, we investigate the model's assumptions and find a number of flaws in its makeup, the most significant being the unrealistic way in which ART coverage expands. These make it inappropriate for use in many real-world policy settings. Secondly, we compare the model's outputs for South Africa to those of ASSA2003, South Africa's most highly developed AIDS modelling tool, for the period 2007-2016 as a test of the former's accuracy. We find that, even when applying a number of different ART coverage and costing scenarios, AIDSCost overestimates the future burden of ART by as much as 100%. Though the model's costing function is disputable, the most serious errors underlie the calculation of vital outputs on which costing depends, most notably AIDS death rates, the number of those on ART and HIV prevalence. Accordingly, we argue that the model should be subjected to thorough refinement before it is used by anyone. Further, we argue that AIDSCost co-author Mead Over, in employing the model to show that 'ballooning' ART burdens will overwhelm US aid budgets, generates unreliable figures which severely overestimate the future financial burden of global ART.

Introduction

AIDSCost , the AIDS costing and projection model designed by Mead Over and Owen McCarthy and released by the Centre for Global Development, adds to the tool belt of those wishing to estimate the costs of global antiretroviral therapy (ART). Not only is the model easy to use, but it also allows projections for a large number of countries with significant levels of infection. However, it remains important that those wishing to use this model understand the logical underpinnings and shortcomings thereof. While its simplicity is laudable, its parsimony comes with various oversimplifications and misrepresentations that call into question its cost projections. This is not merely a question of curiosity. Mead Over has recently used the model to argue that, should the United States continue to support the expansion of ART in developing countries, the financial burden thereof will become overwhelming – there will arise a 'ballooning entitlement', as we shall discuss in more detail later. Over has argued that, in lieu of this, the United States should shift focus away from treatment and towards prevention. Considering the gravity of the issue at hand – namely, the provision of life-saving drugs to multitudes of people by the world's largest HIV/AIDS donor – it is of vital importance that we interrogate the reliability of Over's cost estimates.

This paper will begin with a brief overview of the workings of AIDSCost. Thereafter, a brief analysis of the model's main shortcomings will be given and some recommendations made. Finally, the model's outputs for South Africa will be compared with those of ASSA2003 for the period 2007-2016, in order that we may derive some measure of the former's quality. As ASSA2003 employs a large variety of data and is calibrated to fit actual trends in AIDS deaths by age, gender and race, we may refer to it as a kind of gold standard. McCarthy and Over have openly solicited comparisons of their model with others, ASSA2003 among them (2009: 29). It is our hope that the following analysis will aid the authors in improving AIDSCost where necessary.

Section 1 – the mechanics of AIDSCost

AIDSCost is actually comprised of two programmes: AIDSProj and AIDSDif. AIDSProj provides all the key outputs we seek to measure (incidence, prevalence, treatment costs and the like), while AIDSDif facilitates comparison between the costs and benefits of different AIDSProj scenarios. Since we do not concern ourselves with AIDSDif in this paper, we will henceforth refer to AIDSProj as AIDSCost.

For ease of understanding, let us assume that we are looking at the world through the eyes of the model. Fresh from the programming laboratory, we have been given our first job: to calculate the future global burden of Antiretroviral therapy (ART). To do this, we decide that we need to track HIV positive individuals through a progression of states – being AIDS sick, needing first-line treatment and receiving second-line treatment, for example. We approach the problem in the following way:

1.) How many *new* people are infected with HIV each year; in other words, how do we estimate incidence? We have data on total number infected for 2007, but what about beyond that? Let us assume that, each year, incidence will be some multiple of the incidence in the previous year. Let us create a variable that the user can adjust, *incmult*, with values between 0 and 1 (1 being 100% of the previous year's incidence).

2.) We now have the stock of HIV positive people each year, but need to calculate how many of these are actually AIDS-sick, ie. eligible for ART. Let us define *erate* as the parameter that tells us what proportion (again between 0 and 1) of HIV positive people become newly AIDS-sick each year, and *ndrate* as the parameter that tells us what proportion of AIDS-sick not receiving treatment die each year. Those AIDS-sick that survive but do not receive treatment constitute *unmet need* for ART each year.

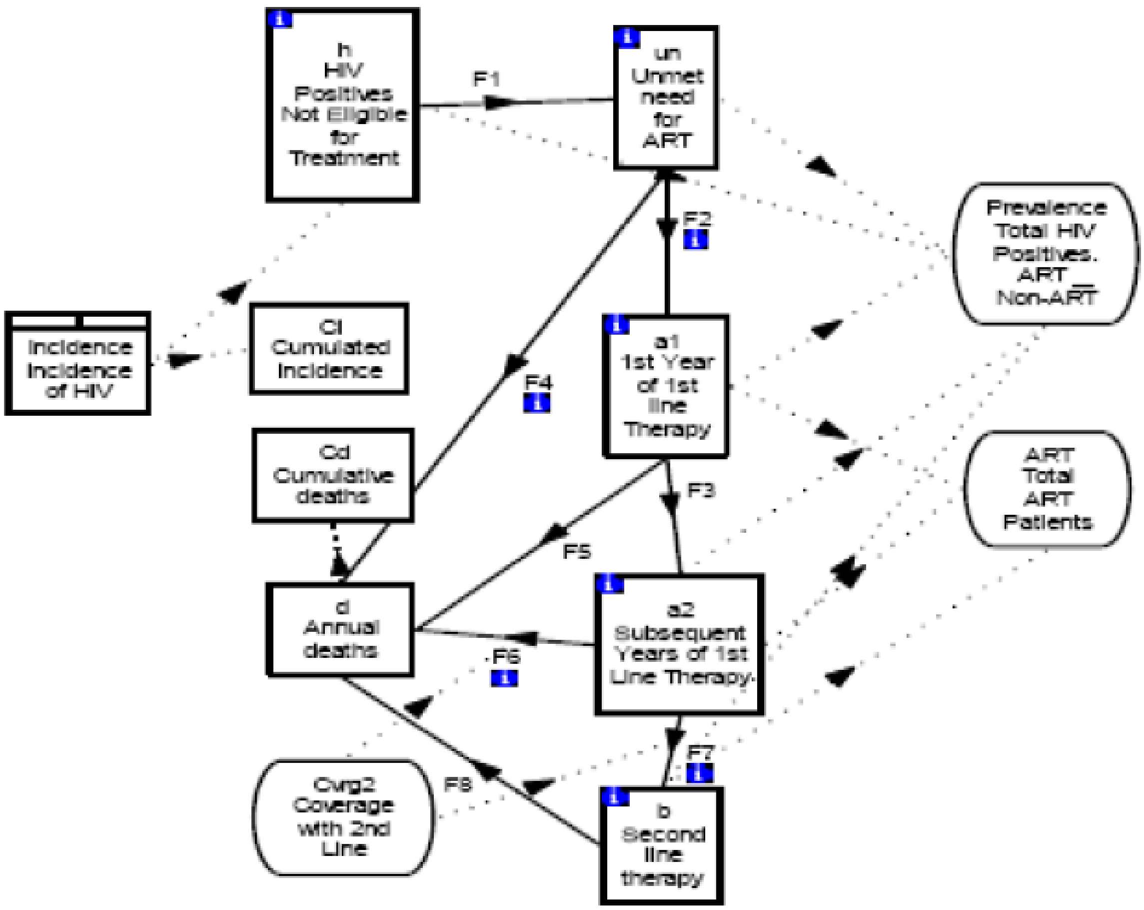
3.) Next, we need to calculate how much of this need for ART is satisfied each year. We thus create the parameter *uptake* with values between 0 and 1. If *uptake* is 0.85, for example, in any given year 85% of AIDS-sick people not already on ART and needing treatment receive it. We assume that no one is taken off of ART until they die, and call this claim to lifelong treatment 'entitlement'. We recognise that *uptake* is an extremely important and highly variable policy target, and so assign it no default.

4.) We need to be more specific about treatment – after all, there is a massive difference in cost between first- and second-line treatment. The number of those on their first year of first-line treatment is labelled *a1*, and is simply the number of those new to ART each year. We recognise that the first year of first-line therapy is one in which treatment failure can be high. We thus create *adrate* to capture the death rate on *a1*, and calculate the number of those on post-first-year-first-line therapy each year as *a2*. This includes the number of the previous year's surviving *a1* minus those *a2* who have failed first-line therapy and thus become eligible for second-line therapy. *Adrate2* gives this latter proportion.

5.) To calculate those on second-line therapy, we need to determine how many people who need it actually get it each year. We have already seen that those that need second-line therapy are those that fail first-line therapy. We define the proportion of these that are given this treatment each year as *cvrg2*. The number of those on second-line therapy then becomes this proportion minus those who die on second-line therapy each year, the latter being given by *bdrate*.

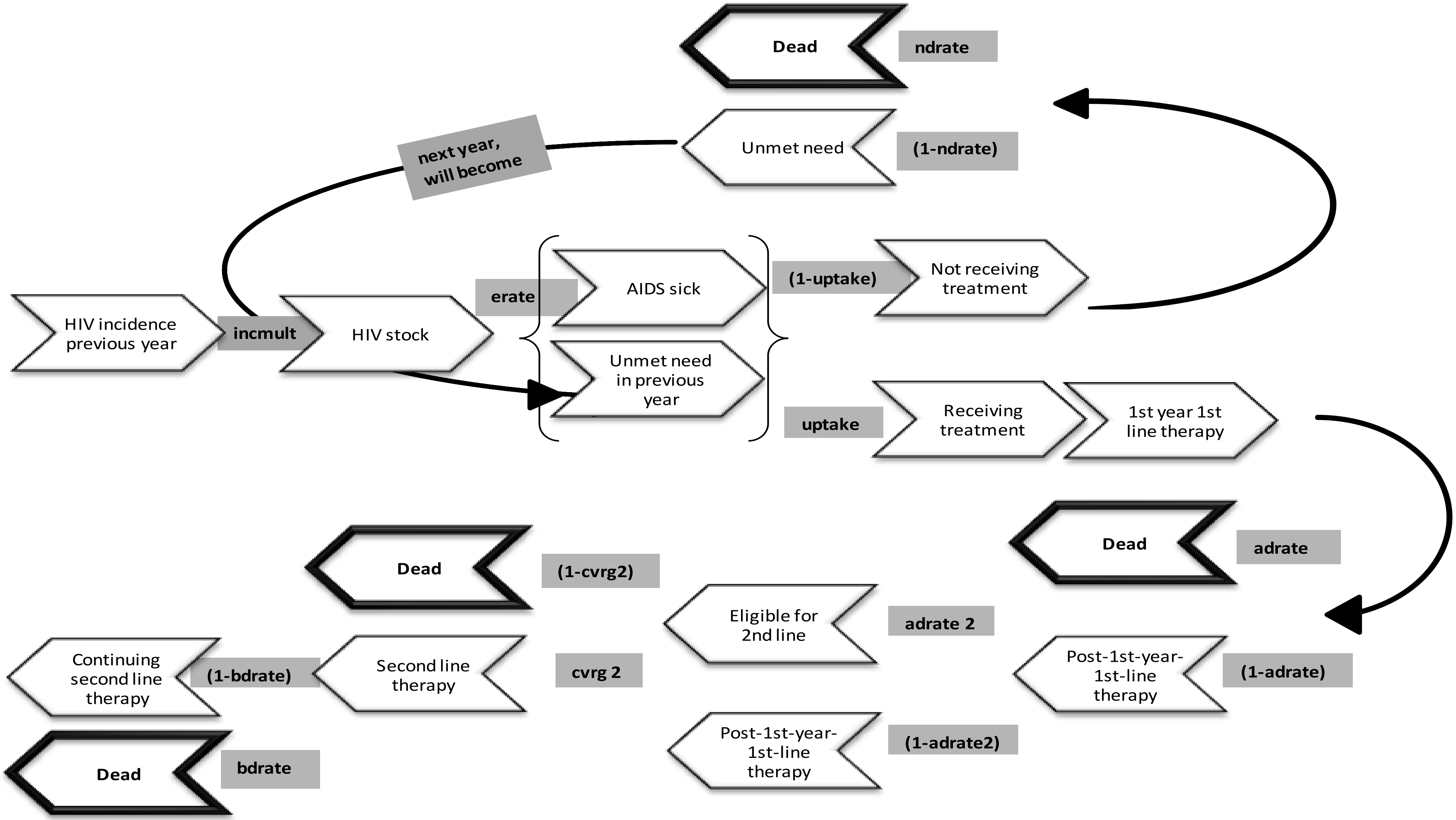
We now have a basic idea of how AIDSCost works. McCarthy and Over provide a diagram of the mechanisms involved (2009: 39):

