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HIV Sentinel Surveillance in Cambodia - 2006

Ministry of Health
National Center for HIV/AIDS,
Dermatology and STDs

Report on

HIV SENTINEL SURVEILLANCE in Cambodia 2006

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Report on HIV Sentinel Surveillance in Cambodia, 2006

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FOREWORD

I have the great honor to present the HSS 2006 Report, one in a series of reports, which makes available the results of HIV Sentinel Surveillance (HSS). The report provides information about the magnitude of and trends in the HIV/AIDS epidemic in Cambodia. This type of information is valuable for evaluating interventions, guiding strategic planning and shaping national policies on HIV/AIDS prevention and care and treatment.

The National Center for HIV/AIDS Dermatology and STDs (NCHADS) has conducted HSS regularly among various sentinel groups, such as entertainment workers (brothel-based and informal female sex workers), police, and pregnant women receiving antenatal care (ANC). Because HSS has repeatedly examined HIV prevalence among sentinel groups over time, trends in HIV prevalence may be generated. In 2006, additional testing was performed to estimate the percentage of new HIV infections among the two sentinel groups surveyed, brothel-based female sex workers and pregnant women receiving ANC. Due to the nature of HIV epidemics, and the fact that HIV infection cannot be cured, prevalence is related only to the balance of new infections and deaths. Using HIV prevalence trends alone, however, may not be sufficient to depict the complete picture of Cambodia's HIV/AIDS epidemic—additional data are needed to determine whether a decline in prevalence is due to an increase in deaths or a decrease in new infections. Hypothetically, an increase in prevalence could be due to an increase in new infections or it may be that persons are living longer because of the benefit of antiretroviral treatment. Therefore, investigating HIV incidence may provide more concrete information to help programmers better understand the dynamics of Cambodia's HIV epidemic.

Data on HIV prevalence among sentinel groups, collected by all rounds of HSS, were used to derive estimates and projections of HIV/AIDS among Cambodia's general population. This exercise was led by NCHADS in close collaboration with national and international organizations. The latest HIV/AIDS estimation and projection exercise was undertaken in 2006, in which both the HIV prevalence data from HSS 2006 and Cambodia Demographic Health Survey 2005 were used. The data showed that HIV prevalence has declined among the general population, and although the prevalence has declined among high risk groups, in 2006 it was still high (14.7% among female sex workers and 1.1% among ANC women). In addition, the incidence data confirm that the rate of new HIV infections has declined among female sex workers and women attending antenatal clinics. Based on the estimation exercise, HIV prevalence among Cambodia's general population aged 15-49 years was 0.9% in 2006, corresponding to approximately 67,000 persons in that age group living with HIV/AIDS.

Although the declining trend of HIV prevalence among the general population reflects the success of HIV/AIDS prevention, the tasks of preventing and reducing the rate of HIV transmission are far from over. Furthermore, the provision of care and treatment needs to be scaled up in order to respond to the increasing number of people in need of antiretroviral treatment as the epidemic continues to mature.

Finally, I would like to express my gratitude to all those who have contributed to the HSS 2006 survey and to the HIV/AIDS estimation and projection workshop, and particularly to our Cambodian men and women who have accepted our invitation to participate in the survey and provide their blood sample for the good of the country.

Phnom Penh, 06 July 2006
NCHADS Director

MEAN CHHI VUN, MD, MPH

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- Laboratory team:
  - National Institute of Public Health for quality control and HIV incidence testing
  - US CDC Laboratory for quality assurance monitoring and BED incidence testing training

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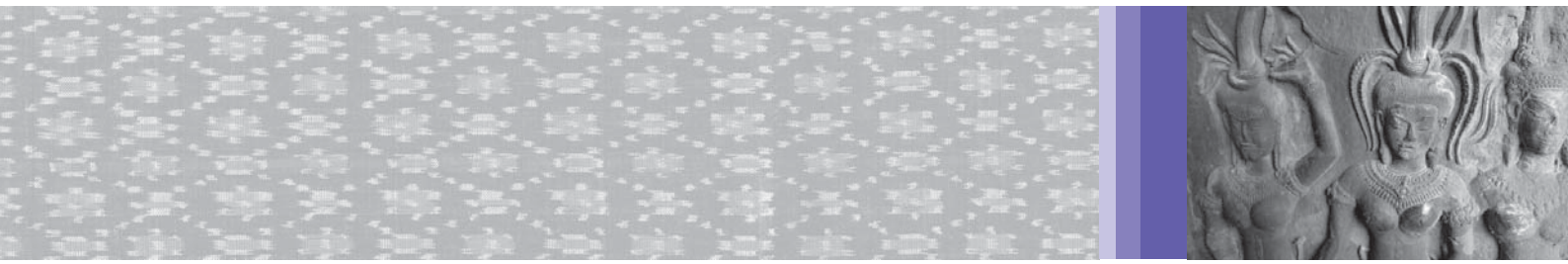

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EXECUTIVE SUMMARY

In Cambodia, sentinel surveillance data have been used to estimate national HIV prevalence and project trends in HIV and AIDS incidence and mortality. In 2006, Cambodia conducted its tenth round of HIV sentinel surveillance (HSS) in 22 of its 24 provinces and municipalities. The two sentinel groups surveyed were brothel-based female sex workers (FSWs) and pregnant women attending antenatal care (ANC) clinics. Rapid HIV tests were performed in the provinces to measure seroprevalence and dried blood spot specimens were prepared for quality control retesting at the National Laboratory of Public Health. In addition to HIV seroprevalence, HIV incidence was measured in this HSS round by the BED-incidence assay. As in the previous survey round, HSS 2006 implementation included strict quality control of HSS laboratory results to assure the validity of HIV seroprevalence data, and in this round, HIV seroincidence data. Quality control adjustments of data from this and previous surveys were applied consistently to assure comparability of results over time and a better picture of epidemic trends.

As in previous years HIV seroprevalence was higher among FSWs (14.7%) than among ANC women (1.1%). Estimated HIV incidence also was higher among FSWs (1.68%) than among ANC women (0.07%). Seroprevalence among ANC women varied by ANC location— seroprevalence was higher among women attending urban ANC clinics (1.4%) compared with those attending rural clinics (1.1%). Seroprevalence among young FSW aged 15-19 years (2.9%) was much lower than among FSW aged 20 years and older (14.4%).

ANC data are used to generate national estimates of prevalence, numbers of persons living with HIV and with AIDS, HIV incidence, and deaths due to AIDS. Pregnant women who attend ANC clinics are not representative of all pregnant women in Cambodia (less than half of all pregnant women in Cambodia seek care from ANC clinics) and pregnant women aged 15-49 years are not representative of all Cambodian women in that age group. With these factors taken into account, HSS and other data were used to estimate that 0.9% of Cambodian adults aged 15-49 were living with HIV in 2006. Among 67,200 persons aged 15 years and older estimated to be living with HIV in 2006, more than half (52%) were women, and 30,100 (45%) were living with AIDS and considered to be in need of antiretroviral therapy.

HIV prevalence in Cambodia has appeared to decline from an estimated peak of 2.0% in 1998 to 0.9% in 2006. Projections suggest that prevalence may be stabilizing—early declines were explained by a reduction in the number of new infections (incidence) in high risk groups and the increasing number of deaths that occurred as the epidemic matured. With rapid scale-up and widespread availability of antiretroviral therapy, however, Cambodia has successfully reduced mortality among persons living with HIV, resulting in more stable prevalence.

Although Cambodia has achieved remarkable success in lowering HIV prevalence, incidence, and mortality, this is no time for complacency. Surveillance, prevention, control, and treatment efforts must be maintained and in some cases expanded or strengthened, to sustain these hard fought gains against the HIV epidemic.

INTRODUCTION

HIV sentinel surveillance in Cambodia

Cambodia's first documented case of HIV infection was reported to the National Blood Transfusion Center in Phnom Penh in 1991. In 1992, the Cambodian National AIDS Program, with support from the World Health Organization (WHO), conducted an unlinked, anonymous HIV seroprevalence survey of selected sentinel groups in Phnom Penh. An estimated 4.2% of brothel-based (formerly called "direct") female sex workers tested positive for HIV antibody. In 1994, the National AIDS Program, with support from WHO, implemented the first national HIV sentinel serosurvey (HSS) in five provinces. The survey was conducted to help determine characteristics and the extent of the epidemic through analysis of cross-sectional HIV epidemiologic data from selected populations (sentinel groups) in selected geographic areas. Including the 1994 survey, HSS has been conducted ten times, most recently in 2006. As more is understood about the epidemic in Cambodia, HSS sentinel groups and group definitions have changed. Not all groups have been surveyed each round or from every province (see Appendix I, Table 1). Over the years, sentinel groups have included:

1. Brothel-based female sex workers
2. Informal female sex workers, including at various times one or more of the following groups:
   a. Beer promoters
   b. Women who work in massage houses
   c. Women who work in karaoke lounges
   d. Women who work in entertainment establishments (e.g., discotheques and restaurants)
3. Freelance sex workers (terminology used in 1999 survey to describe women who work in karaoke lounges, massage parlors, and bars)
4. Military
5. Military police
6. Police
7. Pregnant women attending antenatal care (ANC) clinics
8. Married women of reproductive age
9. Tuberculosis patients
10. Hospital inpatients
11. Men and women living in households
12. Sexually Transmitted Disease (STD) patients

ANC women have been surveyed in each HSS round except for that of 1998 when the group was temporarily replaced by married women of reproductive age. Seroprevalence data from the ANC sentinel group is the main source of data used to construct the national estimate of HIV prevalence, i.e., the number and percent of Cambodians living with HIV at the time of the survey. HSS results have been an important source of information used in consensus workshops on estimating national HIV prevalence and making HIV/AIDS projections. The workshops have been held in Cambodia for each round of HSS since 1999. The Consensus Working Group comprises NCHADS staff and several international consultants.

Changes implemented in 2006

Several changes implemented in HSS 2003 were sustained in 2006:

- Assurances of confidentiality were signed by all survey staff
- Individual informed consent was required
- HIV testing was decentralized and conducted in provincial laboratories rather than in one national lab
- Simple, rapid assays were used for HIV testing
- Quality control testing was performed by the national reference laboratory
- Quality control test results were used to adjust data

In addition, the following changes in HSS methods or data analysis were made in 2006:

- An HIV incidence assay was used to measure the proportion of HIV infections that were recently acquired
- Data were weighted by urban-rural population distribution
- Results of the 2005 Cambodia Demographic and Health Survey[1] were considered to estimate prevalence of HIV in the general population
- The Asian Epidemic Model[2] (AEM) was used to project numbers of HIV infections, persons in need of antiretroviral therapy, and deaths among persons with HIV through 2012

Comparability with previously published HSS results

HSS 2006 results are not directly comparable with results published in previous HSS reports. In 2006, as in previous years, the best data and most up-to-date methods available were used to estimate HIV prevalence. Epidemiologists and surveillance experts are continuously working on improving data collection and analysis methodology to improve the accuracy of results. As additional data and improved methods become available, estimates are commonly revised. Estimates of HIV prevalence from previous years have been revised because of a few adjustments in the estimation methods and the availability of additional data:

1. **Quality control adjustments.** As in 2003, HSS 2006 data were adjusted based on results of quality control testing. Compared with HSS 2003 test performance, results of quality control retesting of HSS 2006 specimens showed an improvement in provincial test performance. Quality control results from previous surveys were used to perform similar data adjustments, thus allowing us to revise estimates in seroprevalence by sentinel group for each year. For a more detailed description of quality control adjustments, see the Technical Notes in Appendix III of the HSS 2003 Report.[3]

2. **Urban-rural population weights.** HIV prevalence among women seeking antenatal care from urban clinics and from rural clinics was estimated separately. A combined national prevalence of HIV among pregnant women seeking antenatal care was estimated based on the relative proportions of the population (urban-rural population distribution).

3. **Demographic and Health Survey data.** The 2005 Cambodia Demographic and Health Survey (CDHS) was a household survey that may not have included several population groups which may be at higher risk for HIV infection. We conducted an exercise to adjust the estimated prevalence among the household population by adding an estimated or plausible prevalence among various populations and estimated population size (see Appendix 2 of the Report of the Consensus Workshop)[4]. The prevalence changed only slightly. The CDHS HIV prevalence among household women was compared with the ANC prevalence to derive a calibration factor (i.e., a multiplier) to apply to the ANC data to estimate prevalence of HIV among general population women (see Technical Notes in Appendix III of the HSS 2003 Report).[5]

Adjustments and improvements in calculations were applied in a consistent way to data from 1996 through 2006 so that the revised national data are comparable over time. Results presented in this report are estimates and not actual case counts. We have an increasing understanding of the best practices for making

[1] National Institute of Public Health, National Institute of Statistics, and ORC Macro, Cambodia Demographic and Health Survey 2005. 2006, Cambodian National Institute of Public Health, National Institute of Statistics, and ORC Macro: Phnom Penh, Cambodia and Calverton, Maryland, USA.

[2] Brown T, Peerapatanapokin W. The Asian Epidemic Model: a process model for exploring HIV policy and programme alternatives in Asia. Sexually Transmitted Infections 2004;80 (Supplement 1):i19-i24.

[3] National Center for HIV/AIDS, Dermatology, and STDs. Report on HIV Sentinel Surveillance in Cambodia 2003. Phnom Penh, Cambodia. 2006.

[4] National Center for HIV/AIDS, Dermatology, and STDs. Report of a Consensus Workshop. HIV Estimates and Projections for Cambodia, 2006-2012. 2007, Cambodian Ministry of Health: Phnom Penh.

[5] National Center for HIV/AIDS, Dermatology, and STDs. Data Management Unit Facility ART Report. Phnom Penh, Cambodia. January 2009.

mathematical estimations, and with improved knowledge comes the responsibility for revising estimates. Similarly, the Joint United Nations Programme on HIV/AIDS (UNAIDS) recently reviewed their estimates worldwide in light of improved methodology. As mentioned above, previously published numbers from earlier HSS rounds should not be compared with numbers published here. Flexibility is one of the strongest attributes of any surveillance system. As more data become available and surveillance methods improve, we must be flexible about using the best available data and methods. Estimates presented in this report have been reviewed by a team of national and international experts, many of whom have served on the Consensus Working Group for several years, ensuring continuity in interpretation of results. The HSS 2006 Consensus Working Group believes that this report presents the data as accurately as possible.

The HIV epidemic in Cambodia first entered the treatment era in 2001 with antiretroviral treatment (ART) becoming available in only one clinic in Phnom Penh. Cambodia had rapidly scaled up coverage—the number of HIV infected adults receiving ART increased from about 400 in 2002 to approximately 29,000 by the end of 2008. Fortunately, treatment improves the quality of life and lengthens survival among persons with HIV and AIDS. Such improvements, however, make it difficult to interpret trends in HIV prevalence. That is, HIV prevalence alone may become a less useful indicator of the dynamics of Cambodia's epidemic—prevalence may rise as increasing numbers of persons benefit from ART and live longer, healthier lives. Whether increasing prevalence is due to fewer deaths or an increasing number of new infections will be difficult to discern in the absence of additional information.

Because of the challenges in interpreting HIV prevalence data without information on HIV incidence and deaths, supplementary surveillance tools need to be added to the national surveillance system. Data on the entire spectrum of the epidemic—HIV exposure, incidence, morbidity, antiretroviral resistance, and mortality—are needed to monitor trends in the Cambodian epidemic and the impact of prevention, care, and treatment programs. Using the best surveillance methods available is a public health imperative. As a step in this direction, HSS 2006 included HIV incidence testing using the BED-assay, a relatively new testing technology which recently was approved for surveillance purposes. Because HIV incidence testing technology is relatively new, it had not been routinely incorporated in HSS. However, HIV incidence testing was conducted retrospectively on specimens archived from the 1999, 2000, and 2003 surveys as part of a special study[6] and these data were used to construct trends and provide a better understanding of Cambodia's epidemic than that provided by prevalence data alone.

Objectives

Main Objective

To obtain national estimates of HIV prevalence and incidence in two key female sentinel groups.

Specific Objectives

1. To estimate HIV incidence and prevalence in selected female sentinel groups;
2. To compare HIV prevalence among pregnant women attending antenatal care clinics (HSS 2006 data) with HIV prevalence among household women obtained from Cambodia's 2005 Demographic and Health Survey (CDHS) ;
3. To derive a calibration factor from the HSS-CDHS comparison to estimate HIV prevalence among general population women;
4. To estimate the prevalence of HIV infection among the general population; and
5. To project incidence, prevalence, and mortality and provide data needed for trend analysis, monitoring and evaluation, and program planning.

