Projections for HIV/AIDS in Cambodia: 2000-2010

The Cambodia Working Group
on HIV/AIDS Projection

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FOREWORD

Since 1991, when the first case of HIV was detected in the country, Cambodia has been actively responding to the terrible burden imposed by this disease. In the past, the national response has primarily focused on prevention included an extensive condom promotion program, STI services, interventions for high risk groups including sex workers and the uniformed services, establishment and promotion of VCT, and health services strengthening. Increasingly, Cambodia is complimenting prevention with care and support services for people living with HIV/AIDS, their families and their communities. With so many complex and necessary components to the HIV/AIDS response, tools with which to effectively guide interventions play a critical role.

In1995, the National AIDS Control Program (NAP) began HIV surveillance in Cambodia by measuring HIV prevalence among certain populations (HIV sentinel surveillance - a system that grows stronger each year). In 1998, the NAP became known as the National Center for HIV/AIDS, Dermatology and STI (NCHADS) and, since then, NCHADS has continued to lead HIV Surveillance in Cambodia. In 1997, a behavioral surveillance system was developed to collect information on risk behaviors contributing to the disease's spread. There have also been two large scale surveys of sexually transmitted diseases, and well as numerous other smaller scale research activities.

The surveillance system and related research has proved invaluable to understanding HIV in Cambodia. However, it can only answer questions about what has happened in the past and what is happening in the present. As the HIV epidemic matures and care and support of people with HIV becomes even more important, knowing in advance what may drive further disease spread, and who and how many might be affected is critical.

The Asian Epidemic Model, while not able to tell exactly what will happen in the future, is able to look at the past and the present HIV trends and the associated risk behaviors, and project what could credibly happen to HIV among the Cambodian population in the upcoming years. This is a strong weapon in fine-tuning interventions and scaling up resources to match the needs that Cambodia faces, and the model will be updated as new data becomes available.

I would like to thank NCHADS staff and partners for their commitment to making the Asian Epidemic Model a reality in Cambodia. And in particular, I would like to commend the agencies, organizations and individuals who have dedicated themselves to slowing the spread of HIV and assisting the affected people of Cambodia.

Phnom Penh, November 2002

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Background – The Need for Projections

Cambodia has one of the highest HIV prevalences in Asia, making it essential for national planners and program developers to understand the magnitude and potential impacts of the epidemic on the people of Cambodia and on the country's development. Where should prevention resources be allocated to have the greatest impact? What care needs must be anticipated and planned for? How can one most effectively mitigate the impacts of the epidemic?

Any future national planning efforts in the country need to incorporate an HIV/AIDS strategy component. Thus, realistic assessments of the situation are needed to help direct prevention efforts and to assist in mobilizing and targeting the resources needed to provide appropriate care and support for those living with HIV and AIDS and their children and parents. To provide this essential information for Cambodian national planners, the Cambodia Working Group on HIV/AIDS Projection, with support from Family Health International (FHI), USAID and the East-West Center, has developed a model for the HIV epidemic in the country and a new set of HIV/AIDS projections for use in planning. This executive summary presents the most important findings of the first round of projections based on this model.

The Cambodia Epidemic Today – Impacts of Changing Behavior

The current and future state of the Cambodia epidemic

Figure S - 1 shows the number of HIV infections over the course of the epidemic assuming behaviors remain as they were in 2000 through the end of 2010. From this baseline scenario, the state of the Cambodia HIV/AIDS epidemic *today* in 2002 is:

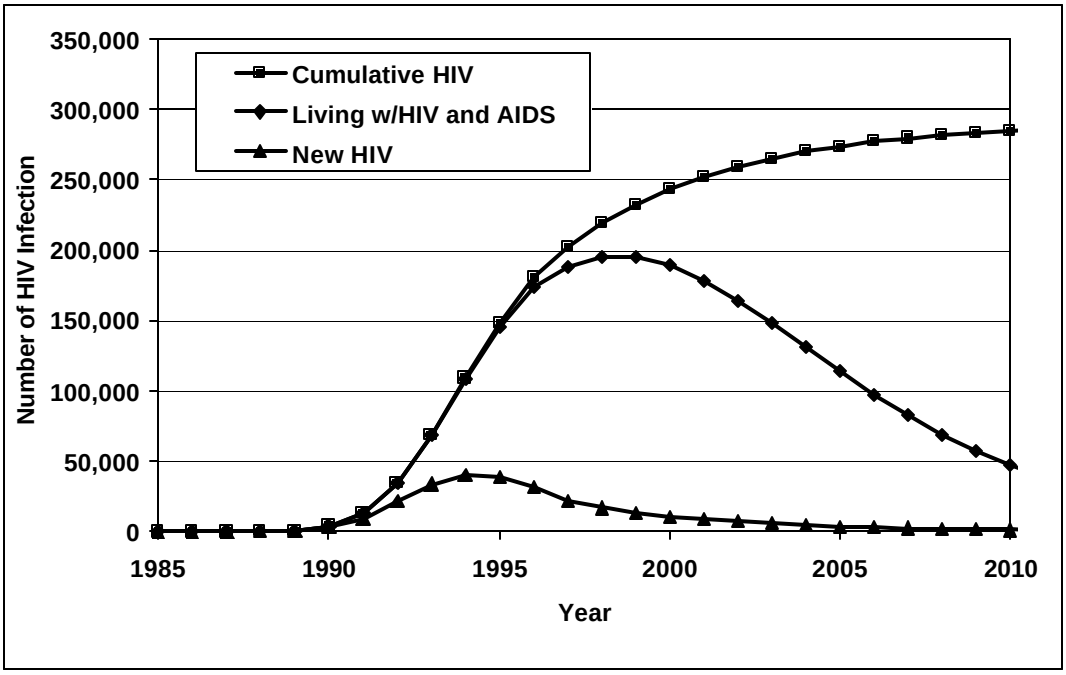
- 259,000 people (238,000 adults and 21,000 children) have been infected with HIV in Cambodia since the start of the epidemic.
- 94,000 of these people have subsequently died of AIDS.
- 164,000 people are currently living with HIV and AIDS in the country.
- 7,300 new infections will occur this year of which 2,600 are children
- 22,400 Cambodians will develop serious AIDS related illnesses this year requiring medical care and 21,200 will die of AIDS complications.

These projections show:

- *Approximately 3 percent of Cambodian men and 2 percent of Cambodian women are living with HIV.*
- *Almost half of new infections at present involve transmission between husbands and wives. New alternatives should be explored to interrupt this transmission, which also leads to the infection of many Cambodian children at birth.*
- *Approximately one-third of new infections are from mother-to-child. Half of these infections can be averted by providing short course AZT or nevirapine to pregnant women.*

- *Over the next five years approximately 20,000 Cambodians a year will die from AIDS related causes.*
- *Over 70 percent of these AIDS related deaths will occur in people aged 20-44, the most productive sector of the workforce.*
- *Unless prevention efforts are sustained at a high level, the epidemic could quickly regain momentum and start to increase rapidly.*

Figure S - 1. Total number of people currently living with HIV and AIDS, new HIV infections, and cumulative HIV infections over time in Cambodia – baseline scenario.



Successes to date – the benefits of the Cambodia response

Cambodia has taken a multisectoral approach to HIV prevention with many sectors of Cambodian society contributing to an aggressive response to the epidemic. Through careful epidemiological and behavioral monitoring beginning in 1994 this response has been directed to change the behaviors producing the majority of new infections. Because most new infections in the early stages of the epidemic were occurring through sex work, major efforts were focused on promoting condom use in sexual interactions and reducing the number of men visiting sex workers. These efforts substantially changed the levels of risk behavior in the country:

- The percentage of adult men visiting sex workers annually has fallen from more than one-quarter of the population in the early 1990s to roughly ten percent in 2000, and

- Condom use when visiting sex workers has become the norm.

The model finds that these behavioral changes, along with the resulting reduction in other sexually transmitted diseases, have had tremendous benefits. They have:

- Prevented approximately 830,000 adult HIV infections through the year 2002. The model shows that without the extensive behavior changes which began in 1992-1993 almost 680,000 males, 360,000 women and 53,000 children would have become infected with HIV by the year 2002, a total of 1.1 million people. Without these behavior changes, roughly 130,000 Cambodians would have been infected with HIV each year between 2000 and 2010.

- Reduced the number of new HIV infections each year from about 40,000 in 1994 to 7,300 in 2002.

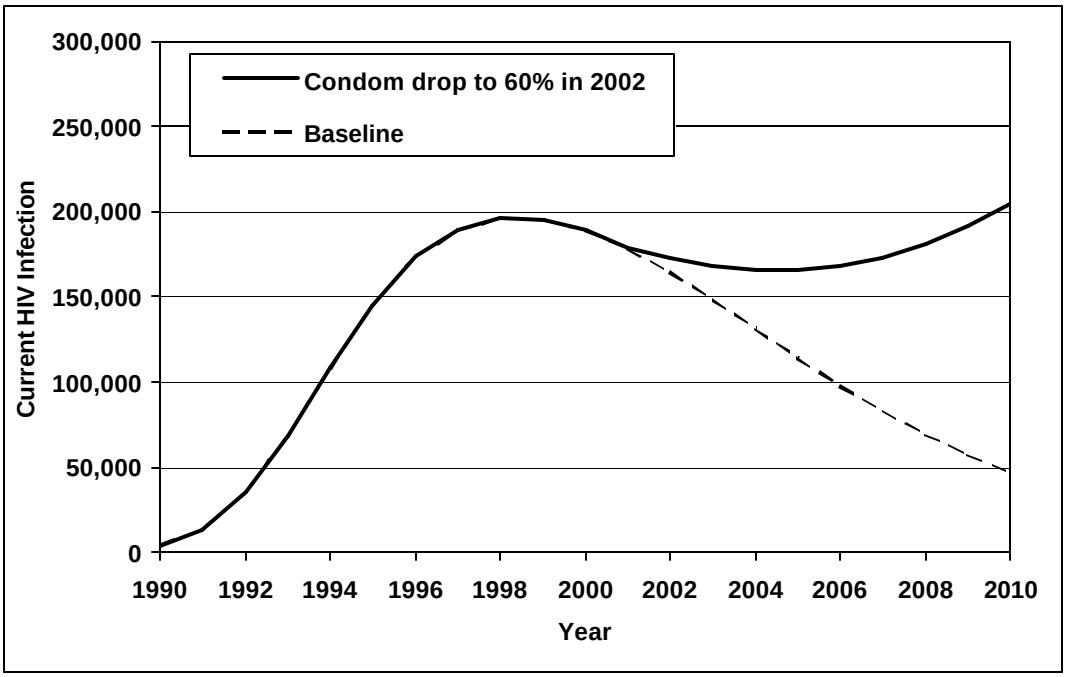
Maintaining these lower levels of transmission in sex work is not an easy task. Despite the risks of HIV infection, many young Cambodian men continue to become clients of sex workers, and sex work is shifting from more obvious brothels to more clandestine indirect forms, which are more difficult to reach with comprehensive prevention efforts. Furthermore, recent efforts to close entertainment venues in some places in the country may have a negative impact by making it harder to maintain the high levels of condom use as sex work shifts into more difficult to reach settings in reponse. Sustaining the success requires a *serious and continuing effort* to ensure that heterosexual risk reduction programs maintain the level of effort and effective approaches in the more direct sites, while evolving and expanding to deal with the ongoing changes in the forms of sex work.

But while sex work largely determined the course of the Cambodia epidemic in the early and mid 1990s, producing 90 percent of new infections in 1990 and 70 percent in 1995, the success of condom promotion efforts for sex workers and clients has recently made other modes of transmission more dominant. The model shows that in the year 2002, almost one-half of new infections involved transmission between husband and wife and one-third from mother to child – only 20 percent were now directly attributable to sex work. These changes highlight a need for expanded prevention efforts to address these other increasingly important modes of transmission, while simultaneously sustaining at a high level the essential efforts to keep HIV transmission through sex work at low levels.

The Need for Vigilance - Sustaining the Success

But while Cambodia's HIV/AIDS prevention efforts have paid great dividends, there is no room for complacency. The model makes clear the serious consequences of any failure to sustain prevention efforts. Figure S - 2 shows the effects of condom use falling to 60 percent between clients and direct sex workers in 2002 – the epidemic once again begins growing explosively as it did in the mid 1990s. With 3 percent of adult Cambodian males living with HIV, any significant drop in condom use will inevitably lead to a resurgence of the epidemic. Thus, intensive multisectoral prevention efforts must be sustained and further expanded to cover other increasingly important forms of transmission, even as care and support needs create greater demands on resources through the future.

Figure S - 2. Effects of failure to sustain high levels of condom use in sex work – rapid epidemic regrowth (Figure assumes condom use between clients and direct sex workers falls to 60% from 86% starting in 2002).



Results of Projections – Four Scenarios for Policy Development

Four scenarios, that is possible alternatives, for the future of the epidemic were designed to compare the effects of different levels of program effort and budget:

Scenario 1 - Baseline – all behaviors remain as they are in the year 2000. That is:

- Approximately 10 percent of adult males visit sex workers annually
- Condom use in sex work remains at approximately 86 percent
- Sexually transmitted diseases remain at current levels

Assumption: effort levels and budget stay where they were in 2000.

Scenario 2 – Heterosexual Risk Reduction

- Programs for risk reduction in sex work are strengthened. In this scenario by 2005, only 5 percent of males visit sex workers and 90 percent use condoms.

Assumption: additional budget and resources are provided to ensure ready access to condoms, heavily promote norms of not visiting sex workers among the young, and strengthen the 100 percent condom program efforts to reach indirect sex work.

Scenario 3 – Heterosexual Risk + MTCT (Mother to Child Transmission)

- In addition to strengthening programs for sex work, appropriate antiretroviral therapy or nevirapine is provided for HIV positive women at antenatal clinics and at time of labor and for children of HIV positive mothers following birth by 2005. This is assumed to reduce the number of children infected by their mothers by 50 percent.

Assumption: additional budget and resources over scenario 2 are provided to implement voluntary counseling and testing for all pregnant women and provide maternal antiretroviral therapy.

Scenario 4 – Heterosexual Risk + MTCT + Couples

- In the final scenario all of the activities in the preceding scenario are undertaken along with efforts to promote voluntary HIV counseling and testing and encourage condom use in couples where one partner is infected with HIV. These efforts are assumed to produce 30 percent condom use among couples with one partner living with HIV.

Assumption: additional budget resources are provided over scenario 3 to strengthen access to voluntary HIV counseling and testing before and after marriage and to promote condom use within infected couples.

The results of these 4 scenarios are shown in Figure S - 3 and in Table S-1.

Figure S - 3. Impact of the four expanded intervention scenarios on cumulative HIV infections in the Cambodia population 2000 to 2006.

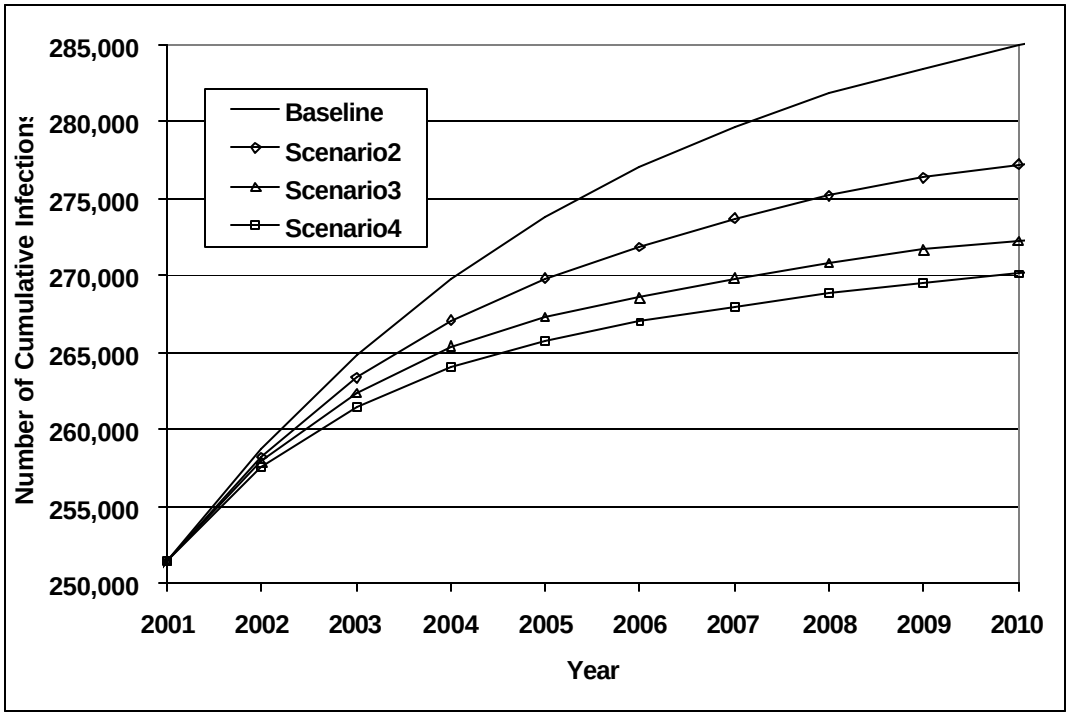


Table S - 1. Comparison of HIV infections between years 2000 and 2010 in the four scenarios

	Scenario 1 Baseline	*Scenario 2 Het*	*Scenario 3 Het +MTCT*	*Scenario 4 Het +MTCT +Couple*
Year	*2010*	*2010*	*2010*	*2010*
Cumulative new infections Adult + Child	42,100	34,400	29,400	27,200
Cumulative new infections Adult	25,300	18,000	18,000	16,100
Cumulative new infections Child	16,800	16,400	11,400	11,200
Total new infections averted by behavior changes after 2001	-	7,700	12,700	14,800

PROJECTIONS FOR HIV/AIDS IN CAMBODIA: 2000-2010

INTRODUCTION – THE NEED FOR PROJECTIONS

Cambodia has one of the highest HIV prevalences in Asia, making it essential for national planners and program developers to understand the magnitude and potential impacts of the epidemic on the people of Cambodia and on the country's development. Where should prevention resources be allocated to have the greatest impact? What care needs must be anticipated and planned for? How can one most effectively mitigate the impacts of the epidemic?

Any future national planning needs to incorporate an HIV/AIDS strategy component. Thus, realistic assessments of the situation, based on careful analysis of available epidemiological and behavioral data, are needed to help direct prevention efforts and to assist in mobilizing and targeting the resources needed to provide appropriate care and support for those living with HIV and AIDS and their children and parents. To provide this essential information for Cambodian national planners, the Cambodia Working Group on HIV/AIDS Projection, with support from Family Health International (FHI), USAID/Cambodia and the East-West Center, has developed a model for the HIV epidemic in the country and a new set of HIV/AIDS projections for use in planning. The model, based upon existing data sources in the country, seeks to reconstruct the past history of the Cambodian epidemic and explore its future directions.

The Cambodia Working Group on HIV/AIDS Projections was formed in early 2002 to advise on the behavioral and epidemiological inputs to the modeling process, review the results of the modeling exercise, and prepare policy recommendations based on the outcomes and significant findings of the modeling work. It includes members from the National Center for HIV, AIDS, Dermatology and STD (NCHADS), research institutions in Cambodia and international agencies. After the Working Group reviewed and made decisions on the key inputs, East-West Center researchers, using the Asian Epidemic Model, generated a fit to the epidemiological trends in the country. This document provides a detailed description of the model itself, the process of fitting the model to Cambodia, the inputs used, and the results obtained.

THE ASIAN EPIDEMIC MODEL (AEM)

Structure and methodology of the model

Over the years a number of epidemiological models have been developed for calculating the course of HIV/AIDS epidemics. These include the iwgAIDS model developed by the Interagency Working Group of the United States Government [Stanley 1990], SimulAIDS [Robinson and Silarug 1996], and variants of the Anderson-May model [May and Anderson 1988]. Often when applied in Asia, as most have been in Thailand, these models have had some difficulties in correctly reproducing the historical epidemiological trends in some sentinel groups [Robinson and Silarug 1996, Surasiengsunk S and Kiranandana 1998]. For example, despite extensive work in the early 1990s, it was impossible to find an iwgAIDS fit that

correctly replicated the epidemiological patterns of the Thai epidemic. Every attempt gave male to female ratios that were inconsistent with available epidemiological data.