Figure 1: Structure of the AIDSCost model (as per model manual)



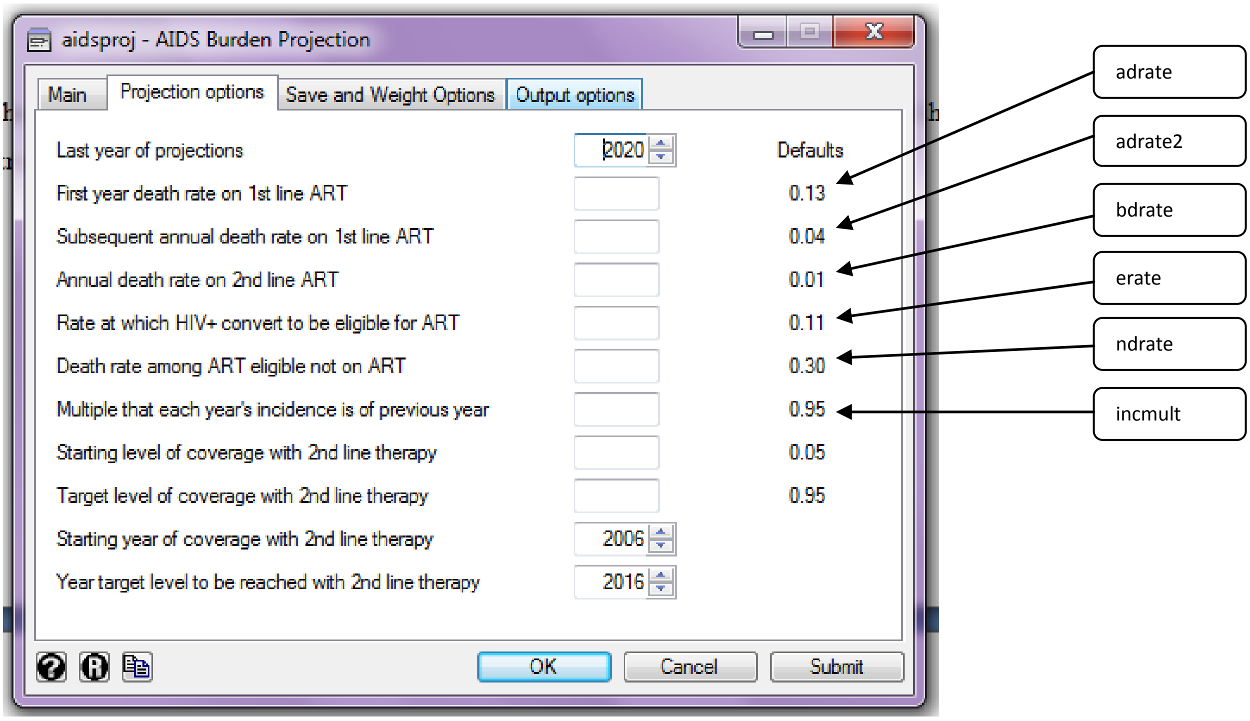
The following alternative depiction, however, is more intuitive:

Figure 2: The modus operandi of AIDSCost



The model presents users with the following interface and default values:

Figure 3: User interface and defaults



The user is able to adjust each of the parameters above as he/she sees fit, while a previous screen allows for the tweaking of the *uptake* parameter. The importance of this *uptake* must be stressed. This is the only parameter that does not have a default value and is a pivotal input in determining the number of patients on, and thus the cost of, ART. Note that *uptake* (the rate at which people who need ART, but are not already on ART, gain access to ART) is not the same as ART coverage (which includes the numbers already on ART both in the numerator and the denominator). As we shall see, a positive *uptake* rate invariably tends to 100% coverage over time. This is because the model does not allow the user to specify a starting level of first-line coverage, nor does it allow for a target level of first-line coverage. Only second-line starting levels and targets can be specified. It is also important to note that each of the above parameters stays constant over time. Setting an *uptake* rate of 0.85, for example, commits the area in question (country, region or world) to meeting 85% of unmet need each year until the last year of projection. Lastly, when estimating across different countries and regions, the model does not allow for variability in the parameters. If different values of the parameters are required for different countries or regions, individual runs are required.

Using the output data, AIDSCost then calculates the total cost of ART in region i and year j according to a simple cost function:

$$TC_{ij} = ART1 * C_{ART1} + ART2 * C_{ART2}$$

Where ART1 and ART2 are the number of people on first-line and second-line ART respectively, and C_{ART1} and C_{ART2} are the unit costs of the two treatments (including pharmaceutical and non-pharmaceutical costs).

Section 2 – problems and areas for further research

Exploring the mechanics of the AIDSCost model reveal a number of troubling issues, many of which have potentially catastrophic (and we do not use the word lightly) implications for the projection of ART costs. There are several pressing issues that deserve attention.

1. ART specification

As mentioned above, AIDSCost does not allow the user to specify target overall coverage levels, only target *uptake* rates and second-line coverage targets. Total coverage tends to 100% over time. This has to do with the fact that *uptake* is specified as a constant rate of need satisfaction amongst those not already on ART. As this can be confusing, it is worth summarising the difference between ART coverage and ART uptake:

$$ART\ uptake = new\ to\ ART(t) / unmet\ need\ for\ ART\ (t-1)$$

$$Total\ coverage\ (\%)(t) = \frac{total\ number\ on\ ART\ (up\ to\ and\ including\ t)}{total\ need\ for\ ART\ (t)} * 100$$

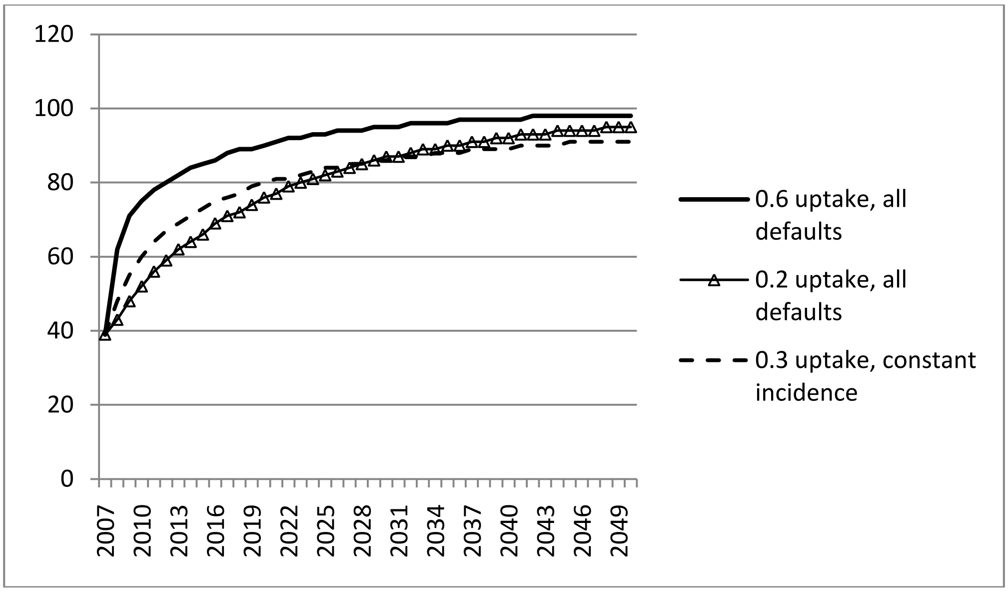
$$Total\ number\ on\ ART = ART\ already\ enrolled + new\ to\ ART$$

$$Total\ need\ for\ ART = total\ number\ on\ ART + unmet\ need\ for\ ART$$

$$\therefore Total\ coverage\ (\%) = \frac{ART\ already\ enrolled + new\ to\ ART}{ART\ already\ enrolled + new\ to\ ART + unmet\ need\ for\ ART} * 100$$

The coverage shortfall is given by unmet need for ART; as this tends to zero, total coverage tends to 100%. In other words, if there is no unmet need everyone who needs ART gets it. If we think back to our model diagram, we see that unmet need must decline consistently over time. This is because each year we have fewer people infected (declining incidence) and thus fewer new people each year that need ART (since the number of AIDS sick is calculated as a constant proportion of those with HIV). Moreover, some of those that need ART but don't get it die and do not form part of unmet need in the next year. Put another way, since the level of satisfaction of need amongst those not on ART does not decline (being a constant proportion, *uptake*), as time passes we are satisfying a given percentage of a declining number. Total ART coverage, thus, will tend to 100%. Graphically, the process is depicted thus:

Figure 4: The push to 100% total coverage



While it is possible to specify an extremely low *uptake* rate that will effectively place 100% ART coverage outside of the 2050 projection range, this forces the user into a rather absurd trade-off that is unlikely to present itself in the real world.