[6] Saphonn V, Parekh B, Dobbs T, et al. Trends of HIV-1 Seroincidence Among HIV-1 Sentinel Surveillance Groups in Cambodia, 1999-2002. JAIDS. 2005.39:587-592.

METHODS

Overview

A cross-sectional design was used to obtain HIV prevalence data from four sentinel groups. Venous blood specimens were drawn in an anonymous fashion, specifically for the purpose of HIV testing. Participants were informed of the purpose of the survey and their rights to refuse participation without repercussions. Oral consent was obtained from each participant and documented before any information was collected or blood drawn. There were no identifiers on any of the blood specimens that could be traced back to the individual, although survey specimens could be linked to sentinel sites and geographic location. The survey protocol was approved by the Cambodian National Ethics Committee and US CDC.

Sentinel groups

Two sentinel groups were sampled for HSS 2006:

1. Female sex workers (FSWs), brothel-based
2. Pregnant women attending antenatal care clinics (ANC)

Sentinel provinces and sentinel sites

HSS 2006 was conducted in 2 municipalities (Phnom Penh and Pailin) and 20 of Cambodia's 22 provinces, hereafter referred to collectively as provinces (Appendix I, Table 1). Samples of ANC women were selected separately from provincial capitals and remaining districts (covering the whole province); FSWs were selected from urban areas. ANC women were recruited from purposively selected sentinel sites, with efforts made to sample from the same sites as those included in previous HSS rounds and as many sites included in the 2005 CDHS as possible (Appendix II, Table 1). FSWs were recruited from randomly selected sites within each sentinel province.

Sampling

Table 1 lists target sample sizes for each sentinel group and Table 2 summarizes the sampling strategy used in HSS 2006.

Table 1. Target sample size by sentinel group

Sentinel group	Target sample size, per province
FSW (brothel-based)	150
ANC women	300 in provincial capitals 300 in remaining districts 600 total

Female Sex Workers

The target sample size for FSW was 150 per province. In provinces where the total number of FSW was 150 or fewer, all FSW in the province were sampled. In provinces where the estimated number of FSW was substantially greater than 150 (e.g., 200 or more), two-stage cluster sampling was done. Although all urban-area establishments (brothels) had been listed before the survey started, the number of women working in each brothel was not required to be documented. An average number of FSW per brothel was calculated for each province by dividing the estimated total number of FSW in the province (obtained from the Provincial AIDS Offices) by the total number of brothels in the province. To determine the number of clusters to select in order for a take-all sample to achieve a total provincial sample size of 150, the desired sample size was divided by the average number of FSW per brothel. For example, if there were an average 10 FSW per brothel, 15 clusters were selected randomly with equal probability to achieve a sample size of 150. In a province with an average of 15 FSW per brothel, 10 clusters were selected. All women at the selected brothels were asked to participate in the survey and each woman was assured the right to refuse participation without repercussion. After individual informed consent was obtained from the participant, a venous blood specimen was drawn and a specimen information sheet was completed. The specimen number, collection date, province, age, education level, age at first sex and at first commercial sex, and cumulative duration of sex work was recorded on the specimen information sheet. Information on each cluster (brothel) was also completed, including the name and geographic location of the establishment, its cluster number, the total number of women present on the day the provincial surveillance team visited, the number of women who were invited to participate in the survey, and the number of women who chose not to participate.

ANC women

Pregnant women who presented at sentinel ANC sites (Appendix I, Table 1) for their first prenatal visit were eligible for participation. After obtaining individual informed consent for each woman recruited, ANC clinic staff drew a venous blood sample and completed the specimen information sheet. The specimen number, collection date, province, age, education level, and age at first sex were recorded on the specimen information sheet. Information on the clinic (name and geographic location) was also recorded. The target sample size was 300 for provincial capitals and 300 for remaining districts. Women were recruited consecutively (i.e., in the chronological order that they presented for services) until a sample of 300 was reached. Sampling stopped after a period of three months, regardless of whether the desired sample was achieved.

Table 2. Summary of sampling strategies

Sentinel group	Sampling strategy	Sample
FSW (brothel-based)	Provinces with ≤150 FSWs: Take-all Provinces with >150 FSWs: Two-stage cluster sampling 1st stage: equal probability sample of brothels; 2nd stage: take-all sample of FSWs	Census Self-weighted, probability sample
ANC women	Consecutive sampling at purposively selected sentinel ANC sites sample	Non-probability sample

Training of personnel

Training for HSS 2006 was conducted at several levels:

1. A three-day pre-surveillance training workshop, primarily for provincial AIDS managers, was convened in Phnom Penh just before the start of data collection.

2. In each province, the Provincial AIDS Manager was responsible for establishing and training a provincial surveillance team and ANC clinic staff.

    a. The provincial surveillance team had primary responsibility for conducting the survey among SWs. Training covered mapping, sampling, confidentiality, informed consent, universal precautions, specimen collection, processing and transport of specimens, and record keeping, including instruction on completing the specimen and cluster information sheets.

    b. ANC clinic staff were responsible for conducting the survey among pregnant women. Their training covered eligibility criteria, the consecutive sampling technique, confidentiality, informed consent, universal precautions, specimen collection and handling, and record keeping, including instruction on completing the specimen information sheet.

3. Three two-day regional laboratory trainings were convened for provincial surveillance team staff responsible for specimen collection, processing, testing, and recording of results. Specific topics covered were: universal precautions, performance of Determine™ HIV-1/2 (Abbott Diagnostics) and HIV 1/2 STAT-PAK (Chembio Diagnostics, Inc.) simple rapid HIV assays; interpretation and recording of test results; and preparation, drying, and storage of dried blood spot (DBS) specimens to be transported to the National Laboratory of Public Health (NLPH) for quality control retesting and BED incidence testing.

4. NLPH Serology Department technicians had previously received training by US CDC laboratorians. In 2004, training covered processing and testing DBS specimens for HIV using two enzyme immuno-assays and Western blot. The proficiency of all staff performing quality control assays had been evaluated by the US CDC instructors and NLPH was enrolled in CDC's proficiency testing program. In 2007, US CDC provided an additional one-week training on the BED incidence assay. Again, proficiency of NLPH technicians to perform the BED incidence assay was tested and found to be satisfactory.

5. US CDC conducted a separate three-day training for NCHADS Surveillance and Data Management staff on the epidemiologic, statistical, and data management and analysis aspects of using the BED incidence assay for detection of recent HIV infection and estimating incidence.

Specimen collection, handling, and HIV testing

Five milliliters of blood were collected from each participant into vacutainer tubes containing EDTA anti-coagulant. Specimens were stored in a cool box until transport each day to the provincial referral hospitals or laboratories. ANC specimens were stored in a cool box at the ANC clinics until they were picked up by PAO staff twice a week and delivered to the provincial laboratories for testing and preparation of DBS specimens. WHO/UNAIDS Guidelines for Using HIV Testing Technologies in Surveillance were followed with slight modification:

1. A two-test algorithm was used for both sentinel groups.

2. Whole blood specimens from both sentinel groups, regardless of historical HIV prevalence, were tested with Determine.

3. For the FSW group (2003 HIV prevalence greater than 10%), Determine non-reactive specimens were considered HIV-negative. However, Determine reactive specimens were confirmed with StatPak (a slightly more specific assay). If both tests were reactive, the specimen was considered HIV-positive. If StatPak was non-reactive, the specimen was considered HIV-negative. This method is called sequential testing.

4. A different approach was used for the ANC group. An unexpectedly high rate of false negatives in some provinces in 2003 was found to have a major impact on survey results for the low prevalence ANC group. The false negative (and false positive) results were adjusted based on results of quality control retesting, for the 2003 and previous surveys. Although false positive and negative results had less of an impact in the higher prevalence groups, adjustments were performed on data from all sentinel groups in 2003 so that data were comparable. To reduce the number of false negatives in 2006, we used a parallel testing algorithm. That is, all ANC specimens were tested with both Determine and StatPak regardless of the Determine results. If both tests were reactive, the specimen was considered HIV-positive. If Determine was reactive and StatPak was non-reactive, the specimen was considered HIV-negative. If Determine was non-reactive and StatPak was reactive, both tests were repeated (Table 3).

5. For both groups, testing was done at sites other than where specimens were collected or after the participant had left the premises.

6. At the time rapid tests were performed, DBS specimen cards were prepared from all specimens for quality control retesting. Standard operating procedures developed by NLPH were followed. DBS specimens were allowed to dry completely and stored with desiccant until transport to the NLPH in Phnom Penh. DBS were stored in Phnom Penh at -80° until the time of quality control testing. A second DBS specimen card was prepared on all HIV-positive specimens for BED incidence testing.

Table 3. HSS 2006 testing algorithm and interpretation of results.

FSW specimens that are:			**Intepret as HIV:**
Determine	**StatPak**		
Nonreactive	N/A	→	Negative
Reactive	Nonreactive	→	Negative
Reactive	Reactive	→	Positive
ANC specimens that are:			
Determine	**StatPak**		
Nonreactive	Nonreactive	→	Negative
Nonreactive	Reactive	→	Repeat both assays*
Reactive	Nonreactive	→	Negative
Reactive	Reactive	→	Positive

** Interpreted as HIV positive if same results obtained on repeat testing*

Quality control testing

Quality control retesting was performed on all HIV-positive and 10% of HIV-negative specimens. HIV rapid test results were not provided to NLPH staff responsible for quality control testing. In previous surveys, retesting was performed on only 10% of all specimens from high-prevalence groups (e.g., FSW), regardless of whether they had initially tested positive or negative. However, it was necessary to confirm all HIV positive specimens for subsequent BED testing to prevent misclassification of a Determine false-positive specimen as "recent" (i.e., false recent).

DBS specimens were tested at NLPH using two enzymeimmunoassays (EIAs)—Vironostika HIV Uni-Form II Plus O® (Organon Teknika) and Murex HIV-1.2.O (Abbott Diagnostics). New LAV Blot I (Bio-Rad Laboratories) Western blot assay was performed on specimens with discordant EIA results.

HIV incidence testing

HIV incidence testing was performed on DBS specimens from all confirmed HIV-positive specimens using the Calypte® HIV-1 BED Incidence EIA and DBS Control Pack. DBS cards for all specimens identified as positive by HIV rapid assay were selected for incidence testing. HIV incidence was estimated using a newly developed strategy that distinguishes recent seroconversion from longer-standing infection. Briefly:

1. DBS specimens were eluted and the eluant was incubated on goat-anti-human IgG coated micro-well plates to allow capture of HIV and non-HIV-IgG.

2. BED-biotin peptide antigen, a multi-subtype derived branched peptide which binds only to HIV-1-specific antibodies, is added, followed by streptavidin-peroxidase which binds to the biotin.

3. After further incubation, TMB substrate is added to react with the streptavidin-peroxidase for color development. The level of color that develops depends on the proportion of total human IgG that is HIV-1-specific IgG.

4. Optical density (OD) values of the color reaction are read using a spectrophotometer. The higher the ratio of HIV-1-specific IgG to total human IgG, the darker the color and the higher the OD values.

5. The OD values are normalized (OD-n) using a calibrator specimen included on every run.

6. Specimens with OD-n ≤1.2 during initial BED-CEIA testing will be confirmed by further BED testing of the sample in triplicate, where the median value of the three results will be considered the final OD-n for the confirmatory run.

7. An HIV-1-positive specimen for which the confirmatory BED-CEIA gives an OD-n of ≤ 0.8 will be considered to be from a recent HIV-1 infection, with seroconversion having occurred within the previous 153 days (95% CI 146-165 days), based on multiple seroconverter studies. Otherwise, the specimen will be classified as long-term infection.

Summary of HIV assays:

The following HIV test kits were used in HSS 2006:

Simple rapid assays for HSS testing:
- Determine™ HIV-1/HIV-2 Assay (Abbott Diagnostics)
- HIV 1/2 STAT-PAK (Chembio Diagnostics, Inc.)

EIA for DBS Quality Control Testing:
- Vironostika HIV Uni-Form II Plus O® (Organon Teknika)
- Murex HIV-1.2.O EIA (Abbott Diagnostics)

Assay for Incidence:
- Calypte® HIV-1 BED Incidence EIA and DBS Control Pack (This assay has since been renamed Aware™ BED™ EIA HIV-1 Incidence EIA)

Data entry, adjustments, and analysis

HSS data were entered by NCHADS staff into a computerized database using Epi-Data. To minimize data entry error, a second round of data entry was performed by NIPH. Data were analyzed with Stata-10, a statistical software package with which NCHADS staff are familiar.

Quality control adjustments:

Based on results of HSS 2006 quality control testing, province- and group-specific false positive and false negative rates were calculated for both sentinel groups. These rates were used to adjust results for interprovincial variation in test performance (see Technical Notes in Appendix III of the HSS 2003 Report.[1] National group-specific false positive and false negative rates were likewise calculated based on results of previous QC testing for survey years 1999, 2000, 2002, and 2003 and used to adjust group- and year-specific prevalence. Because rates did not vary widely by year within each sentinel group in the earlier years, the Consensus Working Group in 2004 proposed that the rates for the three years (1999, 2000, and 2002) be averaged to adjust survey data collected before 1999. Adjusting all the data consistently renders them comparable and allows us to construct trends in prevalence.

Population adjustments:

National ANC prevalence for 2006 was estimated by adjusting (weighting) the data using the 2006 province-specific female population aged 15-49 years. Methods used for selecting FSWs provided a self-weighted sample.

Smoothing:

For trend analysis, the Estimations and Projections Package (EPP) was used to smooth the data. Smoothing attenuates fluctuation due to sampling variation and generates a trend line consistent with current knowledge about the dynamics of Cambodia's HIV epidemic.

Provincial data:

Appendix III presents provincial data for ANC women and FSWs through 2006 and for other sentinel groups through 2003. In 2003 and 2006 it was possible to adjust provincial data using quality control (QC) results to improve the accuracy of prevalence estimates. Because the sampling method used to select specimens for QC retesting was stratified by sentinel group and year but not by province, province-specific adjustments could not be made for survey years 1996-2002. Furthermore, because provincial level age-specific population data for the informal (non-brothel-based) FSW (IFSW) group is not available, IFSW data could not be weight-adjusted; and, because this group's composition has changed with each survey, the data could not be smoothed. Owing to the large fraction of the total FSW population sampled, sampling variation was minimal and data smoothing was not necessary for calculating provincial-level estimates. Adjustments made to the data are summarized in Table 4.

[1] National Center for HIV/AIDS, Dermatology, and STDs. Report on HIV Sentinel Surveillance in Cambodia 2003. Phnom Penh, Cambodia. 2006.

Table 4. Adjustments to national and provincial data by sentinel group and survey year

	National prevalence estimates*			Province-specific prevalence estimates		
	QC-adjusted	**Weighted**	**Smoothed**	**QC-adjusted**	**Weighted**	**Smoothed**
FSW						
1996-2002	√	√	√			
2003	√	√	√	√		
2006	√	√	√	√		
ANC women						
1996-2002	√	√	√			√
2003	√	√	√	√		√
2006	√	√	√	√		√
IFSW						
1996-2002	√					
2003	√			√		
Police						
1996-2002	√	√	√			√
2003	√	√	√	√		√

Provincial-level data should not be used to calculate province-specific prevalence in the general population because the sampling methods were not designed with this objective in mind. Furthermore, provincial data should not be compared with previously published data—previous results included a substantial proportion of false positives (21.0-25.5% of ANC results from 1999-2002) and false negatives. Although retrospective retesting of specimens from 1999-2002 have allowed us to adjust national results for trend analysis, provincial quality control adjustments could only be made for 2003 and 2006

Calculating HIV Incidence:

Briefly, annualized HIV incidence (i.e., percent of new infections per year) was calculated separately for ANC women and FSWs using a mathematical formula based on the recommended window period of 155 days, the number of recent infections identified by the incidence assay, and the number of HIV seronegative specimens identified by HSS. Because of the small number of incident infections in our two sentinel populations, only pooled national estimates (across all 22 provinces) for each population could be calculated. Incidence estimates were then adjusted as recommended by CDC and WHO using two different adjustment methods to account for imperfect sensitivity and specificity of the assay.

* Provincial data aggregated

The Calypte® HIV-1 BED Incidence EIA may be used to estimate HIV-1 incidence in cross-sectional serosurveys including sentinel surveys among ANC attendees or other populations. However, the data must be adjusted to account for the misclassification by the BED-CEIA of infections as recent (false recent) among those individuals with long-term infection. WHO guidelines advise use of two adjustment formulae (McDougal et al. method and Hargrove et al. method). The two sets of adjustments are expected to give similar results in most settings. Both formulae were used to develop separate incidence measures and cross-check results for consistency. Detailed information about HIV incidence calculations is presented and Appendix IV.

