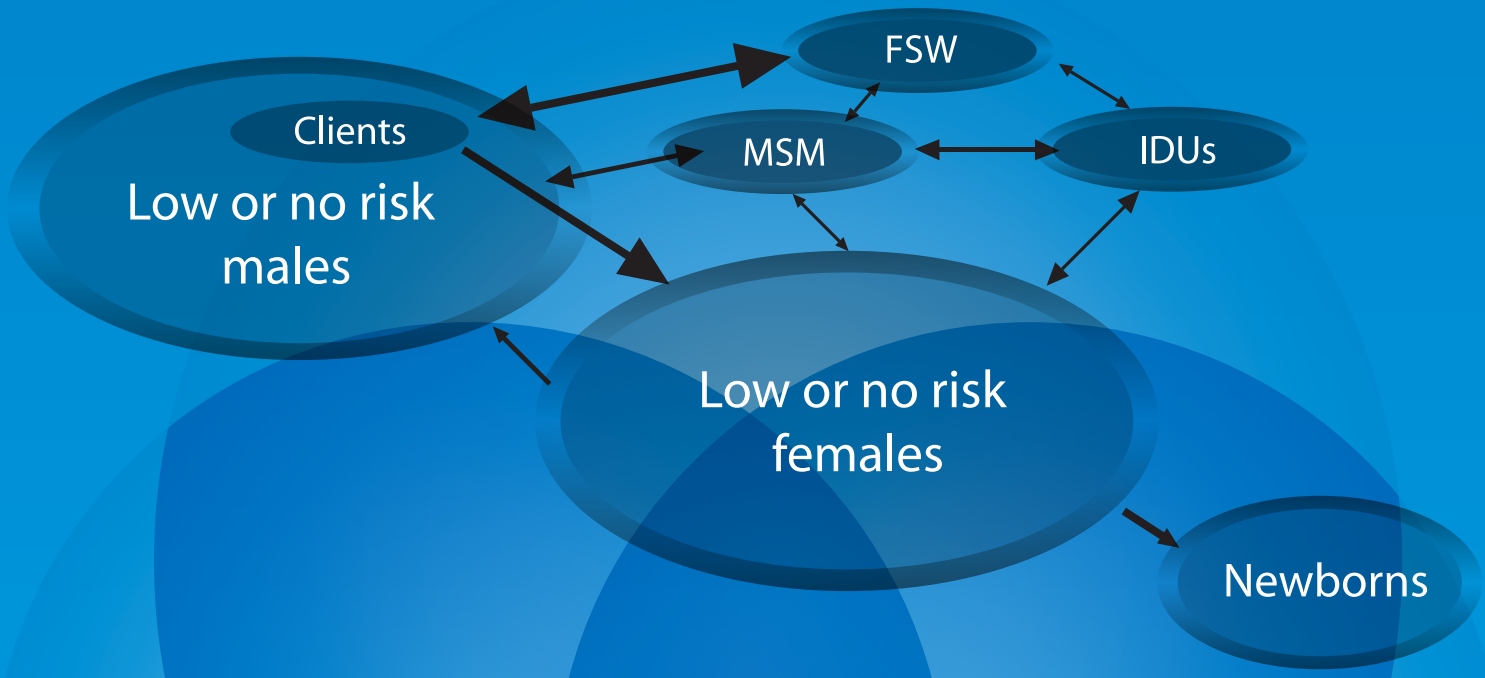
The Asian Epidemic Model for Dhaka City 2006
Technical Report



Dhaka
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Technical Report

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A^2 (Analysis and Advocacy) Project
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List of Acronyms

A²□	Analysis and Advocacy
AEM□	Asian Epidemic Model
AIDS□	Acquired Immune Deficiency Syndrome
BAP□	Bangladesh AIDS Program
BBS□	Bangladesh Bureau of Statistics
BBSW□	Brothel-based female sex workers
BSS□	Behavioral Surveillance Survey
DFID□	Department for International Development (now defunct ODA)
DGHS□	Directorate General of Health Services
FHI□	Family Health International
FSW□	Female Sex Workers
GFATM□	Global Fund to Fight AIDS, Tuberculosis and Malaria
GO/GOB□	Government of Bangladesh
HAPP□	HIV/AIDS Prevention Project
HBSW□	Hotel-based female sex workers
HIV□	Human Immunodeficiency Virus
HSS□	HIV Sentinel Surveillance
ICDDR,B□	International Center for Diarrhoeal Disease Research, Bangladesh
IDU□	Injection Drug Users
IMPACT□	Implementing AIDS Prevention and Care Project
MAP□	Monitoring the AIDS Pandemic Network
MOHFW□	Ministry of Health and Family Welfare
MSM□	Men who have Sex with Men
MSW□	Male Sex Workers
NAC□	National AIDS Committee
NASP□	National AIDS and STD Programme
NGO(s)□	Non-Government Organization(s)
PLHA□	People Living With HIV/AIDS
RTI□	Reproductive Tract Infection
SBSW□	Street-based female sex workers
STI/STD□	Sexually Transmitted Infection/Disease
SW□	Sex Worker
TC-NAC□	Technical Committee-National AIDS Committee
UN□	United Nations
UNAIDS□	Joint United Nations Programme on HIV/AIDS
UNICEF□	United Nations Children's Fund
USAID□	United States Agency for International Development

1. The Status of HIV Vulnerability and Response in Bangladesh

HIV prevalence has remained at a very low level in Bangladesh. There have been only 874 HIV and AIDS cases detected in the country [1], and UNAIDS estimated about 11,000 adult infections in 2005 [2]. But surveillance and other epidemiological data indicate that the situation may be changing. Trends in reported cases have been steadily increasing over the last few years, and there is now a concentrated HIV epidemic among injection drug users (IDU) in a locality in Central Bangladesh [3].

Seven rounds of serological surveillance since 1998 have generally found extremely low HIV levels (less than 1 percent) in female, male, and transgender sex workers, men who have sex with men, and occupational groups of men that may be more vulnerable to HIV [4-9]. The significant increase in HIV infections among IDU was found in 2004-2005 in the sixth round of national HIV Serological Surveillance (HSS), when 4.9 percent of all the injectors surveyed in Central City-A tested positive [9]. This trend continued in the seventh round of national serological surveillance (2005-2006) so that 7.0 percent of all the injectors surveyed tested positive [10].