The inability to set total coverage targets renders the model inappropriate for calculations involving countries, like South Africa, where, for any given period, policy targets are stated as levels of coverage and not rates of annual *uptake*. In such cases, it becomes difficult for users to determine, ex ante, the appropriate values to assign to the parameters. The costs of a target ART coverage level of 80% for the year 2015, for example, cannot be directly estimated. Rather, users must specify some target value of *uptake* and then read the corresponding total coverage level from the AIDSCost outputs. Thus, in our case (discussed in the next section), we had to specify a number of *uptake* rates until we reached our desired level of coverage (80%) by 2012 (the actual policy target). While it is possible to reverse engineer the output and, in so doing, retrieve the correct coverage for the correct date, this process is time consuming and impractical.

Another problem, perhaps due to the above, is that total ART coverage can expand in an unrealistic manner. Again using our example, we found that total coverage made a jump from 27% in 2007 to 72% in 2008 (discussed in more detail below). It is doubtful, especially given the need for measured budgetary planning over a number of years, whether real-world ART scale-up would be so sudden at the outset. Further, it takes an extremely optimistic view of the ability of developing countries to roll out treatment - a problem likely to be exacerbated by the unwillingness of some individuals suffering from AIDS to go onto ART (see Steinberg [2008], for instance).

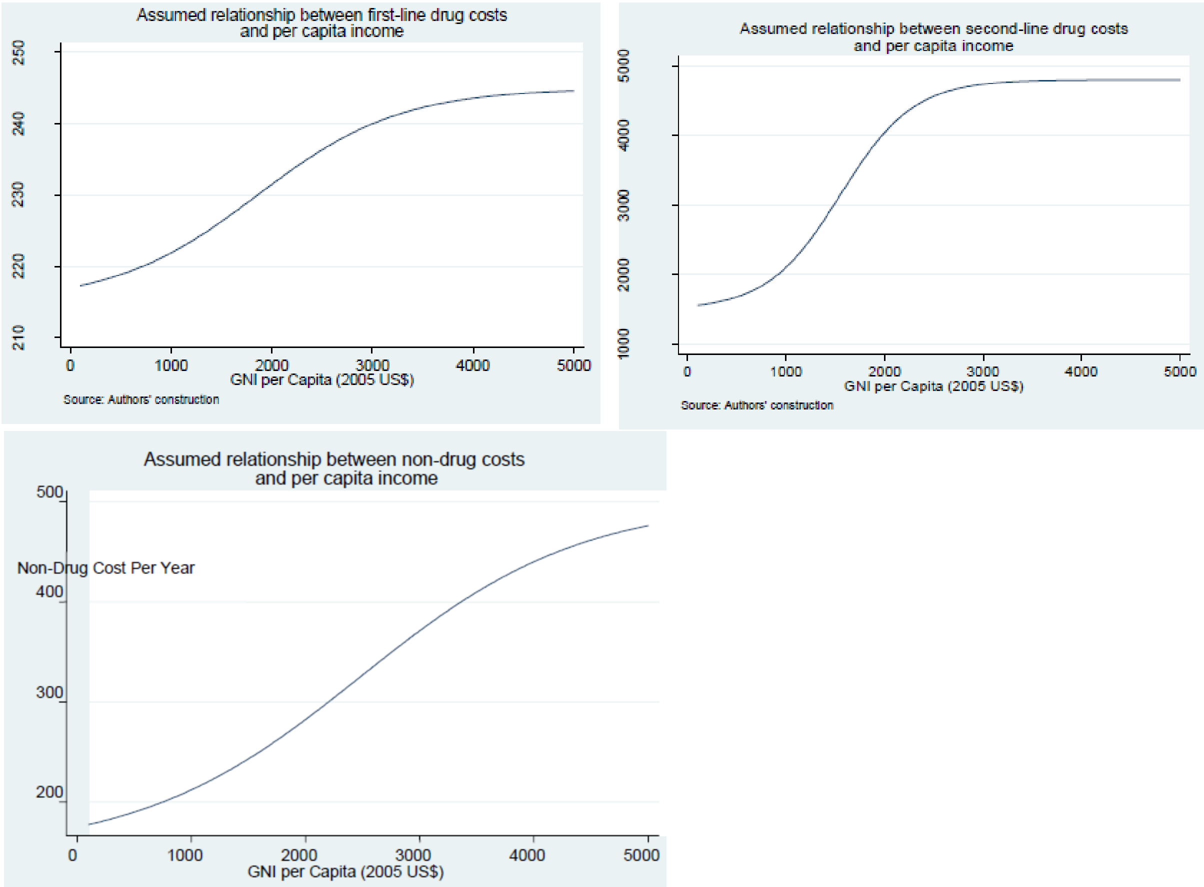
Considering the above, it is our contention that the following changes be investigated by the model designers:

- Adding adjustable target levels and rates of total ART coverage
- Allowing for the direct adjustment of levels and rates of *uptake* of 1st line treatment
- Allowing for coverage levels to remain constant beyond a certain date
- Providing for a more gradual progression from initial rates to target rates of coverage, possibly in the form of a ‘linear/exponential’ option

2. Costing assumptions

Over assumes that costs follow logistic functions of the following forms, and vary according to Gross National Income per capita:

Figure 5 – Costs and GNI



Source: (McCarthy and Over, 2009: 7)

However, there are a number of reasons to believe that these assumed relationships are too simple. Firstly, in low-income settings, non-drug costs may be considerably higher than these curves suggest due to the costs of setting up previously nonexistent primary healthcare infrastructure. Neglecting these costs is likely to lead to serious underestimation of ART rollout costs in very low income settings. Secondly, it seems unlikely that costs are so neatly related to GNI per capita alone. Such a measure neglects the effects the size of the epidemic in a given country may have. Large epidemics, even in middle income countries, could prompt the mobilisation of international civil society behind cost-lowering movements (eg. in South Africa), increase demand for generics and provide economies of scale – all of which may contribute to lower per patient drug costs than AIDSCost would predict.

Perhaps the most disconcerting assumption of AIDSCost is that regarding the way that costs change over time – the assumption, that is, that they do not change at all. We do not consider ourselves able enough to predict future changes in the costs of ART. We do, however, deem it unlikely that costs will not change over time. In the case of Brazil, for example, there was significant variation in the costs of antiretrovirals (ARVs) between 2001 and 2005 (Nunn et al, 2007). In the past, the entry of China and India as producers of ARVs has significantly lowered AIDS treatment costs. ARV producers in countries such as Thailand, Brazil and South Africa, for example, rely heavily on raw materials sourced from these two countries (Grace, 2004). As evidenced by this very debate, the epidemic is not yet under control and the drive to expand access to affordable treatment is still underway.

The Clinton Health Access Initiative, for example, brings together pharmaceutical companies and governments to facilitate bulk orders of combination ARV therapies. Since 2003, the initiative has negotiated pricing agreements with forty formulations of ARVs, together with eight companies, with seventy countries having access to reduced prices for these medicines (Clinton Foundation 2010: online). Its work continues. UNITAID's Medicines Patent Pool initiative, established in July 2010, is doing similarly admirable work in securing ARV price reductions for developing countries (see UNITAID, 2010: online). As another example, on the 14th of December 2010 South Africa's Department of Health announced a new tender for ARV drugs that will see costs decline significantly in the country (TAC, 2010: online). Such examples are illustrative of how substantial price reductions can be achieved through better coordination and bargaining activities - without compromising the incentive to produce drugs. We see no reason to believe that the market for ARVs has reached any kind of stable price equilibrium. This is especially so since ART represents a lifelong commitment to treatment; since it preserves life, increased rollout is only going to provide bigger and bigger markets.

Bongaarts and Over, however, assume that "the effects of greater competition have largely been exhausted for the last generation of first-line drugs. The next generation will cost more because they are still under patent" (2010: 177). This point was pre-empted by Grace (2004). Perhaps this is true. There still, however, seem to be ways of decreasing costs related to this last generation. Mozambique has just unveiled plans to build the first public factory for ARVs in Africa, which is set to begin producing its own pills by 2012 (Timeslive, 2010: online). Regardless of whether drug prices will rise or fall, the point is that they will change. AIDSCost cannot afford to ignore this.

We propose that the following is required:

- An option to discount or inflate prices should be added. Price changes would have perhaps the most obvious and significant effect on the future cost-effectiveness of ART. Gauging the effects of different pricing assumptions, thus, is pivotal.

- It would be helpful if users were allowed the option of inputting actual price data for individual countries and years rather than relying on assumed cost curves. Spectrum (another AIDS projection model), for instance, allows users to input national survey data through which modelled results are forced (Stover, 2004). Even a few actual numbers would increase the precision of the estimates. Further, without this option no use can be made of future advances in ARV costing and data collection.

3. Incidence assumptions

AIDSCost assumes that incidence in each year is some constant multiple of incidence in the previous year. The default value for *incmult* is 0.95, or a 5% decline in incidence each year. This, however, completely neglects any effect that ART might have on prevention. Much evidence has been presented in support of the proposition that high ART coverage rates reduce HIV incidence – see, for example, De Cock et al (2009), Castilla et al (2005), Reynolds et al (2009), Janssen et al (2001) and Montaner et al (2006). Mathematical modelling – by Blower and Farmer (2003), for example – has added further weight to this proposition. In Brazil, between 2000 and 2001, widely available ART led to a 58% decline in new cases of HIV (Blower and Farmer, 2003); Granich et al (2009), meanwhile, posit that universal ART coverage in Sub-Saharan Africa would reduce incidence by 95%. While expanding ART coverage keeps people alive longer, thereby increasing HIV prevalence, treatment decreases viral load and thus renders each individual significantly less infectious. De Cock et al give a succinct summary of the logic:

> "Transmission only occurs from infected persons who are numerically far fewer than HIV-negative susceptible persons; viral load is the greatest risk factor for all modes of transmission; ART [Antiretroviral Treatment] lowers viral load; prevention of mother-to-child transmission offers proof of concept; and there is observational evidence of reduced transmission from discordant heterosexual couples when the index partner is on ART" (2009: 488).

Large-scale behavioural disinhibition – ie. when those on ART engage in more risky sexual behaviour because they perceive themselves to be less infectious – could counteract this effect. Crepaz et al (2004), however, conducted a metaanalysis of the literature on the subject during the period 1996-2003 and found no evidence to suggest that people receiving Highly Active Antiretroviral Therapy (HAART) exhibited an increase in sexually risky behaviour. Kennedy et al (2007), too, conducted a review of the relevant literature during the period 1990-2006 and, similarly, found no evidence that ART is associated with sexually risky behaviour in developing countries. Though there is certainly space for more work in this area – Kennedy et al found only three primary articles that met their criteria – there is as yet little reason to believe that ART is firmly associated with behavioural disinhibition. Another issue is that the preventative effects of ART may depend on high and sustainable levels of coverage. However, an assumption of *universal ART coverage* in AIDSCost's defaults *still* delivers the same decline in HIV incidence of 5% each year. In light of the various pieces of research available on the relationship between ART and HIV incidence, the exclusion of any kind of dynamically estimated incidence variable represents a sizeable error.