Timeframe

The timing of HSS data collection has shifted slightly each year (Table 5). HSS 2006 data collection began in most provinces in October 2006. Although the survey started later in some provinces, the duration of data collection in each province was three months. The first round of quality control retesting was completed in May 2007, with additional retesting completed just before BED incidence testing commenced. BED incidence testing was delayed until guidelines for use in surveillance and recommendations on data adjustment were released by WHO. In the interim a Consensus Workshop was held (25-29 June 2007) to estimate national HIV prevalence and project estimates of HIV incidence, prevalence, advanced HIV disease (i.e., numbers of persons in need of antiretroviral therapy), and deaths.[2] Upon release of the guidelines an amendment to the approved protocol was submitted to and approved by all relevant ethical committees. BED incidence testing was completed in January 2008, shortly after training and proficiency testing was completed. A dissemination meeting was convened in August 2008 to present estimates of and trends in HIV prevalence and incidence among ANC women and FSWs.

Table 5. Timeframe for HSS data collection

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996			1996	1996	1996	1996	1996	1996	1996			
1997					1997	1997	1997					
1998					1998	1998	1998					
1999											1999	1999
2000	1999	1999									2000	2000
2001	2000											
2002												
2003								2003	2003	2003	2003	
2006										2006	2006	2006
2007	2006	2006										

[2] National Center for HIV/AIDS, Dermatology, and STDs. Report of a Consensus Workshop. HIV Estimates and Projections for Cambodia, 2006-2012. 2007, Cambodian Ministry of Health: Phnom Penh

RESULTS

Sample size

A total of 14,730 specimens were collected from the two sentinel groups in 2006 from 22 provinces compared with 13,277 collected in 2003 from the same groups and provinces. Sample sizes for the most recent HSS rounds are shown in Table 5. Sentinel groups and provinces included in each HSS round from 1992 through 2006 are shown in Appendix I, Table 1).

Table 6. Comparison of sample sizes from 1999 through 2006

	Year (*number of provinces*)				
Sentinel Groups	**1999 *(20)***	**2000 *(21)***	**2002 *(20)***	**2003 *(22)***	**2006 *(22)***
Female sex workers	2,259	2,180	2,110	2,411	2,266
Informal female sex workers*	1,488	1,799	1,232	1,633	--
Policemen	4,141	4,711	4,379	5,796	--
Antenatal clinic attendees	5,397	6,562	9,168	10,866	12,464
Total	**13,285**	**15,252**	**16,889**	**20,706**	**14,730**

* *Informal female sex workers included: beer promoters and freelance sex workers (defined as women working in bars, karaoke lounges, and massage parlors) in 1999; beer promoters and women working in bars, karaoke lounges, and massage parlors in 2000; beer promoters and women working in beer gardens and karaoke lounges in 2002; and beer promoters and karaoke workers in 2003.*

Percent refusal

The proportion of refusals for each sentinel group by province is shown in Table 6. The percent refusal among ANC women (0.7%) in 2006 was lower than that observed in the last two rounds of HSS (1.9% in 2002 and 2003). The refusal rate among FSWs (1.5%) was also lower than that observed in previous HSS rounds (4.8% in 2002 and 3.4% in 2003).

Quality control testing results

Quality control (QC) retesting of specimens by NLPH demonstrated that test performance of the rapid testing algorithm was excellent in most provinces. In the four previous surveys, overall sensitivity (ability to correctly detect HIV-positive specimens) and specificity (ability to correctly identify HIV-negative specimens) was lower than the >99% expected. After the 2003 HSS, NLPH QC testing results were validated by comparing with results from US CDC Laboratory in Atlanta, Georgia. To ensure a more accurate estimate of prevalence, QC results were used to adjust the raw survey data (see the Technical Notes in Appendix III of the HSS 2003 Report for detail).[1] For trend analysis, year-specific adjustments were applied retrospectively so that consistent adjustments were used for each survey round, including HSS 2006, allowing year-to-year comparisons.

[1] National Center for HIV/AIDS, Dermatology, and STDs. Report on HIV Sentinel Surveillance in Cambodia 2003. Phnom Penh, Cambodia. 2006.

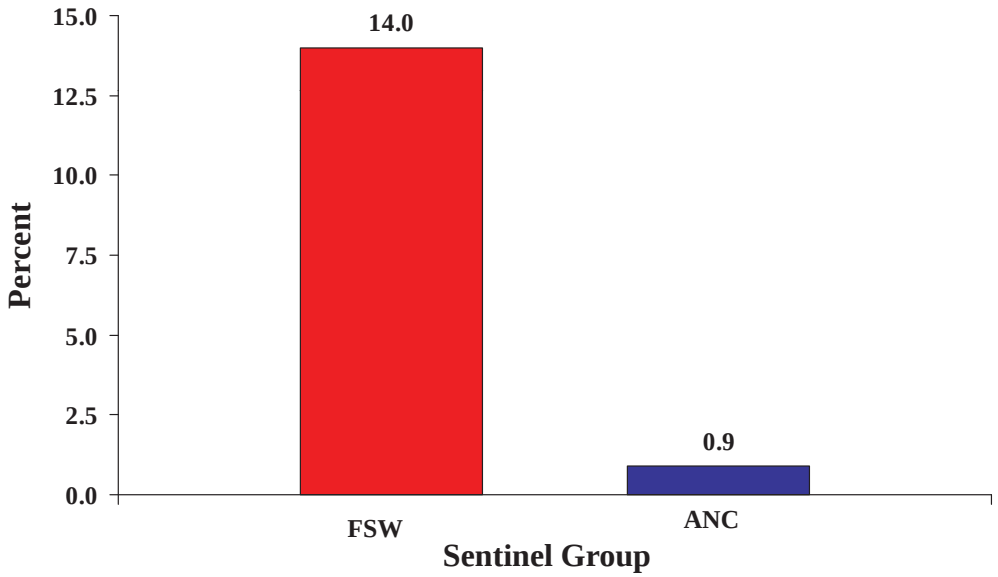
Table 7. Percent refusal by province and sentinel group, 2006

No.	Province	FSW	ANC
1	Banteay Meanchey	0.0	0.2
2	Battambang	0.7	0.0
3	Kampong Cham	0.0	0.0
4	Kampong Chhnang	7.7	2.0
5	Kampong Speu	0.0	0.0
6	Kampong Thom	3.3	1.0
7	Kampot	1.8	1.3
8	Kandal	0.0	0.0
9	Koh Kong	1.2	3.1
10	Kratie	12.0	1.2
11	Oddar Meanchey	1.7	0.0
12	Pailin	0.0	0.4
13	Phnom Penh	5.3	0.0
14	Preah Vihear	0.0	1.3
15	Prey Veng	0.0	0.0
16	Pursat	0.0	0.0
17	Ratanak Kiri	0.0	0.0
18	Siem Reap	0.0	0.0
19	Sihanoukville	0.7	0.7
20	Stung Treng	0.0	4.4
21	Svay Rieng	0.0	0.2
22	Takeo	4.0	3.2
	Total	**1.5**	**0.7**

HIV seroprevalence estimates, 2006

Figure 1 shows the HIV seroprevalence estimates for each of the two sentinel groups included in HSS 2006. Results shown are the unsmoothed HIV seroprevalence point estimates. Data were adjusted for results of quality control retesting (as described above) and the ANC data were appropriately weighted. As in previous HSS rounds, HIV seroprevalence among FSWs (14.0%) was much higher than among ANC women (0.9%). In both groups, HIV seroprevalence in 2006 was lower than that estimated in HSS 2003 (see section on trends by sentinel group below).

Figure 1. HIV seroprevalence among sentinel groups in Cambodia, 2006*

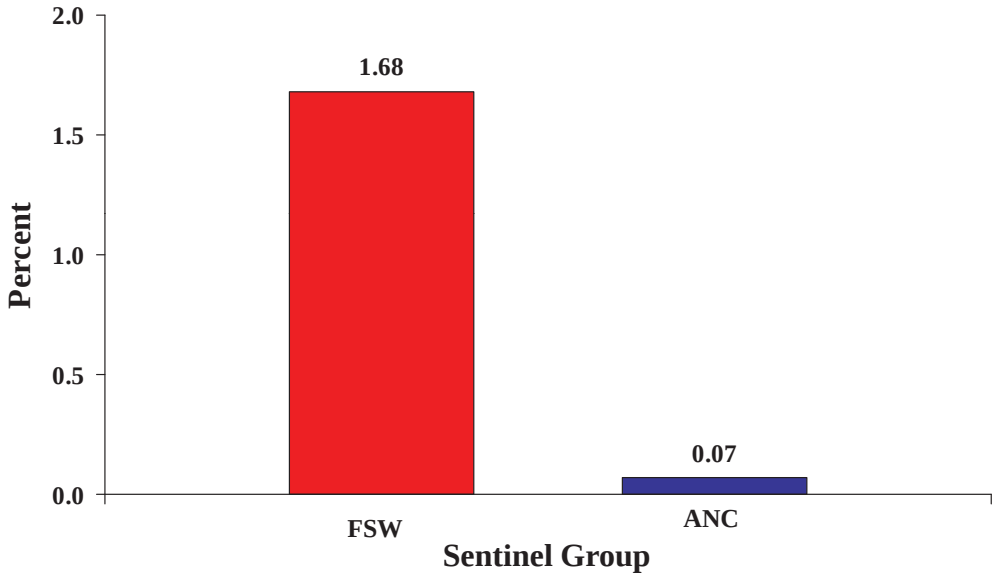


**Unsmoothed HIV seroprevalence estimates are based on HSS data adjusted for results of quality control; ANC data are weighted for provincial population size; FSW data are self-weighted.*

HIV seroincidence estimates, 2006

The survey methods included measuring the proportion of HIV infections that were recently acquired (Figure 2). The estimated annual rate of new HIV infections (i.e., HIV seroincidence) among ANC women (0.07%) and FSWs (1.68%) was substantially lower than in 2002, when HIV incidence was last estimated (see section on trends by sentinel group below).

Figure 2. HIV seroincidence among sentinel groups in Cambodia, 2006*



**Data for ANC women were adjusted using CDC and WHO-recommended methods. Female sex worker data did not require adjustment.*

Trends by sentinel group

Data from previous surveys were reanalyzed in the same way as the 2006 data—this revision allowed us to compare estimates and construct trends in HIV prevalence and incidence estimates for the two sentinel groups.

Antenatal care attendees

Prevalence

Figure 3 shows: (1) the trend in HIV prevalence among ANC attendees adjusted for quality control retesting results and weighted for provincial population size; and (2) the EPP-smoothed trend line. Both the smoothed trend line and actual QC-adjusted, weighted results show that the proportion of ANC women living with HIV has declined from 1999 through 2006. Readers should note that the smoothed estimates shown here for previous years (1996-2003) do not match results for the same years shown in the 2003 HSS report. That is because the adjustment and estimation methods take into consideration the additional data collected since 2003 in the reanalysis of data back to 1996.

HIV infections are usually not evenly distributed between urban and rural areas. Figure 4 shows the trends in HIV prevalence among women attending ANC clinics in provincial capitals (urban) and in remaining districts (rural). For purposes of consistency with previous HSS rounds and CDHS 2005, the provincial capital or remaining district classification was used to define urban or rural areas. HSS 2006 data were also analyzed using the 2004 National Institutes of Statistics, Ministry of Planning reclassification of urban areas, and very little difference between results was observed.

HIV prevalence among urban ANC women is higher than that among rural ANC women and at the peak of the epidemic, around 1998-1999, urban prevalence (2.8%) was almost one percentage point higher than rural prevalence (2.0%). Figure 4 also shows trends in total ANC prevalence. In this report, total ANC prevalence closely follows rural ANC prevalence because the total is weighted by population distribution. Because about 80% of the population lives in rural areas, more weight is given to rural prevalence than to urban prevalence. The combined national estimate is based on the relative proportions of Cambodia's population and assumes that ANCs located in urban areas serve mostly women who are urban residents, and ANCs located in rural areas serve mostly women who are rural residents.

Figure 3. Estimated HIV prevalence among pregnant women attending ANC clinics in Cambodia, 1996-2006

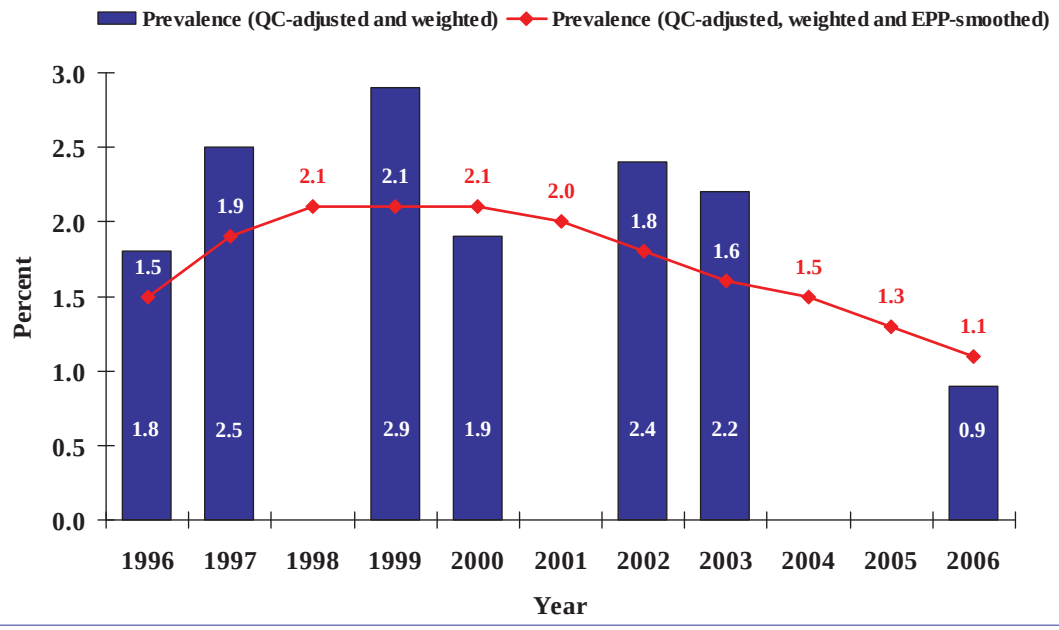
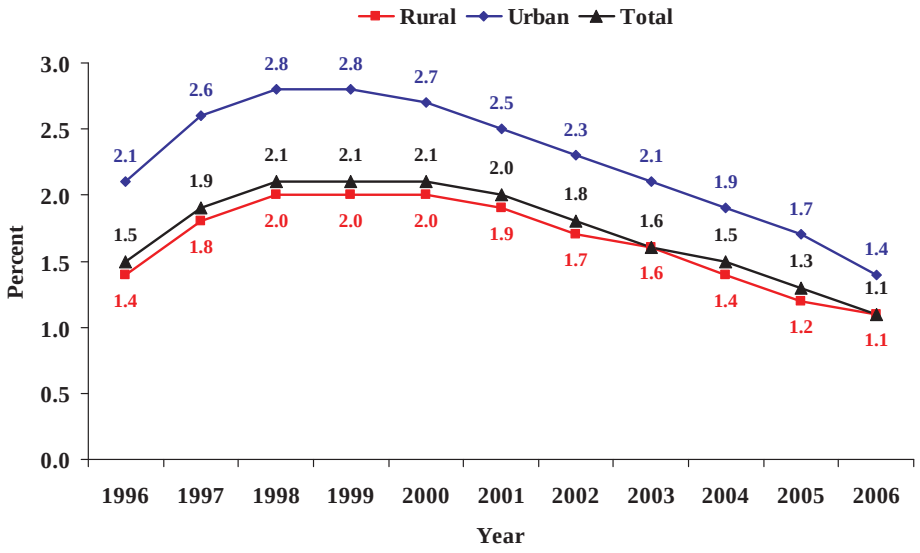


Figure 4. Estimated HIV prevalence* among pregnant women attending ANC clinics in Cambodia, by urban or rural location, 1996-2006

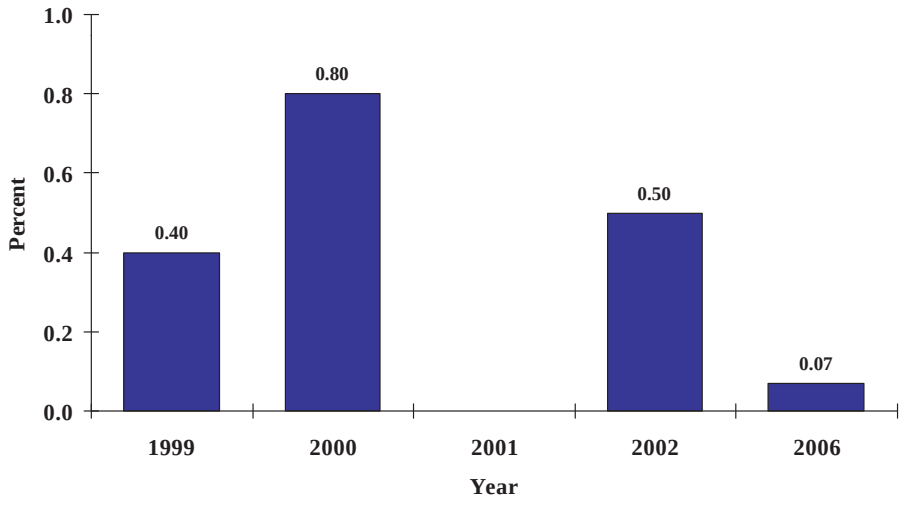


*QC-adjusted, weighted, and EPP-smoothed

Incidence

As mentioned above, the survey also measured the proportion of HIV infections that were recently acquired. Figure 2 shows that 0.07% of pregnant women attending antenatal care clinics in Cambodia in 2006 were newly infected with HIV—an annual HIV incidence rate of 70 per 100,000 pregnant women. In other words, of 100,000 pregnant women, approximately 70 had become HIV infected in 2006. The survey found that the estimated rate of new HIV infections (i.e., the HIV incidence rate) among pregnant women has declined substantially compared with estimates for 1999, 2000, and 2002 (Figure 5).