The difficulty in getting a good fit has a number of sources. In the Thai epidemic, behavior change induced by the prevention programs in the country radically altered the course of the epidemic – behavior changes that occurred on a time scale of one or two years. Thus, models that could not input changes in behavior on a relatively short time frame had difficulty. Second, the nature of epidemics in Asia requires that sex work assume a central role, which it does not in some models. Key components of sex work transmission include: client to sex worker, sex worker to client, client or former client to wife/regular partner, and ex-sex worker to husband/regular partner. Thus, models need to include all of these routes and the possibility of turnover in client and sex worker populations to provide a good fit. Asian models must also allow for transmission through needle sharing, which has played a key role in many Asian countries. Finally, the facilitating effects of other STIs play a central role in sex-work mediated HIV transmission and many of the existing models incorporated their own internal STI and STI treatment models, which sometimes did not correctly reproduce observed historical trends in STIs.

Recognizing these limitations of existing models for use in Asian settings, the Asian Epidemic Model (AEM) was developed by East-West Center to focus very strongly on sex work and injecting drug use as the major routes of transmission. The AEM is a *process* model – it seeks to model the key processes that give rise to HIV transmission in Asia. Because it is intended for application in understanding *Asian* epidemics, the primary emphasis is sex work, sharing of needles, and heterosexual transmission between males and their non-paid female sexual partners, including spouses. These have been the primary driving forces behind HIV epidemics in the region. To address the limitations in earlier models, it includes two classes of sex work, turnover in both client and sex worker populations, the ability to enter behavior changes on an annual basis in all key populations, and the direct entry of STI levels from observed sources.

The model has two major components – one that calculates heterosexual transmission and another which handles transmission through needle sharing (see Figure 1 and Figure 2). These two components sub-divide the population into 7 sub-populations:

- Males who are clients of sex workers
- Males who are not clients of sex workers
- Males who are injecting drug users (IDUs) who share needles often
- Males who are injecting drug users who do not share often
- Females who are direct sex workers (many partners per day)
- Females who are indirect sex workers (fewer partners per day)
- Females who are not sex workers (general females)

Pediatric transmission is subsequently calculated based on fertility patterns and HIV prevalence among women.

To date there is no evidence that needle sharing has been contributing in a significant way to the Cambodian epidemic. Thus, for application in Cambodia, the injecting drug component of the Asian Epidemic Model has been turned off (it is mentioned here for completeness).

Figure 1. Structure of the heterosexual component of the AEM

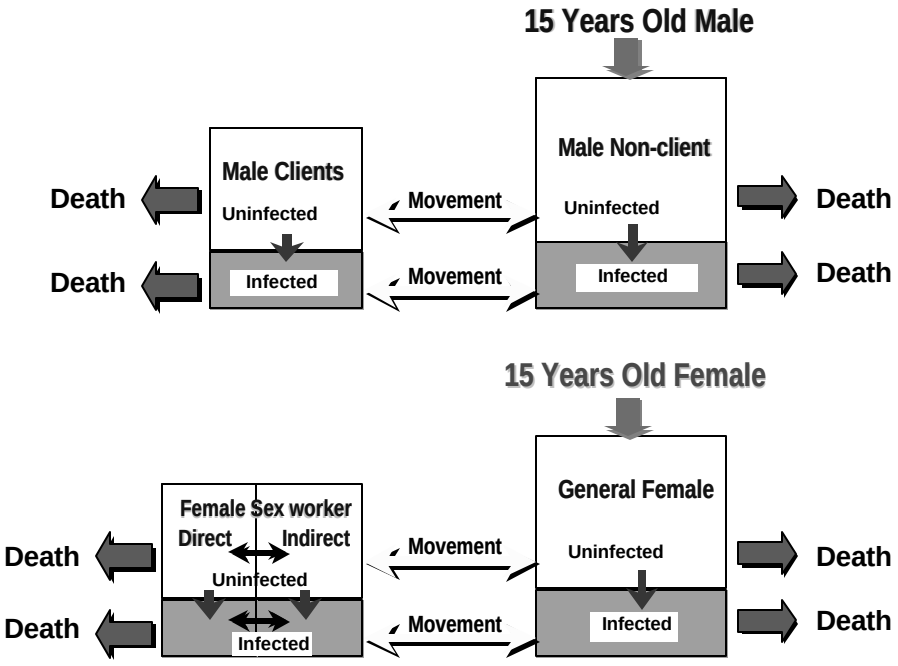
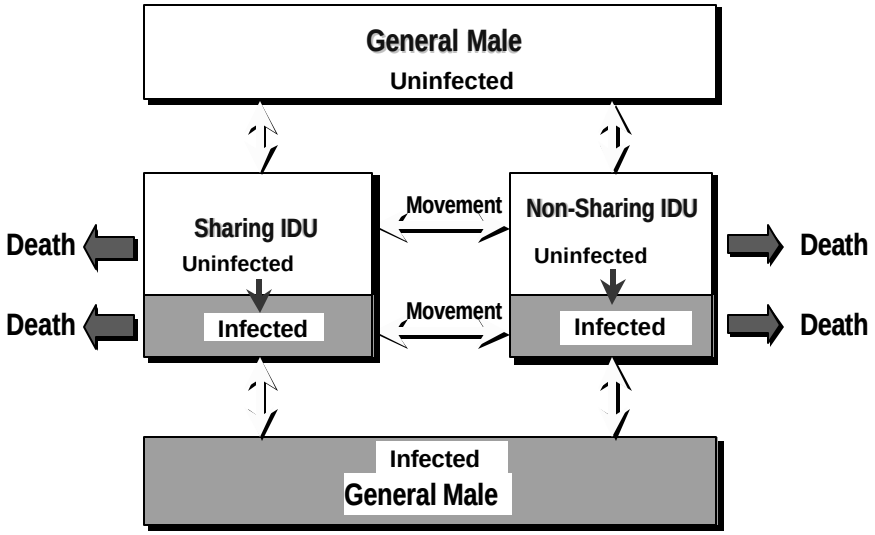


Figure 2. Structure of the injecting drug use component of the AEM showing division into sharing and non-sharing injecting drug users (IDU).



Each of these sub-populations is further divided into those who are infected and those who are not (white and shaded boxes respectively in the above figures).

Each sub-population is assumed to consist of those aged 15 and above. Population projections from the National Institute of Statistics and the US Bureau of the Census for years before 1995 are used to bring the correct number of 15 year olds into the uninfected general male and female sub-populations each year [NIS 2000, US Bucen 2001]. Sexual activity below that age occurs at low enough rates that it will not

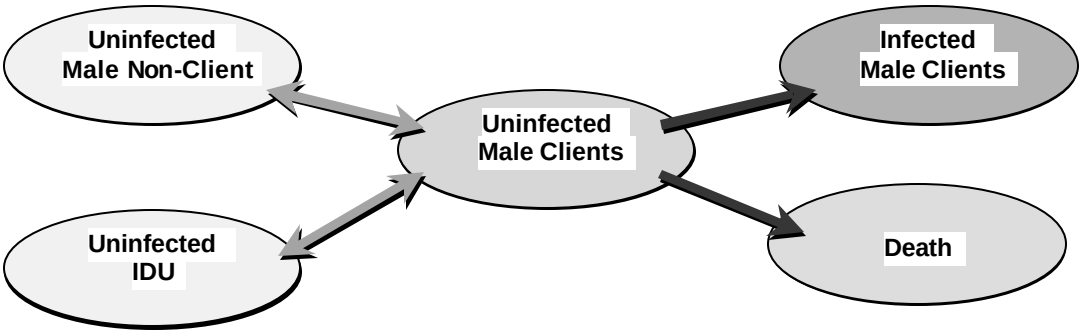
contribute substantially to the HIV epidemic. In addition most surveys, which provide the behavioral inputs to the model, only sample individuals from age 15 upwards. (NOTE: pediatric HIV infections are calculated separately as described below).

It should be noted that the AEM is *not* an age-structured model (that is, it does not look at levels of sexual activity by specific age groups), but treats the entire 15 and above population as at some risk of HIV by sexual and needle sharing transmission. New HIV infections are calculated from *average* rates of reported risk activity in the 15+ population *as a whole*. All sexual activity rates used as inputs are calculated from survey data by making appropriate adjustments for the age structure of the survey to calculate average levels of sexual activity in the 15 and older population. For example, the fact that young people in Cambodia become sexually active around age 20 means that the average rate of risk in the 15 and above population will be lower than if they were to become sexually active at age 15.

Both infected and uninfected are allowed to leave any sub-population by death or by moving to another sub-population. Members of uninfected sub-populations may also become infected with HIV and are then moved to the correct infected sub-population. Rates of movement in and out of the client, sex worker and injecting drug use populations are calculated from the average duration of sex work or injecting drug use as obtained from surveys. And both AIDS-related and non-AIDS related mortality are included. The AEM follows these movements into, out of, and among sub-populations over time to maintain the correct sizes for each sub-population.

An example of the possible movement of one sub-population, uninfected male clients, is shown in Figure 3. There are a number of ways men can leave this sub-population. They may become infected, moving to the infected client sub-population, may become non-clients (e.g., young married men stopping visits to sex workers), may become IDUs, or may die. Men can also enter this sub-population from the uninfected non-client and IDU sub-populations.

Figure 3. Movement of men into and out of the uninfected male client sub-population in the AEM.



Calculating new adult infections

Sexual transmission with HIV, which moves these men between the uninfected and infected sub-populations, is calculated using standard epidemiological equations as illustrated in Figure 4. The detailed formulas used account for a number of factors influencing HIV transmission including:

- Infection status of sexual partner (e.g., sex worker prevalence)
- Number of contacts between clients and sex workers
- Use of condoms (protects from infection)
- Presence of another sexually transmitted disease (increases transmission)
- Circumcision status of the male partner (circumcised is lower risk)
- Probability of female to male transmission in a single contact

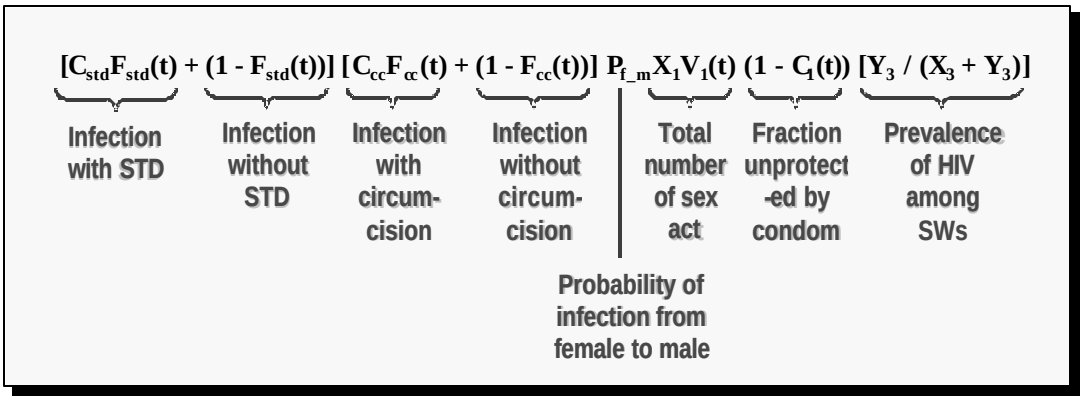


Figure 4. Example of the calculation of number of new infections among clients.

Additional terms in the equations address transmission from females to males through non-paid female sexual partners, including casual partners and spouses/regular partners. Similar approaches are used for calculating sexual infections among women, who are divided into general population females, direct sex workers and indirect sex workers. A fuller description of these equations is being developed now.

Calculating adults living with HIV, AIDS cases and deaths

Once annual new infections have been calculated for adult men and women, a program module applies the progression rates from HIV infection to AIDS (approximately 8 years on average with the UNAIDS fast progression rates used) and from AIDS to death in order to calculate the number of surviving people living with HIV and AIDS, the number of AIDS cases, and the number of deaths related to AIDS. This calculation is done exactly as in the Epimodel program [Chin and Lwanga 1991]. The UNAIDS fast progression rates from HIV to AIDS and from AIDS to death have been used for adults as provided by the UNAIDS Reference Group on Estimation and Projection [Schwartlander et al. 1999]. These have been found to be the most

appropriate values in developing country cohorts examined to date [UNAIDS Reference Group 2002a]. These are shown in Table 1.

Table 1. Fast UNAIDS adult HIV to AIDS and AIDS to death progression rates used. Percent developing AIDS by years after infection, and percent dying by years after developing AIDS. NOTE: Year 0 is the year of infection or progression to AIDS.

Years after infection or developing AIDS	*%HIV progressing to AIDS*	*%AIDS progressing to death*
0	0.0	25
1	1.0	95
2	4.0	100
3	13.0	100
4	21.0	100
5	31.0	100
6	40.0	100
7	50.0	100
8	60.0	100
9	70.0	100
10	76.0	100
11	81.0	100
12	86.0	100
13	90.0	100
14	92.9	100
15	94.9	100
16	96.4	100
17	97.4	100
18	98.1	100
19	98.7	100
20	99.1	100

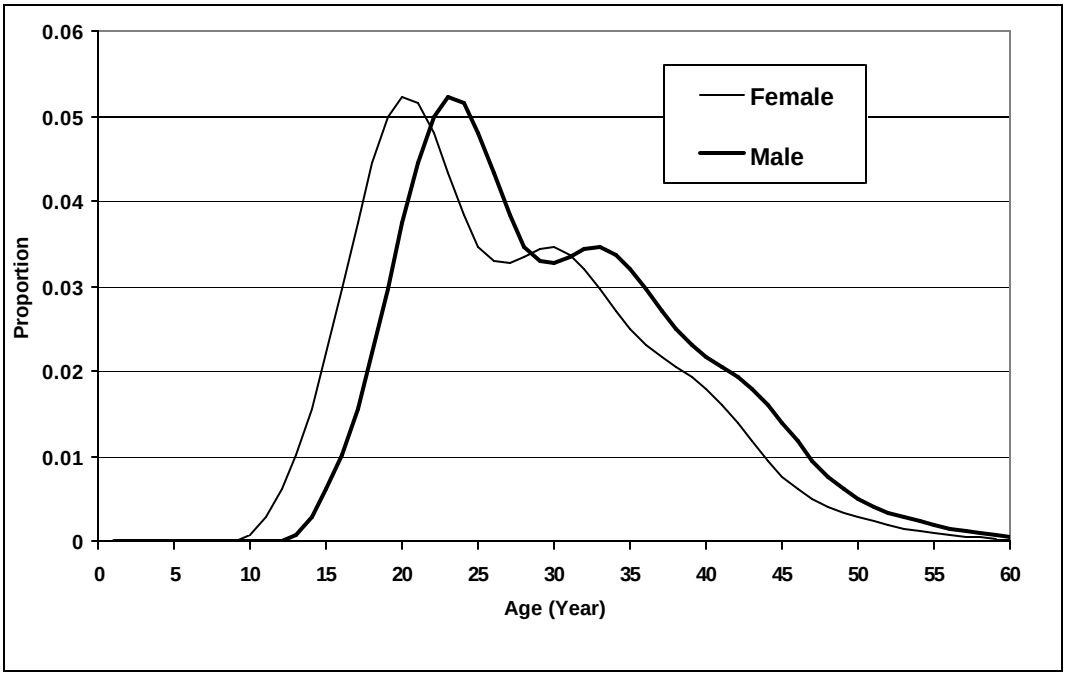
Calculating age distributions for HIV and deaths

Age distributions of HIV infections and AIDS-related deaths are needed for planning purposes. Given the number of new male and female infections in each year of the projection, a straightforward procedure is used for calculating age distributions.

Because the bulk of HIV infections in Cambodia are sexual in origin, new infections are assumed to distribute themselves in age in the same pattern as other sexually transmitted infections (STIs). Given that the majority of male STIs will be acquired in sex work settings, the age distribution for male STIs in Cambodia was obtained by

multiplying the age distribution of clients in the Behavioral Surveillance Survey (BSS) 2000 survey [NCHADS BSS 2000] by the reported frequency of visiting sex workers among the clients. It was assumed that most female STIs infections originated with the woman's primary partner, i.e., her husband. Thus, the age distribution for females was back shifted 3 years lower in age because married women are 3 years younger on average than their husbands [NIS 2001]. These age distributions have been used to produce the age structures for men and women shown in Figure 5. The peak for the male STI infections occurs at age 23 and for females at age 20.

Figure 5. Normalized Age distributions of male and female STI infections in Cambodia.



New HIV infections in a given year of the projection are then distributed into separate single year age groups for men and women using these STI age distributions. Each single year age group is then progressed forward using the HIV to AIDS and AIDS to death progression rates described earlier. Summing these single year age cohorts over all years of the epidemic allows the current age distribution of people living with HIV and/or AIDS to be calculated as well as the age structure of deaths.

Calculating pediatric HIV, AIDS and deaths

Once the numbers and age structure of adult females living with HIV are determined, the number of new pediatric HIV infections in a specified year can be calculated. The number of women with HIV in each single year age category for that specified year is multiplied by the age specific fertility for women at that age and then by the probability of mother-to-child transmission. This provides the number of infected children for mothers in each single year age group. These were split between new male and female infections based on a male to female sex ratio at birth of 1.04. These

numbers can then be summed to yield the total number of children infected in the year specified. Children are then progressed from HIV to AIDS and AIDS to death using the UNAIDS fast pediatric progression rates shown in Table 2 [Schwartlander et al. 1999]. The fast progression has been chosen because of the high infant mortality rates seen in the country. Transmission from infected mother to child is assumed to occur at 24.2% per existing studies in Thailand [Shaffer et al 1999]. It should be noted that women with AIDS are assumed to stop bearing children here given that they are ill and average survival is comparatively short, thus only women with HIV infection, but not AIDS, are included in this calculation.

Table 2. Pediatric HIV to AIDS and AIDS to death progression rates used in the calculation of pediatric HIV, AIDS and death, based on infection occurring at birth.

Years after infection or developing AIDS	*%HIV progressing to AIDS*	*%AIDS progressing to death*
0	15.7	95
1	43.0	100
2	59.7	100
3	70.8	100
4	79.8	100
5	86.9	100
6	91.9	100
7	95.0	100
8	96.5	100
9	97.0	100
10	97.4	100
11	97.8	100
12	98.1	100
13	98.4	100
14	98.7	100
15	98.9	100
16	99.0	100
17	99.2	100
18	99.3	100
19	99.4	100
20	99.5	100

Input Parameters – Key sub-populations and sexual behaviors

Because the AEM is a process model, it requires data that describe the processes of HIV transmission as inputs. In the model developed for Cambodia, these data fall into two main categories:

- Sizes of relevant sub-populations and changes in these populations over time

- Sexual behaviors and condom use with different partner types

In the real world, none of these things are static – they all change over time. For example, according to survey data, the number of men visiting sex workers has fallen by a factor of two in Cambodia over the last 5 years. Condom use with sex workers has gone up substantially, but condom use with other female sexual partners has only increased a little. The AEM has been structured in such a way that all relevant behavioral variables of this type can be entered on a year-to-year basis. For example, levels of condom use with direct sex workers can be specified for each year of the projection with input values taken from existing survey data. This means that trends in behaviors over the years must be prepared for use as inputs to the model. The sources and assumptions of the behavioral trends required as model inputs are laid out in this section.

Models are only as good as their inputs and assumptions. Invalid inputs will generally yield invalid results. This makes it crucial that users of model results understand the inputs, which have been used in constructing the model. Careful analysis of existing data is essential to ensure the inputs are realistic. Fortunately, Cambodia has collected a substantial amount of epidemiological and behavioral data, and that information has been analyzed to prepare the input data for these projections. This section of the paper briefly describes the most important inputs used and the sources from which the data was taken.