4. Death rates vs. failure rates

The AIDSCost manual gives a rather confusing explanation of *adrate2*. Initially, *adrate2* is described as "the rate at which people fail first-line therapy and therefore become eligible for second-line therapy" (2009: 35). When the model is run, however, the definition for *adrate2* is "ART death rate during subsequent years on 1^{st} line". To resolve this, consider the equation for post-first-year-first-line therapy (McCarthy and Over, 2009: 35):

(1)

$$\Delta a2 = \big((1 - \boldsymbol{adrate}) * a1\big) - (\boldsymbol{adrate2} * a2))$$

The second term, meanwhile, is decomposed thus:

(2)

$$\boldsymbol{adrate2} * a2 = (\boldsymbol{adrate2} * (1 - cvrg2) * a2) + (\boldsymbol{adrate2} * cvrg2 * a2)$$

Equation (2), using the first definition, merely states that the number of those from the post-first-year-first-line ART group needing second-line ART is made up of those needy receiving second-line ART and those needy not receiving second-line ART. This makes sense. A quick look at these equations will confirm that *adrate2* does not make sense if read as a straightforward death rate. If it denoted such a rate, equation (1) would state that changes to *a2* were made up of all those surviving first-year-first-line ART minus all those that died in *a2*. If death were the only outflow from *a2,* however, no one would move to second-line therapy. Patients, it seems, first fail post-first-year-first-line therapy and *then* either move on to 2nd line therapy or die. Therefore, as long as *cvrg2* is positive the number of patients that die will always be less than the number of those that fail post-first-year-first-line therapy, since the latter includes the former. This is not a trivial error, as the incorrect definition is the one presented in both the model interface and model printout. Since death rates and failure rates can be very different, users are likely to both misuse and misread AIDSCost.

Section 3 – comparing AIDSCost to ASSA2003

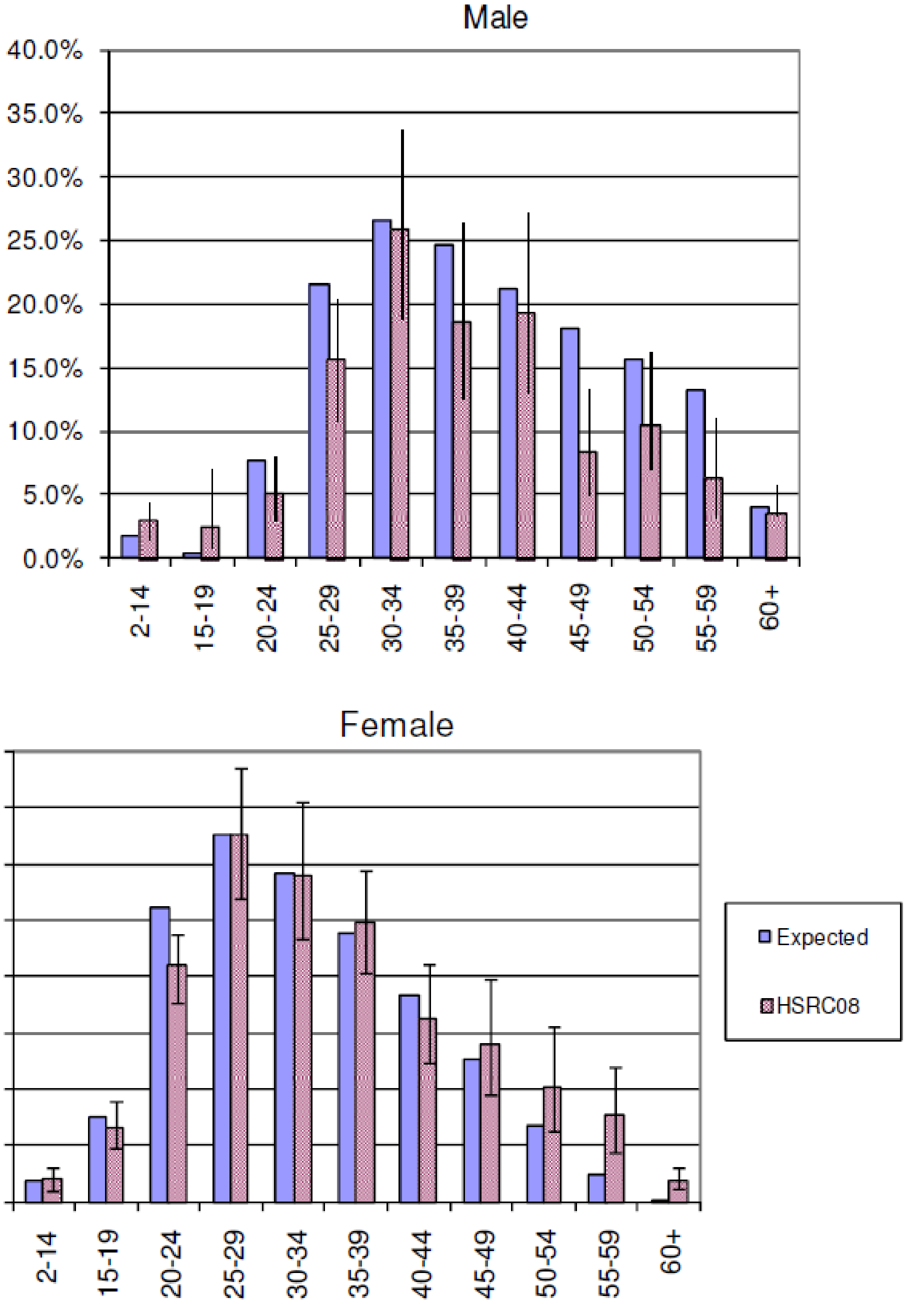
This section compares AIDSCost's outputs with those of the ASSA2003 model for South Africa. ASSA2003 is a demographic model which can be used to project the course of the epidemic with and without ART. It was released in 2006 but, because it used HIV prevalence data from Antenatal clinics up until 2003, it is known as ASSA2003. The model makes use of a substantial amount of demographic data and has been calibrated to fit actual death rates by age, race and gender. As discussed below, its projections are consistent with national HIV surveys of population-level HIV prevalence and it is hence seen as a very reliable model of the South African AIDS epidemic. Comparing the demographic projections of AIDSCost with those of ASSA2003 for South Africa is thus an appropriate test of the model's reliability.

1. Methodology

In the tables below, we compare the outputs of the AIDSCost model for South Africa for the period 2007-2016 to those of ASSA2003 for the same period. Since AIDSCost allows for the adjustment of only a few parameters, and owing to discrepancies between the models, it is not possible to estimate both using precisely the same assumptions. ASSA2003, for example, does not differentiate between first- and second-line treatment, while AIDSCost does not allow for the specification of a target level for ART coverage (as previously discussed) as ASSA2003 does. The models, thus, are not directly comparable. This, of course, does not change the fact that both will be used, and have been used, to leverage competing arguments that are of vital importance for policy-making (see, for example, Over [2008] and Nattrass and Geffen [2005]). So even though the models' infrastructure is not directly comparable, their outputs – which are broadly the same – are.

Considering the South African case allows us to use ASSA2003 as a reliable benchmark – as it was designed to apply only to South Africa, it uses much more specific data than AIDSCost. We note that the model's estimates correlate well with actual survey data. The 2008 Human Sciences Research Council household prevalence survey, for example, follows the ASSA2003 projections quite closely:

Figure 6 – ASSA2003 estimates for HIV prevalence in 2008 vs. HSRC's national survey of HIV prevalence in 2008



Source: Dorrington (2009: 632)

This point is echoed by Rehle and Shisana (2009: 634). This consistency was also in evidence after the 2006 HSRC survey (see Gallo et al, 2006 and ASSA, 2006, for example). Kibel et al, meanwhile, go so far as to refer to the model as "the gold standard" (2010:132). While, as with any model, there are issues – Dorrington (2009: 631), for example, mentions that the model may slightly overestimate male prevalence – it has proven itself robust in estimating the aggregated outputs that AIDSCost provides. Insofar as we may view AIDSCost's country-specific outputs as a proxy for its overall quality, and insofar as our assumption regarding ASSA's reliability holds, we may view large discrepancies with ASSA as indicators of AIDSCost's flaws.

The National Strategic Plan for HIV/AIDS calls for the provision of 'adequate treatment' (we presume that this includes ART) to 80% of all those that need it by 2011 (Department of Health, 2007: 14). With one year to go, however, it seems unlikely that this target will be met. Thus, we specify a target of 80% coverage, to be reached by 2012, for both models. We believe that this is still rather optimistic, but wish to capture the thrust of actual policy in South Africa. Furthermore, we do not wish to leave ourselves open to the charge of underestimating costs.

We run AIDSCost using all default assumptions except for those regarding target coverage for second-line treatment, which we specify as 80% (*cvrg2)* to be reached by 2012 (target year). As mentioned, we experimented with different *uptake* values until we arrived at the one that corresponded to 80% overall coverage in 2012. Though the uncertainty added a certain edge to the unspectacular business of using STATA, we imagine that the fun would disappear after a very short while. The correct value turned out to be 0.6, or 60% *uptake* each year. The following results are of interest (the full results are included in Appendix A):

Table 1: AIDSCost cost projections 2007-2016

	% overall ART coverage	% 2nd line coverage	# 1st year 1st line	# Subsequent years 1st line ART	# 2nd line ART	Cost 1st line treatment (000s 2006 USD)	Cost 2nd line treatment (000s 2006 USD)
2007	27	5	153,333	281,111	25,555	316,709	135,032
2008	60	17.5	744,001	403,266	27,267	836,357	144,078
2009	70	30	472,320	1,034,416	31,834	1,098,410	168,210
2010	75	42.5	395,778	1,403,958	49,100	1,312,007	259,444
2011	78	55	372,498	1,692,127	79,497	1,505,111	420,062
2012	80	80	362,978	1,948,515	132,850	1,685,078	701,979
2013	82	80	356,352	2,186,366	193,874	1,853,641	1,024,430
2014	84	80	349,747	2,408,937	261,899	2,011,080	1,383,874
2015	86	80	342,507	2,616,860	336,366	2,157,378	1,777,357
2016	87	80	334,576	2,810,166	416,741	2,292,516	2,202,059

Note the ever-increasing overall ART coverage.