Figure 5. Estimated HIV seroincidence* among pregnant women attending ANC clinics in Cambodia, 1999-2006



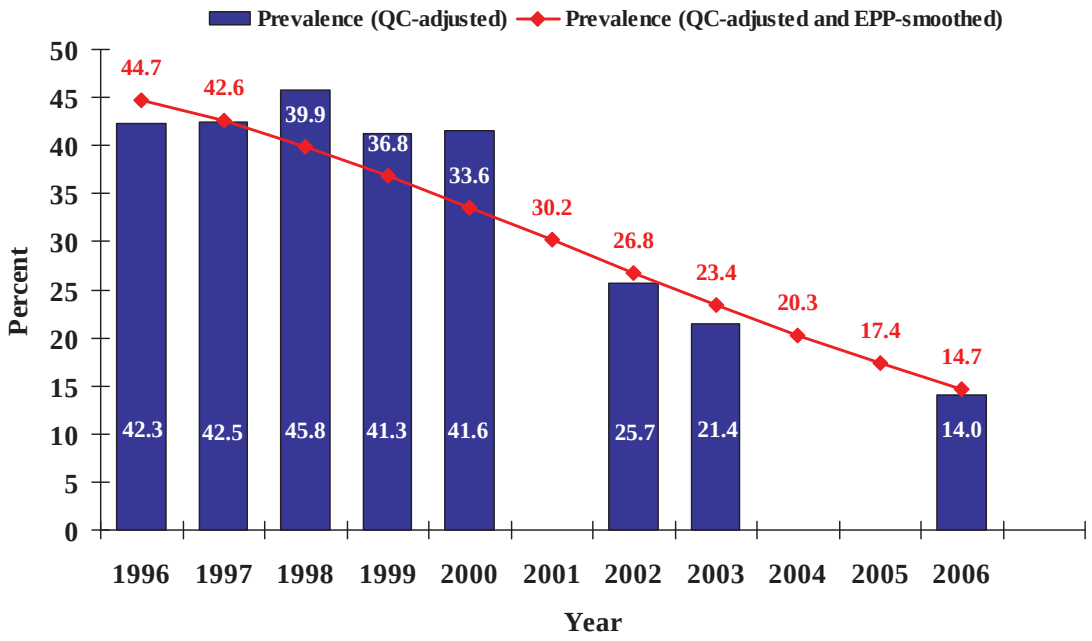
**Data were adjusted using CDC and WHO-recommended methods.*

Brothel-based female sex workers

Prevalence

Figure 6 shows: (1) the trend in HIV prevalence among FSWs adjusted for quality control retesting results; and (2) the EPP-smoothed trend line. In 2003, the proportion of FSWs living with HIV (21.4%) was less than half the 1998 prevalence (45.8%). In 2006, HIV prevalence (14.0%) had declined even further and was less than a third of the 1998 prevalence.

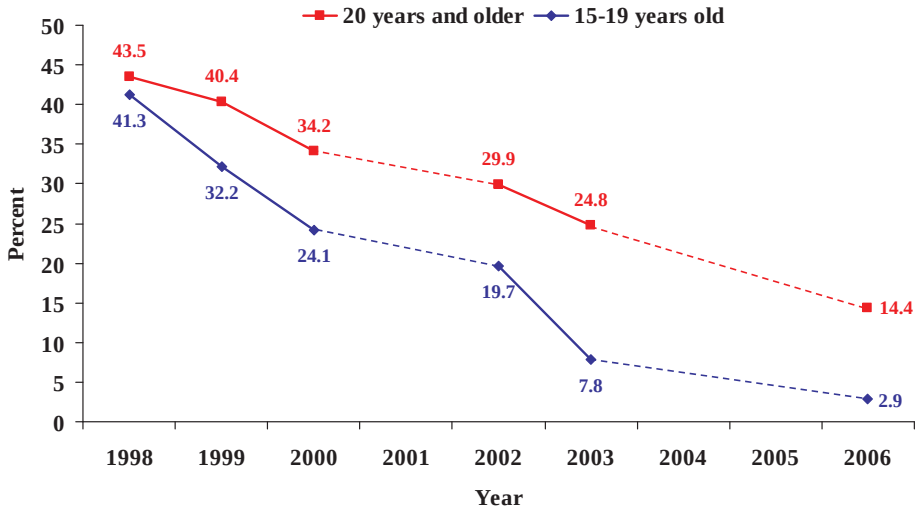
Figure 6. Estimated HIV prevalence among brothel-based female sex workers in Cambodia, 1996-2006



Prevalence among young persons as a proxy for incidence

HIV prevalence among young persons who are more likely to have only recently engaged in high risk behavior is thought to serve as a proxy for HIV incidence (new infections). Indeed, data from Cambodia's 2003 Behavioral Surveillance Survey (BSS) showed that brothel-based FSW younger than 20 years of age had been working in the profession, on average, for 14 months. Figure 7 shows trends in HIV prevalence among brothel-based FSW aged 15-19 years and those aged 20 years and older. Since 1999 the two trend lines have diverged—prevalence among young FSWs is declining more rapidly than HIV prevalence among FSWs aged 20 and older. In 2006, the difference in HIV prevalence between the two groups was almost five-fold. These data suggest that HIV incidence, that is, the rate of new HIV infections, among brothel-based FSW is declining.

Figure 7. Estimated HIV prevalence among brothel-based female sex workers in Cambodia, by age group, 1998-2006*

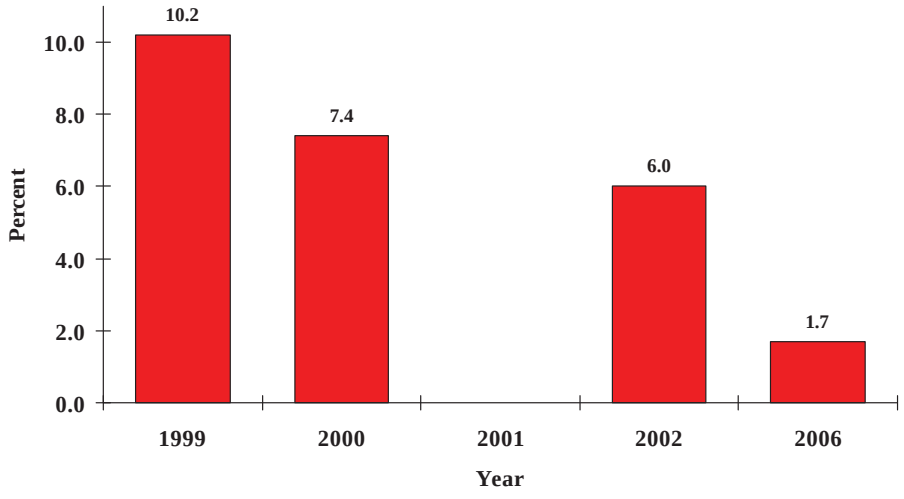


*QC-adjusted, weighted, and EPP-smoothed

Incidence

As mentioned above, the survey also measured the proportion of HIV infections that were recently acquired. Figure 2 shows that 1.68% of FSWs in 2006 were newly infected with HIV—an annual HIV incidence rate of 17 per 1,000 FSWs. In other words, approximately 17 of every 1,000 FSWs had become HIV infected in 2006. The survey found that the estimated rate of new HIV infections (i.e., the HIV incidence rate) among FSWs has declined compared with estimates for 1999, 2000, and 2002 (Figure 8). These results are consistent with the data on prevalence among young FSWs (Figure 7) which suggested declining incidence and add credibility to using prevalence among young persons as a proxy for incidence.

Figure 8. Estimated HIV seroincidence among female sex workers in Cambodia, 1999-2006



*Data did not require adjustment because of the low recent infection to HIV positive ratio.

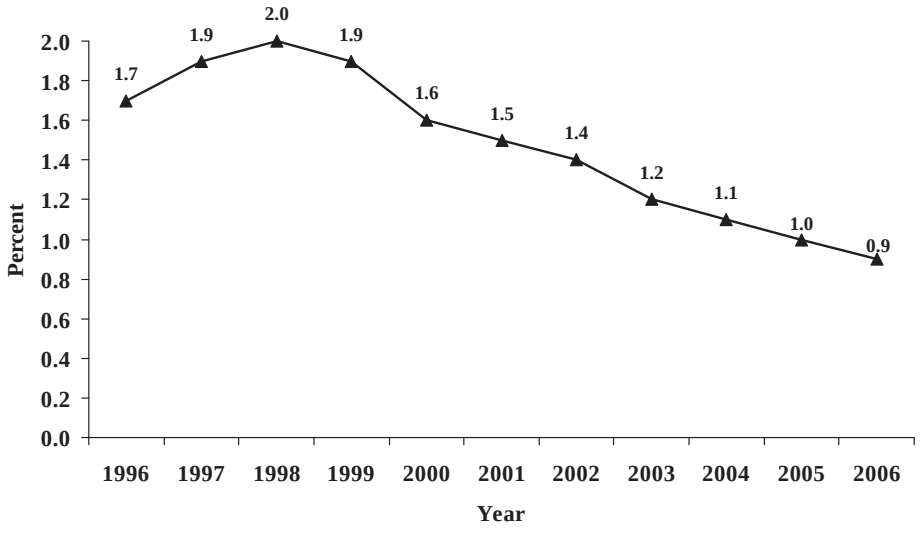
Modeled national trends

HIV prevalence among Cambodian adults

Figure 9 illustrates the modeled trend in HIV prevalence among Cambodian adults aged 15-49 years. The overall proportion of Cambodian adults living with HIV peaked at 2.0% in 1998 and decreased consistently to 0.9% by 2006. Figure 10 shows that HIV prevalence is higher in urban areas (1.1% in 2006) than in rural areas (0.8% in 2006). National HIV prevalence more closely follows that of rural prevalence based on the fact that the majority of Cambodia's population live in rural areas.

Prevalence declines may result from a decrease in new HIV infections, an increase in deaths among persons with HIV, or both. Without data on incidence and deaths, epidemiologists and statisticians must construct models with available data to gain a better understanding of the dynamics of the epidemic. In Cambodia, the available data include census population estimates, trends in HIV prevalence trends among ANC women, ratio of HIV prevalence among ANC women to women in the general population, and male-to-female ratios of persons living with HIV (see the Technical Notes in Appendix III of the HSS 2003 Report).[2] Initially, these declines in prevalence were the result of a reduced number of new infections and increased mortality. Our models suggest that HIV incidence has continued to decline, but the number of deaths among persons with HIV also has been declining since the use of antiretroviral therapy has become widespread.

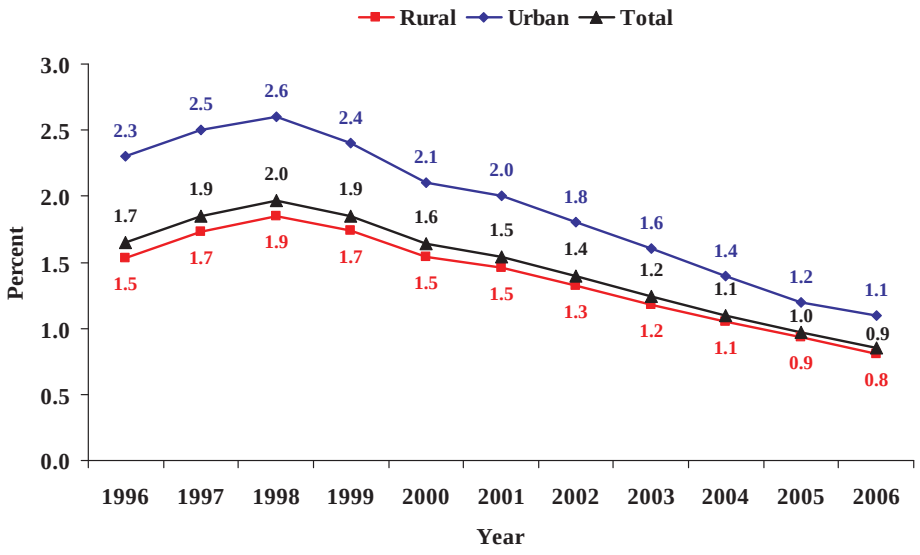
Figure 9. Estimated HIV prevalence* among adults aged 15-49 years in Cambodia, 1996-2006



**QC-adjusted, weighted, and EPP-smoothed*

[2] National Center for HIV/AIDS, Dermatology, and STDs. Report on HIV Sentinel Surveillance in Cambodia 2003. Phnom Penh, Cambodia. 2006.

Figure 10. Estimated HIV prevalence among adults aged 15-49 years by urban or rural residence in Cambodia, 1996-2006*



*QC-adjusted, weighted, and EPP-smoothed

Asian Epidemic Model Estimates and Projections

The national prevalence estimates presented in Figure 9 and Figure 10 were generated using WHO/UNAIDS Estimation and Projection Package (EPP) software.[3] The Asian Epidemic Model (AEM)[4] used these estimates and other available data to project trends in HIV prevalence, incidence, mortality, and the number of persons in need of antiretroviral therapy through 2010.[5]

Number of Cambodian adults living with HIV

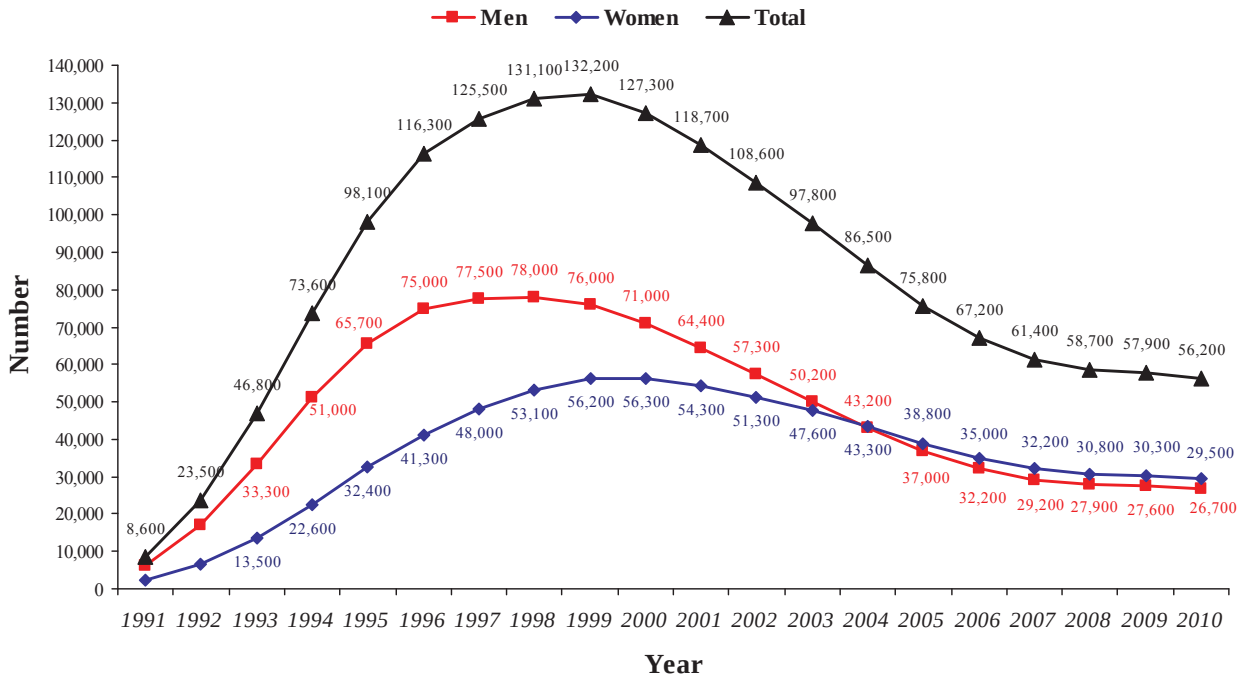
Figure 11 shows the projected number of Cambodians aged 15 years and older living with HIV from 1991 through 2010. The number peaked at 132,200 in 1999 and decreased to 67,200 by the end of 2006. Decreases are projected to continue through 2010, when an expected 56,200 persons in Cambodia will be living with HIV. The pattern among men is similar to that overall, with a peak of 78,000 in 1998. The number of women living with HIV peaked at 56,300 a couple years later. In 2005, the number of women living with HIV surpassed the number of men for the first time since the epidemic began. Projections suggest, however, that the male-to-female ratio will remain relatively stable through 2010.