There are also indications that HIV is spreading to other areas and sub-populations. In the sixth round of surveillance HIV was detected for the first time among IDU in other cities, Southeast D and Northwest F1, and by the seventh round was at more than 1% at these two surveillance sites, as well as in Central E (1.1%, 1.8%, and 1% HIV respectively). Although HIV infection among female sex workers has generally been less than 1% in surveillance, in two rounds of surveillance the second highest HIV infection rates were recorded among casual female sex workers sampled in Northwest K1 (2% in 2003-2004, and 1.7% in 2004-2005), albeit small numbers were sampled. Among hotel-based sex workers as well, a prevalence of 1.5% HIV was found in Southeast A in the 2003-2004 surveillance.

Despite the low prevalence of HIV, national Behavioral Surveillance Survey (BSS) has reported some of the highest risk levels in Asia [11, 12]. Female sex workers (FSW) in Central-A hotels consistently report working 4 nights a week with 7 to 10 clients a night [7, 13, 14]. This is much higher than the 3 to 5 clients per night that were typically reported by brothel-based workers in Thailand at the height of its epidemic [15, 16]. Injection drug users report that they share needles about three-quarters of the time [7, 14, 17]. Essentially all the men who have sex with men surveyed report having anal sex, and around 90 percent report having sex with male sex workers [7, 14]. Condom use in all these groups has remained at less than 40% over the years of surveillance, and consistent condom use is typically in the 3-10% range [18].

Although there was no indication of extensive HIV infection in the country, Bangladesh took steps early to initiate a national response. A National Policy on HIV/AIDS was developed and approved in 1997. A National AIDS Committee (NAC) was formed to act as the premier advisory body on HIV and AIDS to the Directorate General of Health Services, Ministry of Health and Family Welfare (MOHFW). The MOHFW oversees the National AIDS/STD Programme (NASP) that is involved in implementation of government programs to achieve the national objectives for HIV and AIDS prevention [19]. In 2004 a 5-year National Strategic Plan was developed with the involvement of key stakeholders and technical input from NASP and UNAIDS, which was adopted by the NAC [20]. This plan recognizes that prevention of HIV/AIDS is a larger development issue that is linked to cultural, social and economic factors that demand a wide and accelerated response. There is an emphasis on care and support services, and the need for good quality monitoring and evaluation. It also seeks to fulfill the country's commitments under UNGASS and the Millennium Development Goals. An Operational Plan to fulfill the recommendations of the National Strategic Plan was prepared in 2006 by the NASP in consultation with key partners.

HIV prevention in the country has been well funded by various international donor agencies. Since 2001 the major source of funding to the MOHFW has been through a joint grant from the World Bank and the United Kingdom's Department for International Development (DFID) to support the national HIV/AIDS Prevention Project (HAPP), which has now been extended until December 2007. The other major internationally-funded interventions in the country are the Global Fund to fight AIDS, Tuberculosis and Malaria (GFATM) 2nd round and 6th round funded projects.

Generally, the well-established network of non-government organizations (NGOs) in Bangladesh carries out the various HIV prevention interventions in the field, with funding support from the government or directly from international donors. The main activities for at-risk groups include condom promotion, harm reduction and demand reduction services for IDU, STI management, behavior change communication, voluntary counseling and testing, and medical and counseling support to PLHA [18]. Drug substitution is not yet available as various policy barriers have to be addressed first.

HIV interventions are in place at strategic geographic locations, with the major metropolitan centers of Dhaka, Chittagong, Sylhet, Rajshahi, and Khulna covered, as well as other locations with high concentrations of particular risk groups [18]. Comparison of the behavior of those in interventions with those who are not has shown that interventions can make a difference in the level of risk behaviors such as needle-sharing, condom use and STI-treatment-seeking, however, the effects are not seen consistently in all intervened groups. Sizeable proportions of the respondents in behavioural surveillance reported that while they received useful information through exposure to interventions, it did not lead to behaviour change. [7]

The problem in Bangladesh appears to be in attaining wide-scale geographical coverage of at-risk groups in sufficient numbers and of a high enough quality and intensity to make an impact. The quality of interventions is variable, and capacity building is still required in some areas. Preliminary coverage analyses show that while high proportions of particular risk groups are in contact with HIV prevention endeavours, other groups lag behind, such as male clients of female sex workers [18]. The extent and intensity of the contact with those who are enrolled in interventions program is unclear. Forces that hinder HIV prevention objectives have to be countered as well, such as violence and interference by law enforcement, and discrimination against certain groups, and HIV-positive people.

Considering the HIV situation and the risk indicators in Bangladesh, experts have been predicting for the last few years that the epidemic spread of HIV is imminent. One way to explore what the impact of HIV is likely to be is through the use of computer modeling packages that make projections of the number of HIV infections and AIDS cases to be expected. The A^2 (Analysis and Advocacy) Project in Bangladesh, supported by Family Health International (FHI) Bangladesh, has applied the ***Asian Epidemic Model (AEM)*** developed by Tim Brown and Wiwat Peerapatanapokin at East-West Center [21] to assess the likely pattern of HIV spread in the country based on the current risk indicators and HIV prevalence. ***The results for Dhaka City indicate a significant epidemic can be expected if prevention measures remain as they are at present and behavioral risk does not improve appreciably.***

This report summarizes the technical details of the AEM, the process used to extract country-specific indicators for the model, the final inputs used, with sources and literature references, and the projection results of the AEM Dhaka Baseline Scenario.

2. The A^2 Project in Bangladesh

The modeling work described in this report is an outcome of the A^2 (Analysis and Advocacy) Project in Bangladesh, which is a joint regional project of Family Health International (Bangladesh Country Office and the Asia Regional Program Office), East-West Center, and USAID/Health Policy Initiative Task Order 1 (Constella Futures). A^2 came out of the realization that although the countries of Asia have collected a wealth of data on HIV and AIDS over the years, critical analysis of this data has been lacking. As a result, responses in the region are directed in an ad hoc fashion without a clear understanding of where new infections are occurring, the effectiveness and targeting specificity of current prevention and care approaches, or the long term impact of different prevention and care program alternatives. The aim of A^2 is to bridge this gap between knowledge and action and to improve responses by building national capacity to pool existing local epidemiological, behavioral and response data, analyze it with state-of-the-art modeling tools, and determine where responses should be targeted to have the maximal impact and what resources are needed to make a difference. Locally relevant, targeted messages are then produced to move policy makers, program managers, and donors to make the right choices. [22]

A^2 is currently underway in 4 Asian countries: Bangladesh, China (Yunnan and Guangxi Provinces), Thailand, and Vietnam. Bangladesh was one of the first countries to initiate A^2. The project work began in October 2003 with funding support from the FHI Bangladesh IMPACT project, and continued after 2006 with funds from the FHI Bangladesh AIDS Program (BAP).

