Policy Brief

International AIDS Vaccine Initiative

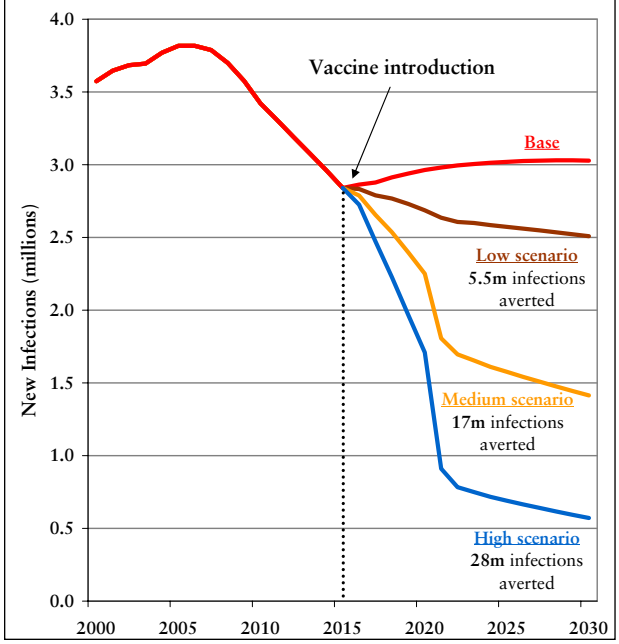
Estimating the Impact of an AIDS Vaccine in Developing Countries

An AIDS vaccine could reduce new infections by half

Twenty-five years into the pandemic, more than 25 million people have died from AIDS, 39 million people are living with HIV worldwide, and four million become newly infected each year.[1] Even as countries expand programs to prevent and treat HIV/AIDS, the 11,000 new infections each day speak to the ever-growing humanitarian, social, and economic burden the world faces. While the global community works to offer treatment and care services to those already touched by AIDS, there is an urgent need to strengthen HIV prevention activities in order to stem the tide of new infections.

Vaccines are consistently among the best tools for fighting infectious diseases. An AIDS vaccine should be considered one of the best hopes to end the spread of HIV. However, questions surrounding potential AIDS vaccines remain: how effective would an AIDS vaccine be? Would a vaccine still be needed if existing prevention programs and antiretroviral treatments (ARTs) are significantly expanded while a vaccine is still being developed? What will be the impact of first generation vaccines if they only provide partial protection against HIV?

Figure 1. New HIV infections in low and middle income countries



A 50% effective vaccine given to just 30% of the population could cut the number of new HIV infections in the developing world by more than half in 15 years.

To address these questions, IAVI has been modeling the future epidemiology of the AIDS epidemic and the impact that a vaccine could have. This analysis shows that including vaccines as part of a comprehensive response can make a significant impact in ending the AIDS pandemic in the coming decades. Additionally, in order to yield significant benefits, a vaccine would not have to be 100% effective or reach 100% of an at risk population. A vaccine that is 50% effective, given to just 30% of the population could reduce the number of new HIV infections in the developing world by more than half over 15 years. A vaccine that is more effective or reaches a greater number of people would have an even larger impact.

Similarly, IAVI's analysis suggests that even if current prevention and treatment services are expanded over the coming decade, in line with ambitious international goals, a vaccine would still have a tremendous beneficial impact in blunting the AIDS epidemic. Thus, a comprehensive response to the AIDS epidemic should include investing in research for a vaccine to complement expanded prevention and treatment programs. As the world strives to implement the existing array of prevention methods, it also needs to find a vaccine to add to the current menu of HIV prevention tools.

This policy brief summarizes recent work conducted by IAVI with support from the Futures Group and describes how a partially effective AIDS vaccine used in conjunction with expanded access to HIV preven-

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tion and treatment programs could slash the number of new HIV infections and save tens of millions of lives.[2]

Models demonstrate the health and economic benefits of AIDS vaccines

Models are mathematical representations of real world phenomena that can be useful for exploring potential scenarios and their ramifications. IAVI, working with the Futures Group, developed an AIDS vaccine model as part of the Spectrum Policy Modeling System, which has been used to explore other AIDS prevention and treatment scenarios. The model is intended to be an easy-to-use tool for national teams to explore the impact of AIDS vaccines on the epidemic in their countries by applying country-specific demographic, epidemiological, and vaccine uptake data.[3,4]

The model enables policy-makers to consider AIDS vaccines with a range of characteristics consistent with the leading vaccine candidates in the research and development (R&D) pipeline, including first generation vaccines which may provide only partial protection against HIV. The model also allows policy-makers to analyze different vaccine delivery scenarios, from broad coverage of the adult population to more targeted vaccination of high-risk groups including injecting drug users, sex workers and men who have sex with men.