It is also essential that the model outputs be tested against trends in the HIV data over time – the results of the model should be similar to historically observed epidemiological trends. After a discussion of the input values, this report will turn to a comparison of the modeling results with historical HIV trends.

Sizes of sub-populations over time

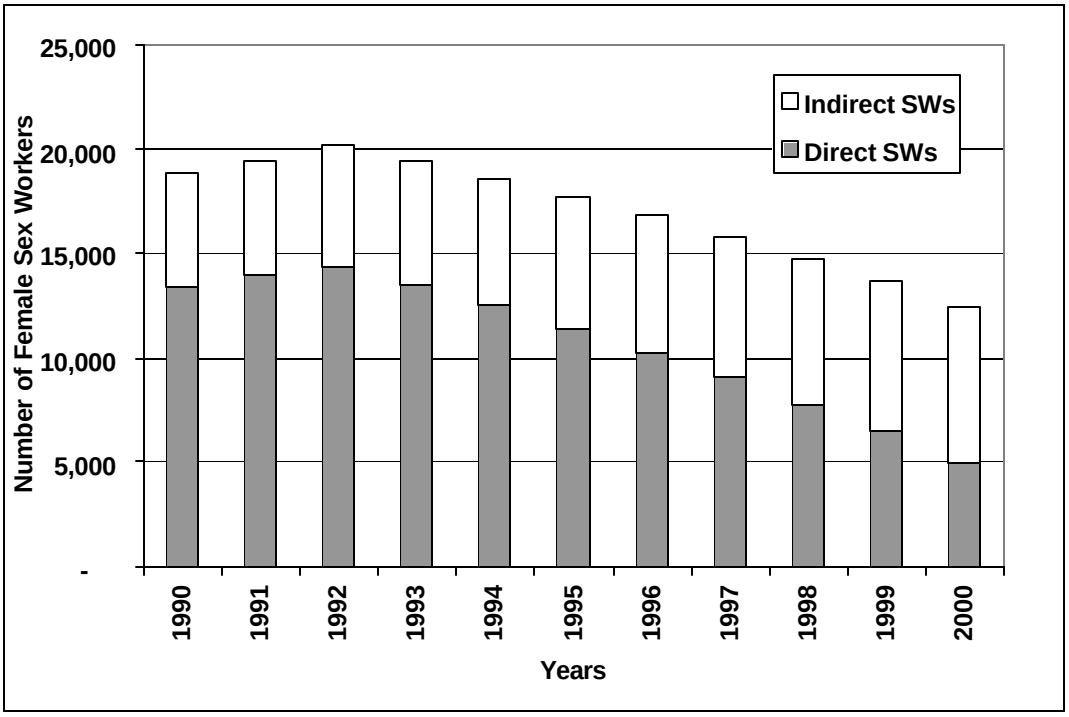
There are several important sub-populations in the model as outlined earlier. This section discusses the estimated sizes of these sub-populations over time and the source for these estimates.

General population males and females. Population sizes for men and women aged 15 and above are drawn from a combination of two sets of population projections: one by the National Institute of Statistics, Ministry of Planning, Cambodia [NIS 2000] and the population projections for earlier years done by the US Bureau of Census [US Bucen 2001]. For times up to 1995, the US Bureau of the Census population values have been used. National Institute of Statistics data was available from adjusted censuses and population projections for 1998, 2001, 2006 and 2011. All intervening years' populations were estimated by linear interpolation.

Male clients and non-clients. Based on behavioral surveys in 1996 [Brown 1997] and 2000 [NCHADS BSS 2000], the percentage of male farmers 15-49 visiting sex workers each year dropped from 20% in 1996 to approximately 8% in 2000. Farmers were used to set the trend because this information was available in the 1996 survey [Brown JC 1997] and could be extracted in the later surveys. Farmers also represent the majority of the population in

Cambodia. After adjusting for occupation and age structure these numbers become 27% of 15 and older men for 1996 and 11% for 2000. From 1992 to 1995, the percent of men visiting sex workers was derived by extrapolation of the trend from the year 1996 to 2000. Prior to 1992, this value was held constant at the 1992 levels, which is approximately 43%. The value after the year 2000 was held constant at the same level as in the year 2000.

Figure 6. Number of direct and indirect female sex workers (who sell sex only), 1980-2000.



Direct and indirect sex workers. The total number of contacts per night for direct sex workers, which is the number of sex workers multiplied by their reported number of clients per night, must equal the total number of contacts per night for clients, which is the number of clients multiplied by the number of sex worker visits per night reported by the clients. This means the number of direct workers can be estimated as: the number of clients, calculated as described above from survey data, multiplied by the frequency of client reported contacts with direct sex workers, then divided by the number of clients per night reported by direct sex workers. Client reported contacts were taken from BSS 2000, which found 15.9 visits to direct sex workers per year on average, while the client numbers per night reported by the sex workers averaged 3.2 (see Table 3 below for data). Both contact rates were assumed constant over time since no data for other times was available for client reports and the sex workers reported clients per night appeared to stay roughly constant.

For the year 2000, the number of direct sex workers calculated this way was approximately 5000. This number agrees with the reported number of direct sex workers collected by NCHADS in a nationwide survey of sex

establishments in 2000. NCHADS reported roughly 4,900 direct sex workers in that year.

Substantial discussions were undertaken of the number of indirect sex workers in Cambodia, because it is hard to estimate this number given available data. The number of workers in indirect establishments in the NCHADS survey in 2000 was 7,400 but some of these report not selling sex. It is also likely that there are other women selling sex outside of the establishments surveyed. No reliable estimates of the true extent of indirect sex work are presently available. This difficulty exists because the behavioral surveillance examines women in the entertainment industry, not all of whom are indirect sex workers, while in the AEM, only those women who actually sell sex are to be considered.

After extensive discussions, it was agreed that a reasonable value to use for the number of indirect sex workers in the year 2000 was 7,500. This allows for the fact that not all workers in indirect establishments sell sex, but that there are other women outside of these establishments who do. This gives a direct/indirect ratio of 2/3 in 2000, i.e., a dominance of indirect sex work at present. Because sex work in Cambodia is believed by the Working Group to be shifting from direct to indirect forms, this ratio was set to increase as one goes backward in time, rising to 2.5 in 1992. This means that direct sex work was strongly dominant at that time, while indirect has become more prevalent today. The size of the indirect sex worker population in the intervening years was then calculated by multiplying the direct/indirect ratio by the size of the direct sex worker population for each year.

Because of concerns about the uncertainty in the number of indirect workers, scenarios were undertaken with different sizes of indirect sex worker populations. It was found that numbers in the ranges considered reasonable did not substantially alter the outcomes because most HIV transmission still occurred in the direct sex work settings. In BSS 2000, for example, over 90 percent of sex work contacts reported by the males were with direct sex workers.

It should be noted that these estimates imply a declining number of sex workers over time, which did raise concerns among some members of the Working Group. However, the large reported reduction in client numbers in behavioral surveys combined with a roughly constant number of sexual contacts per night reported by direct workers (see below), does imply there has been a reduction in the number of sex workers. Some of this may have been taken up by a shift of workers to the indirect sector of sex work, but given the relatively low reported rates of indirect sex worker contact it would appear there has been an overall reduction in demand for sexual services in response to the epidemic, leading to a subsequent decline in supply of sexual services.

Sexual behaviors over time

The key sexual behaviors, tracked over time, needed as inputs for the model are frequency of sexual contact with sex workers, frequency with other female partners and use of condoms with different partner types: direct and indirect sex workers, non-paid casual sexual partners, and wives. Because HIV transmission is significantly increased by the presence of other sexually transmitted diseases, data on the fraction of sexual encounters in the presence of another STI is also required. This section discusses the major sexual behavior related inputs used in these projections.

Frequency of client contacts – direct sex workers. The number of clients per night for direct sex worker has been collected in three rounds of behavioral surveillance surveys (BSS I, BSS II, and BSS III) and two STI surveys in 1996 and 2001 [NCHAD BSS 1997-1999, NCHADS STI 2001, Ryan and Gorbach 1996]. The findings of these surveys are presented in Table 3. The average of these numbers is 3.2, multiplying this number by 365 days in a year yields an estimate of 1,159 clients per year per sex worker. Because no clear trends are apparent in this data, this number has been kept fixed over the course of the projections.

Table 3. Mean number of clients per night reported by direct sex workers in various surveys in Cambodia from 1996 to 2001.

Survey	*N*	*Mean*
STI 1996	200	3.3
BSS I (1997)	245	3.6
BSS II (1998)	804	3.0
BSS III (1999)	792	2.6
NCHADS STI 2001	140	3.4

Frequency of sexual contact - indirect sex workers. The number of sexual contacts with clients for indirect sex workers was derived by multiplying the number of clients by the average number of reported sexual contacts with indirect sex workers (1.4 per year from BSS 2000) then dividing by the number of indirect sex workers as described above. The value for the indirect sex workers in the year 2000 is 65 sexual contacts with clients per year or 1.25 sexual contacts per week.

Frequency of sexual contact – married couples and extramarital contacts. The BSS 2000 survey measured coital contacts between husband and wife. Because the highest age of interview in the survey was 49, coital contacts above that age were assumed to decline linearly. After adjusting for unmarried men, the final number of coital contacts per year among general couples is 53, roughly once a week, which is in good agreement with a large number of international studies of married couples. There is no data of the frequency of extramarital contact in Cambodia available. Thus, this number was estimated from data in Thailand, where sexual behavior patterns are similar. The Mahidol Media Effectiveness Survey [Thongthai and Guest 1995] looked at extramarital contacts (non-sex work

related) and found an average rate of 16 contacts per year. These two coital frequencies are also kept fixed over time in the absence of data to the contrary.

Percentage of general population males and females with extramarital contact with non-sex work partners. These were set at 9% for males and 1.6% for females based on surveys done among general population men in BSS IV and among working women in BSS II. The influence of higher values for the males should be explored in future modeling work, especially if sex work contacts are declining as behavioral data indicates. But because STI rates are much lower between "sweethearts" these sexual contacts will generally contribute at a lower rate to HIV transmission than sex work contacts.

Condom use over time - direct sex workers. Condom use from 1996 to 1999 and in 2001 was based on values from the BSS and STI surveys for condom use at the last client contact. It was reduced 10% from the reported values in the surveys to account for sexual contacts with non-paying partners or regular clients, where condom use is lower. Condom use before 1992 was assumed to be 15%, the level reported among direct sex workers in Thailand before the start of the HIV epidemic. Condom use from 1992 to 1995 was set by interpolating between the 15% in 1991 and the value in the 1996 STI survey. The trends based on this are shown in Figure 7.

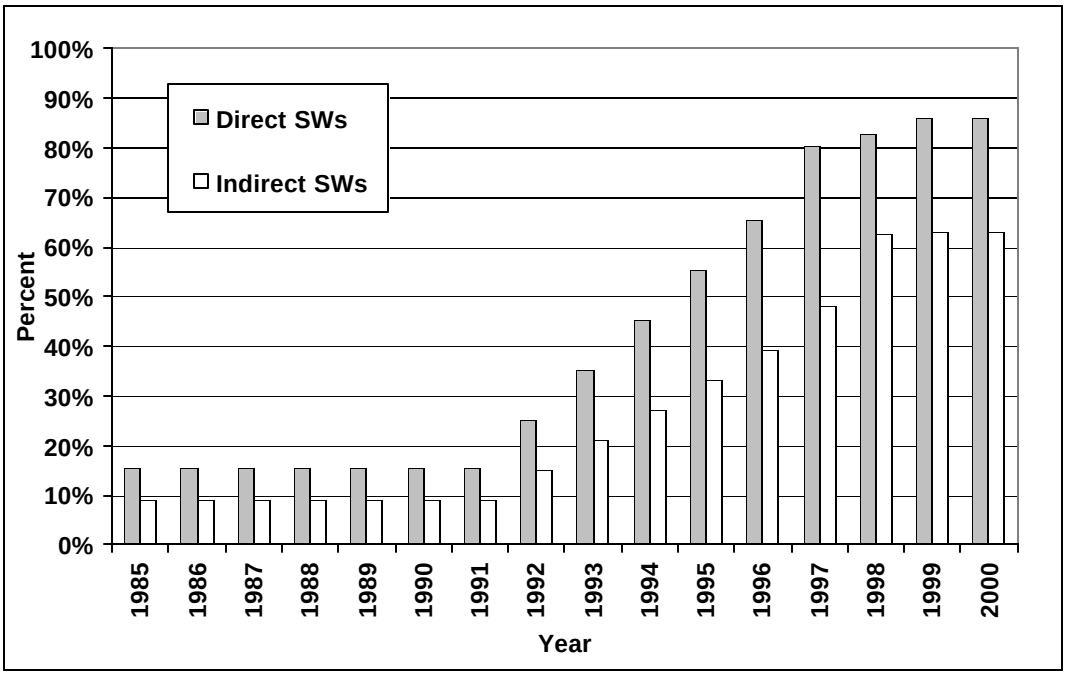
Some have expressed concern that the condom use seems to rise rather early, before extensive prevention programs were in place in Cambodia. Under the assumptions used here, by 1993 condom use is approximately 35% among direct sex workers, rising to 45% in 1994. However, there is substantial evidence in early studies that indicates that, at least in Phnom Penh, condom use did come up fairly rapidly. For example, the Women's Municipal Association conducted a survey in early 1993 and found 80% of sex workers reported their recent clients had used condoms [Women's Municipal Association 1993]. A survey by World Vision among Phnom Penh sex workers and male clients in March and April 1994 found 87% of the men reporting using condoms with the last sex worker and 96% of sex workers saying they used condoms with the last client [World Vision 1994]. And a study by Dunn et al. [1995] of sex workers in Toul Kork in 1994 and 1995 reported a fairly steady 60-70% of clients using condoms. Certainly rates in Phnom Penh would be higher than elsewhere, but Klement et al [1995], in their situation assessment in late 1995 estimated that use in provincial towns was at half the level of Phnom Penh, which would still put it in the 35-40% range. And a small survey by Medecins Sans Frontieres in Banteay Meanchey Province in early 1995 found 80% levels [Escoffier 1995]. One final piece of data to consider: PSI began distribution of Number One condoms in December 1994 and had distributed 5 million pieces by the end of the first year and there were other sources of condom supply, including the French government and other overseas development aid [Klement et al. 1995]. Given the populations sizes involved and the frequency of sexual contacts it can be estimated that there were approximately 14 million sex work contacts that year. If at least another 2 million condoms were distributed through other channels, a coverage of 50% would be achieved.

Some of this increase in condom use, prior to the implementation of aggressive programs with nationwide reach, may be attributed to diffusion of information

from the highly publicized epidemic in neighboring Thailand. Some may be attributed to early prevention efforts, especially in Phnom Penh. But it should also be remembered that sex workers in Cambodia are quite mobile and thus prevention efforts in Phnom Penh may have had beneficial spillover effects among sex workers in other parts of the country.

Condom use over time - indirect sex workers. Condom use levels for indirect sex workers from 1997 to 1999 were set based on the values reported in the BSS and other surveys. Like the direct sex workers, It was reduced 10% from the value in the survey in order to account for some sex contact with non-paying partner, which use much less condom. The condom use before 1997 was set to 60% of the condom use level of direct sex workers because in 1997, the condom use in indirect sex workers is about 60% of the condom use in direct sex workers. The condom use after 1999 was set to 73% of the condom use level of direct sex workers because in 1999, the condom use in indirect sex workers is about 73% of the condom use in direct sex workers. The overall trends in condom use with direct and indirect sex workers are shown in Figure 7.

Figure 7. Percentage of sexual acts where condoms are used by direct and indirect sex workers with clients over time used as inputs to the model.



Condom use over time – general population couples. Condoms are not a contraceptive of choice among married couples. Based on the Cambodia Demographic and Health Survey (DHS) in 2000 [NIS 2001], the current use of condom among couples is only 0.6%.

STI among direct sex workers. The STI prevalence (percentage of sex workers infected who have gonorrhea or clamydia or both on clinical examination) as determined from the STI surveys in 1996 and 2001 was used [Ryan and Gorbach

1996, NCHADS STI 2001]. The STI prevalences are roughly 39% in 1996, but fall steadily to 23% in 2001. The values in other years were assumed to follow the linear trend from 1996 to 2001. This is important in the model because the presence of another STI greatly enhances HIV transmission.

STI among indirect sex worker. There are many classes of indirect and freelance sex workers in Cambodia. The orange sellers, based in parks and relatively inexpensive, were studied in the STI surveys. They had higher STI prevalence than the direct sex workers. Beer promotion girls, another type of indirect worker, were studied in the BSS surveys. They tend to charge more than the orange sellers for services and have fewer clients. The surveys found the self-reported STI symptoms among the beer promotion girls were lower than among direct sex workers. For most forms of indirect sex worker, no data on STIs is available at all. Given the lack of concrete data on the mix of different types of indirect workers and on their STI prevalence, there is no way to determine if their overall HIV prevalence is higher or lower than that of the direct workers. Thus, for the purposes of these models, the prevalence of STIs among indirect sex workers has been made the same as the prevalence among direct sex workers.

Other Parameters in the Model

The population size and behavioral inputs to the model specified above are determined from external data sources, primarily surveys and research studies in Cambodia. There are a number of additional parameters that describe the transmission of the virus in a sexual or needle sharing contact. The most important of these parameters are:

- The start year of the sexual and injecting drug use epidemics
- Probability of transmission from female with HIV to male sexual partner in a single sexual contact (vaginal intercourse)
- Probability of transmission from male with HIV to female sexual partner in a single sexual contact (vaginal intercourse)
- Probability of infection in a single use of a needle shared with a partner with HIV
- Multipliers on the per contact transmission probability for sex where one partner has another sexually transmitted disease. The presence of other sexually transmitted diseases can significantly increase the transmission of HIV. Hayes [1995] has estimated that these factors can be from 10 to 50 for male to female transmission and from 50 to 300 for female to male transmission.

General ranges of these values can be established from the literature, however the start year and probabilities of transmission are best set by comparing the model with the epidemiological data trends in the country. This process will be described in the next section.

ESTIMATING INFECTION LEVELS IN CAMBODIA - FITTING THE MODEL

Calculating the prevalences for model comparison

Different results are obtained from the model if important input parameters such as the probability of male-to-female or female-to-male transmission or the start year of the epidemic are changed. To determine which input parameters provide the best fit, the parameters are adjusted and the output prevalences from the model are compared to the current prevalences from epidemiological data sources for each key sub-population. The objective of this process is to identify a set of parameters for which the model accurately reproduces the observed trends in HIV prevalence over time in all the different sub-populations.

The four sub-populations for which one wishes to examine changes in prevalence (percent of members of the sub-population infected with HIV) over time are:

- Direct female sex workers
- Indirect female sex workers
- General population adult males
- General population adult females (non-sex worker)

The first two (direct and indirect sex workers) can be obtained directly from the Cambodian national HIV sentinel surveillance (HSS) data, which has been collected since 1992 in Phnom Penh and nationally since 1994. (Although as mentioned earlier, there are some questions about how representative the indirect sex worker data is of indirect workers as a whole). However, the estimation of infection levels among the general population groups from available data requires some additional attention because no randomly sampled source of HIV prevalence data exists for the entire adult general male and female populations.

In terms of data sources for males, NCHADS has done HIV sentinel surveillance among police, military, and motorcycle taxi drivers, however, these groups were selected because they were believed to have higher risk behaviors and they are not representative of the general male population. The most complete source of general population trend data for males is the HIV testing among blood donors at the national blood bank. Approximately 90% of blood donors are male. Thus, the trend of HIV prevalence among blood donors may be a good approximation to the trend for general population males with the understanding that data in recent years may be an underestimate of general population male prevalence because of increasing screening and deferral for risk as procedures at the blood bank change. However, blood donors also have a different age structure than the male population at large, typically being somewhat younger. This means that while the trends may have some validity, the absolute levels of HIV infection need to be calibrated by some other means.