[3] Ghys PD, Brown T, Grassly NC, et al. The UNAIDS Estimation and Projection Package: a software package to estimate and project national HIV epidemics. Sexually transmitted infections 2004;80 (Suppl 1):i5-9.

[4] Brown T, Peerapatanapokin W. The Asian Epidemic Model: a process model for exploring HIV policy and programme alternatives in Asia. Sexually Transmitted Infections 2004;80 (Suppl 1):i19-i24.

[5] National Center for HIV/AIDS, Dermatology, and STDs. Report of a Consensus Workshop. HIV Estimates and Projections for Cambodia, 2006-2012. 2007, Cambodian Ministry of Health: Phnom Penh.

Figure 11. Estimated number* of adults aged ≥15 years living with HIV in Cambodia at year-end, 1991-2010



**AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data*

HIV incidence

Figure 12 shows trends in the projected number of people newly infected with HIV. The estimated number of new infections peaked at 27,800 in 1994, with 18,500 new infections among men and 9,300 new infections among women. Since the mid-1990s, incidence has declined rapidly. In 2006 an estimated 1,330 persons became newly infected with HIV. Current projections suggest that approximately half that will become infected with HIV in 2010.

Among men, HIV incidence (number of new infections) peaked in 1994 and has declined steadily, meaning that fewer men became infected each year after 1994. Many experts believe that most men were likely infected though sex with FSWs. Declines in new HIV infections among men have been attributed to behavioral changes among FSWs and their clients[6,7]. These changes include an increase in the proportion of men who use condoms consistently during sex with FSWs and a decrease in the proportion of men who visit FSWs.

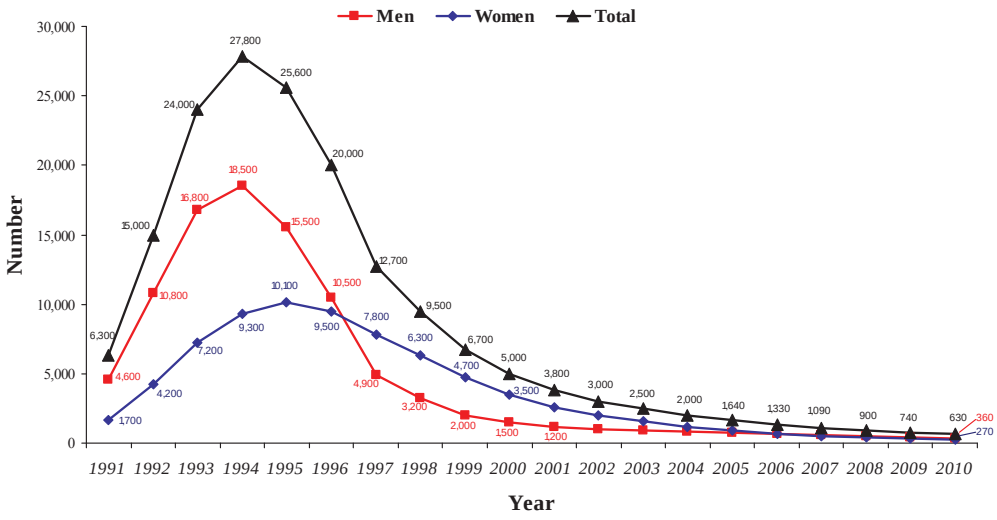
Among women, HIV incidence did not increase as rapidly or to the same level as it did among men. The peak in HIV incidence among women was reached a year after the peak among men. Sexual behavior reported by Cambodian women[8] and the slightly delayed rise in HIV incidence among women compared with incidence among men provide support to the hypothesis that most women in the general population get infected by their husbands.

[6] GNational Center for HIV/AIDS, Dermatology, and STDs. Cambodia 2003 Behavioral Surveillance Survey: HIV/AIDS Related Sexual Behavior among Urban Sentinel Groups. Phnom Penh, Cambodia. 2005.

[7] National Center for HIV/AIDS, Dermatology, and STDs. Cambodia 2007 Behavioral Surveillance Survey. Dissemination Workshop Presentation. Phnom Penh, Cambodia. 2008.

[8] National Institute of Public Health, National Institute of Statistics, and ORC Macro. Cambodia Demographic and Health Survey 2005. 2006, Cambodian National Institute of Public Health, National Institute of Statistics, and ORC Macro: Phnom Penh, Cambodia and Calverton, Maryland, USA.

Figure 12. Estimated number* of new HIV infections among Cambodian adults aged ≥15 years, 1991-2010

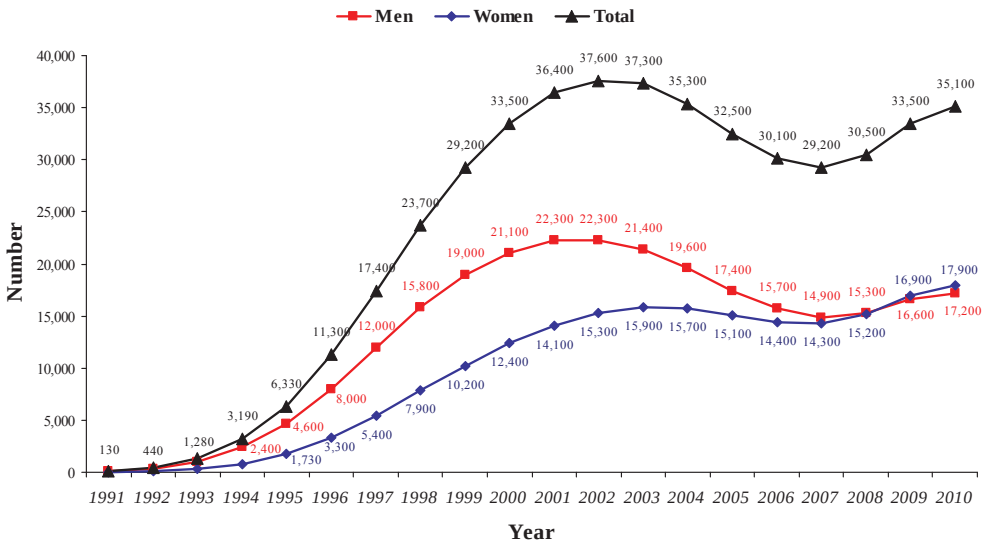


**AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data*

Need for antiretroviral therapy

In Cambodia, persons living with HIV and a CD4$^+$ T-lymphocyte count which has fallen to 250 cells/μL or below are considered to be in need of (or eligible for) antiretroviral therapy (ART). An estimated 14,400 women and 15,700 men were considered to be in need of ART in 2006 (Figure 13). Projections suggest a decline in the number of persons in need of ART in 2007 followed by increases through 2010. By 2010, an estimated 35,100 persons will be in need, with almost even numbers of men and women eligible for ART.

Figure 13. Estimated number* of Cambodian adults aged ≥15 years in need of antiretroviral therapy, 1991-2010

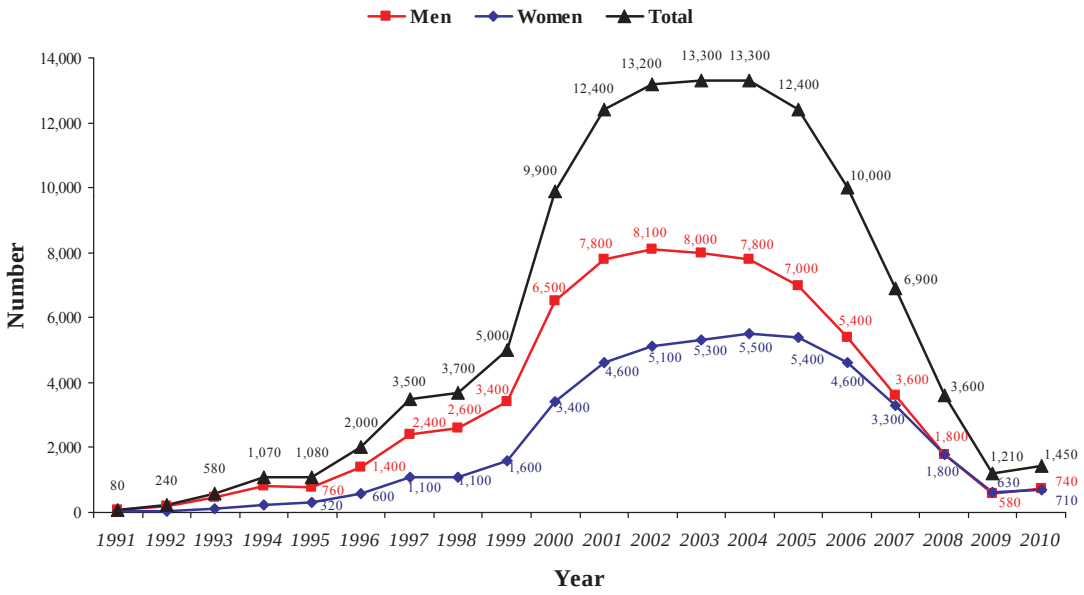


**AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data*

HIV mortality

Trends in the number of deaths among persons with HIV/AIDS are shown in Figure 14. Because progression from HIV infection to severe immunosuppression and death takes an average of 8-10 years, and Cambodia's epidemic probably did not start until the late 1980s, the number of deaths observed in the early 1990s was relatively low. The curve inclined rapidly after 1998, reaching its peak in 2003 and 2004. The marked decline in the mortality curve after 2004 is probably attributable to the rapid scale-up and widespread use of ART.

Figure 14. Estimated number* of deaths among Cambodian adults aged ≥15 years, 1991-2010

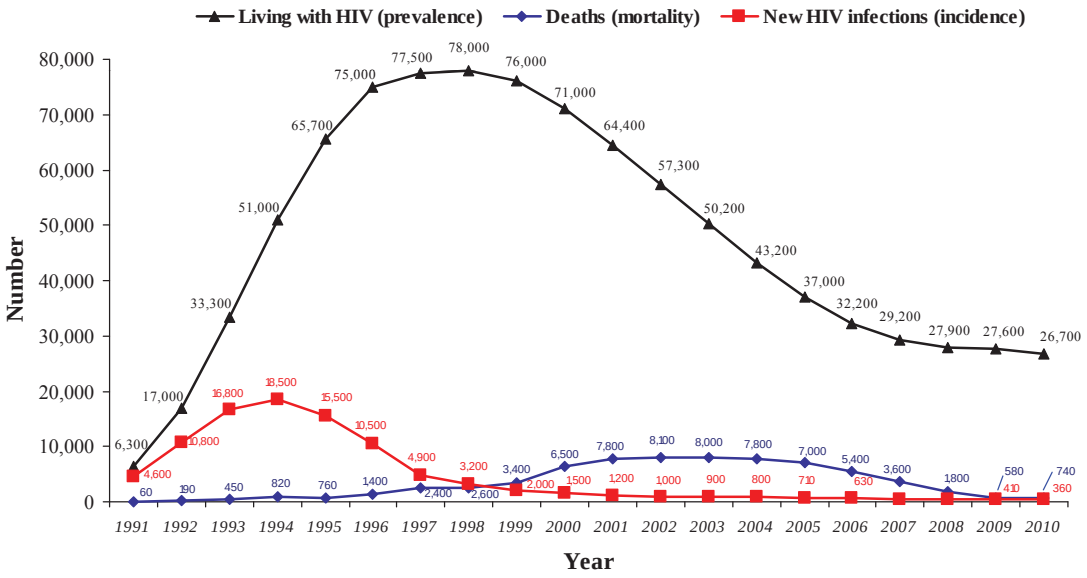


**AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data*

HIV incidence, prevalence, and mortality

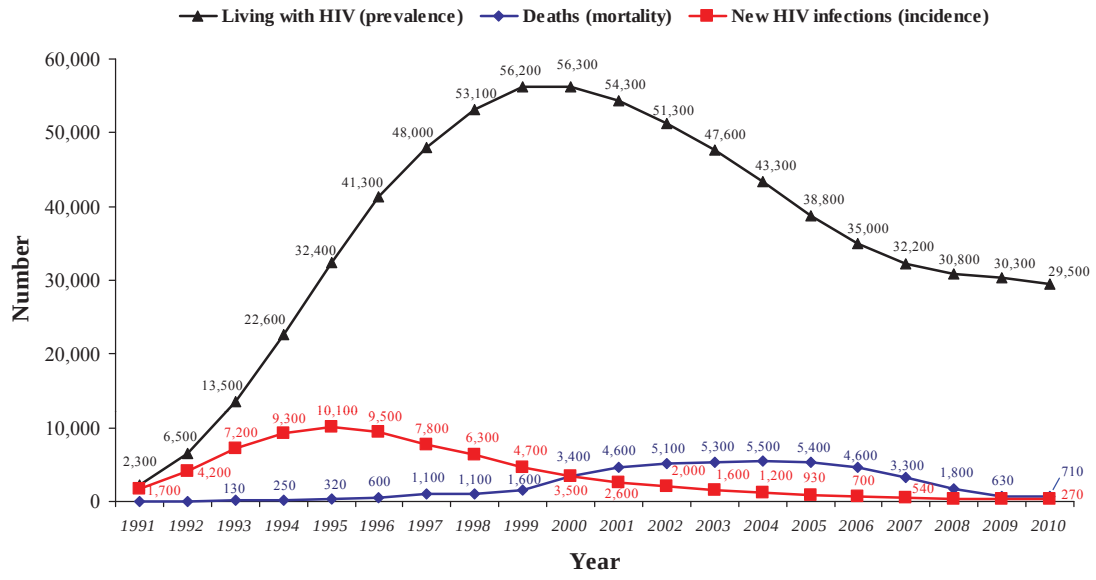
Previous figures have presented incidence, prevalence, and mortality separately. However, these events occur in the population simultaneously. Figures 15 and 16 show the projections for all three measures in one graph for men and another for women. From 1999 through 2007, the number of deaths among men with HIV far outnumbered the number of new infections, resulting in declines in HIV prevalence (Figure 15). For example, in 2003, an estimated 8,000 deaths occurred compared with 900 new infections. The model projected that, because of ART, the differential between numbers of deaths and new infections will not be nearly as great from 2008 to 2010, and therefore prevalence will stabilize. Similar patterns were projected for women although the number of deaths did not outnumber the number of new infections until 2001, resulting in a slight delay in prevalence declines compared with that observed for men (Figure 16). Prevalence among women was also projected to be relatively stable from 2008 forward.