IAVI's epidemiological impact modeling project is part of a larger effort to document the need for an AIDS vaccine and to estimate the health and economic benefits that are likely to result from widespread vaccination in countries affected by the disease. Results from this exercise can help build support for AIDS vaccine R&D, and assist decision-makers in thinking about the challenges and issues they are likely to face in the coming decades.

Building on the UNAIDS global estimates model and previous studies of vaccine impact, the model summarized in this paper aims to improve on previously conducted analysis by: [5,6]

- incorporating current thinking of how an AIDS vaccine will work. The model includes the possibility that a first generation product might offer only modest levels of protection from infection but nevertheless, could help reduce the spread of AIDS from an infected person to others or slow the pace at which an infected person becomes ill and succumbs to an AIDS death;
- including the assumption that the range and implementation of other prevention and treatment options will have expanded by the time a vaccine is introduced;
- providing a tool for carrying out a wide range of country, regional, and global assessments of vaccine impact, in contrast to earlier work which largely focused on specific sub-national areas or small population groups.

The vaccine model assumes that universal access goals are achieved

The United Nations (UN) has called on countries to provide universal access to a comprehensive package of HIV prevention, treatment and care services including: HIV education programs including stigma reduction, condoms, treatment for sexually transmitted infections, antiretroviral therapy, and social programs. The UN has set coverage targets for these services, depending on whether the epidemic is low-level, concentrated, or generalized in each country.[7] Based on these guidelines, countries have set their own specific goals and have committed to try to reach them by 2010.

As a part of the baseline scenario, the vaccine model described here optimistically assumes that the UN universal access goals for expanded prevention and treatment will be met and sustained through 2015, when a vaccine is also assumed to be introduced. The model reinforces the findings from other recent studies showing that although the ambitious targets set by the UN would lower the number of new infections and reduce cases of AIDS-related disease and deaths, achieving these goals will not be sufficient to end the pandemic.[8] It is estimated by UNAIDS that three million people would still be newly infected each year through 2015, indicating that an AIDS vaccine would play an important role.

The model provides national, regional, and global projections of vaccine impact

The analysis described here used the following seven countries (in four regions) to build an estimate of the epidemiological impact of vaccines for the developing world as a whole: Nigeria and South Africa (Sub-Saharan Africa), Brazil and Mexico (Latin America), China and India (Asia), and Russia (Eastern Europe). These countries were selected because they are representative of the epidemic in their regions and because

they are among the countries with the greatest absolute numbers of infections. Collectively, they contain 46% of people living with HIV and 70% of all new adult HIV infections in the developing world.

Using readily available data, projections of the HIV epidemic to 2030 were made for each of the selected countries, reproducing the key dynamics of the HIV epidemic in each country. [9] The country-specific results for each indicator of vaccine impact (prevalence, incidence, deaths averted) were extrapolated to the regional level, based on the countries' proportional contribution to their respective region's epidemic in 2005. The regional totals were then added together to obtain a global total for the developing world.

Table 1 - Vaccine characteristics and coverage

	Scenario		
	Low	Medium	High
General population coverage [12]	20%	30%	40%
Reduction in susceptibility	30%	50%	70%
Reduction in infectiousness	30%	50%	70%
Increase in survival time	100%	100%	100%

First generation vaccines may only provide partial protection

Although the exact level of protection that will be conferred by first generation vaccines is still unknown, scientists believe they may only be partially effective in protecting against HIV.[10] Based on the leading vaccine candidates currently being tested in clinical trials, an AIDS vaccine could have a combination of the following three mechanisms of action:

1. Protect the vaccinated individual against HIV infection (i.e. reduced susceptibility);
2. Reduce the probability that a vaccinated individual who later becomes infected will transmit his/her infection to others, (i.e. reduced infectiousness);
3. Slow the rate of progression from HIV infection to death in vaccinated individuals (i.e. increase in average survival time following infection).

All three of these possible effects are included in the three main scenarios (Low, Medium, and High) that were tested in the HIV vaccine model. Plausible ranges were chosen to reflect current understanding of AIDS vaccine science (Table 1). Coverage levels were based on previous work that indicates uptake of a partially effective vaccine in the general population would be modest.[11]

Partial efficacy vaccines could significantly blunt the AIDS epidemic

The results generated by this new model show that an AIDS vaccine could substantially alter the course of the AIDS pandemic and reduce the number of new infections, even if vaccine efficacy and population coverage levels are relatively low and other programs for treatment and prevention have been scaled up (Figure 1). The model also shows that an AIDS vaccine could significantly reduce the number of deaths attributable to AIDS (Table 2). The reduction in AIDS mortality is smaller than the predicted decrease in new infections, because some deaths will be averted by expanded access to antiretroviral treatment.