Fortunately, NCHADS and FHI did an HIV survey among general household male in 5 provinces in 1999. This data was adjusted according to provincial ANC prevalence levels in all provinces to estimate a nationwide value of 3.0% for the male prevalence in that year. This value provides an anchor point for adjusting the trend curve from blood donors in 1999 to reflect the national male prevalence. Blood donors' prevalence in 1999 was 2.9% and this was adjusted upward slightly to fit the 3.0% figure in the general male population in that year. Both blood donors trends and the resulting general male population trends are shown in Figure 8. The prevalence in men grew rapidly from 0.1% in 1991 to a peak of 3.9% in 1995 and has now declined to roughly 2.7%.

For general population females, the best source of data available is the antenatal clinic data from the sentinel surveillance system. However, because of the small sample size in each province, this data fluctuates substantially on a year-by-year and province-by-province basis, making it difficult to estimate the national HIV prevalence among women. In order to deal with this statistical fluctuation, individual fits of smoothed curves were done in each province using the UNAIDS/WHO Estimation and Projection Package (EPP), currently being developed at the East-West Center. This package does a least squares fit of seroprevalence data in specific populations with an epidemiologically defined curve, which allows for both the traditional S-shaped curve during the growth phase of an epidemic and for plateauing of the epidemic at an endemic prevalence level. For a more complete description of the EPP see the *UNAIDS/WHO Manual on Estimating and Projecting National HIV/AIDS Epidemics* [UNAIDS Reference Group 2002b]. National prevalence among ANC women was then calculated by averaging these smoothed provincial prevalences weighted by the size of the female population aged 15-49 in each province. The result is shown in the upper curve in Figure 9.

Figure 8. HIV Prevalence among General Adult Male follow the trend of HIV Prevalence among Blood Donors.

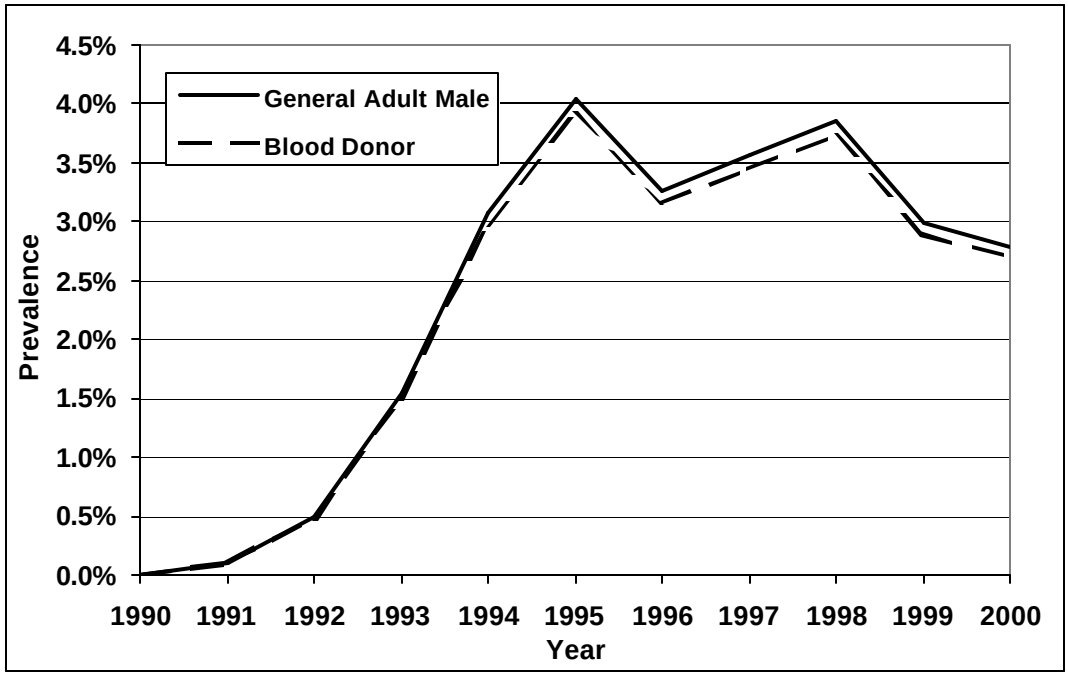
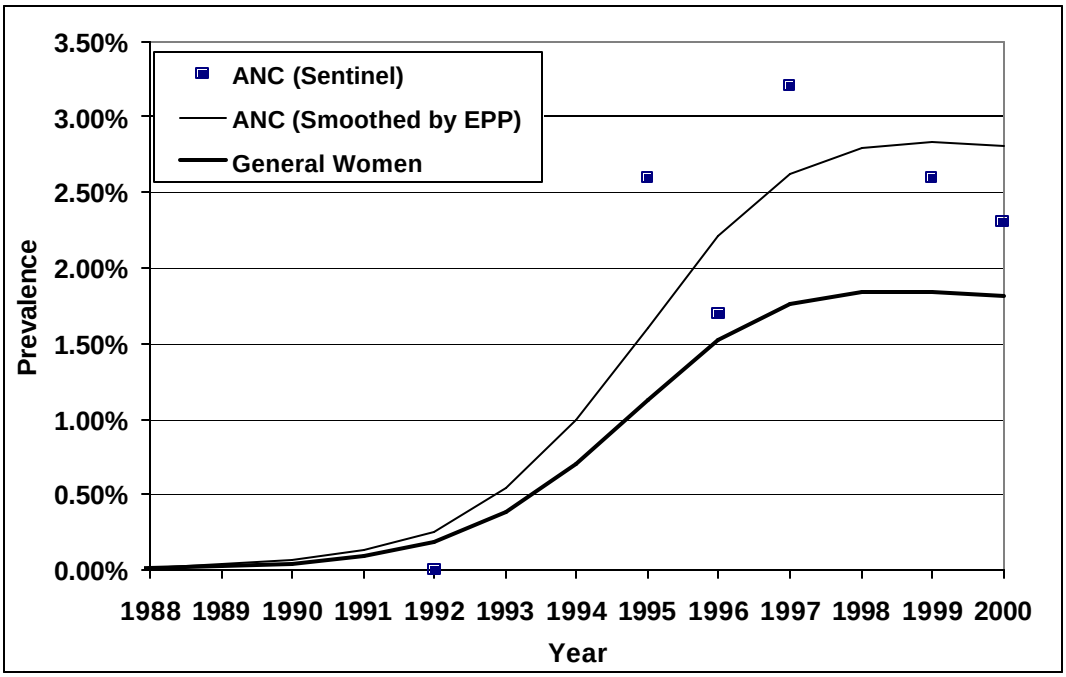


Figure 9. Comparison of prevalence among pregnant women at antenatal clinics with calculated prevalence among all adult women.



However, the female antenatal clinic data must also be adjusted because the age structure of women attending antenatal clinics is not the same as the age structure of women in the total adult population. In general, antenatal clinic attendees are younger than the average adult female in Cambodia because women tend to bear children at young ages. Because younger women have more risk in general than older women and the epidemic is comparatively young, this means that ANC women tend to have higher prevalence than the population of women at-large. As a result, once adjustments are made for the age structure, one finds that the prevalence in the general female population is somewhat lower than in antenatal clinic women. While antenatal clinic women have an HIV prevalence of roughly 3%, general population females are closer to 2%. This is illustrated in Figure 9, showing the mean prevalence among antenatal clinic women compared with what the adjusted prevalence among general population adult women. The recent paper by Saphonn et al. [2002] also found the general prevalence among ANC women to be somewhat higher than that in a household based sample of women (1.62% versus 1.24%), although the confidence intervals were large and overlapped. However, the fact that only one-third of women in Cambodia have received antenatal care in the last 5 years, as quoted in this article, does mean that the relationship of antenatal prevalences with those in the general population merits further study.

Fitting the model to the data

Once the general male and female adult prevalences are calculated from the blood donor and antenatal clinic data, all four of the sub-population prevalence data sets mentioned earlier can be compared with the model's outputs. To simplify this process, the program has an interface which allows it to display the prevalence trends from

each epidemiological data set on the same graphs as the prevalence curves produced by the model. This is illustrated in Figure 10. The upper right box shows direct (higher curves) and indirect (lower curves) sex workers, the bottom left contains general population males and the lower right contains general population females. Jagged, non-smooth lines are the epidemiological data sets as described above, while the smoother lines are the prevalence curves produced by the model. (NOTE: the upper left hand box is for drug users, which have been turned off in modeling the epidemic in Cambodia).

In Figure 10, the male-to-female transmission parameter has been set too high and the sexual transmission model curves are all too high compared to the data. One can also change the start year of the sexual or injecting drug use epidemics as illustrated in Figure 11. This figure shows the effects of choosing a start year for the epidemics which is too early, the prevalence curves produced by the model all rise prematurely.

By adjusting the parameters and start years, a set of parameters was found for which the model reproduced the time trends in prevalence in all four epidemiological data sets fairly well. This final fit is shown in Figure 12. The HIV infections, AIDS cases, and deaths calculated from this fit will be discussed fully in the next section of this document.

Figure 10. Example of the screen used for fitting the model to epidemiological data over time. Smooth curves are those produced by the model, jagged curves are trends from the epidemiological data.This example uses too high a male-to-female transmission probability.

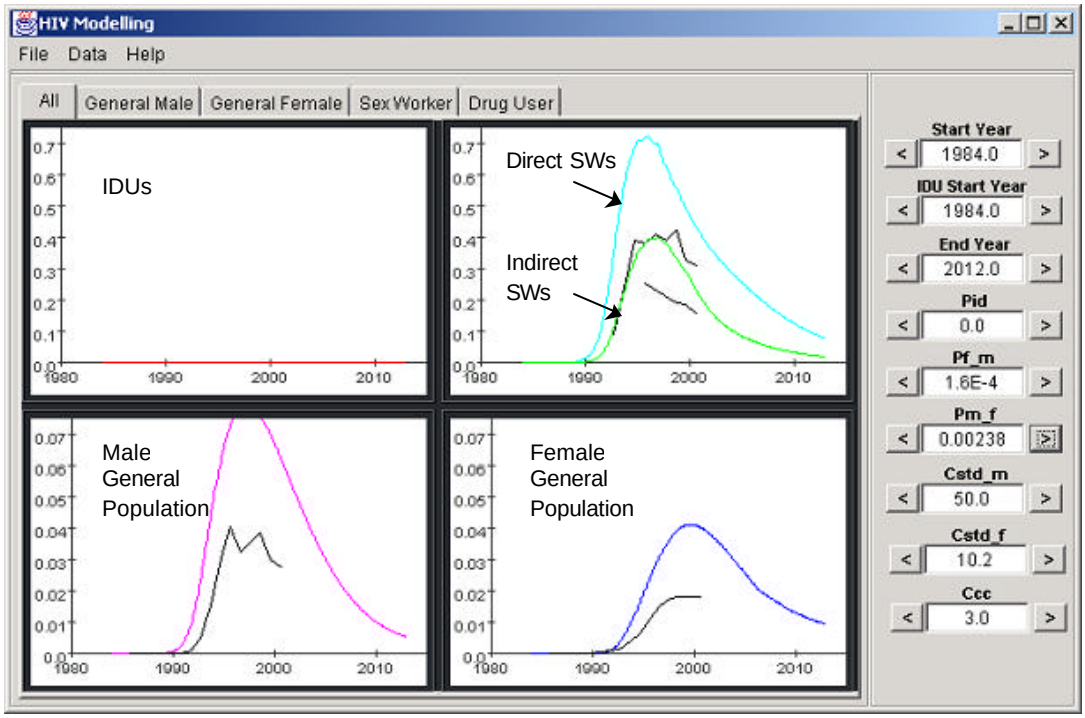


Figure 11. Example of fitting the epidemic with too early a start year. Model predicted prevalences, shown by the smooth curves, rise too early.

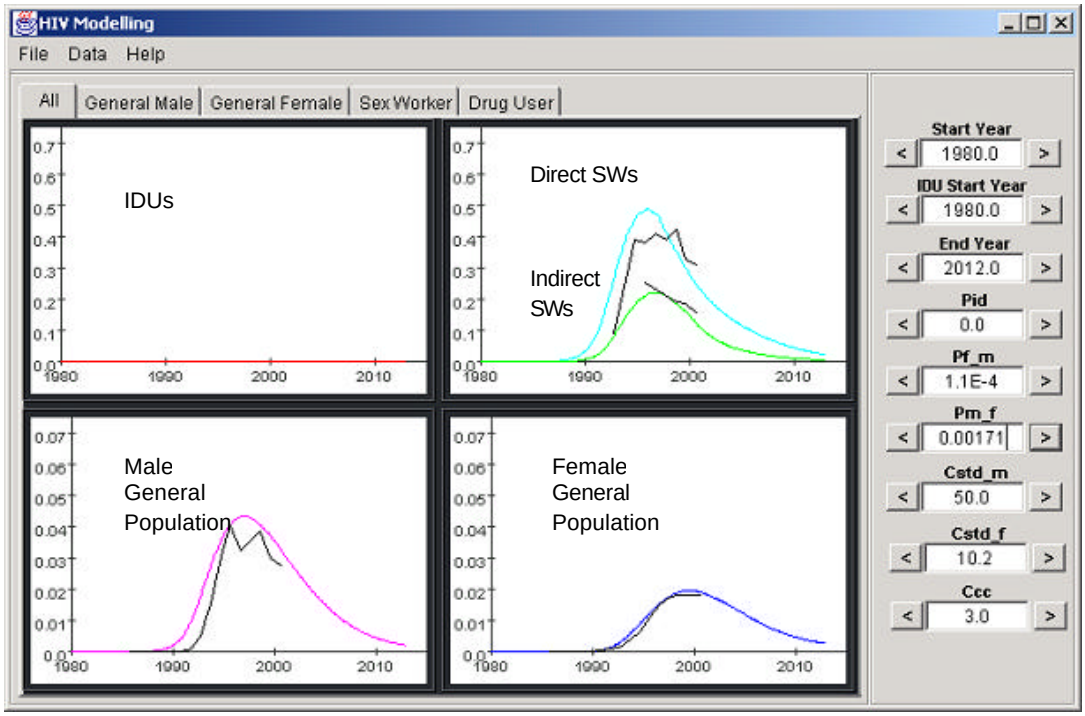
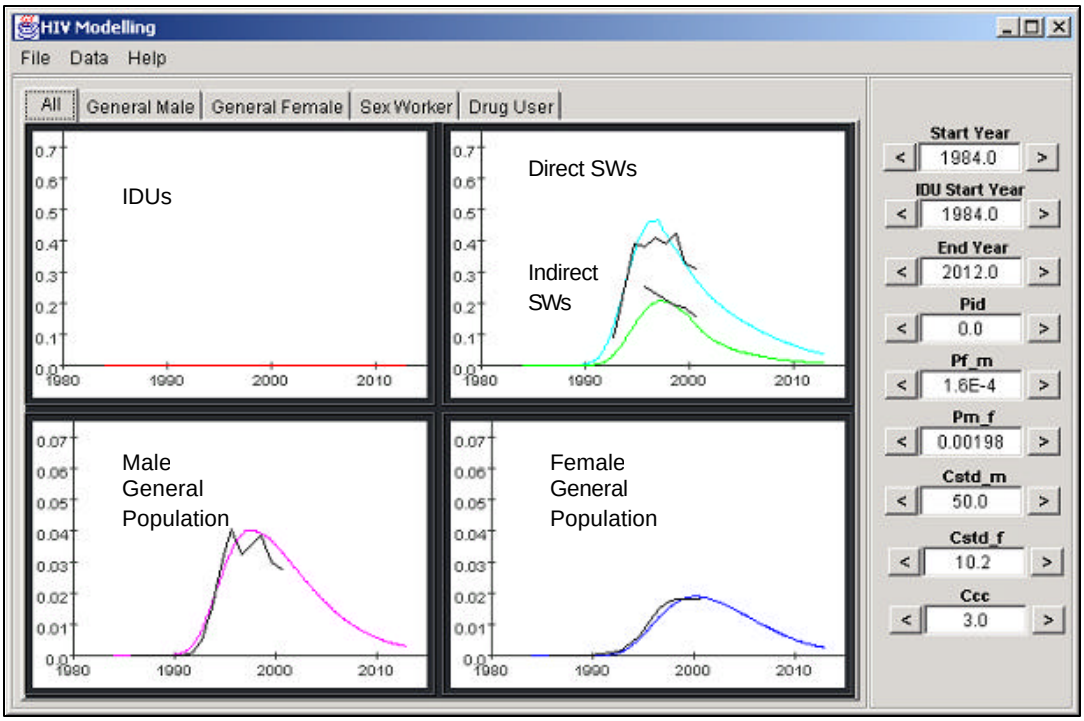


Figure 12. The best fit obtained by adjusting the parameters to reproduce observed epidemiological trends.



The parameters which have been used to obtain this fit are:

- **Male to female transmission: 0.00198/sexual act**.
- **Female-to-male transmission: 0.00016/sexual act**.
- **Start year for both sexual and IDU epidemics: 1984**.
- **STI multipliers: 50 for males and 10.2 for females**. These are the low end of the range of values given in Hayes et al. [1995].

Figure 13 through Figure *15* show in more detail how the results of the model compare with the observed national sentinel data for direct and indirect sex workers and the estimated prevalence for the male and female general population. In general, the agreement is good – trends seen in the data over the last decade are reproduced by the model. The general male fit is somewhat higher than the corresponding data trends in recent years, but this would be expected as increasing blood deferral among blood donors artificially drives down the HIV prevalence among donors on which the historical trends presented here are based.

In conclusion the model reasonably reproduces eight years of epidemiological data trends in Cambodia for all four sub-populations considered. The behavioral, epidemiological, and transmission values used in the model are consistent with those measured in other studies in Cambodia and the ranges presented in the scientific literature. For completeness Appendix A presents all population sizes, behavioral parameters, and other parameters used in preparing the baseline scenario presented later in the next section.

Figure 13. Comparison of the projected HIV prevalence from the model with historical trends in direct and indirect sex workers

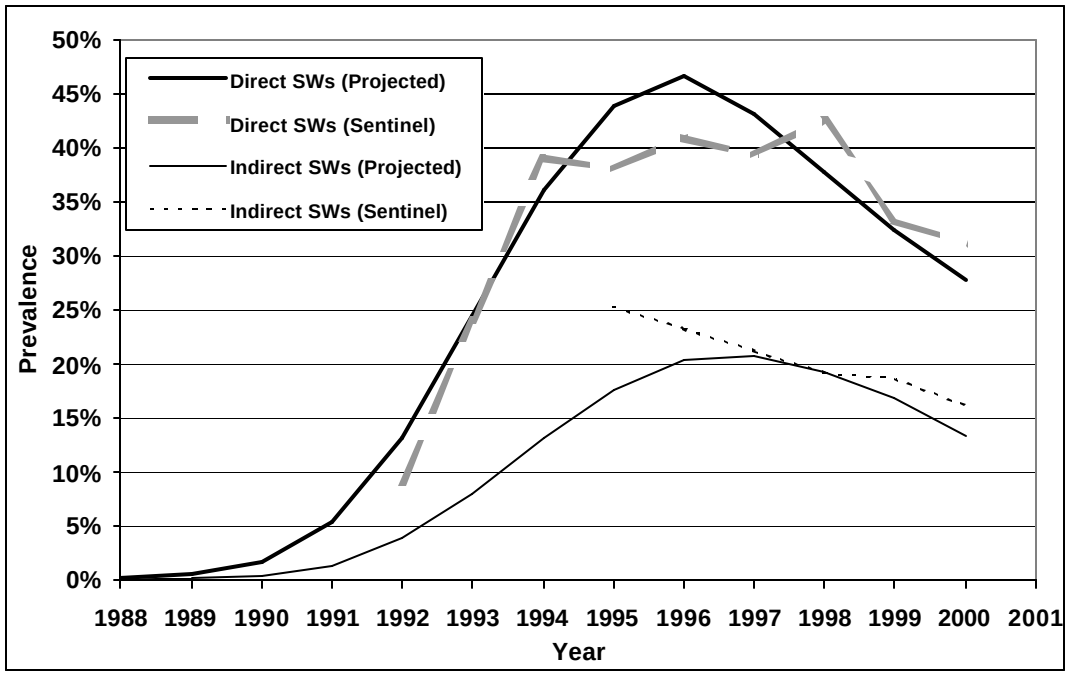


Figure 14. Comparison of the projected HIV prevalence from the model with estimated historical prevalence trends in the male general population.