Figure 15. Estimated number of new HIV infections (incidence) and deaths (mortality) among Cambodian men aged ≥15 years and estimated number living with HIV (prevalence), 1991-2010*



*AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data

Figure 16. Estimated number of new HIV infections (incidence) and deaths (mortality) among Cambodian women aged ≥15 years, and estimated number living with HIV (prevalence), 1991-2010*

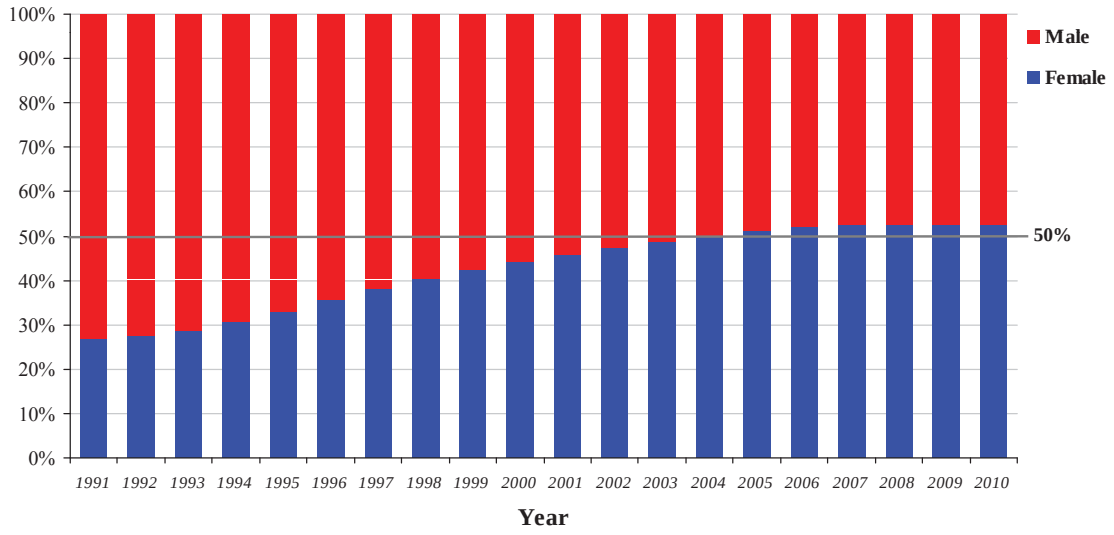


*AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data

Relative proportions of persons living with HIV

Figure 17 illustrates the natural history of Cambodia's epidemic and how the proportion of women among persons living with HIV grew as the epidemic matured. This growth has slowed in recent years. The proportion of women among adults living with HIV increased from 27% in 1991 to 52% in 2006, where it is projected to remain through 2010.

Figure 17. Percent distribution by sex: Cambodian adults aged ≥15 years living with HIV, 1991-2010



*AEM-projected estimates modeled from QC-adjusted, weighted, and EPP-smoothed HSS data

CONCLUSIONS

Results of the 2006 HIV Sentinel Survey (HSS), conducted in 22 of Cambodia's 24 provinces and municipalities showed that from 2003 to 2006, HIV prevalence* declined from:

- 1.2% to 0.9% among all adults
- 1.6% to 1.1% among pregnant women
- 23.4% to 14.7% among brothel-based female sex workers

The survey also measured the proportion of HIV infections that were recently acquired and found that the estimated rate of new HIV infections (i.e., the HIV incidence rate) among pregnant women and female sex workers has declined compared with estimates for 1999, 2000, and 2002. Statistical projections suggest that HIV incidence is declining among Cambodia's general population, as well.

In 2006 an estimated:

- 0.07% of pregnant women in Cambodia were newly infected with HIV—an annual HIV incidence rate of 70 per 100,000 pregnant women. In other words, of 100,000 pregnant women, approximately 70 had become HIV infected in 2006.
- 1.7% of female sex workers in Cambodia were newly infected with HIV—in other words, 17 of every 1,000 female sex workers became infected in 2006.
- 1,330 Cambodians aged older than 15 years were newly infected with HIV—an annual HIV incidence rate of 15 per 100,000 population.

HIV incidence has declined steadily since it peaked around 1994 with an estimated 27,800 new infections—an annual incidence rate of 483 per 100,000 Cambodian adults.

Another of Cambodia's notable successes is the rapid decline in mortality observed since antiretroviral therapy became widely available. The Asian Epidemic Model projected that the number of deaths will have declined from a peak of 13,300 in 2004 to approximately 1,450 in 2010.

Despite impressive declines in HIV prevalence and incidence, largely attributed to a successful prevention program, HIV infection rates in Cambodia remain high compared with other countries in the region. Cambodia ranked second highest in HIV prevalence percent among all countries in South and Southeast Asia, according to the UNAIDS 2008 Report on the Global AIDS Epidemic. Only Thailand, with an estimated adult HIV prevalence of 1.4% in 2007 ranked higher than Cambodia.

Although Cambodia has achieved remarkable success in lowering HIV prevalence and incidence, this is no time for complacency. Sentinel surveillance, special surveys among more recently identified high-risk populations, and surveillance for antiretroviral resistance will continue to be needed to provide the foundation for planning and modifying Cambodia's response to the epidemic. Prevention, control, and treatment efforts must be maintained and in some cases expanded or strengthened, to sustain these hard fought gains against the HIV epidemic.

* Quality-control adjusted and EPP-smoothed estimates

APPENDIX I

HSS Sentinel Sites and Groups, 1992 through 2006

Table 1. Summary of changes in HSS sentinel sites and groups from 1992 through 2006

	YEAR										
	1992	1994	1995	1996	1997	1998	1999	2000	2002	2003	2006
PROVINCES	PNP	PNP BMC BTB SHV SRP	PNP BMC BTB SHV SRP KDL KHK PST RTK	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KEP KTH MDK PVH	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KTH	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KTH PAL	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KTH PAL PVH	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG KTH PAL PVH	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KEP KTH PVH OM	PNP BMC BTB SHV SRP KDL KHK PST RTK KCM KCN KPT KRT KSP PVG STG SVG TKO KEP KTH PVH OM
GROUPS	FSW TB POL MIL ANC - - - - STD -	FSW TB POL MIL ANC - - - - - -	FSW TB POL MIL ANC IFSW - - - - -	FSW TB POL MIL ANC - - - - - -	FSW TB POL MIL ANC - - HINP - - -	FSW - POL - - IFSW - - - MWR	FSW TB POL - ANC BEG FRL HINP HH - -	FSW TB POL - ANC IFSW - HINP - - -	FSW TB POL - ANC IFSW - - - - -	FSW - POL - ANC IFSW - - - - -	FSW - - - ANC - - - - - -

**No survey was conducted in 1993, 2001, 2004, or 2005.*

Provinces:

BMC: Banteay Meanchey
BTB: Battambang
KCM: Kampong Cham
KCN: Kampong Chhnang
KSP: Kampong Speu
KTH: Kampong Thom
KPT: Kampot
KDL: Kandal
KHK: Koh Kong
KRT: Kratie
MDK: Mondul Kiri
OM: Oddar Meanchey
PAL: Pailin
PNP: Phnom Penh
PVG: Prey Veng
PVH: Preah Vihear
RTK: Ratanak Kiri
SRP: Siem Reap
SHV: Sihanoukville
STG: Stung Treng
SVG: Svay Rieng
TKO: Takeo

Groups:

ANC: Antenatal clinic attendees
BEG: Beer girls
FSW: Female sex workers (brothel-based)
FRL: Freelance
HH: Household
HINP: Hospital in-patients
IFSW: Informal FSW (non-brothel-based)
MIL: Military personnel
MWR: Married women of reproductive age
POL: Police personnel
STD: Sexually transmitted disease patients
TB: Tuberculosis patients

APPENDIX II

Table 1. ANC Sites, HSS 2003 and 2006

		Provincial capital sites		Remaining district sites	
No	Provinces	2003	2006	2003	2006
1	Banteay Meanchey	Serey Sophorn	Serey Sophoan HC	Bort Tran Reu Sey Krork Phnom Tuch Poi Pet Kum Ru Svay Chek Chhub Vary Sras Chhik	Poipet Muoy HC Chub Vari HC Reusey Krok HC
2	Battambang	Svay Por HC Chamka Somrong HC Anlong Vel HC	Svay Por HC	Phnom Sampov HC Peam Ek HC O-Dambong Muoy HC Chrey HC O- Mal HC	Peam Ek HC O-Dambong Muoy HC Phnom Sampov HC
3	Kampong Cham	Beng Kok HC Kampong Cham RHAC	Beng Kok HC Veal Vong HC	Chrey Vean HC Suong Muoy HC Skun HC	Chrey Vean HC Suong Muoy HC Skun HC
4	Kampong Chhnang	Kampong Chhnang Provincial RH Psa Chhnang HC	Kampong Chhnang Provincial RH Psa Chhnang HC	Ponley HC Ak Piwat HC Prey Khmer HC Sala Lekpram HC Chrey Bak HC	Ponley HC Sala Lekpram HC Prey Khmer HC
5	Kampong Speu	Roka Tep HC Chum Kravan HC	Roka Tep HC Chum Kravan HC	Srorng HC Veangpreah Srei HC	Kong Pisey HC Veangpreah Srei HC Roleang Sen HC
6	Kampong Thom	Kampong Thom Provincial RH Sra Yov HC A-Chaleak HC	Kampong Thom Provincial RH Sra Yov HC	Tang Krasang HC Balang HC Baray HC	Tang Krasang HC Balang HC Baray HC
7	Kampot	Krang Ampel HC	Krang Ampel HC	Chhuok HC Kampong Trach HC Trapeang Reang HC Tani HC	Chhuok HC Kampong Trach HC Tuok Meas HC
8	Kandal	Chey Chumneas RH Svay Rolom HC	Chey Chumneas RH	Siem Reap HC Beng Kyang HC	Siem Reap HC Beng Kyan HC Prek Pnov HC Kean Svay HC
9	Koh Kong	Smach Meanchey RH	Smach Meanchey RH Steng Veng HC		
10	Kratie	Roka Kandal HC O-Reusey HC	Kratie RH O-Reusey HC	San Dan HC Sam Bur HC Kanch Chhor HC	San Dan HC Sam Bur HC Kanch Chhor HC
11	Oddar Meanchey	Oddar Meanchey Provincial RH	Oddar Meanchey Provincial RH	Anglong Veng HC Kok Mon HC Ampel HC Chong Kal HC Bos Sbov HC Kon Kreal HC Kok Kpuos HC O-Smach HC Trapeang Prasat HC	Anglong Veng HC Kok Mon HC Ampel HC Chong Kal HC

12	Pailin	Suon Koma HC	Suon Koma HC	Sala Krao HC	Phnom Spong HC O-Chral HC
13	Phnom Penh	Prampimakara HC Chamkamon RH	Prampimakara HC Chamkamon RH		
14	Preah Vihear	Preah Vihear Provincial RH Tbeng HC	Preah Vihear Provincial RH Tbeng HC	Cheb HC Ro Vieng HC Ku Len HC Chorm Ksan HC Phnom Dek HC Chnuol HC Sa Ang HC	Phnom Dek HC Roveang HC Kulen HC Chuom Ksaan HC
15	Prey Veng	Prey Veng Provincial RH Kampong Leav HC	Prey Veng Provincial RH Kampong Leav HC	Nokor Reach HC Prek Ksay Khor HC Neak Leung Hospital	Srok Preah Sdech RH Prek Ksay Khor HC Kampong Trabek HC
16	Pursat	Peal Ngek HC Prey Nhy HC	Peal Vek HC Prey Nhy HC	Trapeang Chong HC Trakor HC Kra Vanh HC Beng Khna HC Kan Dieng HC Mei Tek HC	Trapeang Chong HC Trakor HC Kra Vanh HC Beng Khna HC
17	Rattanakiri	Rattanakiri Provincial RH	Rattanakiri Provincial RH Prey Ngy HC	Kon Mom HC O-Yadav HC Lom Phat HC Veurn Sey HC	Kon Kramom HC O-Yadav HC Lom Phat HC Veurn Sey HC
18	Siem Reap	Mondul Muoy HC Sambo HC Por Meanchey HC Chreav HC Chong Khneas HC	Mondul Muoy HC Sambo HC Por Meanchey HC	Puok HC Prasat Bakong HC Sam Rong HC Kandek HC Kampong Kdey HC Prey Chruok HC Dom Dek HC Sa Veuy HC Tek Vel HC Sorsor Sdorm HC Kampong Tkov HC Preah Dak HC	Puok HC Prasat Bakong HC Sam Rong HC Kandek HC
19	Sihanoukville	Krong RH	Krong RH Sangkat Lek Muoy HC	Andong Thmor HC Steng Hav HC Veal Renh HC	Andong Thmor HC Steng Hav HC Veal Renh HC
20	Stung Treng	Steng Treng Provincial RH	Stung Treng Provincial RH	Sre Krasang HC Kom Phon HC Siem Pang HC Thala Borivath HC Sras Reusey HC	Sre Krasang HC Kam Phon HC Siem Pang HC Thala Borivath HC
21	Svay Rieng	Svay Rieng Provincial RH Chek HC Cham Lom HC Sorng HC Basak HC	Svay Rieng Provincial RH Chek HC Cham Long HC	Svay Chrum HC Don Sor HC Kandeang Reay HC Chan Tri HC Preah Ponlea HC Chork HC Krol Kor HC	Svay Chrum HC Don Sor HC Kandeang Reay HC Chan Tri HC
22	Takeo	Roka Khnong HC Takeo Provincial RHAC	Roka Khnong HC Takeo Provincial RHAC	Sam Rong HC Puth Sath HC Lom Chorng HC Chorn Chum HC Prey Lvea HC	Sam Rong HC Puth Sath HC Ang Tasom HC Chorn Chum HC

APPENDIX III

DATA TABLES

Table 1. HIV seroprevalence[1] among sentinel populations in Cambodia, 2006

No.	Province/Ville	FSW	ANC					
			PC[2]		RD[3]		PC + RD	
		No. tested	Prev. %	No. tested	Prev. %	No. tested	Prev. %	No. tested	Prev. %
1	Banteay Meanchey	153	30.7	300	1.3	300	1.3	600	1.3
2	Battambang	149	20.6	300	1.7	300	1.3	600	1.5
3	Kampong Cham	126	11.1	300	0.7	300	0.1	600	0.8
4	Kampong Chhnang	72	12.5	296	1.4	300	0.7	596	1.0
5	Kampong Speu	112	25.8	294	[1.0]	300	0.3	594	0.7
6	Kampong Thom	89	10.1	300	0.7	295	0.7	595	0.7
7	Kampot	54	5.6	299	1.7	293	0.0	592	0.8
8	Kandal	130	3.1	274	0.7	300	0.7	574	0.7
9	Koh Kong	82	20.7	249	1.6	NS[4]		249	1.6
10	Kratie	44	9.1	297	1.0	296	0.0	593	0.5
11	Oddar Meanchey	119	12.6	300	0.0	298	0.3	598	0.2
12	Pailin	76	10.5	301	2.3	169	1.8	470	2.1
13	Phnom Penh	142	11.3	599	0.8	NS		599	0.8
14	Preah Vihear	63	11.1	275	0.4	264	0.8	539	0.6
15	Prey Veng	135	4.4	150	0.7	449	0.9	599	0.8
16	Pursat	115	10.4	299	1.0	370	0.5	669	0.8
17	Ratanak Kiri	57	5.3	300	0.3	259	0.0	559	0.2
18	Siem Reap	98	20.4	300	0.3	300	1.0	600	0.7
19	Sihanouk Ville	149	26.7	300	1.7	296	1.7	596	1.7
20	Stung Treng	61	11.5	164	1.2	204	0.0	368	0.5
21	Svay Rieng	60	10.0	301	1.0	298	0.0	599	0.5

[1] Adjusted for quality control

[2] PC: Provincial Capital

[3] RD: Remaining District

[4] NS= not sampled

Table 2. HIV seroprevalence[1] among sentinel groups in Cambodia, 1996 - 2006

Sentinel group	Year															
	1996		1997		1998		1999		2000		2002		2003		2006	
	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.	No. tested	% Pos.
FSW	1,859	44.7	1,132	42.6	2,284	39.9	2,259	36.8	2,180	33.6	2,109	26.8	2,411	23.4	2230	14.7
IFSW	NS[3]		NS		1,358	18.4	1,488	19.3	1,799	15.6	1,232	14.3	1,633	11.7	NS	
Policemen	1,775	4.9	1,325	3.9	2,650	4.8	4,141	3.7	4,711	3.7	4,375	2.5	5,796	2.5	NS	
ANC attendees	3,429	1.5	5,003	1.9	NS		5,397	2.1	6,562	2.1	9,166	1.8	10,867	1.6	12370	1.1
Military personel	1,429	5.9	1,249	7.1	NS		NS		NS		NS		NS		NS	
Tuberculosis patients	1,826	3.9	1,035	5.0	NS		2,166	7.9	2,739	6.0	2,356	8.4	NS		NS	
Hospital inpatients	NS		1,155	6.0	1,173	12.2	1,061	11.0	1,016	10.0	NS		NS		NS	
MWRA[2]	NS		NS		8,879	2.4	NS		NS		NS		NS		NS	
Household men	NS		NS		NS		3,069	1.8	NS		NS		NS		NS	
Household women	NS		NS		NS		3,066	1.2	NS		NS		NS		NS	