We then run ASSA2003 projections using three different scenarios:

1. **ASSA 1** – 80% ART coverage reached by 2012. This scenario most closely resembles AIDSCost's own assumptions regarding ART. As noted, we cannot align all of the models' assumptions. ASSA2003 does, however, provide great flexibility and transparency with regard to its ART assumptions, and allows us to input our own ART coverage levels – in this case, those given by AIDSCost. Since AIDSCost does not allow for investigation of coverage rates before 2007 (where coverage was 27%), and since we are looking to mimic the model's assumptions as closely as possible, we tweak ASSA2003 thus:

Table 2: Tweaking ASSA2003 to fit AIDSCost

	Original ART coverage assumptions		**Tweaked**
2000		2	2
2001		4	4
2002		6	6
2003		8	8
2004		23	23
2005		30	27
2006		37	27
2007		44	27
2008		50	60
2009	"Subsequent"		70
2010	"Subsequent"		75
2011	"Subsequent"		78
2012	"Subsequent"		80
2013	"Subsequent"		82
2014	"Subsequent"		84
2015	"Subsequent"		86
2016	"Subsequent"		87

It may seem puzzling that we kept coverage at 27% for 2005, 2006 and 2007. This has to do with the fact that AIDSCost, as mentioned, only gives us information on coverage from 2007. Since we wish to mimic AIDSCost's assumptions, this forces us to guess at pre-2007 coverage rates. Now, we could have used ASSA's defaults up until 2007 and then switched over to AIDSCost's. ASSA's defaults, however, already exceed 27% total coverage in 2005, with coverage being 30% and 37% in 2005 and 2006 respectively (the ASSA2003 modeller's best estimate of what ART coverage was actually likely to be in those years). Since we wish to avoid the unrealistic assumption that coverage will drop from 37% in 2006 to 27% in 2007 (when we switch to AIDSCost's assumptions), we keep coverage constant at 27% for 2005 and 2006. We see little reason to replace ASSA's pre-2005 coverage with our own imagined figures. Further, we note that other options available to us (say, 24% in 2005 and 26% in 2006) do not vary much from ours. This seems an imperfect but plausible estimation of AIDSCost's own pre-2007 coverage rates. Beyond 2006, we make use of AIDSCost's exact coverage figures (using a 0.6 *uptake* value and 2012 *uptake* target).

2. **ASSA 2** – 80% target reached by 2012, gradual scale-up. This scenario employs AIDSCost's assumptions of ART coverage up to 2007 – as above - but then assumes gradual linear rollout of ART until 2012 (Appendix B).

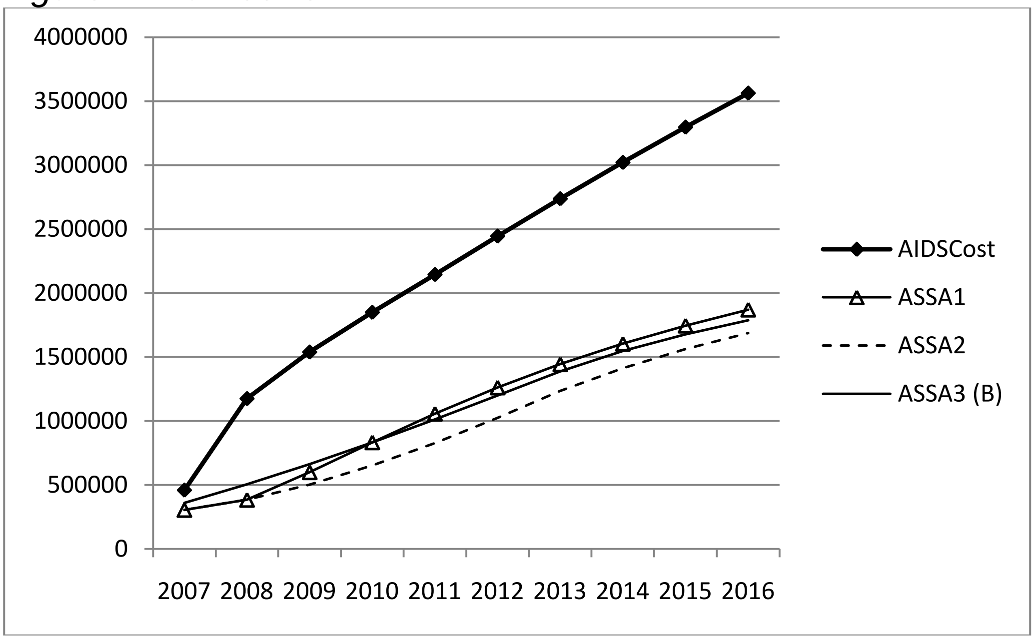
3. **ASSA 3 (baseline)** – Employs ASSA's default ART assumptions, but assumes gradual linear scaling up of ART from 50% in 2008 to a target of 80% in 2012, after which its level remains constant. This scenario arguably represents the best benchmark against which to measure the quality of AIDSCost, as it most clearly demonstrates the full strength of ASSA2003 to model South African reality (Appendix B).

Finally, we compare AIDSCost's results to all three ASSA scenarios.

2. Results

While the full results of these comparisons are included in Appendix C, the following findings are of interest:

Figure 7: Number on ART



Firstly, AIDSCost seems to posit an unrealistically high number of people on ART for almost all periods under consideration and compared to all ASSA scenarios. Adam and Johnson (2009), for example, estimate that 568 000 individuals were enrolled in ART in 2008 (ASSA's baseline projection was 504 548), whereas AIDSCost estimates this figure to be 1 174 534.

Figure 8: HIV+, not AIDS sick

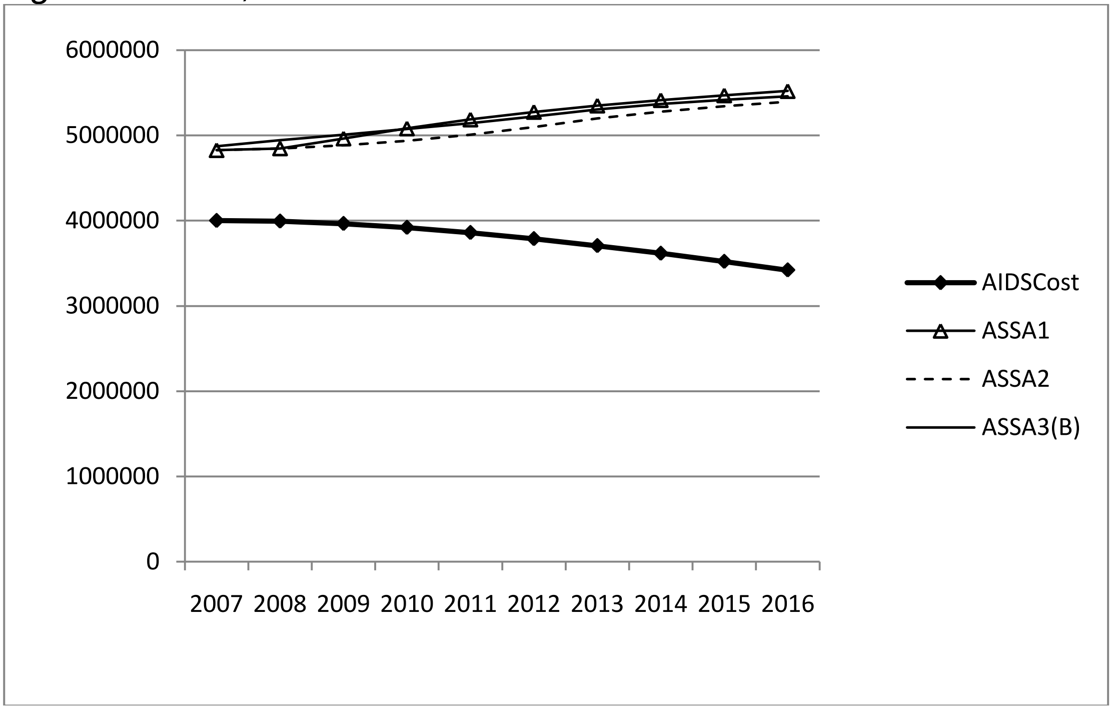
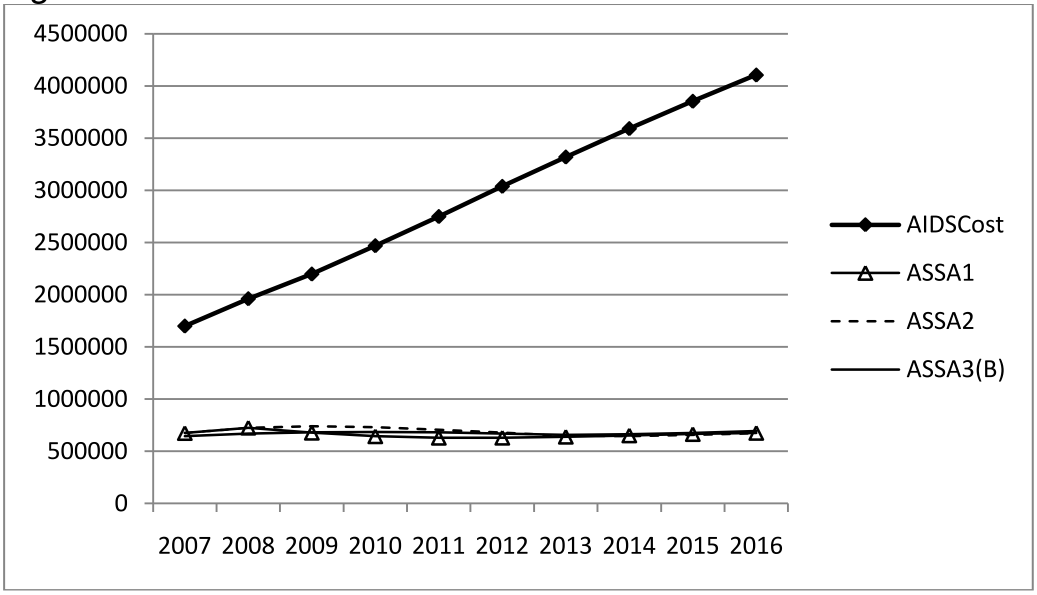
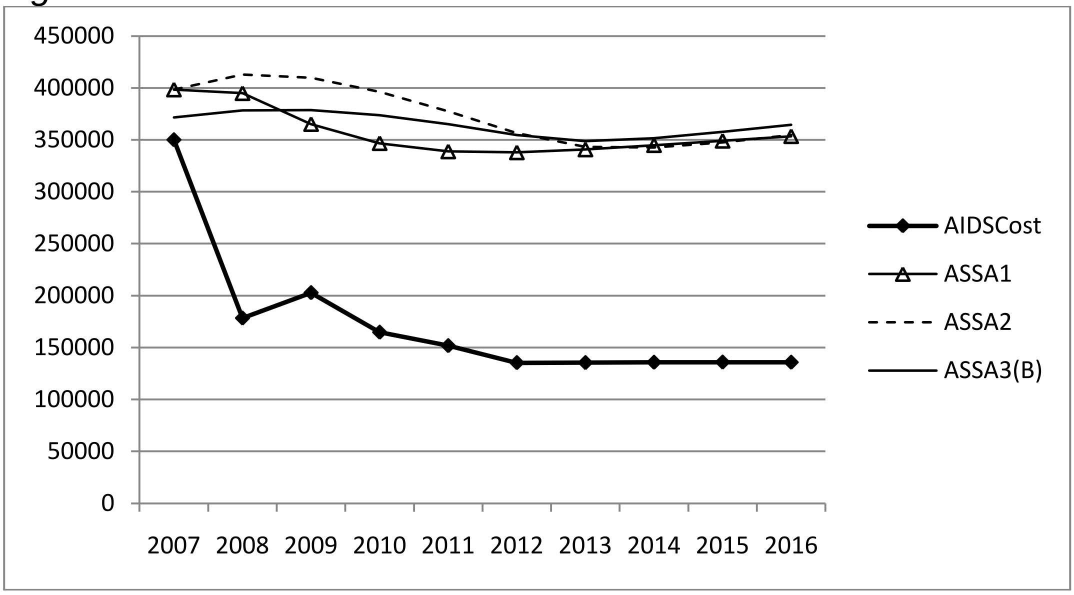