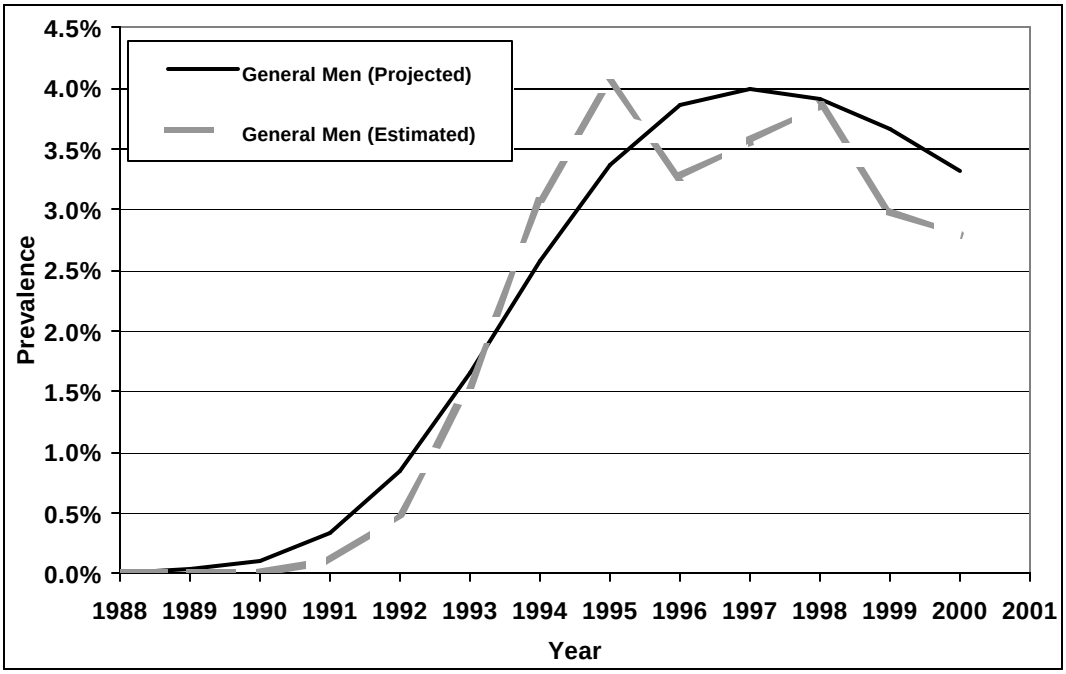
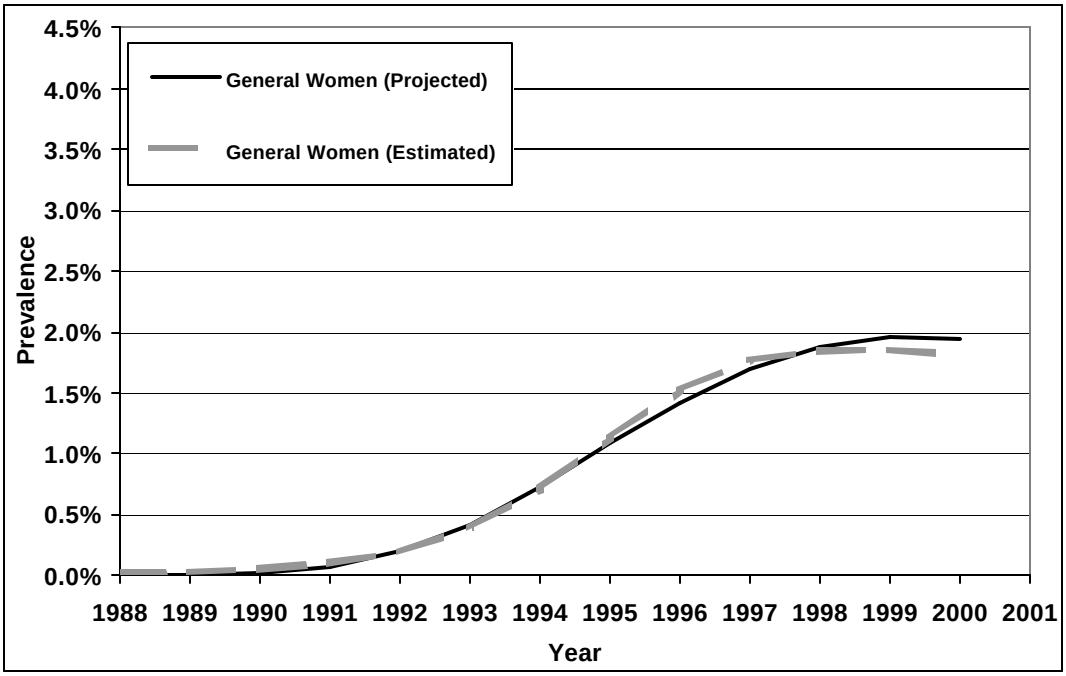


Figure 15. Comparison of the projected HIV prevalence from the model with estimated historical prevalence trends in the female general population.



RESULTS OF THE PROJECTIONS

Assessing The Impact of Policy Decisions – Four Scenarios

In order to explore the potential impact of the National AIDS Program over the next eight years, four scenarios for the future of the HIV epidemic in Cambodia have been run. At a meeting in early 2002, the Cambodia Working Group 2002 decided what assumptions were to be used in each of these scenarios. The first, referred to here as the *baseline* scenario, represents a continuation of the levels of risk behavior, condom use, and STIs seen in the last available data sets (2000 for risk behavior and 2001 for STI), and the other three describe what might result from a more aggressive National AIDS Program to further change risk behavior and reduce HIV transmission from mother to child.

Starting situation at the beginning of the year 2002

The same past behavioral trends and starting situation in the year 2002 have been used for each scenario. These are summarized as:

1. Males visiting sex workers. As discussed earlier, the percentage of men visiting sex workers was set at 27% for 1996 and 11% for 2000. From 1992 to 1995, these numbers were back-extrapolated using the trend from 1996 to 2000. Prior to 1992, the value was held constant at the 1992 levels of approximately 43%. After the year 2000 through 2002 the percentage of men visiting sex workers has been held steady at 11%.

2. Condom use in sex work. Condom use with direct sex workers was assumed to have been approximately 15% before 1992, then to grow steadily to 86% by 1999 and remain stable there. The low level used before 1992 is based on early studies in neighboring Thailand, as no data is available in Cambodia at this time. Condom use was set slightly lower with indirect sex workers (approximately 60% of the condom use level of direct sex workers before 1996, rising to 73% of the direct level by 1999 due to condom promotion efforts).

3. Decreasing sexually transmitted infections (STI). Based on the STI surveys in 1996 and 2001, the percentage of sex workers with sexually transmitted disease declined from 39% in 1996 to 23% in 2001. The values from 1992 to 1995 were set by extrapolating the trends from 1996 to 2001. Before 1992 STI was held constant at the 1992 level. For 2002 it was set at the 2001 level.

Each scenario then considers different prevention possibilities and their impacts on behavior after the year 2002 starting from the situation just described. The assumptions going into each scenario and a brief summary of their results at the end of 2010 are now given. The detailed results for numbers of HIV infections, AIDS cases, and AIDS-related deaths for each scenario through the entire projection period can be found in Appendix B.

Scenario 1 – Baseline

Prevention efforts. The baseline scenario projects into the future assuming that the prevention and behavioral situation remains exactly the same as at the start of the projection in 2002, described in the preceding section. That is, the baseline scenario assumes:

- Current prevention efforts are sustained and maintain risk behaviors at the levels achieved by 2002.

Behavioral Targets. Beginning from the situation just described for the period prior to 2002, the following future behavioral trends were assumed in preparing the baseline scenario:

- Percentage of males visiting sex workers remains stable. The percentage of men visiting sex workers was assumed to be roughly constant at the 2000 levels through the end of the projection in 2010.

- Condom use in sex work remains as it is at present. Condom use remains at the 86% level through the end of the projection.

- Sexually transmitted infections (STIs) remain at current levels. The percent of sex workers with other sexually transmitted diseases was held constant at 23% through the end of the projection.

Scenario 2 – Heterosexual Risk

Prevention efforts. In the Heterosexual Risk scenario, expanded prevention efforts to reduce transmission risk in sex work are undertaken. These would include:

- Ensuring ready access to condoms and continued high levels of condom use in sex work targeted subsidy programs.
- Expansion of programs to promote norms of not visiting sex workers among youth.
- Improvement of the 100% condom use program to have better access to and success with indirect sex establishments.

Behavioral Targets. This scenario proposed the following changes over the baseline scenario in behavior related to sex work:

- The number of male clients and sex workers drops. The percentage of adult males visiting sex workers drops by another 50% by the year 2005, to roughly 5%. With the reduction in client numbers, the number of sex workers declines proportional to the declining of the number of clients.
- Condom use between sex workers and clients increases. By the year 2002, condom use is 90% with direct sex workers and 66% with indirect workers.
- Sexually transmitted diseases fall slightly in proportion to the increase in condom use.

Scenario 3 –Heterosexual Risk + MTCT (Mother-to-Child Transmission)

Prevention efforts. In this scenario, it is assumed that the prevention efforts described in the previous two scenarios are implemented and that, in addition, appropriate antiretroviral therapy (ARV) to reduce mother-to-child transmission is provided for HIV positive women at antenatal clinics by 2005. This is assumed to reduce the number of children infected by their mothers by 50%. That is:

- In order to reduce mother-to-child transmission, resources and logistical support are provided to implement HIV testing and counseling and appropriate antiretroviral therapy for all pregnant women living with HIV.

Behavioral targets. All three behavioral targets are kept as indicated in the previous two scenarios, with a fourth target added:

- Antiretroviral therapy for mother-to-child transmission is fully implemented. All pregnant women in Cambodia are receiving HIV testing and counseling and ARV by the year 2005.

Scenario 4 –Heterosexual Risk + IDU + MTCT + Couples

Prevention efforts. The final scenario looks at the effect of implementing additional programs to address HIV transmission in couples where one partner is infected and the other is not. This is now producing almost 50% of new infections in Cambodia. In this scenario, the prevention efforts described under the previous three scenarios would be undertaken, while additional efforts are undertaken to prevent HIV transmission among couples. Achieving this will require:

- Expanded promotion of voluntary counseling and testing for HIV among married couples and those preparing to marry, coupled with campaigns to encourage those with risk behavior to learn their status and act on it to protect their partners.
- Expanded condom promotion efforts for couples where one partner is infected.

Behavioral Targets. In addition to the four targets specified under the three previous scenarios, this scenario assumes:

- Condom use increases in discordant couples. Condom use between couples where one partner is HIV infected rise from 0.6% at baseline to 30% by the year 2003.

Results of the Baseline Scenario – the Current Situation

The Baseline scenario shows where the Cambodia epidemic is today and allows the probable course of the epidemic to be discussed under the assumption that condom use remains high and no major increases in risk behavior occur. A discussion of the current situation, how the epidemic has changed over time, and where the epidemic is going will assist policymakers in understanding the benefits of the country's earlier

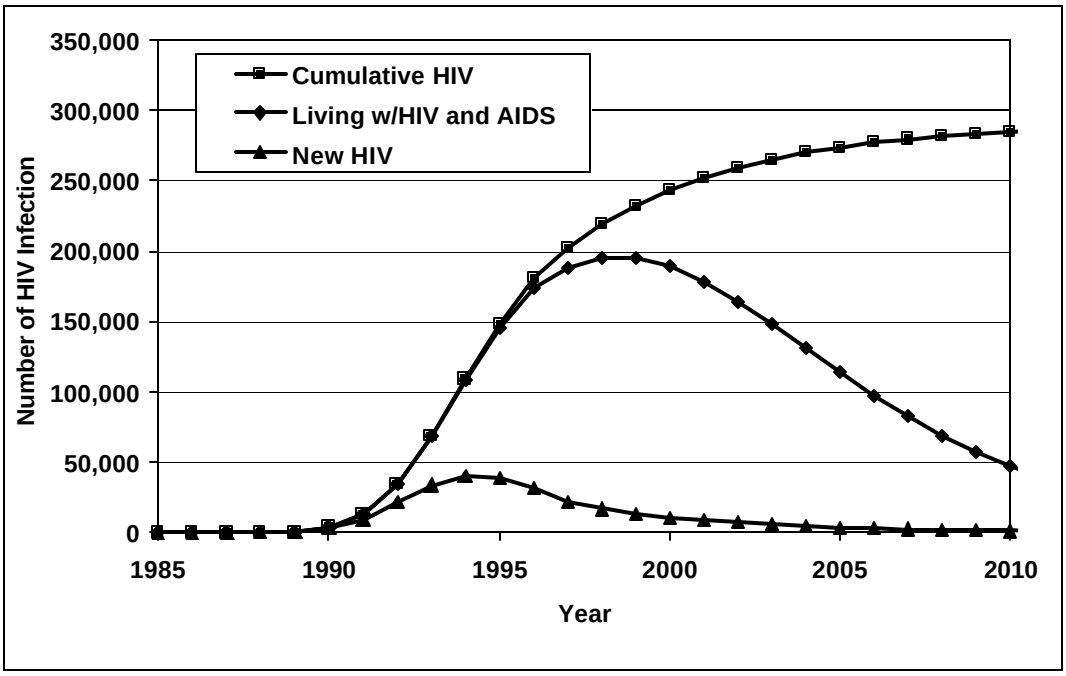
prevention efforts and how resources can best be targeted in the future to have the greatest impacts on prevention and coping.

Table 4. Summary of number of people living with HIV and AIDS, annual new AIDS cases, and cumulative HIV infections, AIDS cases and AIDS-related deaths in the baseline scenario.

Year	Living w/ HIV and AIDS	Annual new HIV	Annual new AIDS	Cumulative HIV	Cumulative AIDS	Cumulative AIDS deaths
1985	8	6	0	8	0	0
1990	4,087	2,895	22	4,101	30	14
1995	144,989	38,822	3,887	148,215	6,782	3,226
2000	188,975	10,553	19,978	242,836	76,032	53,862
2005	114,141	4,014	19,355	273,791	182,677	159,650
2010	47,076	1,422	9,414	284,898	249,351	237,821

Both the HIV/AIDS epidemic and risk behaviors in Cambodia have changed dramatically over the last decade and these changes are reflected in the current state of the Cambodia epidemic as seen in the Baseline scenario. Figure 16 shows the number of new, current, and cumulative HIV infections over the course of the epidemic from the baseline scenario, and Table 4 summarizes the key numbers from this scenario.

Figure 16. The HIV situation in Cambodia in the baseline scenario. The three curves show the number of new infections each year, the number of people currently living with HIV and AIDS, and the cumulative number of HIV infections in the country since the epidemic began.



The current state of the Cambodian epidemic

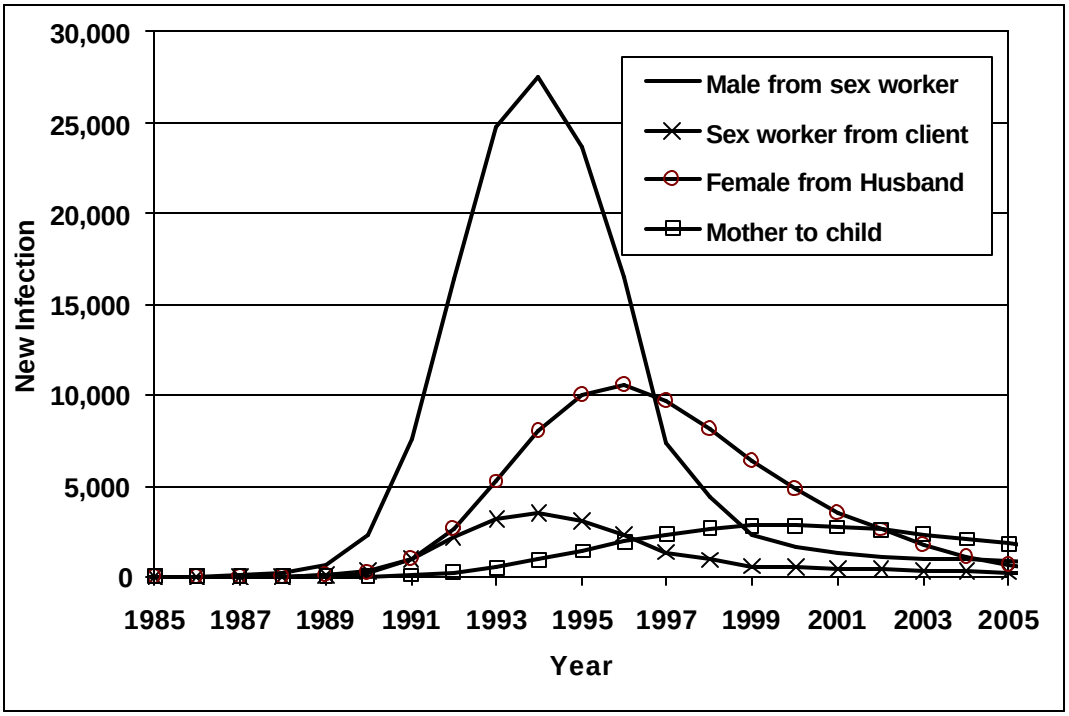
From the baseline scenario, the state of the Cambodia HIV/AIDS epidemic *today* in 2002 is:

- 259,000 people (238,000 adults and 21,000 children) have been infected with HIV in Cambodia since the start of the epidemic.
- 94,000 of these people have subsequently died of AIDS.
- 164,000 people are currently living with HIV and AIDS in the country.
- 7,300 new infections will occur this year of which 2,600 are children
- 22,400 Cambodians will develop serious AIDS related illnesses this year requiring medical care and 21,200 will die of AIDS complications.

History of the Cambodia epidemic - changes in risk behavior reduce new infections

Using the model it is possible to examine the history of the Cambodia epidemic and observe the effects of the extensive behavior changes which have occurred in the last decade. As the new HIV infections curve in Figure 16 shows, infections grew very rapidly in the mid 1990s and then began to decline as condom use grew in the mid-1990s. Figure 17 shows more detail on the distribution of these new infections by the means of HIV transmission from the baseline scenario. This paints a picture which agrees well with the epidemiological history of HIV in the country.

Figure 17. Changing routes of HIV transmission over the course of the Cambodian epidemic as seen through the baseline scenario.



In the early 1990s a large proportion of adult male Cambodians visited sex workers each year, condom use rates in sex work were low, and rates of other sexually transmitted diseases among sex workers were high, greatly increasing HIV transmission. As the country entered the mid 1990s, this environment created fertile ground for HIV transmission, and a substantial outbreak of HIV among sex workers and their clients occurred, producing over 20,000 infections a year from 1993 to 1995. In 1994, when the rate of new infections through sex work peaked, roughly 18% of direct sex workers and 3% of clients were being infected each year. By 1997, one in ten clients and one in two direct sex workers was infected with HIV. The vast majority of current HIV infections in Cambodia were produced in these early days of the epidemic when large numbers of men contracted HIV through sex work.