[1] FSW data were adjusted for quality control (QC), weighted for province-specific population size and EPP smoothed; IFSW data were QC-adjusted; police and ANC data were QC-adjusted, weighted for province-specific population size and EPP-smoothed; data for sentinel groups were not adjusted, weighted, or smoothed

[2] MWRA=married women of reproductive age

[3] NS=not sampled

Table 3: HIV seroprevalence among ANC women by province[1], age group, and year, 1996-2006

Province	HIV Seroprevalence among ANC																	
	15-24									25 +								
	1996	1997	1998	1999	2000	2001	2002	2003	2006	1996	1997	1998	1999	2000	2001	2002	2003	2006
Banteay Meanchey	2.0	2.1	2.1	2.0	1.9	1.8	1.8	1.7	0.6	2.4	3.1	3.3	3.3	3.1	2.9	2.6	2.3	2.1
Battambang	0.9	1.5	1.9	2.0	2.0	1.9	1.8	1.6	1.2	1.3	2.0	2.2	2.2	2.2	2.1	2.1	2.0	1.8
Kampong Cham	0.8	1.1	1.3	1.4	1.3	1.2	1.2	1.1	0.8	1.0	1.8	2.7	3.1	3.1	3.0	2.8	2.5	0.8
Kampong Chhnang	0.8	1.3	1.6	1.7	1.7	1.5	1.4	1.2	0.0	0.9	1.5	2.0	2.2	2.2	2.1	1.9	1.7	1.6
Kampong Speu	0.5	1.0	1.6	2.2	2.6	2.7	2.7	2.7	0.0	0.7	1.3	2.1	2.7	3.0	3.2	3.2	3.1	1.2
Kampong Thom	0.3	0.6	1.0	1.5	1.9	2.1	2.1	2.0	0.0	0.8	1.5	2.1	2.4	2.5	2.4	2.4	2.3	1.1
Kampot	0.1	0.2	0.4	0.6	0.9	1.2	1.4	1.5	0.0	1.0	1.6	2.0	2.1	2.1	2.1	2.1	2.0	1.6
Kandal	1.9	1.9	1.8	1.6	1.4	1.2	1.0	0.9	0.0	2.8	2.7	2.6	2.5	2.4	2.2	2.1	1.9	1.2
Koh Kong	4.4	4.6	4.4	4.1	3.7	3.3	2.8	2.4	0.9	5.0	5.0	4.8	4.5	4.1	3.6	3.1	2.6	2.2
Kratie	0.9	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.9	1.5	1.5	1.4	1.3	1.2	1.0	0.9	0.7	0.3
Oddar Meanchey[2]									0.0									0.3
Pailin	1.3	2.4	2.9	3.0	2.9	2.8	2.7	2.5	0.8	2.2	3.2	3.6	3.6	3.5	3.3	3.1	2.8	3.5
Phnom Penh	2.4	2.7	2.6	2.4	2.2	1.9	1.7	1.4	0.7	3.3	3.6	3.5	3.3	3.0	2.7	2.4	2.0	0.9
Preah Vihear	0.1	0.1	0.2	0.4	0.6	0.7	0.8	0.8	0.0	0.2	0.3	0.6	0.9	1.2	1.4	1.4	1.4	0.8
Prey Veng	1.3	1.7	1.8	1.8	1.7	1.5	1.3	1.1	0.0	1.8	2.5	2.7	2.7	2.6	2.4	2.2	2.0	1.3
Pursat	1.8	2.1	2.1	2.0	1.9	1.7	1.4	1.2	0.8	2.7	2.6	2.5	2.3	2.1	1.9	1.6	1.4	0.7
Ratanak Kiri	1.7	1.8	1.7	1.6	1.4	1.3	1.1	0.9	0.0	2.7	2.9	2.8	2.7	2.4	2.1	1.8	1.5	0.4
Siem Reap	2.4	3.6	4.1	4.1	3.8	3.5	3.1	2.7	0.4	2.8	3.9	4.3	4.3	4.1	3.8	3.4	3.0	0.9
Sihanoukville	2.2	3.1	3.4	3.4	3.3	3.1	2.9	2.6	0.7	2.4	3.6	4.1	4.1	3.9	3.6	3.2	2.8	2.8
Stung Treng	1.3	1.9	2.1	2.1	2.0	1.8	1.7	1.5	0.6	1.8	2.5	2.7	2.7	2.5	2.4	2.2	2.0	0.5
Svay Rieng	1.7	2.1	2.2	2.1	2.0	1.8	1.5	1.3	0.0	3.0	3.3	3.3	3.1	2.8	2.5	2.1	1.8	0.9
Takeo	0.6	1.0	1.2	1.3	1.2	1.1	1.0	0.9	0.8	1.3	2.2	2.7	2.8	2.7	2.5	2.3	2.0	0.6

[1] Data were smoothed with EPP and 2003 and 2006 data were adjusted for qulaity control

[2] Data from Oddar Meanchey province were not collected until 2003 and smoothed estimates could not be generated until 2006

Table 4. Banteay Meanchey: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Banteay Meanchey	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	53.1	56.2	52.7	52.5	37.8		35.4	26.7	30.7
	(156)	(198)	(202)	(148)	(150)		(171)	(150)	(153)
Age <20 years			48.8	45.5	26.3		28.2	7.7	0.0
Age ≥ 20 years			56.8	54.0	40.8		36.5	28.5	31.8
Informal female sex workers			21.1	11.4	13.2		18.9	5.3	
			(94)	(126)	(150)		(45)	(150)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	10.6	9.6	8.6	7.5	6.4	5.3	4.2	3.3	
	(68)	No Survey[5]	(160)	(150)	(150)	No Survey[5]	(170)	(300)	
ANC PC[2] = 1 site in 2006	2.6	3.1	3.2	3.2	3.0	2.7	2.5	2.2	1.3
ANC RD[3] = 3 sites in 2006	2.0	2.7	2.9	2.9	2.7	2.5	2.2	1.9	1.3
Total ANC (PC+RD)	2.2	2.9	3.2	3.1	2.9	2.6	2.3	2.0	1.3
	(178)	(263)	(420) [4]	(106)	(150)	No Survey[5]	(250)	(600)	(600)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 5. Battambang: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Battambang	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	56.5	46.7	52.1	40.0	31.0		11.9	29.5	14.2
	(156)	(102)	(150)	(161)	(147)		(159)	(149)	(149)
Age <20 years			47.1	19.5	25.7		5.9	14.6	0.0
Age ≥ 20 years			54.0	44.9	32.9		13.2	35.2	16.0
Indirect female sex workers			19.5	20.2	23.1		11.5	9.3	
			(103)	(101)	(150)		(130)	(150)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	9.5	8.8	7.9	7.0	6.0	5.0	4.1	3.3	
	(86)	(126)	(152)	(160)	(298)	No Survey[5]	(298)	(311)	
ANC PC[2] = 1 site in 2006	1.2	1.9	2.2	2.2	2.2	2.1	2.0	1.9	1.7
ANC RD[3] = 3 sites in 2006	1.0	1.7	2.0	2.0	2.0	1.9	1.8	1.7	1.3
Total ANC (PC+RD)	1.1	1.8	2.1	2.1	2.1	2.0	1.9	1.8	1.5
	(180)	(253)	(800)[4]	(374)	(401)	No Survey[5]	(600)	(600)	(600)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 6. Kampong Cham: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kampong Cham	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	30.1		30.1	34.0	30.4		23.3	17.3	11.1
	(154)		(150)	(157)	(150)		(133)	(150)	(126)
Age <20 years			32.0	24.1	19.1		26.3	12.1	0.0
Age ≥ 20 years			28.8	37.9	33.0		22.4	18.8	12.1
Indirect female sex workers			9.0	26.9	14.8		13.9	14.7	
			(100)	(200)	(152)		(98)	(150)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.7	3.0	3.0	2.9	2.7	2.5	2.3	2.2	
	(161)	(112)	(150)	(301)	(299)	No Survey[5]	(307)	(300)	
ANC PC2 = 2 sites in 2006	0.9	1.7	2.3	2.5	2.6	2.5	2.4	2.2	0.7
ANC RD3 = 3 sites in 2006	0.6	1.2	1.9	2.3	2.3	2.2	2.1	1.8	0.8
Total ANC (PC+RD)	0.8	1.5	2.1	2.4	2.5	2.4	2.3	2.1	0.8
	(232)	(268)	(600)[4]	(566)	(487)	No Survey[5]	(715)	(600)	(600)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

5Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 7. Kampong Chhnang: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kampong Chhnang	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	39.5	43.9	40.0	45.7	42.9		34.8	24.0	12.5
	(116)	(130)	(150)	(130)	(112)		(68)	(96)	(72)
Age <20 years			49.2	34.2	20.5		13.9	5.3	0.0
Age ≥ 20 years			37.5	47.5	46.6		37.5	28.6	13.0
Indirect female sex workers			13.7	24.0	13.0		22.4	10.0	
			(88)	(47)	(38)		(29)	(40)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	3.2	3.1	2.9	2.8	2.6	2.4	2.2	2.0	
	(171)	No Survey[5]	(150)	(298)	(300)	No Survey[5]	(285)	(300)	
ANC PC[2] = 2 sites in 2006	0.9	1.9	2.8	3.1	3.1	2.9	2.6	2.3	1.4
ANC RD[3] = 3 sites in 2006	0.6	1.0	1.4	1.6	1.7	1.6	1.5	1.4	0.7
Total ANC (PC+RD)	0.7	1.4	1.8	2.0	2.0	1.9	1.7	1.5	1.0
	(258)	(222)	(400)[4]	(301)	(300)	No Survey[5]	(500)	(599)	(596)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 8. Kampong Speu: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kampong Speu	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	49.6		46.7	35.7	37.3		31.4	20.4	11.6
	(115)		(119)	(96)	(117)		(119)	(108)	(112)
Age <20 years			34.8	37.6	46.8		9.8	11.8	0.0
Age ≥ 20 years			49.2	34.7	35.6		34.0	23.1	12.2
Indirect female sex workers			9.0	11.4	29.3		1.6	-	
			(25)	(20)	(22)		(20)	(11)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.3	2.8	3.0	2.9	2.7	2.5	2.2	1.9	
	92	No Survey[5]	150	300	300	No Survey[5]	(285)	(300)	
ANC PC2 = 2 sites in 2006	0.7	1.4	2.1	2.6	2.9	2.9	2.9	2.9	1.0
ANC RD3 = 3 sites in 2006	0.5	1.1	1.8	2.3	2.6	2.7	2.7	2.7	0.3
Total ANC (PC+RD)	0.6	1.2	1.9	2.4	2.7	2.8	2.8	2.8	0.7
	(210)	(250)	(400)[4]	(265)	(300)	No Survey[5]	(498)	(500)	(594)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 9. Kampong Thom: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kampong Thom	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	34.2	35.2	29.2		20.6	26.7	10.1	24.0	12.5
	(95)	(78)	(82)		(84)	(90)	(89)	(96)	(72)
Age <20 years			30.0	35.2	34.0		3.2	-	5.9
Age ≥ 20 years			35.1	34.1	28.0		22.4	31.2	11.1
Indirect female sex workers			31.2	23.6	15.0		9.7	14.0	
			(79)	(51)	(52)		(53)	(50)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.5	2.4	2.3	2.1	1.9	1.7	1.5	1.2	
	No Survey[5]	(105)	(146)	(294)	(300)	No Survey[5]	(285)	(299)	
ANC PC[2] = 2 sites in 2006	0.6	1.1	1.8	2.2	2.4	2.4	2.4	2.3	0.7
ANC RD[3] = 3 sites in 2006	0.3	0.7	1.2	1.6	1.9	2.0	2.0	1.9	0.7
Total ANC (PC+RD)	0.5	1.0	1.6	2.0	2.2	2.2	2.2	2.1	0.7
	No Survey[5]	(248)	(395)[4]	(250)	(300)	No Survey[5]	(473)	(600)	(595)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 10. Kampot: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kampot	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	41.9		58.9	53.4	42.3		32.4	19.5	5.6
	(77)		(67)	(56)	(57)		(53)	(77)	(54)
Age <20 years			59.2	47.7	31.7		27.7	-	0.0
Age ≥ 20 years			58.9	54.2	45.3		33.1	20.8	5.9
Indirect female sex workers			22.7	11.9	30.2		8.4	16.9	
			(62)	(47)	(64)		(38)	(59)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	4.3	3.9	3.5	3.0	2.5	2.0	1.6	1.2	
	(105)	(118)	(147)	(155)	(302)	No Survey[5]	(297)	(303)	
ANC PC[2] = 2 sites in 2006	0.6	1.1	1.5	1.6	1.7	1.7	1.7	1.7	1.7
ANC RD[3] = 3 sites in 2006	0.3	0.6	1.1	1.4	1.5	1.6	1.5	1.5	0.0
Total ANC (PC+RD)	0.4	0.8	1.2	1.5	1.6	1.6	1.6	1.6	0.8
	(208)	(275)	(407)[4]	(255)	(306)	No Survey[5]	(500)	(600)	(592)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 11. Kandal: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kandal	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	17.4	22.4	24.4	37.0	27.0		23.0	16.8	3.1
	(105)	(115)	(103)	(104)	(78)		(100)	(130)	(130)
Age <20 years			36.5	36.0	7.5		13.1	-	0.0
Age ≥ 20 years			22.0	36.4	34.0		26.4	11.8	4.1
Indirect female sex workers			9.8	17.3	25.7		12.4	12.4	
			(100)	(100)	(65)		(40)	(98)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	6.8	6.4	6.0	5.4	4.7	4.1	3.4	2.8	
	(97)	(162)	(150)	(150)	(150)	No Survey[5]	(142)	(169)	
ANC PC[2] = 2 sites in 2006	2.7	3.3	3.4	3.2	3.0	2.7	2.3	2.0	0.7
ANC RD[3] = 3 sites in 2006	1.8	1.6	1.4	1.2	1.1	0.9	0.7	0.6	0.7
Total ANC (PC+RD)	2.5	2.5	2.4	2.2	2.1	1.9	1.8	1.6	0.7
	(200)	(208)	(400)[4]	(300)	(300)	No Survey[5]	(495)	(397)	(574)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 12. Koh Kong: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Koh Kong	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	51.1	51.0	41.5	45.2	52.9		47.0	29.0	20.7
	(119)	(100)	(134)	(151)	(140)		(112)	(100)	(82)
Age <20 years			40.0	50.4	32.6		32.6	-	0.0
Age ≥ 20 years			44.9	42.4	56.6		53.4	36.7	23.9
Indirect female sex workers			17.1		15.2		12.5	2.4	
			(74)		(83)		(71)	(123)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	16.0	19.7	20.5	19.8	18.4	16.7	14.8	12.8	
	(7)	(100)	(151)	(150)	(149)	No Survey[5]	(107)	(167)	
ANC PC[2] = 2 sites in 2006	5.0	4.9	4.7	4.4	4.0	3.7	3.2	2.8	1.6
ANC RD[3] = 3 sites in 2006	4.5	4.4	4.1	3.7	3.3	2.9	2.5	2.1	
Total ANC (PC+RD)	4.7	4.8	4.6	4.3	3.9	3.4	3.0	2.5	1.6
	(38)	(82)	(252)[4]	(100)	(159)	No Survey[5]	(211)	(134)	(249)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 13. Kratie: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Kratie	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	30.6		27.5	29.5	33.0		24.2	11.1	9.1
	(77)		(100)	(102)	(81)		(90)	(81)	(44)
Age <20 years			27.5	21.8	38.4		3.2	-	0.0
Age ≥ 20 years			27.5	30.5	30.9		27.4	13.0	10.5
Indirect female sex workers			9.7	21.9	16.9		13.1	1.6	
			(56)	(35)	(57)		(45)	(61)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.2	2.1	2.0	1.8	1.7	1.5	1.4	1.2	
	(108)	No Survey[5]	(137)	(303)	(300)	No Survey[5]	(300)	(301)	
ANC PC[2] = 2 sites in 2006	1.3	1.3	1.3	1.2	1.1	0.9	0.8	0.7	1.0
ANC RD[3] = 3 sites in 2006	0.9	0.8	0.8	0.7	0.6	0.6	0.5	0.4	0.0
Total ANC (PC+RD)	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.5
	(350)	(270)	(810)[4]	(200)	(254)	No Survey[5]	(419)	(498)	(593)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 14. Oddar Meanchey: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Oddar Meanchey	HIV prevalence percent, by year (Sample size)							
Sentinel Group	1996	1997	1998	1999	2000	2002	2003	2006
Female sex workers							25.5 (110)	12.6 (119)
Age <20 years							29	4.2
Age ≥ 20 years							31.1	14.7
Indirect female sex workers							21.1 (19)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2002	2003	2006
Policemen							(300)	
ANC PC[2] = 2 sites in 2006								0.0
ANC RD[3] = 3 sites in 2006								0.3
Total ANC (PC+RD)							(471)	0.2 (598)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