For the A^2 process (described in more detail in the next section) generally an in-country Data Synthesis Specialist supported by a local advisory Technical Working Group gathers the data available in-country, and with technical assistance from the project regional support team (from EWC, FHI, and USAID/Health Policy Initiative) critically analyzes this data to identify trends, patterns, and data gaps, synthesizes country information into a clear picture of the local situation, and then develops models to explore the future implications and impact of intervention alternatives.

In Bangladesh in order to generate interest in A^2 and build a local technical expert group to involve in the process, the strategy used was to identify an issue around which data analysis and consensus could be built among important stakeholders. At the time, UNAIDS had called upon countries to produce their own estimates of the number of people infected with HIV for the annual UNAIDS global epidemic update. The Government of Bangladesh (GOB) requested FHI to provide lead technical assistance. An essential first step for this was to make estimates of the sizes of the key vulnerable groups. Accordingly, size estimation was chosen as being the A^2 analysis issue that was of importance to all the major government, donor, NGO, and research partners, and one whereby a collaborative effort could demonstrably benefit everyone involved in HIV-related work. The government had its commitment to UNAIDS to fulfill, the donors and NGOs needed sizes for policy, planning, and programming decisions, and researchers and A^2 wanted them for HIV projections.

The collection of size-related data on each of the at-risk groups in the country was done through a series of Focus Group Discussions held at FHI in September-October 2003, where the participants were program managers and monitoring officers from the main HIV-prevention organizations, technical experts, NASP representatives, and members of the groups. The analysis and synthesis of the size estimation data was started informally by a "Size Estimation Task Force" formed of technical experts from donor, research and non-government organizations, with the technical input provided by the FHI A^2 Data Synthesis Specialist.

The progress of the informal estimates group was presented to the Surveillance Advisory Committee in February 2004, which recommended that a presentation be made to the Technical Committee of the National AIDS Committee (TC-NAC). On the basis of the presentation, TC-NAC decided that size estimation and estimating HIV infections ought to be conducted directly under the aegis of the government as the activity of a formal sub-committee of TC-NAC, with the NASP as the focal point and chair of the sub-committee. On 22 March 2004 the first

meeting of the "Working Group on Size Estimation of HIV/AIDS Infection in Bangladesh" was held (referred to here as the 'Technical Working Group'). The core membership included experts from NASP, ICDDRB, FHI, UNICEF, WHO and UNAIDS, and other experts were consulted when required. As before, the A^2 Data Synthesis Specialist did the actual analytic work. The estimates of vulnerable group sizes and HIV-infected people were finalized by the sub-committee at a meeting held on 31 October 2004.

The involvement of the NASP through the entire size estimation process was important in securing government legitimacy and fast-track approval. The final estimates were presented by the Working Group to the TC-NAC at a meeting on 28 November 2004, which was attended by the Additional Health Secretary on behalf of the Ministry of Health and Family Welfare. Based on the recommendation of the TC-NAC, the average estimated number of HIV-infected people in the country was accepted by the Ministry, leading to an announcement by the Hon. Health Minister on World AIDS Day 2004. The final endorsement of the estimates by the GOB was obtained in December 2005.

Originally it was envisioned that the TC-NAC sub-committee would be involved in the next phase of the A^2 process, i.e., the development of projections of the spread of HIV using the Asian Epidemic Model. However, since the size and HIV estimates were still under a process of consideration for approval by the GOB, this was not possible. Hence the A^2 Synthesis Specialist at FHI proceeded to this next phase through informal collaborative linkages with key experts rather than as an official government process. An important partner in this phase of work was the ICDDR,B Center for Population and Health, HIV/AIDS Program, which is the implementing partner of the GOB for the national HIV Serological Surveillance (HSS), and implemented the national Behavioral Surveillance Survey (BSS) until 2004.

The extraction of inputs for the AEM by collecting, analyzing and synthesizing all the available HIV-related data in Bangladesh took about a year starting from around April 2004. The first AEM Baseline Scenario for Dhaka City Corporation along with some key Intervention Scenarios were completed by the FHI Bangladesh Synthesis Specialist in collaboration with Tim Brown in April 2005. The modeling results were presented by Dr. Brown to the NASP, the TC-NAC Technical Working Group, and other key partners and NGOs in Bangladesh in October. This was followed by a period of obtaining feedback and consultations on inputs with experts, so that a revised Baseline was produced in February 2006. This has subsequently been updated several times with new data and using the latest versions of the AEM.

For the A^2 project the AEM has been linked with the Futures Group GOALS model that can project HIV intervention expenses based on coverage and cost input data [23]. The new AEM-GOALS linked modeling tool enables a more comprehensive analysis from the epidemiological, behavioral, and response data, extending from HIV projections to the likely levels of behavior change achievable by programs, and the cost impacts [22]. The overall modeling results can provide policy makers with a evidence base on which to develop practical and cost-effective HIV/AIDS interventions, and care response plans.

The A^2 project in Bangladesh has now moved on to the next phase of using the linked AEM-GOALS model, and is in the process of collecting the cost and coverage inputs. With the linked GOALS and AEM tool the resource needs to implement the national intervention strategy, or particular program strategies can be explored, as well as their effect on behaviors and new infections. The modeling work will be accompanied by the creation of a local Advocacy and Data Use Group that can make use of the analysis and models to strengthen and advocate an improved cost-effective response.