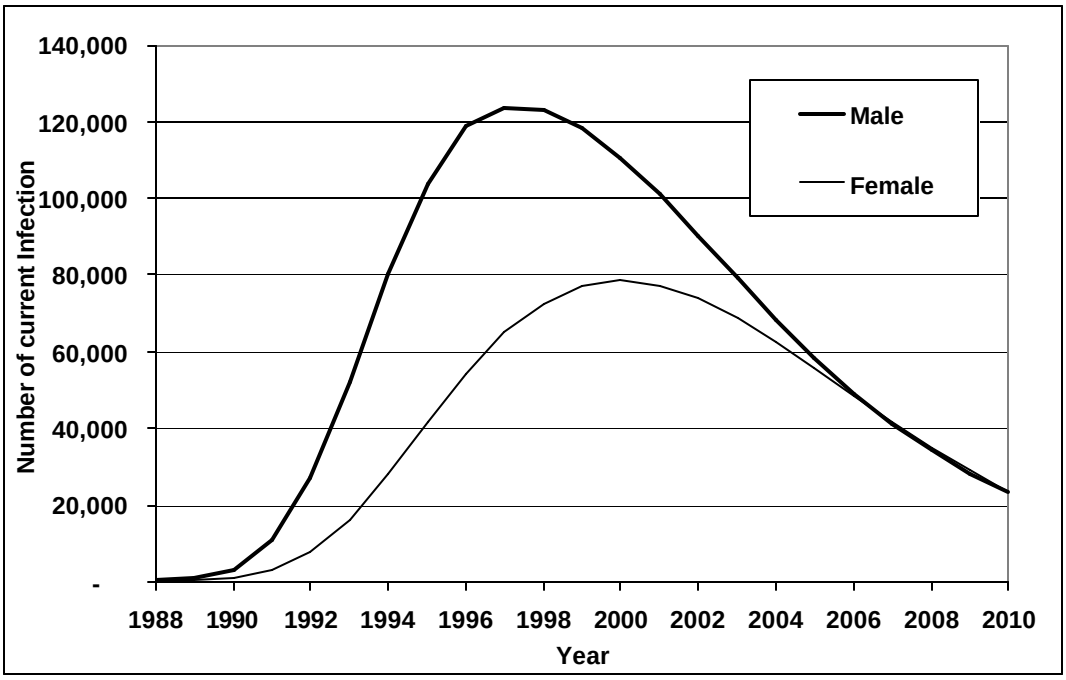
Fortunately, the Cambodian response was already underway as the epidemic began this explosive growth. The first National AIDS Committee was established in 1992 with membership solely from the Ministry of Health. In 1993, the Committee was reconstituted and expanded to include other ministries for a multisectoral response (following recommended international best practices). By this time, several NGOs and other groups in Phnom Penh were already doing prevention programs among sex workers. In early 1994, PSI introduced its "Number One Condom Program" which distributed 5 million condoms in its first year of operation. Government outreach programs to educate sex workers started before 1995 and were rapidly scaled up after this. As a result of these activities condom use increased rapidly in sex work and the number of new HIV and other sexually transmitted disease infections fell rapidly. Simultaneously, NCHADS was monitoring the situation and passing these results on to policymakers and program managers to help galvanize action. With support from USAID and FHI they began conducting HIV sentinel surveillance in 1992 and behavioral sentinel surveillance in 1997.

However, the large pool of clients of sex workers who became infected in the mid 1990s consisted of either young men who would soon marry or already married men. Over time these men would transmit HIV to their wives and other female sexual partners. However, because most men and their wives do not have other sexually transmitted diseases, which make HIV much easier to contract, their per contact probability of transmitting or contracting HIV is much lower [Duerr et al. 1994]. Thus, this wave of infections grew more gradually as seen in the line for “females from husbands” in Figure 17 – it steadily increased until the late-1990s and then began a slow decline. Once the women became infected, it was only a matter of time until some of them transmitted HIV to their newborn children. These are the four waves of the Cambodia epidemic seen in epidemological data (sex workers, clients, wives and girlfriends, and children) and they are clearly seen in the changing routes of HIV transmission produced by the baseline scenario.

Table 5. People currently living with HIV and AIDS by gender in the baseline scenario. The final column gives the ratio of male to female infections.

Year	Male	Female	Total	M/F ratio
1985	6	2	8	3.2
1990	3,236	851	4,087	3.8
1995	103,552	41,437	144,989	2.5
2000	110,561	78,414	188,975	1.4
2005	58,456	55,685	114,141	1.0
2010	23,450	23,626	47,076	1.0

Figure 18. Males and females living with HIV and AIDS over time in the baseline scenario.



Gender balances in the epidemic

The successive waves of the Cambodia epidemic have produced changes in the overall male-female balance of HIV infections. Table 5 shows current male and female infections in the baseline scenario and the ratio of men to women infected. These are illustrated graphically in Figure 18. Males have dominated the Cambodian epidemic throughout, but the male to female ratio has declined steadily until today approximately one and a half as many men as women are living with HIV. By the mid-2000s, the male -female ratio will approach 1.0 as many of the men infected in the early 1990s become ill and pass away.

Changing routes of transmission

Figure 19 and Table 6 summarize how the importance of different routes of transmission has varied over time. Almost two-thirds of the 39,000 people infected in 1995 were males who visited sex workers. Another factor which has grown in importance over the years is husband-to-wife transmission. Because husband-to-wife transmission occurs more slowly, the influence of the huge burst of male infections between 1993 and 1995 is only becoming apparent recently. But in 2000, half of all new infections probably occurred through husband-to-wife transmission, with another one-twentieth produced from wives with past risk behavior infecting their husbands with HIV. Finally, and most importantly, mother-to-child infections have now become a significant portion of new infections in the country and these are amenable to direct intervention by antiretroviral drugs which can substantially reduce mother-to-child transmission such as AZT.

Figure 19. Changing routes of transmission over time in the Cambodian HIV epidemic.

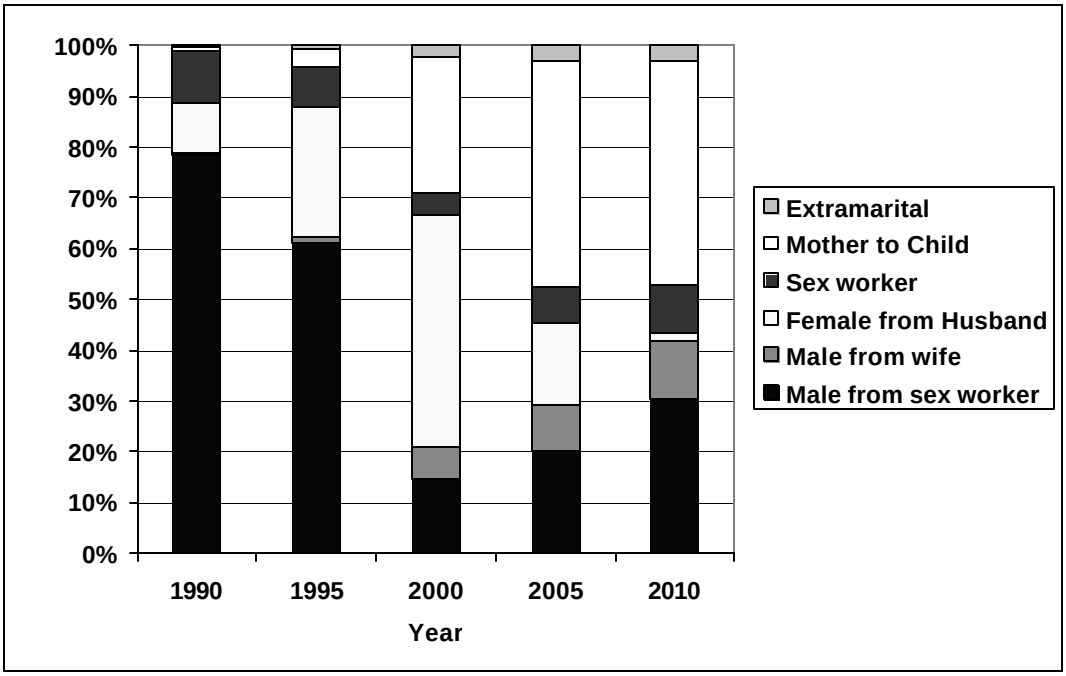


Table 6. Changing infection patterns over the course of the Cambodia epidemic in the baseline scenario. Percentage of new HIV infections by gender and means of infection.

Infection route	*1990*	*1995*	*2000*	*2005*
Males infected by visiting sex workers	79%	61%	15%	20%
Males infected by non-paid female partners (wives or girlfriends)	0%	1%	6%	9%
Female sex workers infected	10%	8%	4%	7%
Females infected by husband or other sex partner	10%	26%	48%	19%
Children infected from mothers	1%	4%	27%	45%
Total number of new infections	*2,895*	*38,822*	*10,553*	*4,014*

Expanded prevention efforts are needed - husband-wife and mother-to-child transmission continues

Table 6 also gives an idea of what factors are now controlling the future course of the Cambodia epidemic:

- *Almost half of new infections at present involve transmission between husbands and wives*. New alternatives should be explored to interrupt this transmission, which also often leads to the infection of Cambodian children at birth.

- *Approximately one-fourth of new infections are from mother-to-child*. Half of these infections can be averted by providing appropriate antiretroviral therapy to mothers which is currently being considered as a national policy.

Unless these programs are undertaken, infected children will come to dominate new infections in the next decade as seen in Table 6.

However, sustaining prevention efforts for sex work is critical

A rough calculation shows that the success of the Cambodia program to date is largely attributable to the behavior changes that have occurred between sex workers and clients. Consider that there were roughly 35,000 new infections a year in the mid 1990s, most of which were occurring through sex work. Then over the next few years the number of clients was cut roughly 60% (reducing the number of new infections to the 14,000 range). Condom use went from 40% to 85% levels (that is, from 60 percent of contacts having a risk of HIV transmission to only 15%), reducing the number of new infections to 3,500. At the same time STI rates fell by half due to the increase in condom use and improvements in STI care. Since much HIV transmission occurs in the context of other STIs, this further reduced the number of new infections. All of these factors have combined so that today less than 2,000 infections a year are attributable to sex work.

But it should be stressed that the sex work which drove the Cambodian epidemic to such high levels remains common in the country. Table 7 shows the size of various populations with higher risk of HIV by virtue of continuing risk behavior or exposure to sexual partners living with HIV. Clearly, clients and sex workers constitute by far the largest and most critical population, still including roughly 10% of the adult male population. These numbers make it clear that if prevention efforts lag with sex workers and clients, the sex work components of the epidemic will rapidly come to dominate again. Thus, maintaining the prevention efforts for sex work and continuing efforts to discourage young men from developing habits of visiting sex workers remain absolutely essential and central components of maintaining Cambodia's prevention successes.

Table 7. Size of various populations with higher risk of contracting HIV in Cambodia in the year 2000.

Population	*Size*
Clients and sex workers	380,000
Children born to HIV+ mothers	12,000
Uninfected partners of those living with HIV	57,000

Estimating the benefits of prevention

The model allows us to quantify the benefits of the prevention programs that produced this extensive behavioral change. Figure 20 shows what would have happened had there been no aggressive national program so that risk behaviors remained as they were in 1993. By the year 2000, approximately 750,000 Cambodians would be living with HIV; prevalence would exceed 10% of the adult population on a national basis. Given that almost 40% of adult males were visiting sex workers with low levels of condom use in 1993 and that most of them would have become infected over the last decade had condom use levels remained low, this high overall level of HIV infection would have been quite possible. Thus the behavioral evidence and the model both indicate that it would have happened on a national scale had extensive and intensive multisectoral, multilevel prevention efforts not been pursued.

The absolute need to sustain prevention successes

However, the fact that half million of Cambodian HIV infections have been averted leaves no room for complacency.– intensive prevention efforts to reduce risk in sex work must be sustained even as care and support needs create greater demands on resources.

When the prevalences shown in these figures are combined with the future course of the epidemic shown by the baseline scenario (Figure 16), it raises an extremely important point:

- *At present over 3 percent of adult Cambodian men and approximately 2 percent of adult Cambodian women are living with HIV or AIDS. Should prevention efforts weaken, the rapid growth in prevalence seen in the mid 1990s could quickly resume.* Figure 21 shows what the model predicts might happen if condom use in sex work fell back to 60% levels in 2002 and remained there as a result of failure to sustain program efforts. The detailed results for this scenario are at the end of Appendix B. Clearly the huge reservoir of HIV in the Cambodian population creates the potential for renewed explosive growth should prevention efforts weaken.

Figure 20. Benefits of prevention - compares the baseline scenario against what the model predicts had behaviors remained as they were in 1993.

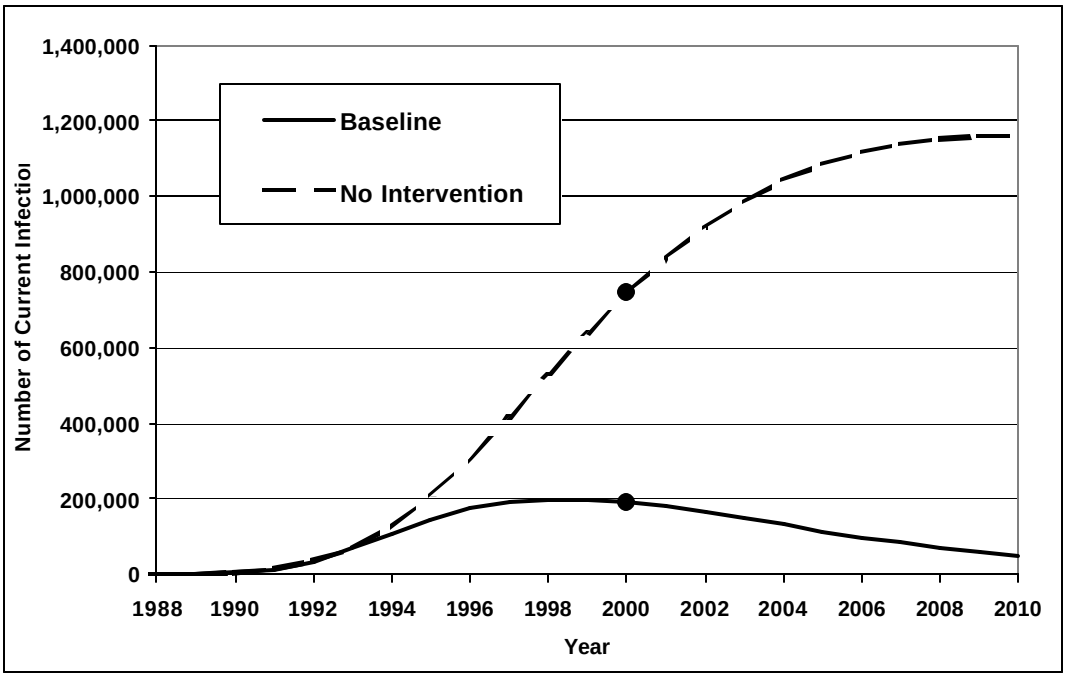
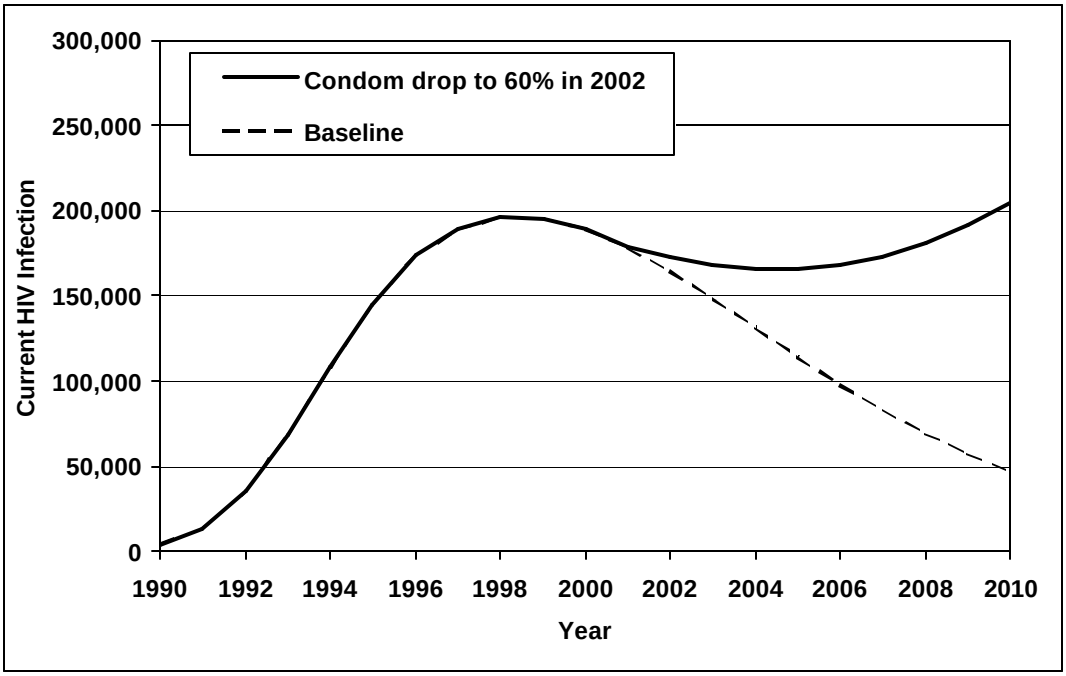


Figure 21. Effects of failure to sustain high levels of condom use in sex work – rapid epidemic regrowth (Figure assumes condom use falls to 60% from 85% starting in 1998).



Steady and high demand for care and support, ongoing AIDS-related deaths

While prevention efforts to date have been extremely successful, the effects of the large number of HIV infections in the mid 1990s are now apparent – and they will place significant demands on care and support resources throughout the next decade. On average, the model assumes an eight-year delay between infection with HIV and the onset of AIDS. Since the bulk of new infections occurred in 1993-1995, these infections are now presenting as AIDS cases. Figure 22 shows the number of AIDS cases expected annually in the baseline scenario. The current number of new annual AIDS cases is approximately 20,000 and this will remain true through the mid-2000s then gradually decrease to 10,000 at the year 2010 (Approximately 10% of these AIDS cases are children and will be discussed in more depth later in this document). This creates substantial ongoing demands on medical and social care services and requires mobilization of community support for those living with and affected by HIV and AIDS. These must be considered in planning resource allocations.

Table 8 presents the number of adult AIDS cases in each year by gender. Men will outnumber women by a factor of 2 among people living with AIDS throughout the next decade, again a consequence of the large burst of male infections in the mid 1990s. The male/female ratios coming from the model compare well with the male to female ratios from annual reports of AIDS cases to the NCHADS. Among the year 2000 reported AIDS cases the ratio was 1.8 in 1999, compared to the 1.9 ratio predicted by the model. Because average survival after diagnosis with AIDS is comparatively short (less than a year in some studies in neighboring Thailand), deaths will track AIDS cases fairly closely. In the baseline scenario approximately 17,000 people died of AIDS in 2000, and through the end of the decade, this number declines very slowly to 12,000. This can be seen in Appendix B where cumulative AIDS deaths are only slightly lower than cumulative AIDS cases for years beyond 2000.

Figure 22. Number of new AIDS cases each year in the baseline scenario showing ongoing demand for care and support.