Table 15. Pailin: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Pailin	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers				37.1	45.8		29.2	29.0	10.5
				(110)	(124)		(109)	(131)	(76)
Age <20 years				17.1	30.2		20.3	14.3	0.0
Age ≥ 20 years				19.9	40.2		31.2	31.8	12.7
Indirect female sex workers				13.4	9.0		5.2	9.1	
				(69)	(70)		(24)	(44)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.6	4.1	5.4	6.1	6.4	6.3	6.1	5.8	
	No Survey[5]	No Survey[5]	No Survey[5]	(162)	(61)	No Survey[5]	(93)	(121)	
ANC PC[2] = 2 sites in 2006	2.3	3.1	3.4	3.4	3.4	3.3	3.3	3.2	2.3
ANC RD[3] = 3 sites in 2006	1.4	2.4	3.0	3.2	3.1	2.9	2.6	2.3	1.8
Total ANC (PC+RD)	1.8	2.6	3.1	3.3	3.3	3.1	2.9	2.7	2.1
	No Survey[5]	No Survey[5]	No Survey[5]	(181)	(182)	No Survey[5]	(341)	(99)	(470)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 16. Phnom Penh: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Phnom Penh	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	42.0	44.4	59.1	49.8	27.6		19.2	23.8	11.3
	(173)	(162)	(150)	(154)	(152)		(162)	(147)	(142)
Age <20 years			54.3	46.8	29.2		13.9	11.6	3.8
Age ≥ 20 years			60.5	52.0	26.6		20.8	28.8	15.7
Indirect female sex workers			8.1	8.4	10.7		13.5	14.0	
			(100)	(210)	(153)		(145)	(136)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	7.5	7.5	7.2	6.7	6.1	5.5	4.7	4.0	
	(153)	No Survey[5]	(150)	(153)	(166)	No Survey[5]	(169)	(258)	
ANC PC[2] = 2 sites in 2006	3.0	2.9	2.7	2.5	2.3	2.1	1.9	1.7	0.8
	(186)	(248)	(400) [4]	(511)	(600)	No Survey[5]	(696)	(572)	(599)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 17. Preah Vihear: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Preah Vihear	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers		25.0			15.4		29.0	19.6	4.4
		(20)			(46)		(50)	(46)	(63)
Age <20 years					10.9		3.2	-	0.0
Age ≥ 20 years					16.8		32.5	22.5	13.2
Indirect female sex workers					8.3		1.6	10.3	
					(39)		(17)	(29)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	1.6	1.8	1.8	1.7	1.6	1.5	1.4	1.2	
	No Survey[5]	101	No Survey[5]	No Survey[5]	(277)	No Survey[5]	(227)	(300)	
ANC PC[2] = 2 sites in 2006									0.4
ANC RD[3] = 4 sites in 2006									0.8
Total ANC (PC+RD)	0.1	0.2	0.4	0.7	0.9	1.1	1.1	1.1	0.6
	No Survey[5]	183	No Survey[5]	No Survey[5]	296	No Survey[5]	432	(568)	(539)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 18. Prey Veng: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Prey Veng	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	31.6		31.3	17.0	19.4		18.0	13.8	11.1
	(91)		(150)	(150)	(149)		(151)	(130)	(135)
Age <20 years			42.7	14.5	3.1		21.1	5.6	0.0
Age ≥ 20 years			27.1	17.5	21.5		16.5	15.2	5.9
Indirect female sex workers			31.1	28.5	11.5		12.4	9.5	
			(100)	(100)	(149)		(32)	(63)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	3.5	3.6	3.5	3.2	3.0	2.7	2.4	2.0	
	(133)	No Survey[5]	(150)	(150)	(150)	No Survey[5]	(157)	(286)	
ANC PC[2] = 2 sites in 2006	1.9	2.4	2.5	2.5	2.4	2.4	2.3	2.3	0.7
ANC RD[3] = 3 sites in 2006	1.4	1.6	1.7	1.6	1.6	1.5	1.5	1.4	0.9
Total ANC (PC+RD)	1.5	2.1	2.3	2.3	2.3	2.1	2.0	1.8	0.8
	(452)	(230)	(400)[4]	(190)	(300)	No Survey[5]	(500)	(582)	(599)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 19. Pursat: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Pursat	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	48.8		61.5	53.6	57.5		57.7	23.4	9.6
	(103)		(131)	(100)	(70)		(71)	(128)	(115)
Age <20 years			56.5	30.7	30.9		46.1	7.4	6.3
Age ≥ 20 years			62.6	57.4	61.8		60.5	27.7	10.1
Indirect female sex workers			26.0	22.4	10.9		13.4	14.8	
			(25)	(17)	(75)		(66)	(27)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	3.2	3.5	3.5	3.3	3.0	2.7	2.3	2.0	
	(58)	(137)	(153)	(299)	(303)	No Survey[5]	(302)	(300)	
ANC PC[2] = 2 sites in 2006	3.3	3.2	3.0	2.7	2.4	2.1	1.8	1.5	1.0
ANC RD[3] = 4 sites in 2006	1.2	1.6	1.8	1.8	1.7	1.5	1.3	1.2	0.5
Total ANC (PC+RD)	2.2	2.4	2.4	2.2	2.0	1.8	1.5	1.3	0.8
	(174)	(279)	(404)[4]	(103)	(400)	No Survey[5]	(500)	(601)	(669)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 20. Ratanak Kiri: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Ratanak Kiri	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	36.2	35.5	24.3	49.4	23.4		14.3	21.6	5.3
	(20)	(38)	(33)	(32)	(23)		(31)	(37)	(57)
Age <20 years			18.2	51.4	18.6		3.2	16.7	9.4
Age ≥ 20 years			25.9	48.5	24.9		18.8	22.6	0.0
Indirect female sex workers			22.0	16.0	27.7		5.9	-	
			(30)	(32)	(40)		(20)	(9)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	0.5	1.1	1.8	2.3	2.5	2.5	2.4	2.2	
	(74)	(111)	No Survey[5]	(98)	(96)	No Survey[5]	(140)	(147)	
ANC PC[2] = 2 sites in 2006	2.5	2.5	2.3	2.2	2.0	1.7	1.5	1.3	0.3
ANC RD[3] = 4 sites in 2006	1.5	1.7	1.6	1.5	1.4	1.2	1.1	0.9	0.0
Total ANC (PC+RD)	2.2	2.2	2.1	1.9	1.7	1.5	1.3	1.1	0.2
	(113)	(201)	(386)[4]	(183)	(310)	No Survey[5]	(399)	(411)	(559)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 21. Siem Reap: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Siem Reap	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	48.4		38.8	24.1	28.6		34.9	24.5	20.4
	(100)		(150)	(150)	(150)		(160)	(151)	(98)
Age <20 years			25.9	17.2	22.5		23.4	6.7	0.0
Age ≥ 20 years			46.1	28.3	32.6		37.9	32.1	21.7
Indirect female sex workers			30.2	22.2	19.0		20.6	18.0	
			(100)	(100)	(150)		(150)	(151)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	8.3	7.7	7.0	6.2	5.3	4.4	3.6	2.9	
	(100)	No Survey[5]	(150)	(150)	(140)	No Survey[5]	(169)	(301)	
ANC PC[2] = 3 sites in 2006	2.8	4.7	5.7	5.9	5.7	5.3	4.8	4.2	0.3
ANC RD[3] = 4 sites in 2006	2.4	2.8	2.9	2.7	2.5	2.2	1.9	1.7	1.0
Total ANC (PC+RD)	2.6	3.7	4.2	4.2	3.9	3.6	3.3	2.9	0.7
	(248)	(204)	(400)[4]	(300)	(300)	No Survey[5]	(500)	(600)	(600)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 22. Sihanoukville: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Sihanoukville	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	50.5		55.6	46.7	23.6		25.9	15.3	22.8
	(99)		(150)	(150)	(150)		(148)	(150)	(149)
Age <20 years			45.9	36.7	12.9		7.9	3.6	0.0
Age ≥ 20 years			60.7	46.9	25.1		28.3	18.0	24.1
Indirect female sex workers			22.6	18.1	10.3		15.8	19.2	
			(100)	(15)	(150)		(152)	(152)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	11.5	10.7	9.7	8.5	7.3	6.2	5.0	4.0	
	(51)	No Survey[5]	(153)	(150)	(155)	No Survey[5]	(150)	(309)	
ANC PC[2] = 2 sites in 2006	2.8	4.0	4.3	4.2	4.1	3.8	3.5	3.2	1.7
ANC RD[3] = 4 sites in 2006	2.2	2.4	2.4	2.3	2.2	2.1	2.1	2.0	1.7
Total ANC (PC+RD)	2.3	3.5	4.0	4.0	3.8	3.5	3.1	2.7	1.7
	(95)	(278)	(400)[4]	(200)	(257)	No Survey[5]	(222)	(347)	(596)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 23. Stung Treng: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Stung Treng	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	20.3	25.5	34.8	34.8	38.5		28.4	24.1	11.5
	(60)	(53)	(51)	(55)	(50)		(65)	(58)	(61)
Age <20 years			54.1	39.6	36.2		9.8	-	0.0
Age ≥ 20 years			30.6	32.2	39.2		32.9	30.4	12.5
Indirect female sex workers			10.7	3.3	27.7		27.5	-	
			(20)	(14)	(20)		(10)	(6)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	0.2	0.4	0.7	1.0	1.2	1.4	1.5	1.6	
	(77)	(113)	(129)	(152)	(216)	No Survey[5]	(192)	(191)	
ANC PC[2] = 1 site in 2006	2.6	2.6	2.6	2.5	2.5	2.4	2.4	2.4	1.2
ANC RD[3] = 4 sites in 2006	0.6	1.0	1.4	1.6	1.6	1.6	1.5	1.4	0.0
Total ANC (PC+RD)	1.6	2.2	2.3	2.3	2.2	2.1	2.0	1.9	0.5
	(264)	(172)	(405) [4]	(163)	(271)	No Survey[5]	(316)	(355)	(368)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 24. Svay Rieng: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Svay Rieng	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	37.3	26.6	27.5	32.4	9.9		33.8	9.1	10.0
	(69)	(88)	(100)	(92)	(56)		(73)	(66)	(60)
Age <20 years			24.8	34.4	10.3		41.8	-	0.0
Age ≥ 20 years			28.8	31.0	9.6		30.7	10.3	10.7
Indirect female sex workers			17.1	14.9	6.1		23.7	15.4	
			(57)	(61)	(58)		(47)	(39)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	0.4	0.6	0.8	1.1	1.4	1.8	2.0	2.2	
	(106)	(140)	(150)	(266)	(300)	No Survey[5]	(300)	(288)	
ANC PC[2] = 3 sites in 2006	4.6	4.3	3.9	3.5	3.0	2.6	2.1	1.7	1.0
ANC RD[3] = 4 sites in 2006	1.1	1.5	1.6	1.6	1.5	1.3	1.2	1.0	0.0
Total ANC (PC+RD)	2.8	2.8	2.6	2.5	2.2	2.0	1.7	1.4	0.5
	(325)	(223)	(400)[4]	(349)	(399)	No Survey[5]	(599)	(580)	(599)

[1] All data adjusted for results of laboratory quality control
[2] PC=Provincial capital
[3] RD=Remaining district
[4] Women at reproductive age, includes pregnant and nonpregnant women
[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

Table 25. Takeo: HIV seroprevalence,[1] by sentinel group and year, 1996-2006

Province Takeo	HIV prevalence percent, by year (Sample size)								
Sentinel Group	1996	1997	1998	1999	2000	2001	2002	2003	2006
Female sex workers	27.2	26.8	41.8	37.6	13.9			29.2	4.2
	(69)	(58)	(99)	(83)	(96)			(126)	(144)
Age <20 years			44.9	30.7	15.7			-	5.4
Age ≥ 20 years			39.7	38.5	12.6			18.3	3.7
Indirect female sex workers			7.8	24.8	18.4			11.9	
			(45)	(53)	(62)			(67)	

Sentinel Group *Data smoothed with EPP*	1996	1997	1998	1999	2000	2001	2002	2003	2006
Policemen	2.2	2.8	3.0	3.0	2.9	2.6	2.4	2.1	
	(128)	No Survey[5]	(122)	(300)	(299)	No Survey[5]	No Survey[5]	(251)	
ANC PC[2] = 2 sites in 2006	1.3	1.5	1.5	1.5	1.4	1.4	1.3	1.3	1.4
ANC RD[3] = 4 sites in 2006	0.4	0.7	1.0	1.2	1.2	1.2	1.1	1.0	0.0
Total ANC (PC+RD)	0.8	1.2	1.4	1.4	1.3	1.3	1.2	1.1	0.7
	(218)	No Survey[5]	(800)[4]	(300)	(290)	No Survey[5]	No Survey[5]	(558)	(581)

[1] All data adjusted for results of laboratory quality control

[2] PC=Provincial capital

[3] RD=Remaining district

[4] Women at reproductive age, includes pregnant and nonpregnant women

[5] Group not surveyed, prevalence estimate obtained by modeling with EPP

APPENDIX IV

TECHNICAL NOTES

APPENDIX IV

HIV Incidence Calculations

The Calypte® HIV-1 BED Incidence EIA may be used to estimate HIV-1 incidence in cross-sectional serosurveys including sentinel surveys among ANC attendees or other populations. However, the data must be adjusted to account for the misclassification by the BED-CEIA of infections as recent (false recent) among those individuals with long-term infection. WHO guidelines advise use of two adjustment formulae (McDougal et al. method and Hargrove et al. method). The two sets of adjustments are expected to give similar results in most settings. Both formulae were used to develop separate incidence measures and cross-check results for consistency. Detailed information about HIV incidence calculations is presented and Appendix IV.

HIV incidence was calculated as the number of recent seroconversions divided by the population at risk (those testing HIV-negative plus those who recently seroconverted) then annualized by multiplying by 365 divided by the estimated length of mean seroconversion duration for the BED-CEIA (or 155 days; 95% CI 146 – 165 days). The total number of people tested, number seronegative, number seropositive and number recently infected must be known for calculating incidence in a given cross-sectional population.

Minor variations of the formula for calculating incidence have been used in earlier studies. Recently, a formula was agreed upon at CDC for calculating incidence. Annual HIV-1 incidence (I_{ann}) was calculated using the following consensus formula:

$$I_{ann} = \frac{(365/w)\, N_{inc}}{N_{neg}\, N + (365/w)\, (N_{inc}/2)} X\ 100$$

where w = window period (155 days), N_{inc} = total number of recent HIV infections identified by in the BED Incidence EIA, N_{neg} = total number of HIV seronegative specimens.

The following adjustments to account for imperfect sensitivity and specificity of the assay (potential falsely identified recent infections) were applied to the incidence estimates as recommended by WHO and CDC.

Sensitivity/Specificity Adjustment (McDougal et al):

1. Calculate the Correction Factor, F

$$F = \frac{(N_{inc}/P) + \gamma - 1}{(N_{inc}/P)(\alpha - \beta + 2\gamma - 1)}$$

2. Multiply N_{inc} in the incidence formula by F:

$$I = \frac{(F)(365/w)\, N_{inc}}{N + (F)(365/w)(N_{inc}/2)} x\ 100$$

Specificity Adjustment (Hargrove et al):

1. Enter data into the following:

$$I = \frac{N_{inc} - \varepsilon P}{(N_{inc}/2) + N_{neg}(w/365) - \varepsilon N_{neg} - \varepsilon(P/2)} x\ 100$$

Symbols for Variables:

Values are calculated:

I = Incidence (number of new infections per year per 100 persons at risk)

F = Adjustment factor for sensitivity/specificity adjustment

Values are measured in a cross sectional survey:

T = total people in the survey

P = total testing HIV positive

N_{inc} = total testing "recent"

N = total testing HIV negative

R = total testing recent in the BED-CEIA

Values are imputed from independent calibration studies:

w = window in days (maximum duration of seropositivity in those testing recent)

α = sensitivity of BED test for detecting recent (< w) infection

β = specificity of the BED test over the period > w to < 2w

γ = specificity of the BED test over the period > 2 w

ε = false recent rate in those with long term (> 2 w) infection

NOTE: $\varepsilon = (1 - \gamma)$ and $\gamma = (1 - \varepsilon)$

Notes

Notes