3. Introduction to the Asian Epidemic Model

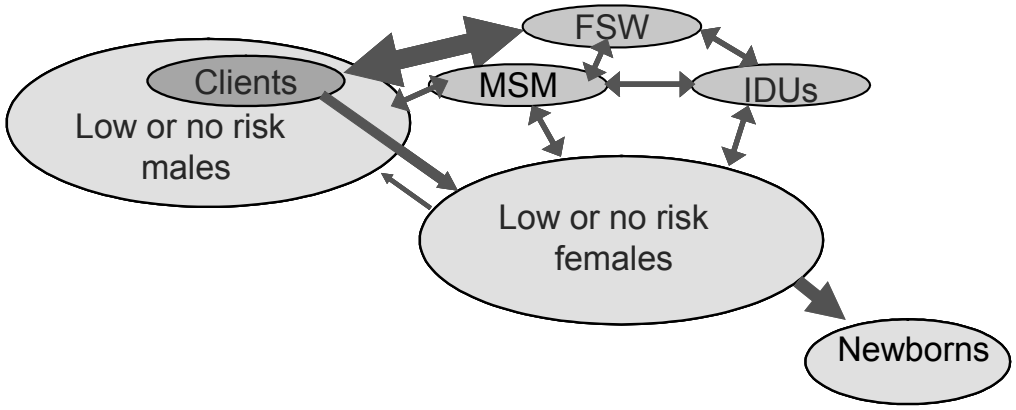
This section provides a brief description of the Asian Epidemic Model used to prepare these projections. A full detailed description is available in Brown and Peerapatanapokin, 2004 [21].

The AEM is a mathematical process model intended specifically for application in Asia as it replicates the dominant patterns of HIV transmission in the region. With accurate data inputs the AEM can tell us the past history of the epidemic, impacts of past and future behaviors on HIV prevalence, and make long term projections if future behaviors can be estimated.

3.1. The basis of calculations in the AEM

The AEM is constructed upon the observation that the primary driving forces for HIV epidemics in Asian countries are sex work and the sharing of needles by injection drug users [24, 25]. Behavioral risk for HIV infection tends to be concentrated in certain populations such as injection drug users (IDU), female sex workers (FSW) and their clients, and men who have sex with men (MSM), which includes male sex workers (MSW) (**Figure 1**). These populations play an important role in fuelling the epidemic, and then HIV is transmitted from them to lower risk populations such as their non-commercial female sexual partners, including spouses, and ultimately to their children.

Figure 1: Behavioral risk for HIV in Asia is concentrated in certain sub-populations

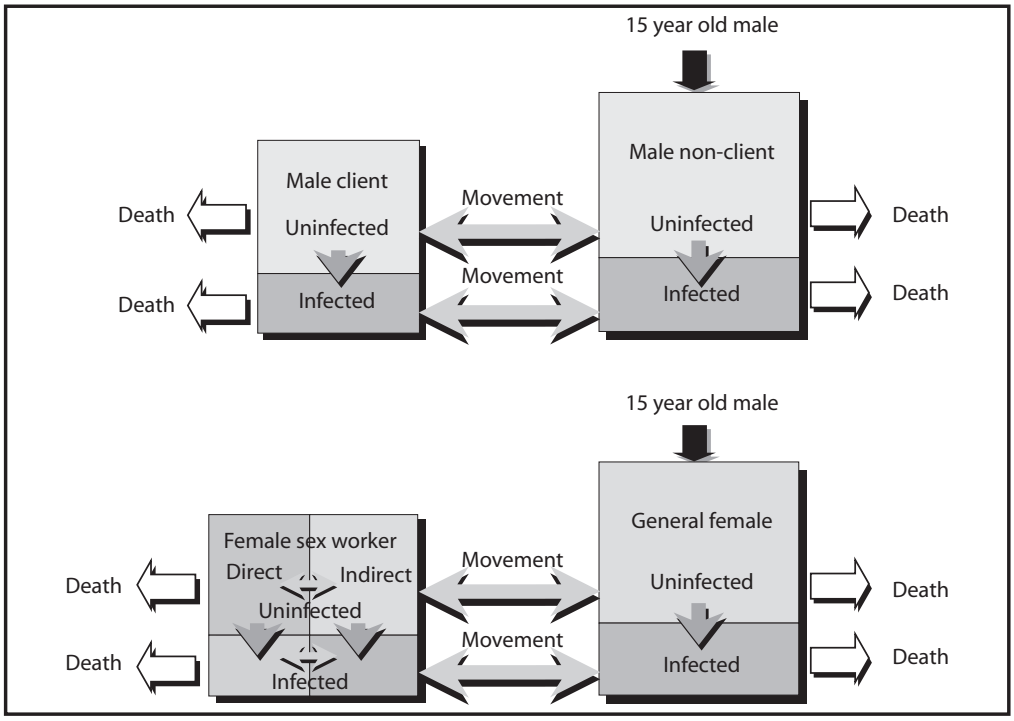


To make a projection of the spread of HIV, the whole adult population (aged 15 years and over) considered in the AEM is divided into the following compartments:

- Males who are clients of sex workers
- Males who are not clients of sex workers
- FSW with a higher frequency of client contacts
- FSW with a lower frequency of client contacts
- Lower risk females (general population females)
- Male IDU in higher risk networks who share needles often
- Male IDU in lower risk networks who do not share often
- Higher frequency FSW who inject drugs
- Lower frequency FSW who inject drugs
- MSM who are not sex workers.
- MSW

Each compartmented sub-population is further divided into those infected with HIV and those who are not, as shown in **Figures 2 to 4.**

Figure 2: Structure of the heterosexual component of the AEM



Brown and Peerapatanapokin

People enter a particular population compartment at age 15, where they can remain or they move because of their behavior into other compartments or by becoming infected with HIV, and they leave the model at death. This population movement mimics the real world situation where for example, women may enter sex work for several years, but then go back to a lower risk life, or males may be clients as youth but then stop visiting sex workers after marriage. **Figure 3** shows the dynamic movement process for men among different risk sub-populations over time.