Figure 9: AIDS sick



Secondly, AIDSCost posits that an extremely high proportion of those living with HIV are AIDS sick – ie. requiring ART. ASSA's estimates for 2007 and 2008 are 675 431 and 726 477 respectively. AIDSCost's estimates for 2007 and 2008, by contrast, are 1 700 000 and 1 961 734 respectively. It is these assumptions that feed into the extremely high numbers on ART we have just seen.

Figure 10: AIDS Deaths



Thirdly, AIDSCost seems to take a very optimistic picture of AIDS deaths, assuming them to decline drastically. This is perhaps an indicator of its default death rates – 13% for first-year-first-line ART, 4% for those that fail 'subsequent years' first-line ART and do not receive second-line treatment, and 1% for second-line ART. Cleary et al (2006), referring to a study undertaken in the Western Cape of South Africa, cite an 86.9% survival rate after 12 months of ART (irrespective of drug regimen), which seems more or less in line with AIDSCost's assumption. Between 12 and 24 months, however, this rate drops to 83.4%, while between 24 and 36 months it drops to 79.5% and between 36 and 48 months it drops to 76.2%. In other words, relative to these numbers, AIDSCost does not assume sufficient numbers of people die. Even assuming that its second-line death rates are plausible (Cleary et al's study included mostly first-line ART), those for first-line certainly don't seem to be. As we can see, even controlling for the drastic increase in treatment coverage between 2007 and 2008 (**ASSA1**), ASSA's death estimates are far above AIDSCost's. To again refer to costs, underestimating the tally of the dead will overestimate the costs of treating the living.

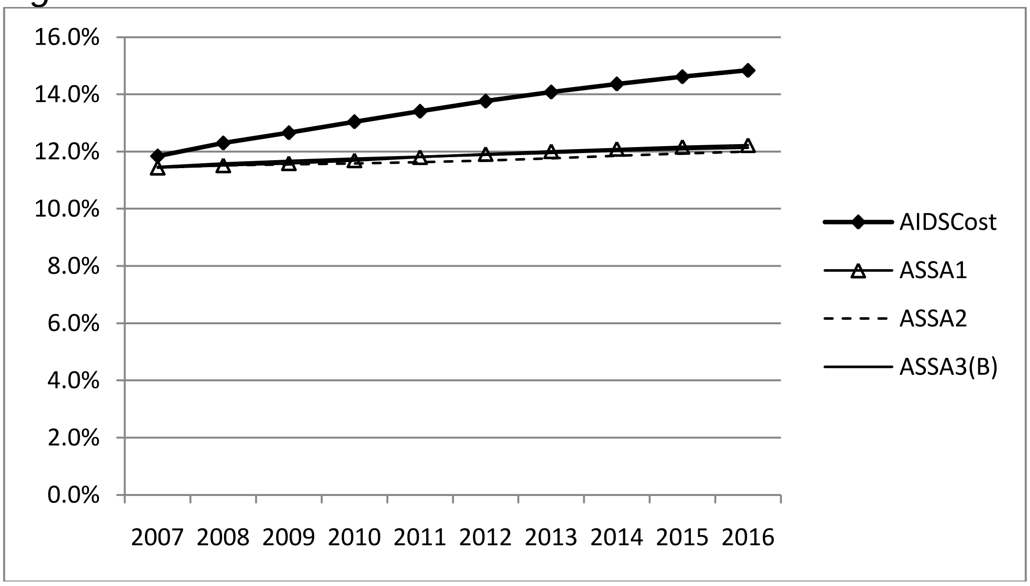
The spike in the curve is peculiar. Using the equation for total deaths given by McCarthy and Over (2009: 36), we did our own manual calculations and found that total deaths in any given year are a function of the previous year's treatment figures. If the second-line death rate is 1% and in 2007 5000 people are on second-line treatment, total second-line deaths will be 50 in 2008. It seems that the kink is a result of the massive amount of people flowing into their first year of first-line therapy in 2008. Death rates in this group are high (13%) and, as their deaths are recorded in 2009, deaths are temporarily boosted in this year. It may seem counterintuitive that putting more people on ART could increase deaths, especially given the 30% death rate among those not receiving treatment. We must remember, however, that 60% of one year's 'unmet need' group are placed on treatment the next year. This effectively takes the death rate of this group to 12% (only 40% do not receive treatment, while only 30% of these die). In 2007, thus, there were roughly 1.2 million people in the 'unmet need' group, but only 12% of these died in 2008. In 2008, however, there were 744 000 people in their first year of first-line therapy (as opposed to 153 000 in 2007), 13% of whom died in 2009.

Table 3: Deaths by treatment regimen, 2008 and 2009

	Without treatment	1st year 1st line	Subsequent 1st line	2nd line	Total
2008	148,800	19,933	9,277	256	178,266
2009	94,464	96,720	11,291	273	202,748

We also noticed that the model's outputs incorrectly list the second-line coverage for 2007 as 0%, when the death calculations clearly take it to be 0.175%. Note that the 2008 figure is also 0.175%, which is at odds with the otherwise constantly increasing levels of second-line coverage.

Figure 11: Prevalence



Lastly, AIDSCost's estimates regarding AIDS deaths affect HIV prevalence rates. AIDSCost's underestimate of AIDS deaths implies that more and more people each year are available to be classified as HIV positive.

Section 4 - costs

1. The difference in dollars

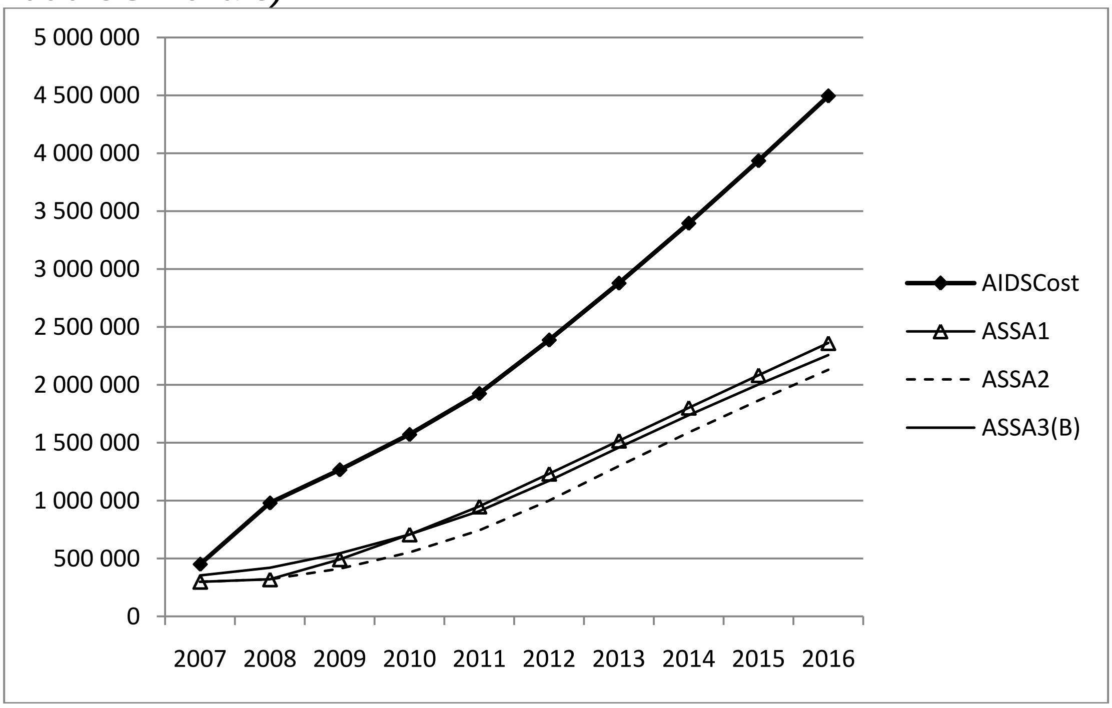
We have an idea of the discrepancies between the models' outputs, but how will these affect cost projections? First, let us consider what happens when AIDSCost does what it was designed to do; namely, assign dollars to the disease. Its cost assumptions for South Africa are as follows:

Table 4: Per patient per annum costs (1000s 2006 USD)

	First line	**Second line**
ARV costs	245	4800
Non-ARV costs	484	484
Total	729	5284

As data on second-line treatment is not presented in ASSA2003, we use AIDSCost's outputs to calculate ratios between first and second-line treatment in each year (Appendix C) and multiply them by ASSA's annual estimates of the number of those on ART. Again, we do this to mimic AIDSCost's own assumptions as closely as possible. Next, we apply the above costing assumption to the ASSA scenarios and achieve the following results:

Figure 12: Projected ART costs for South Africa (1), 2007-2016 (1000s 2006 US Dollars)



	Year	AIDSCost	ASSA1	ASSA2	ASSA3(B)
Cumulative costs	2016	23,284,823	11,769,091	10,211,377	11,563,967
Percentage of AC	2016	100%	50.54%	43.85%	49.66%
Cumulative costs	2012	8,582,484	4,004,145	3,328,950	4,107,696
Percentage of AC	2012	100%	46.65%	38.79%	47.86%

As can be seen, the ASSA2003 baseline projection estimates the costs of expanding ART in South Africa to 80% by 2012 to be approximately half those estimated by AIDSCost at the end of 2016. The exaggeration is even more marked at the end of 2012. Note that even ASSA1, the scenario that most closely mimics AIDSCost's assumptions, estimates costs that are far lower than those put forward by AIDSCost.

