HIV prevention: to package or not to package

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Description of the topic and theoretical focus

Despite some recent reports that HIV incidence is declining in some populations, after more than twenty-five years into the HIV epidemic, HIV infection continues to spread worldwide, in particular in sub-Saharan Africa. One proposal to improve the effectiveness of HIV prevention that has been advocated forcefully is "prevention packages", i.e. the combination of several prevention interventions either at the population level or at the individual level. But the effectiveness of prevention packages compared to individual prevention interventions is not well-understood. In fact, most models for estimating the impact of prevention interventions are unable to distinguish between effects on outcomes of different types of prevention interventions (behavioral interventions, circumcision, microbicides, treatment-as-prevention etc.). In addition, existing models estimating the effects of HIV prevention interventions typically require calibration based on historical disease trajectory, do not capture the underlying biological and behavioral mechanisms of HIV transmission, and ignore feedback effects in the development of the HIV epidemic. We

- investigate the effectiveness of different HIV prevention packages in comparison to the effectiveness of individual interventions
- compare the effectiveness of prevention interventions implemented separately in a population to the effectiveness of joint delivery of several different prevention interventions to the same individual
- examine the effects of interactions between HIV prevention and antiretroviral treatment (ART).

Methods and data

We investigate the combination of a number of different types of prevention interventions, including interventions reducing HIV acquisition probability per unprotected sex act in men (e.g., circumcision), HIV acquisition probability per unprotected sex act in women (e.g., ART-based microbicides), HIV acquisition in both sexes (e.g., HIV vaccine), transmission risk in men and women (e.g. HIV treatment-as-prevention), the frequency of unprotected sex acts, and the number of sex partners per year. Our model uses simple assumptions of sexual behavior and sexual mixing to compute—given different combinations of interventions—HIV incidence, HIV prevalence, and the level of ART coverage that can be achieved with given resources, and mortality. We examine

outcomes of several prevention packages for the case of South Africa (SA) using published estimates for the parameter values in the model.

Preliminary and expected results

Preliminary results from the model for three prevention interventions—behavioral change which reduces by one third the number of individuals who practice unprotected sex; reduction in HIV acquisition risk in men (e.g. circumcision) and women (e.g. microbicides)—indicate substantial but differing magnitude of their impact (Table 1). For instance, a successful prevention that results in 30% of the population practicing abstinence, can result in an almost 70% reduction in incidence in both men and women, and an almost 60% reduction in prevalence in men and women at the end of 20 years. Similar reductions are obtained for male circumcision and women's use of microbicides, using current best estimates of prevention effectiveness. Our model further quantifies important feedback effects (Table 1): Prevention interventions designed to benefit men (e.g., male circumcision) have a substantial beneficial effect on women and vice versa (interventions for women benefit men). For instance, circumcising half of all men reduces the incidence in men by 43% but also reduces the incidence in women by 34%, because effective prevention of HIV acquisition in men decreases male HIV prevalence and thus the risk of HIV-uninfected women engaging in an unprotected sex act with an HIV-infected man.

These cross-gender feedback effects raise the question whether successful implementation of different prevention interventions for men and women could increase the benefits to both groups, over and above the benefits from group-specific interventions. Table 2 shows that such gains in benefits do indeed occur for some outcomes. Additionally, multiple successful interventions for men and women can reduce incidence to a significantly larger degree in each group than is possible through individual interventions, with incidence reductions from 85% to 95% possible in both men and women – otherwise unachievable using any individual intervention.

Our model can also be used to investigate the preventive function of ART. For instance, if the number of individuals receiving ART continues at the rate observed between 2007 and 2008, we would expect to observe steady declines in incidence over the next few years. In contrast, if the number of people on ART remained constant at the current level or were reduced, incidence levels would rise as a consequence.

In addition to these results, we will present estimated effects of simultaneous delivery of different types of prevention interventions at the individual level and will show the effect on outcomes of changing assumptions about the speed of intervention uptake in the population, sexual mixing patterns, and concurrent partnerships.

Table 1: Relative differences in indicators at 20 years for individual prevention interventions over the base-case values without prevention interventions

	HIV incidence		HIV prevalence		ART coverage		Mortality	
Prevention intervention	Men	Women	Men	Women	Men	Women	Men	Women
Interventions reducing the number of individuals who practice unprotected sex								
Reduction in risky sexual behavior by 30%	-69%	-70%	-58%	-57%	63%	49%	-29%	-40%
Interventions reducing the HIV acquisition risk per unprotected sex act in men								
Reduction in HIV acquisition risk per unprotected sex act by 60% in men, 50% coverage	-43%	-34%	-34%	-24%	30%	12%	-17%	-15%
Reduction in HIV acquisition risk per unprotected sex act by 60% in men, 100% coverage	-76%	-65%	-66%	-50%	94%	31%	-34%	-33%
Interventions reducing the HIV acquisition risk per unprotected sex act in women								
Reduction in HIV acquisition risk per unprotected sex act by 60% in women, 50% coverage	-28%	-38%	-20%	-28%	12%	20%	-9%	-20%
Reduction in HIV acquisition risk per unprotected sex act by 60% in women, 100% coverage	-59%	-72%	-47%	-60%	35%	63%	-21%	-44%

Table 2: Relative differences in indicators at 20 years for "prevention packages" over the base-case values without prevention intervention

	HIV incidence		HIV prevalence		ART coverage		Mortality	
Prevention package	Men	Women	Men	Women	Men	Women	Men	Women
Reduction in HIV acquisition risk per unprotected sex act by 60% in men and in women, 50% coverage both sexes	-59%	-59%	-48%	-46%	47%	35%	-24%	-32%
Reduction in HIV acquisition risk per unprotected sex act by 60% in men and in women, 100% coverage both sexes	-89%	-89%	-80%	-78%	140%	98%	-41%	-56%
Reduction in HIV acquisition risk per unprotected sex act by 60% in men and in women, 50% coverage both sexes, and reduction in risky sexual behavior by 30%	-85%	-85%	-74%	-73%	112%	82%	-38%	-52%
Reduction in HIV acquisition risk per unprotected sex act by 60% in men and in women, 100% coverage both sexes, and reduction in risky sexual behavior by 30%	-95%	-95%	-87%	-86%	203%	140%	-46%	-63%