Figure 3: Movement of male clients among different risk sub-populations in the AEM

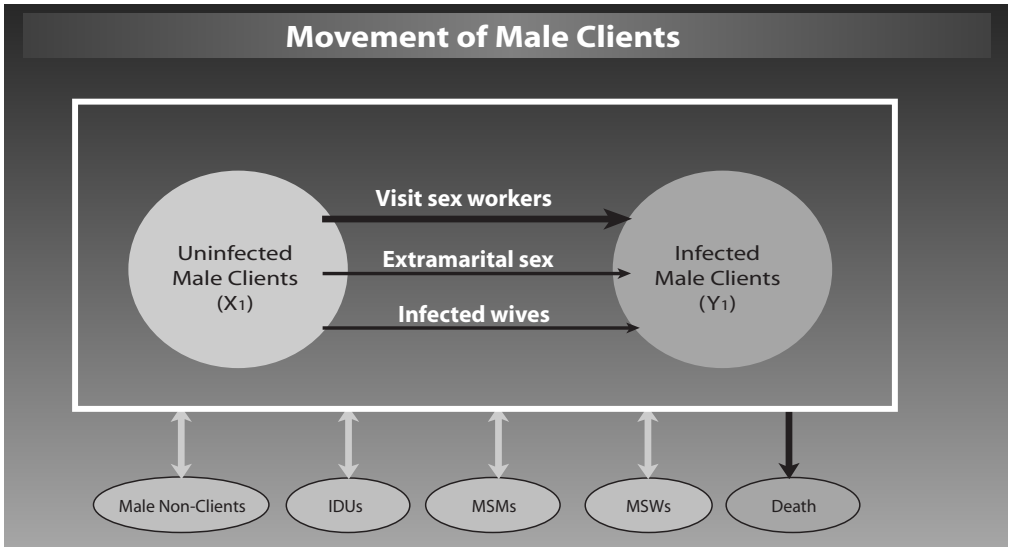


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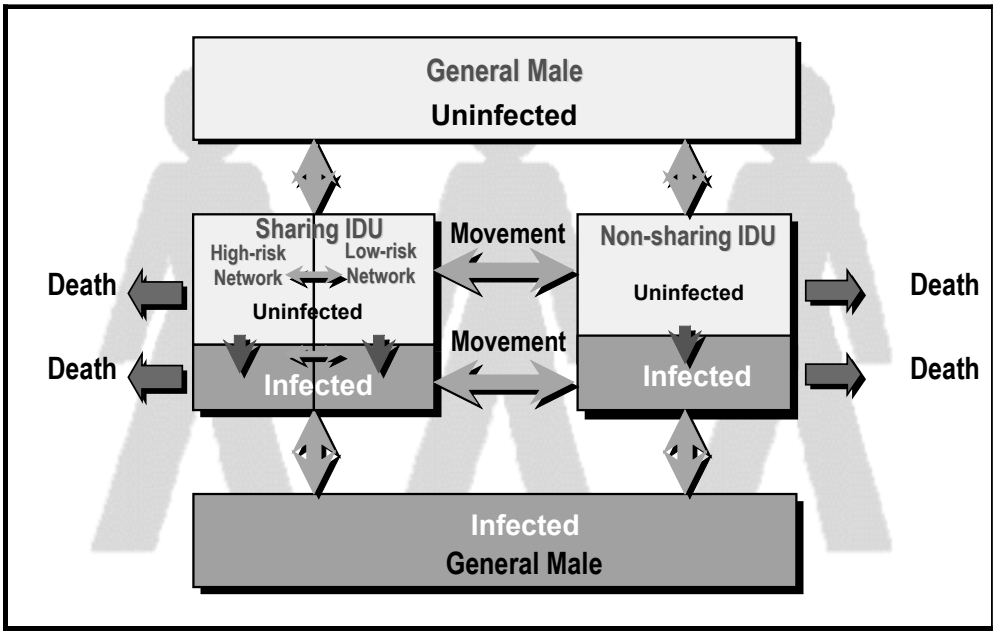
Figure 4: Structure of the injection drug use component of the AEM



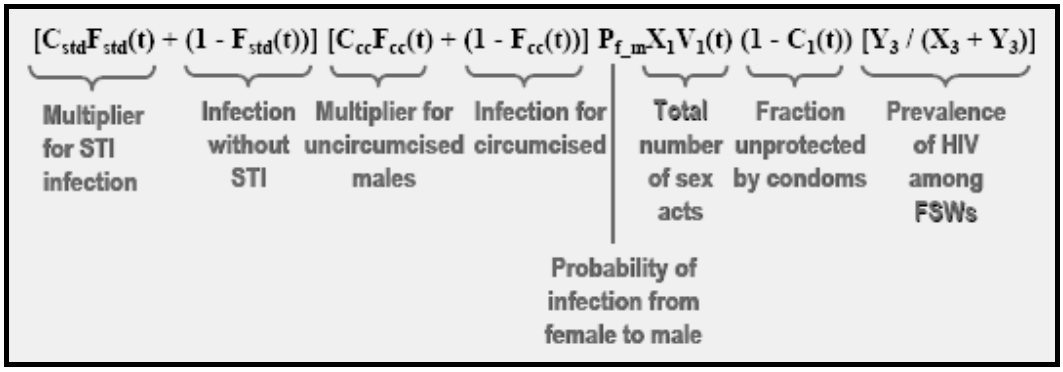
Brown and Peerapatanapokin

The numbers of infected and uninfected people in each sub-population are calculated by the model using standard epidemiological equations for the spread of HIV by heterosexual transmission and transmission through needle sharing, given inputs on HIV prevalence in the different sub-populations, and the frequency of unprotected sexual or sharing acts. The transmission frequencies can be set at country or region specific values. Factors that increase or decrease the risk of HIV infection like sexually transmitted infections (STIs) and the proportion of circumcised males are entered separately as cofactors as well.

Figures 5 and 6 illustrate the calculations for sexual transmission among clients and through needle-sharing by IDU. In the formula shown in **Figure 5** the important factors influencing the sexual transmission of HIV are:

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

Figure 5: Example of calculation of number of new infections among clients



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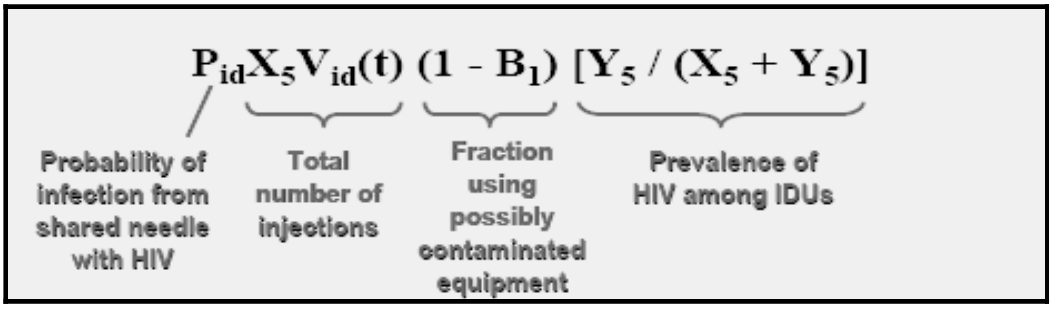
In **Figure 6** the most significant factors influencing the epidemic among the IDU who do share needles often are:

- Frequency of injection
- Prevalence of HIV among other IDU
- Use of new (clean) needles (protective measure)
- Probability of HIV transmission through using infected shared needles

Figure 6: Example of calculation of number of new infections among drug users who share needles often



Brown and Peerapatanapokin

3.2. Data Needs

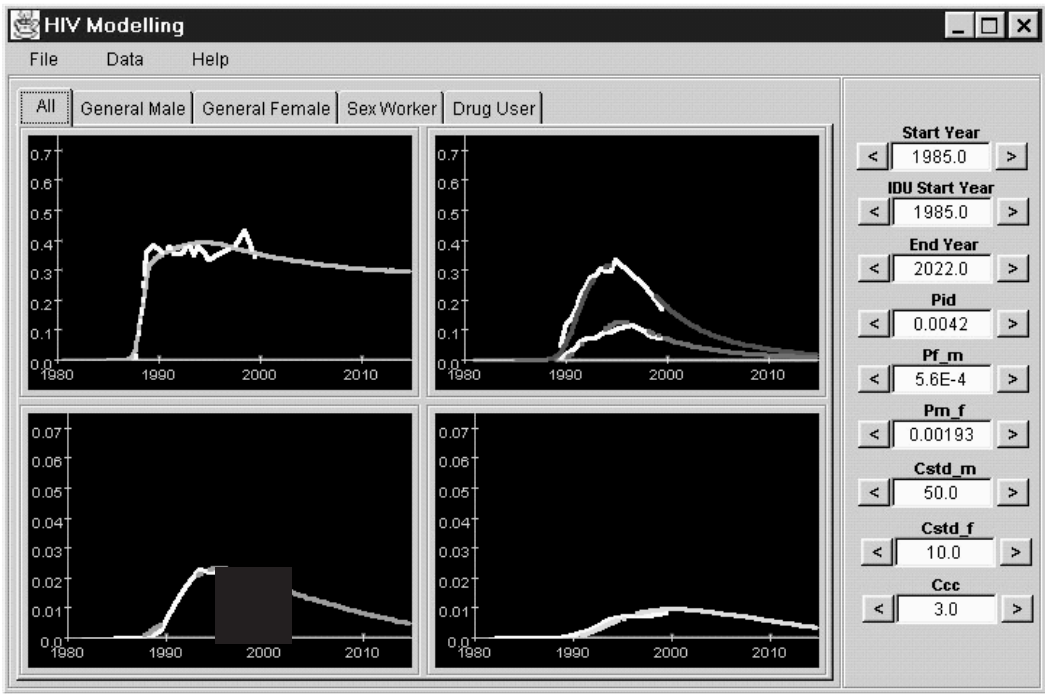
The AEM inputs are entered in an Excel workbook user interface on a yearly basis starting from 1980. They mainly include the following three types of data on each of the key risk populations considered, i.e., IDU, FSW and Clients, MSM and MSW, and low risk men and women:

1. Population sizes and demographic details
2. Epidemiological and biological information, including STI prevalence
3. Risk behavior indicators such as condom use, needle sharing, etc., and also the duration and frequency of risk behaviors.

3.3. The AEM Fitting Process

The AEM is a semi-empirical model. Inputs are read from the user interface workbook to the calculation engine and a projection is made of the number of HIV-infections in each of the sub-populations in the model based on the data inputs and the equations described above. The projected prevalence curves for each population are shown in the "AEM Comparison Screen". The predicted curves are then "fit" (**Figure 7**), i.e., adjusted to match, the actual HIV prevalence overtime (inputs to the model) by adjusting the transmission frequencies and cofactors until the two curves for each population are comparable.

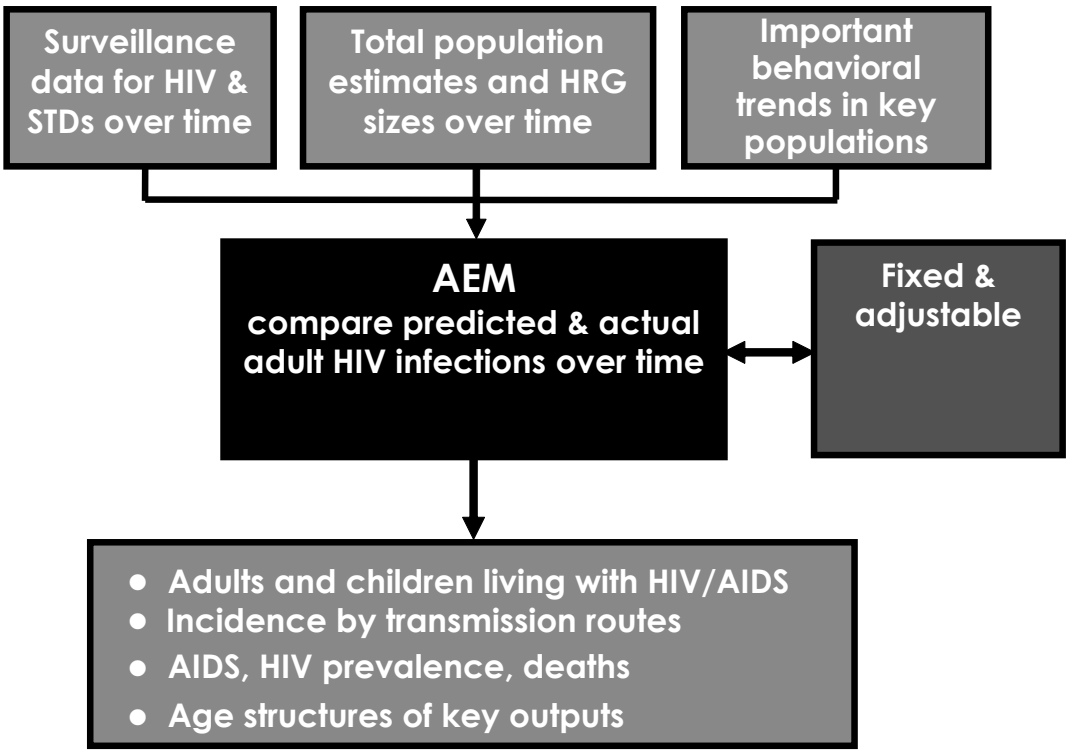
Figure 7: The AEM Comparison Screen used to modulate the predicted HIV curves (colored lines) to match the observed trends (white lines) by adjusting the transmission frequencies and co-factors on the right side of the screen



Brown and Peerapatanapokin

Figure 8 shows the overview of the internal estimation and projection process in the AEM.

