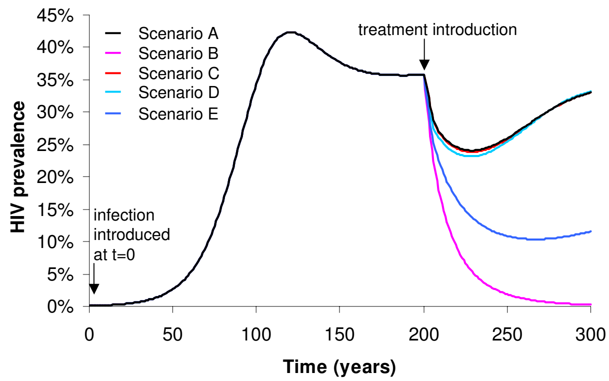

Figure 1
Model predictions of the effect of ART on a mature epidemic, under various assumptions. Model simulations of the potential impact of ART on a mature epidemic, varied by treatment uptake rate, reduction in infectivity due to treatment and impact on risk behaviour at the population level (see Endnote for model description). The model used only incorporates one stage of HIV infection and so individuals initiate treatment at an earlier stage of infection than is realistic, and there is homogeneous sexual mixing. Scenario A – ART uptake = 50% per year, sexual activity post ART = unchanged (2.5 partners per year), reduction in infectivity due to ART = 50-fold. Scenario B – ART uptake = 50% per year, sexual activity post ART halves (1.25 partners per year), reduction in infectivity due to ART = 50-fold. Scenario C – ART uptake = 50% per year, sexual activity post ART = unchanged (2.5 partners per year), reduction in infectivity due to ART = 1000-fold. Scenario D – ART uptake = 90% per year, sexual activity post ART = unchanged (2.5 partners per year), reduction in infectivity due to ART = 1000-fold. Scenario E – ART uptake = 90% per year, sexual activity post ART = reduced by 20% (2 partners per year), reduction in infectivity due to ART = 1000-fold.

Dynamic model structures

Most dynamic models of HIV transmission investigating the impact of ART are deterministic, with a frequency-dependent (density-independent) transmission term. This means that the rate of (sexual) contact between one individual and others within a population does not depend on the density of the population, as it would, for example, in the case of contacts for air-borne infection transmission. HIV transmission models often incorporate relatively complex patterns of sexual behaviour, with model populations stratified into sexual activity groups by rate of partner change, and assuming different degrees of mixing between groups. However, to date most models specifically designed to examine ART impact have assumed homogeneous risk behaviour (although some of these models have investigated changes in risk behaviour of the general population as a result of ART introduction and/or a change upon diagnosis of HIV [4,5]). More realistic incorporation of sexual behaviour is likely to improve the ability of models to capture the observed timescale of African HIV epidemics, namely steady state being reached over decades rather than centuries. Figure 1 shows projections from a homogeneous sexual activity model, illustrating how, with a homogeneous population, realistic prevalence levels (representing epidemics in sub-Saharan Africa) can only be reached over unrealistic timescales (a full description of the model is provided in the Endnote). However, such homogeneous models can simulate HIV epidemics over realistic timescales if they are assumed to represent the 'at-risk proportion' of the total population only. This means that the population is crudely divided into two groups; one group practices no risky behaviour at all, whereas the other has a relatively high rate of (unprotected) sexual partner change. This structure produces an epidemic curve over a realistic timeframe (decades rather than centuries), without producing unreasonably high prevalence levels for the entire population (at-risk and not at-risk).

More sophisticated models incorporating sexual behaviour include partner models [28,29] and network models [30,31]. Gray et al [2] use a stochastic simulation incorporating individuals and their contacts, although some assumptions are not clear in the available publication. The need for complexity will depend on the nature of the research question [32]. For example, where changes in sexual behaviour as a result of ART are to be investigated, a more sophisticated description of sexual behaviour is required [30]. Where the effect of ART on transmission is to be investigated, a more realistic pattern of infectivity is required [2,4]. However, while increased complexity can make models more realistic, it also makes them more difficult to parameterise and it more difficult to analyse and interpret model output.

Behaviour change

The possibility of widescale use of ART leading to changes in patterns of risk behaviour, particularly a disinhibition effect, has been of considerable concern. There are competing possible effects; at the individual level, treated patients may increase the frequency of sexual activity due to the severity of their symptoms decreasing, but may receive effective prevention counselling upon treatment initiation, which would decrease the frequency of risky activities. At the population level, in areas with substantial treatment coverage and successful treatment outcomes, there may be an increase in complacency among the general population regarding an HIV diagnosis, leading to increases in risk behaviour. Despite considerable debate [11-15], this relationship has not been convincingly demonstrated in industrialised countries where ART is readily