Next, we consider an alternative set of costs based on Cleary et al's extensive four-year study of 1729 patients in the Western Cape area of Khayelithsa (2006). The study presents quarterly costs per Markov state (differentiated by treatment regimen and stage of disease) that include clinic visits, days in hospital, ARV costs, Tuberculosis treatment and safety and monitoring laboratory costs (2006: 8). Fortunately, these costs are also presented in 2006 US Dollars. Cleary et al go into some detail regarding the different costs associated with patients of varying CD4 counts. However, as our models offer no means of differentiating beyond the first-line/second-line split we are unable to utilise this detail. Instead, we average the costs across all first-line and second-line patients and arrive at the following annual estimates (AIDSCost's estimates are included for comparison):

Table 5: Cleary et al - per patient per annum costs ('000s 2006 USD)

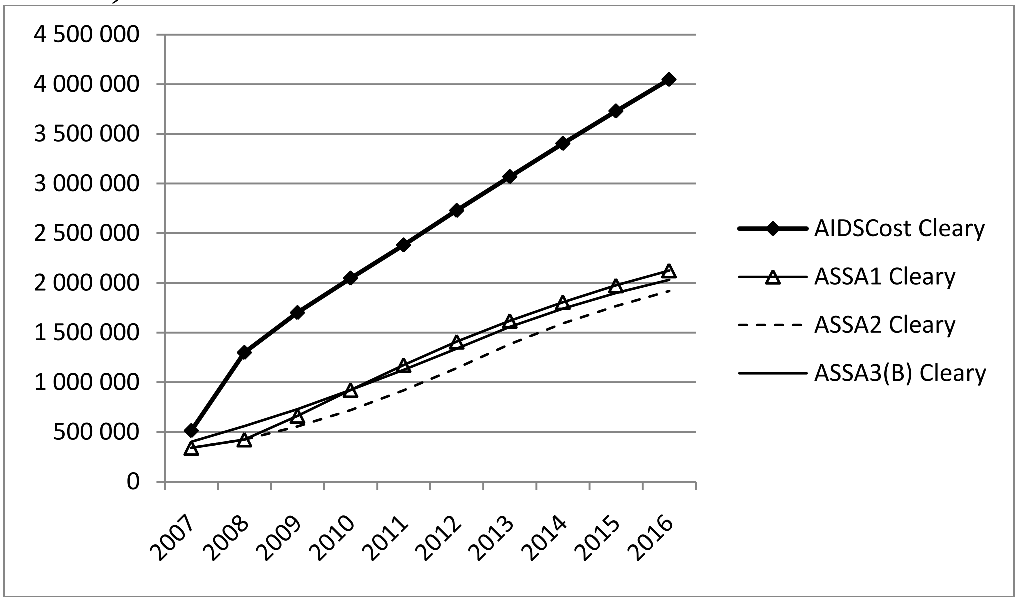
	Cleary et al		AIDSCost	
	First line	**Second line**	**First line**	**Second line**
ARV costs	290.8	952	245	4800
Non-ARV costs	808.2	468	484	484
Total	**1099**	**1420**	**729**	**5284**

AIDSCost's ARV costs for first-line treatment seem roughly in line with Cleary et al's, as do second-line non-ARV costs. Second-line ARV costs, however, seem grossly exaggerated relative to Cleary et al's, while first-line non-ARV costs seem heavily underestimated. The latter assumption seems to support our comments in Section 2; namely, that non-ARV costs are likely to be higher than AIDSCost assumes in developing countries. Tuberculosis may have a significant role to play in this. People infected with the HIV/AIDS epidemic are at greater risk of tuberculosis (see, for example, Arbulu et al, 1993; Chaisson et al, 1987;

Corbett et al, 2003; and Goodman, 1995) and, in countries where health resources are strained, the two diseases may develop alongside one another and add to treatment costs.

When we apply these costing assumptions to our scenarios, we obtain the following results:

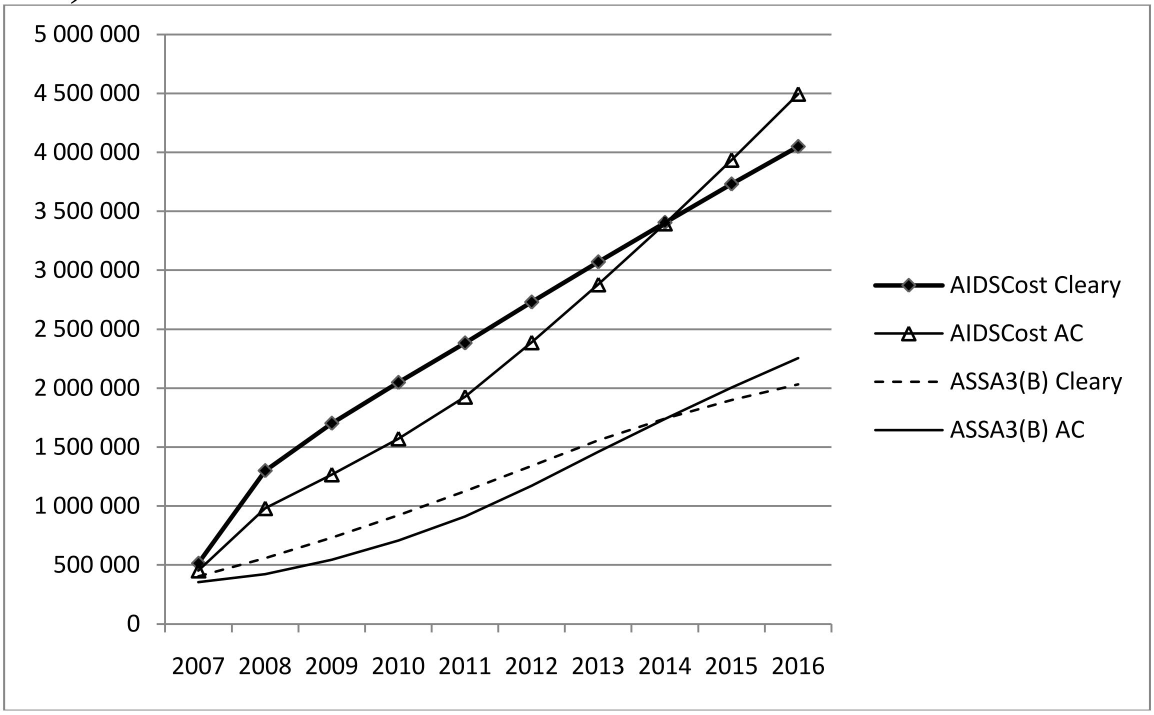
Figure 13: Projected ART costs for South Africa (2), 2007-2016 (1000s 2006 US Dollars)



	Year	AIDSCost Cleary	ASSA1 Cleary	ASSA2 Cleary	ASSA3(B) Cleary
Cumulative costs	2016	24,924,199	12,463,001	10,767,360	12,307,560
Percentage of AC Cleary	2016	100%	50%	43.20%	49.38%
Percentage of AC	2016	107.04%	53.52%	46.24%	52.86%
Cumulative costs	2012	10,672,933	4,935,362	4,103,167	5,078,061
Percentage of AC Cleary	2012	100%	46.24%	38.44%	47.58%
Percentage of AC	2012	124.36%	57.51%	47.81%	59.17%

Again, AIDSCost overestimates cumulative costs by approximately 100% in 2016 and slightly more in 2012. The 'Percentage of AC' row denotes each scenario's costs as a percentage of AIDSCost's original cost estimates. It is interesting to note that Cleary et al's costing assumptions imply greater cumulative costs than those of AIDSCost. This has to do with the higher proportion of those on first-line treatment – Cleary et al's first-line costs are much greater than AIDSCost's. Considering cumulative costs, however, obscures important dynamics in the projections. Consider the following figure, which shows the AIDSCost and ASSA2003 baseline cost projections for both sets of cost assumptions ('AC' being AIDSCost's, 'Cleary' being Cleary et al's).

Figure 14: Total ART costs, Cleary et al costs vs. AIDSCost costs (1000s 2006 USD)



We see that, as time progresses and the proportion of those on second-line treatment grows, AIDSCost's massive second-line ARV costs push up its estimates.

2. Implications for Over's arguments

In a 2008 paper, Mead Over used the AIDSCost model to argue that US-funded global AIDS treatment "could grow to as much as $12 billion a year by 2016 – more than half of what the United States spent on total overseas development assistance in 2006" (2008: 1). The latter figure is based on an 'aggressive' *uptake* rate of 95%. A figure of $4.5 billion applies to the historical *uptake* rate of PEPFAR (President's Emergency Plan for AIDS Relief), 17.9%. Over argues that, should treatment continue to expand, more and more of this funding will go toward so-called 'entitlement spending', which refers to spending on those already receiving ART. Since taking a person off ART is tantamount to unplugging them from life support, the US would risk severe damage to its reputation by cutting back on such spending. In order to avoiding saddling itself with ballooning commitments it can't get rid of, to put it crudely, the US should shift focus away from treatment and toward prevention. It is not the focus of this paper to critique the notion of 'entitlement', and nor is it our place to voice concerns about the trivialisation of human life into the language of political expediency. It does, however, concern us that the projected magnitude of these entitlements is based on all of AIDSCost's defaults. Considering our discussion above, we are not convinced that the numbers Over offers are reliable. We are of the firm opinion that, in scenarios requiring careful examination of costs, AIDSCost is not to be trusted.

Conclusion

Forming a clear idea of the future costs of ART represents the first step towards answering the vital (literally) question of the cost-effectiveness of ART. McCarthy and Over's attempts to model these costs, thus, are laudable. We would do well, however, to note that misinformation is often worse than no information at all, and that every model pretending its fair share of reality should be approached with similarly fair shares of critique and testing. Its authors' intentions notwithstanding, our analysis has shown that there is good reason to believe that AIDSCost, in its current incarnation, is not a sufficiently reliable yardstick against which to measure policy. It produces outputs that reflect highly questionable assumptions, each of which feeds into multiple parameters and compounds problems of cost estimation. In our case, that of South Africa, AIDSCost showed severe discrepancies with the country's leading HIV/AIDS projection model, ASSA2003, its outputs implying an overestimation of costs in excess of 100%. This is no idiosyncrasy of pricing. While we recognise that South Africa is one among many countries, we note that the faults in the model seem less a function of country-specific cost assumptions than flaws in its underlying structure. Until such flaws are attended to, the debate on which costs to use in the model will remain peripheral. AIDSCost needs to tinker on its spine before it begins choosing appendages.