Figure 8: Overview of Estimation and Projection Process in AEM



Brown and Peerapatanapokin

3.4. Outputs

The major outputs of the AEM include HIV prevalence, new and cumulative HIV infections, AIDS cases, and deaths. Outputs are read back into the AEM user workbook, and can be read off a Results Summary sheet. Any of the output variables may be extracted for the population as a whole by age, or by at-risk population. HIV infections, AIDS cases and deaths among children are calculated based on fertility levels and infections among females.

3.5. Limitations of the AEM

Although the AEM provides a dynamic and realistic picture of an epidemic based on work done in Thailand and Cambodia [16, 26], the more complex set of inputs required compared with the UNAIDS workbooks or EPP also limits its being applied everywhere. Many countries lack sufficient data at present to apply the model. In low prevalence countries, the AEM has limited applications, as there is no prevalence basis on which to set the transmission parameters. Caution must also be exercised because the AEM internal model may not fully account for transmission in all settings. For example, if a major mode of transmission is not included such as through contaminated blood, the resulting projections may be wrong. Thus, it is essential that users understand what is driving their local epidemic and make certain that the key local modes of transmission are already included in the AEM.

The closing words of caution provided by the developers of AEM are: "Finally, models are only as good as their inputs. Ö So, unless the user takes great caution in evaluating the quality and validity of epidemiological and behavior inputs to the AEM, a "garbage in - garbage out" situation will ensue". (Brown and Peerapatanapokin 2004)

4. The A^2 Method of Data Extraction and Synthesis

HIV epidemics are complex, often consisting of sub-epidemics in different populations and geographical areas. The mix of sub-epidemics and the contextual factors affecting HIV risk and vulnerability vary greatly from country to country, and even among regions within countries. Therefore, developing the AEM for a country normally requires careful analysis and synthesis of existing information and a solid understanding of the epidemic dynamics. This means that in order to obtain a reliable projection outcome from AEM a phase of intense data analysis and synthesis is necessary, a process referred to as "integrated analysis".

The overall goal of integrated analysis in a given country, province or state is to develop a clear picture of where the epidemic has been, which populations are contributing to it and in what proportion, the geographic patterns, and the determinants of new infections in the various at-risk populations. In short, we need to know how the epidemic in a country started, and where it is now, and what impact will the country responses have on behaviors into the future. This process of first understanding the country's epidemic ensures the quality and local relevance of any models and analyses produced subsequently, and validates the fact that the outcomes reflect local realities. Having AEM projections supported by other in-country data allows the results to be more persuasive when being translated into effective programs and policies.

The integrated analysis process prior to applying the AEM has five essential steps that if done properly can take from 3 months up to a year per country. These are:

1. Collection of as much biological, behavioral, and response information (data and reports) possible.
2. Careful review of the resulting information with a view to assembling the best available data that characterizes the epidemic in a country, and weaning out information of poor or questionable quality.
3. Synthesis and triangulation of the information collected in order to extract trends in the key biological and behavioral inputs required for the AEM over the duration of the epidemic.
4. Identification of gaps in knowledge/data, weaknesses in data/surveillance systems and strategic planning to address them through additional data collection and or rapid assessments and field work.
5. Analysis of the past and current response for its impact on risk behaviors in the present and in the future.

Thus, as a first step in preparing the AEM projections for Bangladesh an HIV-related literature collection was built up, which now contains around 500 journal articles, reports, and news articles extending from the 1980's through 2006. This was done through a search of the online databases such as Pubmed, Medline, and NLM Gateway, and also by gathering all the NGO, government and international agency program and situation assessments, baseline surveys, and surveillance and other ad hoc surveys' research reports (UNAIDS, UN agencies, USAID, DFID, WHO, etc.) that were available in-country, including unpublished grey literature.

Key inputs that influence the estimation of HIV and AIDS burden in the AEM are the magnitude and the trends in behavioral risk associated with the transmission of HIV. These include the levels of risk resulting from the behaviors of injection drug users, and those resulting from the frequency of unprotected sex in a country. These inputs were determined by the A^2 Data Synthesis Specialist after going through the laborious process outlined above to review, synthesize and validate the HIV-related information collected. The final inputs were validated by triangulation of different data sources, and through consultations with local stakeholders. In the few cases where there were significant data gaps, expert opinion was sought or inputs were based on review of the scientific literature from other countries.

5. Applying the Asian Epidemic Model in Bangladesh

The main difficulties applying the AEM in Bangladesh are:

- There are no extensive HIV trends available for the at-risk groups, as there is not a widespread HIV epidemic yet. Hence, the transmission parameters that produce the AEM-projected HIV curves cannot be tuned to fit the local situation. What this means is that the timing of the epidemic, and its exact magnitude cannot be validated by the observed data as yet.
- AEM has extensive information needs and many data gaps were found. The data in Bangladesh is mainly from a few sentinel surveillance sites; hence nationally representative indicators on HIV, STI, or risk behaviors of vulnerable groups are not easily derivable.

To overcome the problems encountered:

- A "Scenario-building" approach was taken, i.e., *a Baseline Scenario projection was made of what is theoretically likely to happen if current risk behaviors stay the same as measured now into the future with no behavior changes.* Thus, the AEM is being used to assess the potential for an HIV epidemic considering the levels of risk behaviors that exist now. It serves as a guide to the relative extent and pattern of the epidemics in the different risk populations.
- The AEM was applied to the Dhaka City Corporation only rather than the whole country, since there is the most behavioral data available from the BSSs and other studies. Two other reasons that make a Dhaka model very relevant at present are that based on the data synthesis the earliest outbreaks of HIV are likely in Dhaka, and from the national size estimates the highest concentrations of the vulnerable groups live there [27].
- Assumptions had to be made regarding some AEM inputs because of weak data or data gaps. Sensitivity analyses were done for these uncertain inputs to ensure that they were appropriate, i.e., they were varied across a reasonable range and the impact on projections was determined.
- Transmission parameters were selected based on the scientific literature and experience from other countries.