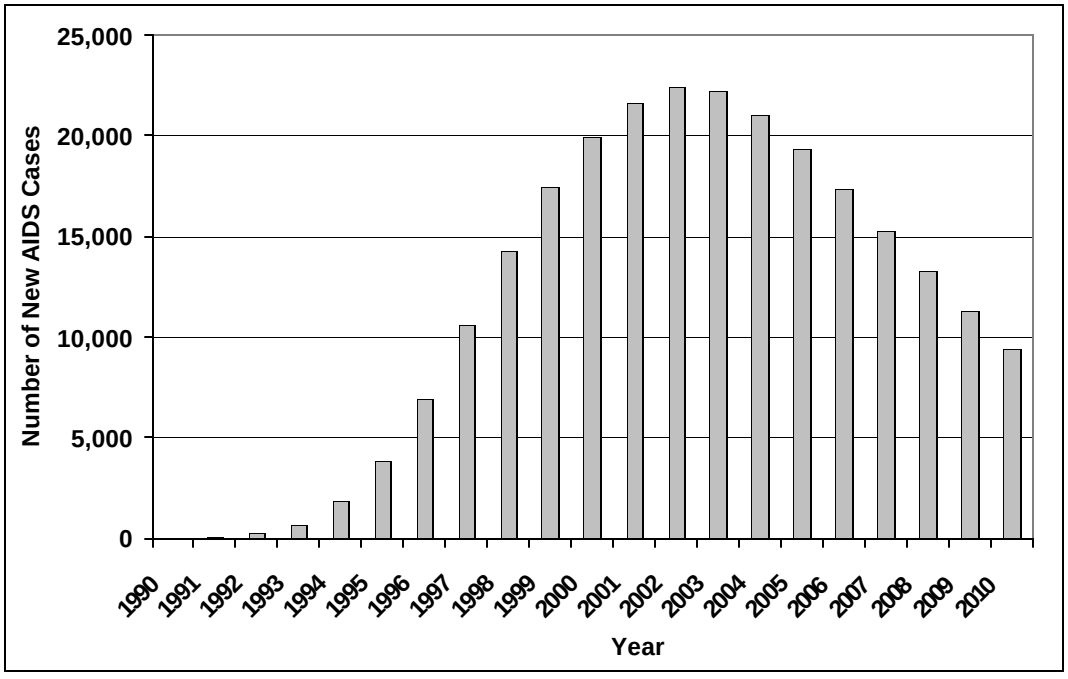


Table 8. Annual new AIDS cases for adults by gender, the final column gives the ratio of male to female AIDS cases in the year specified.

Year	Male	Female	Total	M/F ratio
1985	0	0	0	1.4
1990	15	6	22	2.6
1995	2,852	1,035	3,887	2.8
2000	13,026	6,953	19,978	1.9
2005	10,719	8,636	19,355	1.2
2010	4,622	4,792	9,414	1.0

Age distributions of new infections – the role of the young

New HIV infections are largely sexual in nature and in this scenario have been distributed according to the STI curves as described earlier. The resulting estimates of number of new infections by single year age groups are shown in Figure 23. As in other countries, HIV transmission occurs disproportionately among the young: approximately 50% of the new male and 60% of the new female infections occur between the ages of 15 and 29. As can be seen from the figure, the male curve peaks at age 23 and the female curve at age 20. This is a pattern observed throughout the world. Women tend to become infected earlier than men because women most commonly have older male partners and because they are biologically more susceptible to HIV and other STIs than men.

Figure 23. Age distribution of new HIV infections among men and women in the year 2000 in the baseline scenario.

HIV transmission is highest in the 15-24 age range because these are the ages when men are most likely to visit sex workers regularly and when many young Cambodian men and women are getting married, potentially exposing themselves to HIV risk from a spouse who was sexually active prior to the marriage. It is worth noting in the baseline scenario approximately 15% to 20% of the couples have the wife HIV positive and the husband negative – so husband and wife transmission does occur in both directions.

There is clearly a need for ongoing efforts focused on young people to reduce the number of new infections even further. These should include ongoing efforts to promote safer behavior, delay sexual intercourse, and encourage voluntary premarital counseling and testing for HIV.

HIV & AIDS-related death age distributions imply significant labor force impacts

Figure 24 to Figure 27 show the changing age distributions of current HIV infections and new AIDS related deaths among Cambodia males and females. Appendix C provides the full details of these age distributions for the baseline scenario. Important things to note about current HIV infections:

- *The adult female current HIV age distribution peaks earlier.* In general women are infected at younger ages than men so their age distribution peaks in the 20-24 year old age group, compared to 25-29 for men.

- *Adult women have approximately half the overall level of HIV infection at all ages*. This reflects the influence of large numbers of client infections in the mid 1990s, leaving a strong male dominance in the number of current HIV infections.

- *The peak of male infections will shift to the 30-34 year age group by the year 2005*. Because the majority of male Cambodia infections occurred in the mid 1990s, the peak age increases almost linearly with time through the next 5 years. Women will also shift and the peak will be at the 25-29 age group in 2005.

- *The level of infection in both men and women will fall, but women's levels will fall more gradually*. Many of the men infected in the mid 1990s will be dying from AIDS-related causes now, bringing male levels down quickly, however because women on average were infected later and husband-to-wife transmission continues, levels in women will decline less rapidly.

While most infections occur while people are young, between the ages of 15 and 24, the average eight year time from infection to illness means that deaths occur at older ages. Thus, the patterns for AIDS-related deaths are shifted to somewhat older ages, but still have the same general features:

- *Adult male deaths are substantially higher than female deaths*. Two factors are influencing this difference. More men are infected than women,

and on average men were infected earlier than women, so the men are progressing to AIDS and death sooner.

- *Male deaths will be approximately the same for the year 2000 and 2005, but female deaths will actually increase*. Again the earlier infection of men means that a large portion of the mid 1990s male infection bulge will be dying, thus overall AIDS-related death rates for men will begin to fall significantly after the year 2005. However, women were infected later and continue to get infected at higher rates than men, so female AIDS-related deaths will actually increase slightly after 2005.

- *Women die of AIDS at younger ages than do men*. Because they are infected at younger ages, the peak for the female AIDS-related death distribution is younger than that for males. The peak for women is in the 20-24 age range, while that for men is in the 25-29 age range in 2000.

- *The peak age of deaths will shift steadily to older ages for both males and females.* By 2005, the peaks will be at 25-29 for women and 30-34 for men. This again reflects the influence of the mid 1990s infection burst propagating through the population.

These results have consequences for the Cambodia labor force over the next ten years.

- *70 percent of all new AIDS deaths in the year 2000 are in the 20-44 age range, the most productive segment of the labor force.* This demonstrates that the epidemic will have a serious effect on the Cambodian labor force.

- *Because the HIV and death distributions are shifting to older ages, the impacts will increasingly hit the more experienced and skilled portion of the labor force*.

Figure 24. Current HIV infections by age for males in the years 2000 and 2005 in the baseline scenario.

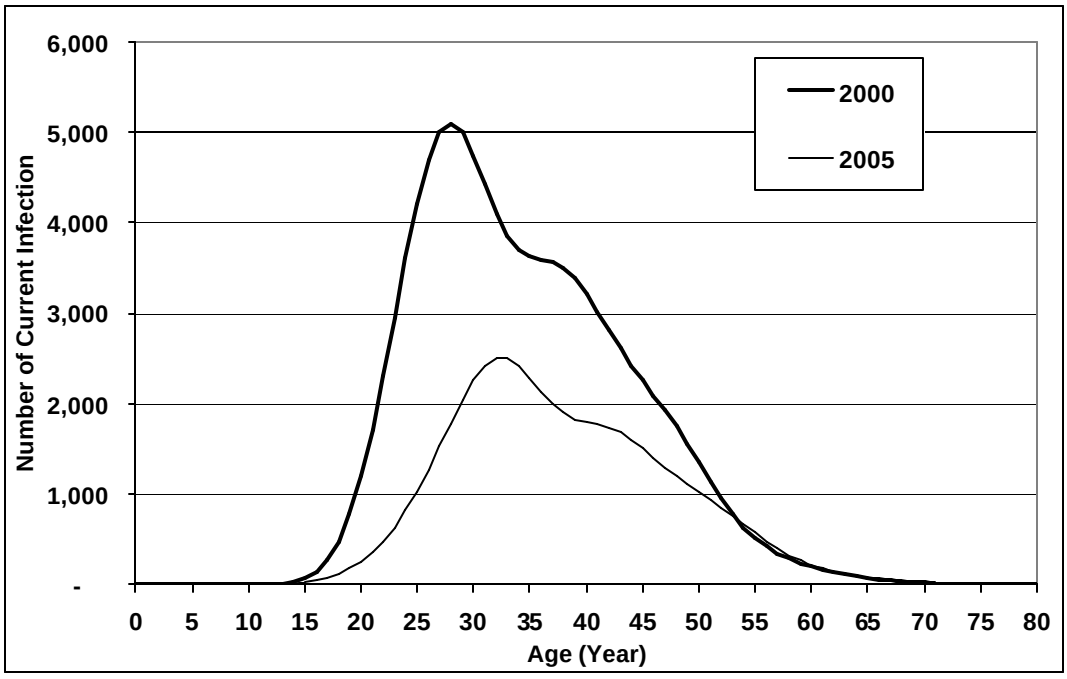


Figure 25. Current HIV infections by age for females in the years 2000 and 2005 in the baseline scenario.

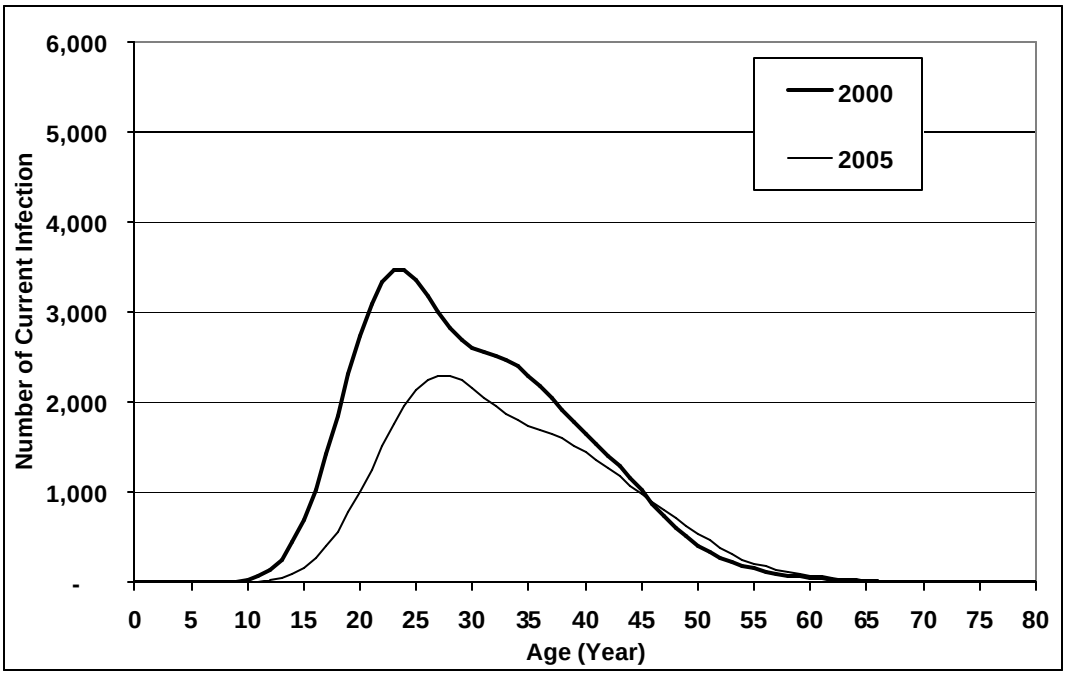


Figure 26. Age distribution of new annual AIDS-related deaths for males in years 2000 and 2005 in the baseline scenario.

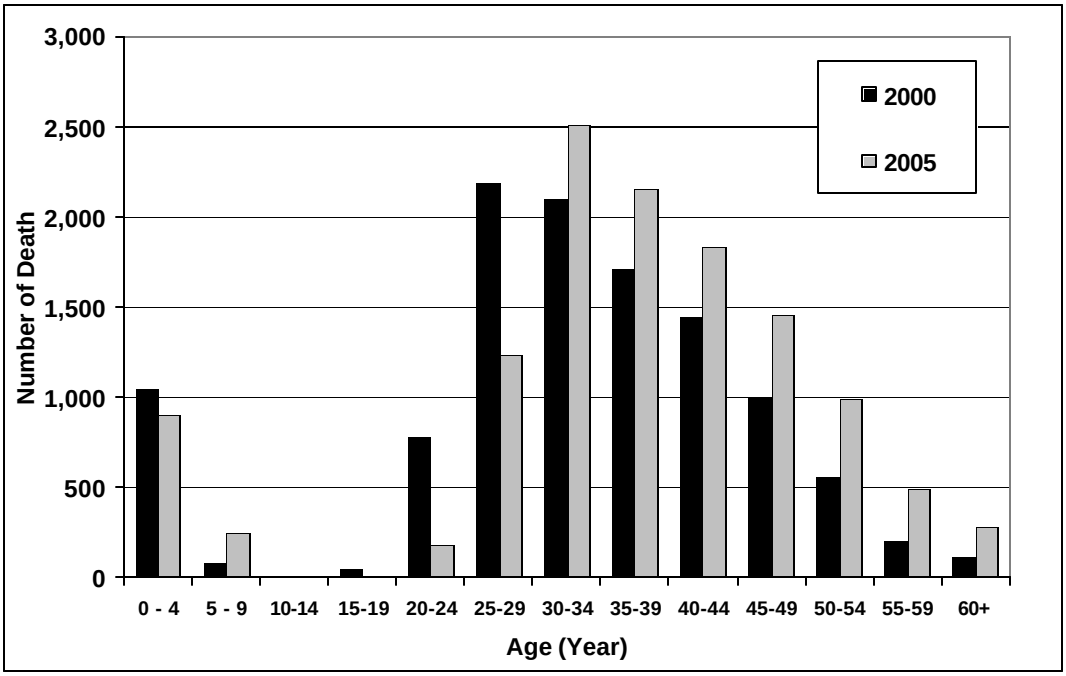
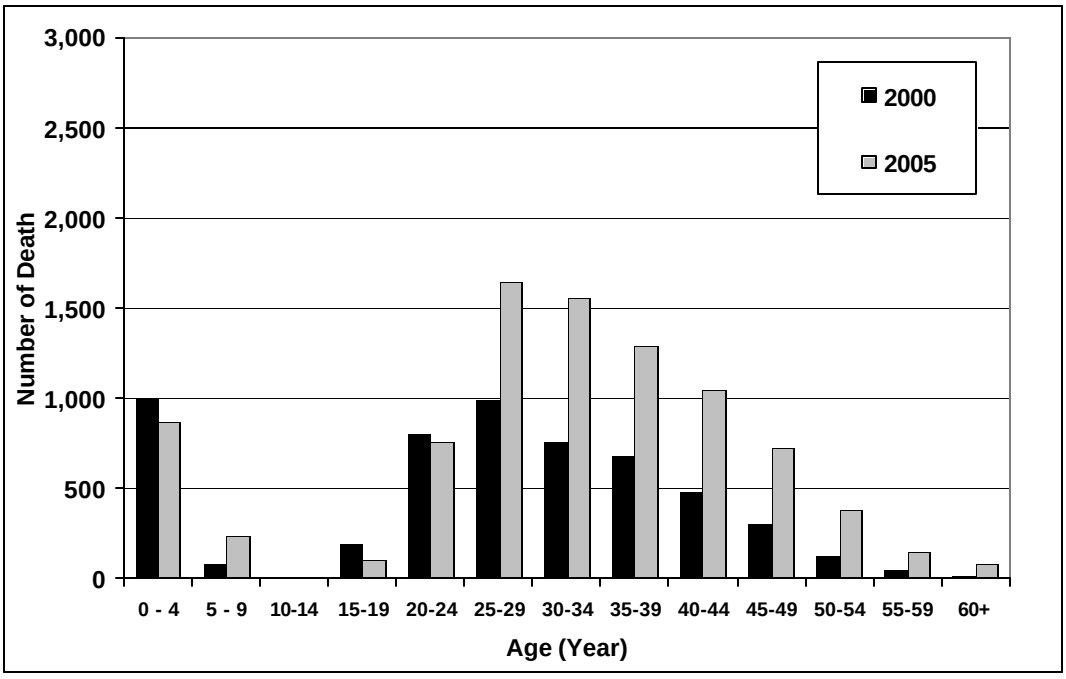


Figure 27. Age distribution of new annual AIDS-related deaths for females in years 2000 and 2005 in the baseline scenario.



Children with HIV and AIDS

As seen in Table 6 approximately one-quarter of new infections in the year 2000 are among children. Table 9 summarizes the situation for children in the baseline scenario. According to the baseline scenario, the number of new HIV infections of children should have peaked in 2000 and be declining slowly now (see Figure 28) as prevalence among women falls slowly. Today roughly 2,800 Cambodian children are being infected with HIV each year.

Table 9. Pediatric HIV, AIDS and deaths in the baseline scenario assuming no intervention.

Year	Pediatric Living w/ HIV and AIDS	Pediatric Annual new HIV	Pediatric Annual new AIDS	Pediatric Cumulative HIV	Pediatric Cumulative AIDS	Pediatric Cumulative AIDS deaths
1985	0	0	0	0	0	0
1990	23	22	6	31	8	8
1995	1,953	1,370	565	3,031	1,106	1,078
2000	6,492	2,832	2,230	15,473	9,092	8,981
2005	6,012	1,796	2,256	27,043	21,144	21,031
2010	3,091	626	1,165	32,237	29,205	29,146

There is a common misconception that most children infected with HIV die rapidly. However, a number of epidemiological cohorts have now established that this is not true. Children infected with HIV fall into two classes. The first group, perhaps 15-20 percent of all infected children, do progress very rapidly to AIDS and die within one

or two years of birth. However, the second group, which constitutes the majority of children with HIV, progress to AIDS and death at rates that are similar to those in adults. That is, they will live a very long time.

This has major policy implications. It means a growing number of children will be living with HIV. As Table 9 shows, this number will be greater than 6,000 children from 2000 to 2005. Most of these children will require ongoing medical management for their health as well as counseling and support. In planning for the future it is important that their needs be addressed. Some will survive long enough to enter adolescence and will need to address issues of sexuality in a way that protects both them and their sexual partners. This has now become an issue in some countries with long-standing epidemics such as the United States. Policymakers should consider options to address these needs.

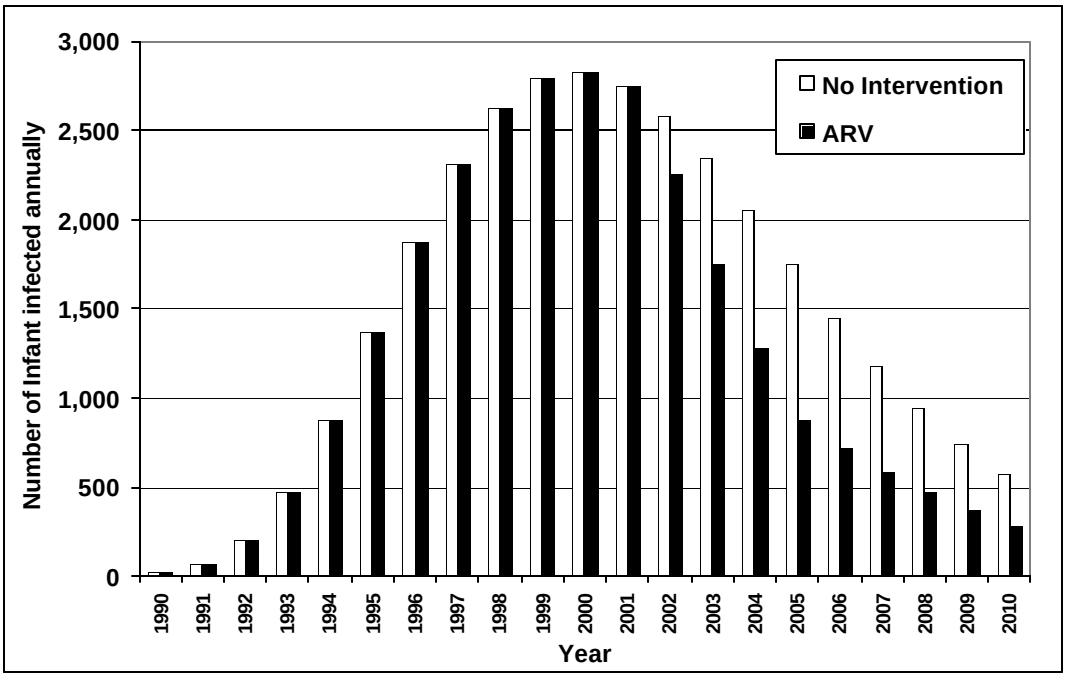
Pediatric AIDS and death will also be growing throughout the period as shown in Table 10. Throughout the next five years roughly 2,200 children per year will develop AIDS. As with adult AIDS and deaths, pediatric deaths will track the pediatric AIDS cases quite closely.