With expanded prevention and treatment efforts but no vaccine (the Baseline scenario), the annual number of new adult HIV infections would decrease from approximately 4 million today to 3.2 million by 2015 and would grow slightly after that due to population growth. Seen in this context, a vaccine which is introduced a decade from now would make a big difference:

- In the Low Impact scenario, an AIDS vaccine with 30% efficacy provided to 20% of the population would avert 5.5 million new infections between 2015 and 2030 (11% of the infections that would otherwise be expected), lowering the annual number of new infections in 2030 by 17%.
- In the Medium Impact scenario, an AIDS vaccine with 50% efficacy provided to 30% of the population would avert 17 million new infections between 2015 and 2030 (35% of new infections that would otherwise occur), reducing the annual number of new infections in 2030 by more than half.
- In the High Impact scenario, an AIDS vaccine with 70% efficacy provided to 40% of the population would avert 28 million new infections between 2015 and 2030 (56% of new infections that

Table 2 - The impact of a vaccine on AIDS mortality in developing countries

	Annual infections by the year 2030 (millions)	AIDS deaths in 2030 (millons)	Cumulative AIDS deaths, 2015-2030 (millions)
Base	3.2	2.8	45
Low	2.7	2.5	42
Medium	1.5	2.0	39
High	.6	1.5	36

would otherwise be expected), reducing the annual number of new infections in 2030 by 81%.

In addition to the humanitarian imperative, this analysis helps to illustrate the potential economic benefits of AIDS vaccines. In an environment of universal access to treatment, each infection averted by a vaccine translates into thousands of dollars saved in averted ART costs.[13]

In addition to the three scenarios listed above, several other possible scenarios were also examined:

- More optimistic. Higher levels of coverage yield dramatic results. For example, a vaccine with, 70% efficacy provided to 70-90% of the population would reduce the number of new infections per year by 88-94%, nearly stopping the spread of AIDS.
- Selective targeting. The model suggests that targeting the vaccine to high-risk populations in countries with relatively modest epidemics still achieves 85% of the effect in terms of avoiding infections and saving lives, as compared to vaccinating the general adult population.
- Incomplete achievement of universal access. If the UN goals are not fully achieved, the magnitude of the AIDS epidemic would be greater than predicted in the baseline scenario, and the absolute impact of a vaccine would also be larger.

More work needs to be done

This modeling work shows that even a partially effective vaccine provided to a modest proportion of the population could lead to a major decrease in new HIV infections. Even if a vaccine is first introduced a decade from now in a world where other prevention and treatment activities have expanded, an AIDS vaccine will still make a significant impact. A highly effective vaccine coupled with broad coverage as a part of a comprehensive package of treatment and prevention could come close to stopping AIDS. This underscores the importance of sustaining investments and policy efforts to accelerate AIDS vaccine research and development.

This study used existing data to carry out "desk studies" of vaccine impact for selected countries with large numbers of HIV infected people, but did not include an in-depth country-level analysis. IAVI plans to work next in selected countries with national teams composed of epidemiologists, modelers, public health specialists, and key policy makers to develop in-depth analyses which can be used for advocacy and policy formulation.

In addition, while this study did not attempt to estimate the costs of AIDS vaccines and their delivery, or calculate their cost-effectiveness, it is likely that a vaccine that reduces the number of infections by 20% to 80% would produce significant health and economic benefits and likely be quite cost-effective, even if it is expensive. IAVI plans to incorporate such cost-effectiveness analysis in the next round of its policy research in this area.

Notes and references

[1] UNAIDS. Report on the global epidemic. 2006, UNAIDS: Geneva

[2] See Policy Research Working Paper #8, "The Impact of an AIDS Vaccine in Developing Countries: A New Model and Preliminary Results," for the full report.

[3] Spectrum is freely available online at www.futuresgroup.com.

[4] Stover J. Projecting the demographic consequences of adult HIV prevention trends: the Spectrum Projection Package. Sexually Transmitted Infections. 2004; Vol. 80, Supplement 1. pps: i14-i28.

[5] Available at http://www.unaids.org/en/HIV_data/Epidemiology/episoftware.asp

[6] IAVI Policy Brief #8 and Research Working Papers #4 and #5.

[7] UNAIDS. Resource needs for an expanded response to AIDS in low- and middle-income countries. August 2005.

[8] Stover J, et al. The global impact of scaling up HIV/AIDS prevention programs in low- and middle-income countries. Science. 2006; 311:5766; 1474-1476.

[9] A full list of sources can be found in the annex of IAVI Research Working Paper #8.

[10] IAVI. AIDS Vaccine Blueprint 2006: Actions to Strengthen Global Research and Development. New York: IAVI; 2006.

[11] Esparza J et al. Estimation of needs and probable uptake for HIV/AIDS preventive vaccines based on probable policies and likely acceptance (A WHO/UNAIDS/IAVI study). Vaccine 2003; 21: 2032-2041. Also based on recent unpublished work conducted by IAVI on demand for AIDS vaccines.

[12] The scenarios all assume that vaccination starts in 2015, but take five years to reach peak coverage.

[13] Stover J, et al. 2006.