As noted, McCarthy and Over have solicited comparisons with other models, ASSA2003 among them. We deem this constructive and have, through our critique, attempted to provide workable suggestions for the improvement of their model. We do find it curious, however, that Over made use of the model (in 2008) before these solicitations were made (in 2009). It is our opinion that, given the true gravity of the millions being weighed, using the model to support claims regarding the unmanageability of ART without its first being properly tested is both careless and irresponsible. Further research is required to investigate whether AIDSCost performs better in countries other than South Africa. Until then, however, its numbers regarding the ballooning 'entitlement' will contain more than a little hot air.

Appendices

Appendix A – AIDSCost projections 2007-2016

AIDSCost with tweaks: 2nd line coverage level (80%) and target year (2012). All cost figures are in thousands of 2006 US Dollars

	HIV not AIDS sick	Unmet need	# on ART	% coverage - ART	People living with HIV	New infections	Adults needing ART	AIDS deaths	# 1st year 1st line	# Subsqnt years 1st line ART	# 2nd line ART
2007	4,000,000	1,240,001	459,999	27	5,700,000	432,857	1,700,000	350,000	153,333	281,111	25,555
2008	3,992,857	787,200	1,174,534	60	5,954,591	411,214	1,961,734	178,266	744,001	403,266	27,267
2009	3,964,857	659,630	1,538,570	70	6,163,057	390,653	2,198,200	202,748	472,320	1,034,416	31,834
2010	3,919,375	620,831	1,848,836	75	6,389,042	371,120	2,469,667	164,667	395,778	1,403,958	49,100
2011	3,859,364	604,964	2,144,122	78	6,608,450	352,564	2,749,086	151,713	372,498	1,692,127	79,497
2012	3,787,398	593,920	2,444,343	80	6,825,661	334,936	3,038,263	135,352	362,978	1,948,515	132,850
2013	3,705,720	582,911	2,736,592	82	7,025,223	318,189	3,319,503	135,374	356,352	2,186,366	193,874
2014	3,616,280	570,844	3,020,583	84	7,207,707	302,280	3,591,427	135,705	349,747	2,408,937	261,899
2015	3,520,769	557,627	3,295,733	86	7,374,129	287,166	3,853,360	135,859	342,507	2,616,860	336,366
2016	3,420,651	543,420	3,561,483	87	7,525,554	272,808	4,104,903	135,740	334,576	2,810,166	416,741

	Total cost of ART	Funding gap - ART	Discretionary spending	Discretionary spending (% total)	Entitlement spending	Entitlement, 1st line	Entitlement spending (% total)	2nd line coverage	Cost 1st line (000s 2006 US$)	Cost 2nd line (000s 2006 USD)
2007	451,741	0	0	0	451,741	316,709	100	0.0	316,709	135,032
2008	980,435	622,887	542,376	55	438,059	293,981	45	0.175	836,357	144,078
2009	1,266,620	540,534	344,321	27	922,299	754,089	73	0.3	1,098,410	168,210
2010	1,571,451	578,300	288,522	18	1,282,929	1,023,485	82	0.425	1,312,007	259,444
2011	1,925,173	574,552	271,551	14	1,653,622	1,233,560	86	0.55	1,505,111	420,062
2012	2,387,057	504,497	264,611	11	2,122,446	1,420,467	89	0.8	1,685,078	701,979
2013	2,878,071	507,310	259,781	9	2,618,290	1,593,860	91	0.8	1,853,641	1,024,430
2014	3,394,954	508,567	254,965	8	3,139,989	1,756,115	92	0.8	2,011,080	1,383,874
2015	3,934,735	508,341	249,687	6	3,685,048	1,907,691	94	0.8	2,157,378	1,777,357
2016	4,494,575	506,773	243,906	5	4,250,669	2,048,610	95	0.8	2,292,516	2,202,059

Appendix B – ASSA2003 vs. AIDSCost

Year	AIDSCost	**ASSA1**	ASSA2	**ASSA3**	AIDSCost	**ASSA1**	ASSA2	**ASSA3**	AIDSCost	**ASSA1**	ASSA2	**ASSA3**
	HIV+, not AIDS sick*				**Unmet need ART****				**# on ART*****			
2007	4,000,000	4,826,839	4,826,839	4,871,134	1,240,001	591,801	591,801	546,114	459,999	305,154	305,154	360,479
2008	3,992,857	4,847,552	4,847,552	4,942,828	787,200	620,839	620,839	530,429	1,174,534	383,933	383,933	504,548
2009	3,964,857	4,963,371	4,883,760	5,007,241	659,630	513,516	601,596	501,486	1,538,570	599,628	501,415	661,441
2010	3,919,375	5,081,511	4,937,253	5,073,573	620,831	415,077	550,815	456,697	1,848,836	833,299	651,379	832,455
2011	3,859,364	5,186,479	5,008,192	5,144,224	604,964	338,633	479,711	401,109	2,144,122	1,057,517	827,368	1,012,951
2012	3,787,398	5,275,640	5,095,831	5,220,683	593,920	281,841	396,380	338,817	2,444,343	1,262,114	1,023,452	1,199,016
2013	3,705,720	5,350,069	5,198,724	5,303,602	582,911	240,109	306,564	272,996	2,736,592	1,443,532	1,234,661	1,387,754
2014	3,616,280	5,413,810	5,279,377	5,367,779	570,844	207,210	253,774	233,920	3,020,583	1,603,788	1,413,032	1,546,129
2015	3,520,769	5,469,862	5,342,934	5,417,788	557,627	179,690	221,784	209,874	3,295,733	1,745,265	1,562,759	1,678,065
2016	3,420,651	5,520,372	5,393,211	5,456,962	543,420	155,555	201,930	194,611	3,561,483	1,870,507	1,687,813	1,787,321

Year	AIDSCost	ASSA1	ASSA2	ASSA3	AIDSCost	ASSA1	ASSA2	ASSA3	AIDSCost	ASSA1	ASSA2	ASSA3
	# living with HIV				**New infections**				**Adults needing ART^**			
2007	5,700,000	5,502,269	5,502,269	5,515,866	432,857	498,654	498,654	496,102	1,700,000	675,431	675,431	644,733
2008	5,954,591	5,574,029	5,574,029	5,611,719	411,214	491,338	491,338	486,386	1,961,734	726,477	726,477	668,890
2009	6,163,057	5,641,567	5,623,507	5,690,735	390,653	478,507	482,936	477,408	2,198,200	678,196	739,747	683,495
2010	6,389,042	5,725,750	5,667,694	5,759,844	371,120	467,174	474,051	468,866	2,469,667	644,239	730,441	686,271
2011	6,608,450	5,816,653	5,716,289	5,825,223	352,564	458,332	465,477	461,207	2,749,086	630,174	708,097	680,999
2012	6,825,661	5,906,350	5,775,058	5,891,374	334,936	451,866	457,606	454,592	3,038,263	630,710	679,226	670,691
2013	7,025,223	5,990,197	5,846,944	5,961,315	318,189	447,359	450,631	449,023	3,319,503	640,128	648,220	657,713
2014	7,207,707	6,066,443	5,924,980	6,031,168	302,280	444,222	446,273	445,564	3,591,427	652,633	645,604	663,389
2015	7,374,129	6,135,221	5,999,014	6,094,700	287,166	441,911	443,502	443,355	3,853,360	665,358	656,080	676,912
2016	7,525,554	6,197,337	6,065,149	6,149,932	272,808	440,157	441,757	441,951	4,104,903	676,965	671,938	692,969

Corresponding ASSA variables and calculations:

***#HIV+ - AIDS sick **AIDS sick not on ART(Adults+Children) ***Adults + Children (ART) ^AIDS sick ^^#HIV+/ASSA population**

Year	AIDSCost	**ASSA1**	ASSA2	**ASSA3**	AIDSCost	**ASSA1**	ASSA2	**ASSA3**
	% coverage - ART				**Prevalence^^**			
2007	27.0	27.0	27.0	44.0	11.8%	11.4%	11.4%	11.5%
2008	60.0	60.0	37.6	50.0	12.3%	11.5%	11.5%	11.6%
2009	70.0	70.0	48.2	57.5	12.7%	11.6%	11.6%	11.7%
2010	75.0	75.0	58.8	65.0	13.0%	11.7%	11.6%	11.7%
2011	78.0	78.0	69.4	72.5	13.4%	11.8%	11.6%	11.8%
2012	80.0	80.0	80.0	80.0	13.8%	11.9%	11.7%	11.9%
2013	82.0	82.0	80.0	80.0	14.1%	12.0%	11.8%	12.0%
2014	84.0	84.0	80.0	80.0	14.4%	12.1%	11.9%	12.0%
2015	86.0	86.0	80.0	80.0	14.6%	12.2%	11.9%	12.1%
2016	87.0	87.0	80.0	80.0	14.8%	12.2%	12.0%	12.1%

	AIDSCost	ASSA1	ASSA2	ASSA3
Year	**AIDS deaths**			
2007	350,000	398,450	398,450	371,691
2008	178,266	394,937	413,018	378,256
2009	202,748	365,143	409,717	378,806
2010	164,667	346,746	396,330	373,728
2011	151,713	338,767	377,508	365,095
2012	135,352	337,837	356,417	354,515
2013	135,374	340,670	343,139	348,865
2014	135,705	344,798	342,615	351,582
2015	135,859	349,004	347,600	357,575
2016	135,740	353,441	354,706	364,525

Corresponding ASSA variables and calculations:

***#HIV+ - AIDS sick** ****AIDS sick not on ART(Adults+Children)** *****Adults + Children (ART)** **^AIDS sick** **^^#HIV+/ASSA population**

Appendix C – Calculating first-line and second-line proportions from AIDSCost

	# on ART***	1st line 1st year	1st line subsequent	2nd line	Proportion 1st year 1st line	Proportion 1st line subsequent	Proportion 2nd line
2007	459,999	153,333	281,111	25,555	33.33%	61.11%	5.56%
2008	1,174,534	744,001	403,266	27,267	63.34%	34.33%	2.32%
2009	1,538,570	472,320	1,034,416	31,834	30.70%	67.23%	2.07%
2010	1,848,836	395,778	1,403,958	49,100	21.41%	75.94%	2.66%
2011	2,144,122	372,498	1,692,127	79,497	17.37%	78.92%	3.71%
2012	2,444,343	362,978	1,948,515	132,850	14.85%	79.72%	5.43%
2013	2,736,592	356,352	2,186,366	193,874	13.02%	79.89%	7.08%
2014	3,020,583	349,747	2,408,937	261,899	11.58%	79.75%	8.67%
2015	3,295,733	342,507	2,616,860	336,366	10.39%	79.40%	10.21%
2016	3,561,483	334,576	2,810,166	416,741	9.39%	78.90%	11.70%

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