Table 10. Number of new pediatric AIDS cases and deaths developing annually in the baseline scenario.

Year	*Pediatric new AIDS Male*	*Pediatric new AIDS Female*	*Pediatric AIDS Total*	*Pediatric deaths annually*
1985	0	0	0	0
1990	3	3	6	5
1995	288	277	565	552
2000	1,137	1,093	2,230	2,217
2005	1,150	1,106	2,256	2,264
2010	594	571	1,165	1,176

In the case of pediatric transmission, a major prevention opportunity presents itself in Cambodia during the next ten years period. New antiretroviral therapies, e.g. nevirapine or short course AZT, are relatively low cost and have been shown to cut the transmission from mother to child almost in half. Should Cambodia effectively implement one of these solutions nation-wide, as proposed in the scenarios described earlier, the 2,800 children infected annually can be cut in half by the year 2005 (see Figure 28).

Figure 28. Number of children born with HIV every year with and without the implementation of antiretroviral therapy(ARV) for pregnant women with HIV.



Comparison of the Four Scenarios

The baseline scenario assumes that prevention activities and efforts remain as they are today. However, as outlined in the history of the Cambodia epidemic given above and in the description of the four scenarios, there are major opportunities for Cambodia to further control this epidemic:

- ?? Sustaining and improving condom promotion and STI care for sex workers and clients.
- ?? Reducing transmission in couples where one partner has HIV by expanding voluntary counseling and testing and voluntary premarital screening.
- ?? Reducing pediatric transmission through provision of maternal AZT.

The four scenarios illustrate some of the benefits of undertaking combinations of the programs outlined above. The full results of each scenario on HIV transmission are presented in Appendix B. Table 11 and Figure 29 summarize the results. Some of the more important differences among the scenarios have been extracted in Table 12 through Table 15.

Figure 29. Impact of the three expanded intervention scenarios on cumulative HIV infections in the Cambodia population over

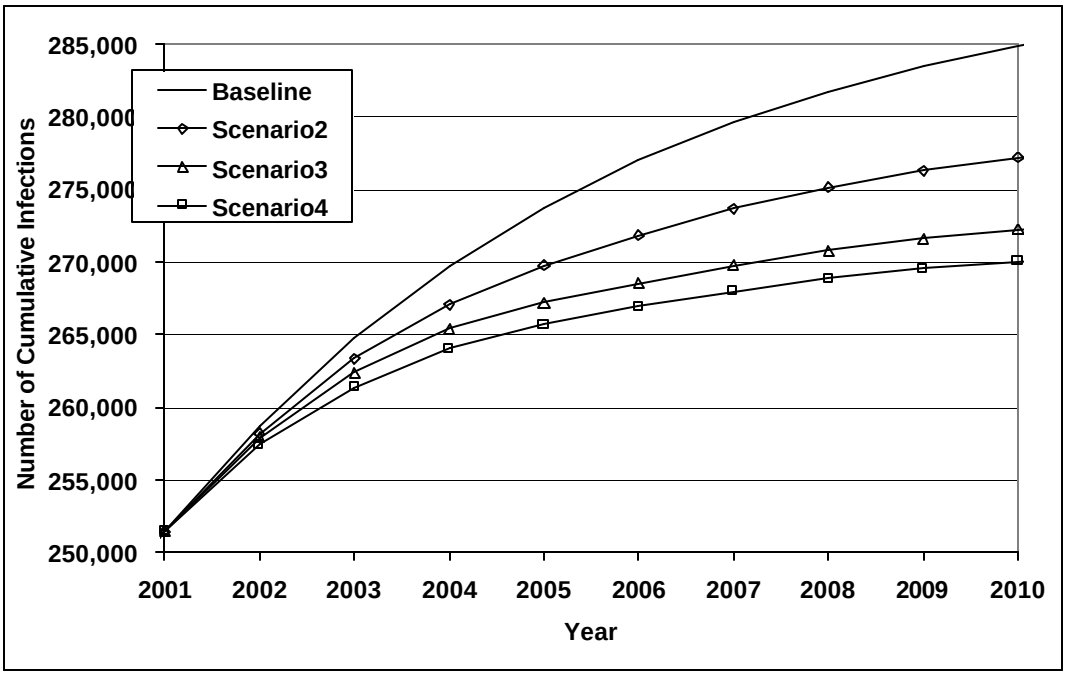


Table 11. Brief Summary of the Results of the Four Scenarios in 2010.

Scenario Description	***Starting Situation***	***Baseline***	***Heterosexual***	***Heterosexual + MTCT***	***Heterosexual + MTCT+Couple***
Scenario Number		***1***	***2***	***3***	***4***
Year	***2000***	***2010***	***2010***	***2010***	***2010***
Total number of people living with HIV and AIDS in *year*	188,975	47,076	40,747	39,543	37,981
Total number of new HIV infections in *year*	10,553	1,422	910	624	533
Total number of HIV infections from beginning through *year*	242,836	284,898	277,224	272,223	270,071
Total number persons with AIDS from beginning through *year*	76,032	249,351	247,367	243,546	242,754
Total deaths from beginning through *year*	53,862	237,821	236,477	232,680	232,089
Total pediatric infections from beginning through *year*	15,473	32,237	31,828	26,827	26,656
Total number of child deaths from beginning through *year*	8,981	29,146	28,891	25,094	24,977

Table 12 shows the cumulative number of HIV infections in each scenario and Table 13 summarizes the number of infections, which are prevented in each scenario. By the year 2010, these range from a low of 7,674 for Scenario 2 (the Heterosexual Risk Reduction scenario) to a high of 14,827 for the most aggressive program (Scenario 4). Each of these infections averted will also translate in the long term into significant savings in medical care costs, worker training costs, and human suffering for the individual and his/her family.

Table 12. Summary of cumulative HIV infections in each of the scenarios.

Year	Baseline	Scenario2	Scenario3	Scenario4
1985	8	8	8	8
1990	4,101	4,101	4,101	4,101
1995	148,215	148,215	148,215	148,215
2000	242,836	242,836	242,836	242,836
2005	273,791	269,814	267,256	265,723
2010	284,898	277,224	272,223	270,071

Table 13. Summary of averted infections in each scenario relative to the baseline.

Year	Scenario2	Scenario3	Scenario4
2005	3,977	6,535	8,068
2010	7,674	12,675	14,827

To see where the averted infections are actually arising, Table 14 presents the infections averted by the end of 2010 by adult male, adult female, and child.

Scenario 2 has only a small impact on new infections of children because most children are being infected by mothers who are already living with HIV in the year 2000. Scenarios 3 and 4 have a major impact because both involve antiretroviral therapy for mother-to-child transmission which will reduce the number of pediatric infections by a factor of 2, averting 5,500 infections of children.

The Heterosexual Risk Reduction Scenario (Scenario 2) will prevent roughly 7,700 infections during the period of next ten year, approximately two-thirds of these infections are men. Scenario 4 has the largest impact on women because it includes a component addressing husband-to-wife transmission which is the source of most new female infections in Cambodia.

Table 15 presents a summary of cumulative AIDS cases in each scenario. The interesting thing to note here is that the different scenarios make little difference in the number of AIDS cases through the end of the year 2005. The most aggressive scenario reduces AIDS cases by roughly 1,200, which is less than 1% of the AIDS cases developing over the five year period. This is because AIDS cases in the near future are largely determined by the burst of infection in the mid 1990s, which generated most of the current adult infections. Thus, regardless of prevention efforts, the medical care needs created by AIDS will continue throughout the next ten years.

Table 14. Infections averted by adult male, adult female, and child by end of 2010 in each scenario.

Infections averted	*Scenario2*	*Scenario3*	*Scenario4*
Child	409	5,410	5,582
Adult male	5,461	5,461	6,042
Adult female	1,804	1,804	3,204
Total	7,674	12,675	14,827

Table 15. Summary of cumulative AIDS cases in each of the scenarios.

Year	*Baseline*	*Scenario2*	*Scenario3*	*Scenario4*
1985	0	0	0	0
1990	30	30	30	30
1995	6,782	6,782	6,782	6,782
2000	76,032	76,032	76,032	76,032
2005	182,677	182,573	181,525	181,443
2010	249,351	247,367	243,546	242,754

IMPROVING FUTURE MODELING EFFORTS

The model presented here represents a new, more sophisticated approach to modeling of the Cambodian HIV/AIDS epidemic. It is an approach that is deeply rooted in the extensive behavioral and epidemiological data that has been gathered over the last eight years of the Cambodia epidemic and used so effectively to guide national prevention and care efforts. The model accurately reproduces the time trends in epidemiological data observed since the mid-1990s and is in reasonable agreement with prevalence patterns in various populations, gender ratios in AIDS cases, and other sources of data on the Cambodian epidemic. Thus the Working Group has confidence that the inputs and the outputs accurately represent the situation through the national behavioral data set collected in 2000.

Filling data and understanding gaps

However, one of the most important benefits of the type of modeling exercise undertaken here is that it forces one to take a long, hard look at the epidemiological and behavioral data, assess its quality, and identify gaps in what we know. In Cambodia, this process identified several specific issues that require additional data collection, stronger efforts to identify and collate existing data sources, or both. These include:

- *The definition of indirect sex workers and their numbers.* One of the persistent issues that came up in the Working Groups' deliberations was the question of who was an indirect sex worker, how well the surveillance system captured them, and what fraction of those labeled "indirect sex workers" in surveillance

actually sell sex. This is clearly an issue calling for much closer attention in future data collection efforts. In addition to its use in strengthening the models and our understanding of the changing contributions of direct and indirect sex work, such data will also guide prevention efforts in determining both levels of current coverage and where they can have the greatest impact.

- *The shifting balance between direct and indirect sex work*. While many people could give anecdotal accounts purporting to show a strong shift to indirect sites, hard data on this shift was lacking. Efforts to count comparative numbers of direct and indirect sites, explore where clients meet and have sex with sex workers, and characterize the relative contribution of these forms of sex work to actual levels of risk activity need to be strengthened. Better counts of the numbers of both direct and indirect workers should also be obtained as part of this process, as a means of characterizing shifts over time.
- *Changing levels of premarital and extramarital sex in the country.* Many people expressed concerns that additional information was needed on the levels of premarital and extramarital sex in Cambodia, especially as this was perceived to be changing in the face of the AIDS epidemic as men sought partners other then sex workers. However, the extent to which this is true in the population at large remains unknown. Available behavioral surveys are limited windows on the entire population, with many of those windows focused on those at highest risk only. Only one general population behavioral survey has been done. This calls for close attention. If condom use with sweethearts and other non-commercial sexual partners remains low and STI levels in the population at large are not reduced, these more personal relationships may become major contributors to HIV transmission in the Kingdom.
- *Changing patterns of sexuality among young people*. Of particular concern is how the behaviors of youth are changing in the face of a serious HIV epidemic. Are young men bringing more pressure on young women and how are the young women responding? Hard data is needed both to guide prevention programs and to allow better characterization of young people's contribution to the epidemic through improvements to the model.
- *Improved understanding of the relationship of ANC women to the larger population of women*. Less than one-third of women in Cambodia seek antenatal care, yet this remains the primary source of HIV levels in the population at large. If estimates and models are to improve, better calibration of the relationship through focused studies is needed. These studies will also assist in efforts to determine feasibility and approaches for implementing programs to reduce mother-to-child transmission.
- *Male-female ratios in the country.* One issue that arose repeatedly was that of the male-to-female ratio in HIV in the country. While numerous sources exist, including AIDS cases, TB patients, blood donors, and the general population HIV survey in 2000, in many cases this data has not been systematically collected or the important information on male-to-female ratios extracted from existing records. An effort should be made to pull this data together and study it for clues as to how the gender balance in the epidemic has changed over time and what its implications for the future may be. This information will also assist in improving estimates of the burden of HIV and AIDS in the Cambodian population.

- *Changing levels of drug use, both injecting and non-injecting*. While injecting drug use has apparently not contributed to the epidemic so far, concerns have been raised that it might in the future. Again much of the data discussed is anecdotal in nature, with little solid data on how drug use is evolving, especially among youth.
- *STIs.* STIs are a major factor in HIV epidemics – in the absence of STIs, HIV transmission occurs at comparatively low rates. While Cambodia now has comparatively low rates of STIs, the levels still remain substantial among sex workers and are contributing to HIV transmission. Better characterization of STI levels and tracking of their trends will improve both HIV/STI prevention efforts and the models.
- *Men having sex with men*. Another gap in understanding of the Cambodian epidemic is the contribution of men who have sex with men, both in terms of their numbers and their risk activities. The one survey done in Phnom Penh in 2000 found many of these men had both male and female partners and also visited female sex workers [Girault et al. 2002]. Given the high probability of HIV transmission through anal sex, these men may be contributing substantially to the epidemic and may represent an urgent prevention need, especially as heterosexual sex work has become less of a factor in driving the Cambodian epidemic.

Improving the model

The Asian Epidemic Model is itself a work in progress and will be evolving substantially over the next year. Important factors such as men having sex with men, increased infectivity during primary HIV infection, and migration will be added and their significance determined. The model will then be repackaged in early 2003 and training materials prepared. Specific changes, which are planned for the next release of AEM, include:

- *An improved user interface*, making it easier for users to enter and verify the various forms of epidemiological and behavioral data required.
- *Men having sex with men.* Addition of components that allow transmission to occur through same sex behaviors among men and to their female sexual partners.
- *Migration*. Allowing external introduction of HIV to specific sub-populations in the model, e.g., from overseas returning workers or sex workers returning from another country.

One additional need that was strongly expressed by many involved in the process is to link these models more directly to policies and to economic costs analyses. That is, we need to determine how specific policies and prevention programs put into place translate into behavior change so that they can be more directly entered into the models. In addition, we need to be able to assess the cost of competing prevention alternatives, which will then allow us to do cost-efficiency rankings of different alternatives and conduct cost-benefit analyses, which will help us to make the case clear that HIV prevention pays for itself in future savings to the country.

However, costing and program impact data, by their very nature, are local – no international "estimates" can be calculated and provided. Thus, Cambodian

researchers and implementers must collect such data in the course of mounting prevention and care efforts. This will be an ongoing challenge, both to the research community in Cambodia, which needs to collect and analyze the locally relevant data, and to the international community, which needs to better understand how to use the resulting data and analyses to best direct limited resources to obtain the greatest HIV prevention and care benefits. Once this data is available, it can readily be used in conjunction with model outputs to calculate cost-effectiveness and conduct cost-benefit analysis.

Updating and applying the model in a sustainable fashion

Data collection does not stop – new information and better analyses are coming in all the time. Our understanding of HIV, its determinants, and the various parameters that go into modeling also improve over time. Fortunately, the modeling process is an iterative one, that is, the models used can be revised periodically as a better understanding is obtained of the HIV situation, new data become available, and new versions of the tools are developed.

In the discussions following this first round exercise, several points were raised which should be taken into account in the next round of modeling:

- *Higher mother-to-child transmission*. Many felt that higher mother-to-child transmission parameters should be used in Cambodia, perhaps with a value of 33% instead of the 24% used here. This is probably a more realistic estimate in that breastfeeding is still common for HIV+ women in Cambodia, driving transmission rates up somewhat.
- *Survival times.* Currently the projections used the UNAIDS progressions for adults and children derived for the 1997 round of global estimates. In the last year, the UNAIDS Reference Group has come out with revised survival times for adult and pediatric HIV infection based on developing country cohorts [UNAIDS Reference Group 2002a]. These would tend to have children live a little longer and adults die more rapidly than the schedules used here. The role of tuberculosis in influencing this survival was raised by some reviewers and should be looked at more carefully in the research literature and future studies.
- *Incorporating new data as it becomes available*. Since these projections were done, a new round of HIV surveillance and another round of behavioral surveillance have been done. In addition, more complete analysis of the 2001 STI survey is available. However, it was not possible to incorporate these new data into this round of modeling because of time limitations on key personnel.
- *More complete sensitivity analyses*. There was insufficient time in this exercise to do a complete sensitivity analysis of the key factors driving this epidemic. For the next round, however, sensitivity on all key analyses should be a primary objective. This will allow us to suggest which data sets are most critical to projection work and focus data improvement efforts on those areas.

As the next round of modeling is undertaken, it is essential that the AEM technology be transferred to Cambodian counterparts so that they can undertake such efforts with limited external assistance in the future.

An evolving epidemic

The new HIV and behavioral data available in 2002 contains several interesting trends whose implications need to be explored carefully in the next round of modeling. Key among these are:

- *HIV levels in pregnant women have apparently stabilized at roughly 2.8%*. It appears now that some of the prevalence decline of the last 4 years was due to statistical fluctuations and that the prevalence is leveling off and falling much less rapidly than previously assumed. This means the projections in this report may overestimate the rate of decline of the epidemic in Cambodia. One possible explanation is that male to female transmission occurs at higher rates than were used here or that male to female STI cofactors are higher. These will need to be explored in the next round of modeling, incorporating the new STI data now available.
- *Male rates in blood donors have continued to fall*. However, while female rates appear to be stabilizing, male infection rates still appear to be declining and the male-to-female ratio has continued to decline. This would be expected based on the dynamics of the epidemic as outlined in this report. As more complete analyses of male-to-female ratios become available from other data sources, it should be possible to improve the models here by incorporating these differences and adjusting the transmission parameters to get a model that more correctly reflects the historical patterns in the Cambodian epidemic.

The primary implications of this are that the situation may improve more slowly than was calculated in this set of projections. Furthermore, new routes of transmission, e.g., MSM, youth, and injecting drug use may become more serious as transmission through sex work is curtailed. This means the epidemic must be monitored carefully, both epidemiologically and behaviorally.

Exploring other modeling scenarios in the future

In closing, one of the strengths of the model presented here is that it can be used to explore "what if" scenarios. These might be differing prevention strategies as was done in the scenarios presented here, or they might be different behavior change patterns in the past or future (e.g., the no intervention scenario presented in the text or the condom use drop scenario presented as the last data set in Appendix B).

However, once a solid baseline is established and the AEM tools are improved, it will also be possible to explore other scenarios that may prove very relevant to the future of the epidemic in Cambodia. Several that were raised during the projection process this time include:

- *Injecting drug use*. What if injecting drug use increases and become a serious contributor to the epidemic? How will this spread to other populations, how will it affect prevention efficacy of other programs, and how can it be contained?
- *Young people*. What if young people become more sexually active as visits to sex workers decline?

- *MSM*. There is clearly a high level of activity between some MSM and their male and female sexual partners in Phnom Penh [Girault et al. 2002]. This might also be the case in many other places in the country. How might this be contributing to the epidemic and what types of prevention programs can impact this avenue of transmission? What are the relationships of HIV prevalence in this population with that in other key groups such as sex workers and female partners of MSM?
- *Mother-to-child transmission.* Due to the limited ANC coverage, MTCT programs in Cambodia may be more challenging to implement than in surrounding countries. The exact implications of more restricted ANC coverage, limitations on the number of women who seek or obtain HIV testing, and resource constraints should be explored in more carefully designed scenarios that include these issues as inputs. These could be done as front ends that calculate the MTCT coverage based on programmatic factors and then feed this into the model for calculation of its impact.

The AEM provides Cambodia with a flexible tool that can be used to explore many prevention and care alternatives and programmatic issues. Applying this tool more precisely will require capacity building in-country, better understanding of available data sources, improvement of data collection systems, and careful design of the scenarios to be examined to ensure they are realistic and achievable given the available capacity and resources. However, the process undertaken here, which improves our understanding of the Cambodian epidemic and helps to redirect prevention and care to have the greatest impact, should contribute to an improved national response.

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APPENDICES