6. Inputs to the AEM Dhaka Baseline Scenario

6.1. Demographic Parameters

The Bangladesh Bureau of Statistics, Planning Division of the Ministry of Planning, Government of Bangladesh, provided population information for Dhaka City Corporation from the last Population Census done in 2001, segregated by single year of age and sex. From the 2001 data provided, population projections starting The Bangladesh Bureau of Statistics, Planning Division of the Ministry of Planning, Government of Bangladesh, provided population information for Dhaka City Corporation from the last Population Census done in 2001, segregated by single year of age and sex. From the 2001 data provided, population projections starting from 1980 up to 2020 were made to obtain the necessary AEM inputs on the number of males and females aged more than 15 years (15+), and the number of males and females in the 15-years-old cohort (**Table 1**). The projections were calculated using the published inter-census population growth rates between the censuses conducted in 1981 and 2001 [28] (calculation details are provided in [29]). The population adjustment ratio (ratio of 15-49 years to 15+ years populations) was calculated from the 2001 census age cohort data.

Age specific fertility rates among women were taken from the Bangladesh Demographic and Health Survey 2004 [30].

6.2. Inputs to the Model on Key Populations and Behaviors

The national size estimates were built up from data at the city and district level, and information specific to Dhaka City was extracted in order to assess the proportion of the various vulnerable groups as shown in **Table 2**, and described in more detail in the sections below.

The second generation HIV surveillance system has been monitoring HIV prevalence and risk behaviors in the most vulnerable groups since 1998. Overall there have been five rounds of Behavioral Surveillance Survey (BSS1 to 5) conducted in the years 1998-1999, 1999-2000, 2000-2001, 2002, and 2003-2004 [4-7, 14]. However, several behavioral surveillance questions from the early rounds were changed to facilitate comparison with other countries [7], so that for many indicators only the BSS4 (2002) and BSS5 (2003-2004) data are strictly comparable.

For the AEM behavioral inputs for the years 1980 to 2002 generally the BSS4 values were used, unless there was other supplemental information to inform the behavioral trend for the years before surveillance began. For the AEM Dhaka Baseline projection it was assumed that behaviors would remain the same as they are now in the future; hence generally data from BSS5 were used for the years 2003 until the end of the projection in 2020. If the observed behavioral trend seemed questionable or inconsistent over the years, generally values representing less risk were used for the AEM inputs, so that a more conservative projection would be obtained, as described in more detail below, and summarized in **Table 2**.

The surveillance sites in Bangladesh are designated by alphabetic codes based on their geographical location for confidentiality reasons and to avoid stigma. However, it is generally understood now that surveillance data for Central City A can be ascribed to Dhaka City [17], and were used as such for AEM.

6.2.1 Female Sex Workers

In the AEM female sex workers are modeled as two broad groups, high and low frequency FSW, on the basis of the number of clients they have in a week. For the Dhaka Baseline Scenario, the hotel-based sex workers (HBSW) in Dhaka were considered to be high frequency sex workers as they consistently report high numbers of clients [7, 14].

The low frequency FSW category for Dhaka included the other types of sex workers present, i.e., street-based, casual, and residence-based sex workers, all of whom generally have fewer clients than HBSW per week. Street-based sex workers (SBSW) are located by clients on the street, with the sex act happening there or at other public locations

[31], while residence-based sex workers may contact clients at outside venues, but the sex act happens at their homes. Casual sex workers are those women who sell sex occasionally, but have another primary occupation. There are no brothels in Dhaka City.

Population Size

In 2004 there were an estimated 3250 hotel-based sex workers in Dhaka, 7000 street-based sex workers and 3000 casual and residence-based sex workers (0.93% of adult females, **Table 2**). Thus, SBSW are the major proportion of all the female sex workers (53%), as well as of the low frequency sex worker category.

Information on the trend over the years in the number of sex workers in Dhaka is scarce. The first study done to estimate the number of street-based (SBSW) was a capture-recapture survey done by CARE Bangladesh in 1997, where they estimated there were about 5000 of them [31]. However, to try to generate a rough trend in numbers for modeling, some of the key factors that were considered were the boom in the readymade garments industry in Bangladesh in the mid-80s, with Dhaka acting as the main hub [32], and the closure of the two large brothels in Narayanganj in 1996 that serviced Dhaka city up until that point [33]. It was assumed that there were probably less female sex workers in Dhaka in the 80's before the garments industry picked up, with its resulting draw on large numbers of workers to the city in search of work. Further, anecdotal information and survey indicates that the sex workers on the streets of Dhaka increased after the closure of the Narayanganj brothels, while hotel-based sex work has been on the rise only since 2000 [13, 31, 33]. Thus it was estimated for modeling purposes that in 1990 there were 5000 SBSW, i.e., about the same as found by CARE two years later, 1000 Casual and residence-based sex workers, and 2000 hotel-based sex workers (0.77% of adult female population), and that in 1980 there were 3000 SBSW, and only about 500 each hotel and casual/residence-based sex workers (0.61% of adult female population) (**Table 3A**). Based on these size estimates, 13% of all FSW were high frequency HBSW in 1980 and 25% were HBSW from 1990 onwards (**Table 3A**). From 1980 to 1990, and from 1990 to 2000, the sizes of FSW populations were increased proportionately using the 'AEM interpolate' function.

Duration

The behavioral surveillance does not directly query the number of years that women stay in the different categories of sex work [7, 14]. However, it does provide information on the number of years FSW reported being in sex work, and the proportion who had been in sex work for less than a year. From these data, an estimate was made (calculation details are provided in [29]) that HBSW sell sex in hotels for an average of 7 years, while the average duration in sex work of SBSW is 8 years (**Tables 2, 3B, and 3C**). There is no information available at present on how long women stay in casual or residence-based sex work.

Sex workers say that older brothel sex workers sometimes do turn to the streets to look for clients [34]. Hotel-based sex workers tend to be younger women [7, 14], but as they get older these women may also end up in street sex work. For lack of better information and considering the social dynamics, the movement from high-frequency to low-frequency sex work each year was left at 1%, the AEM default value [16].

Frequency of Sexual Contacts

In the BSS hotel-based sex workers in Dhaka consistently report entertaining 30 to 40 clients in a week [7, 14]. To keep the AEM projection conservative, the input used was a lower weekly average of about 5 clients a day (**Table 3B**), with HBSW working 4 days a week - which is still high for Asia [35].

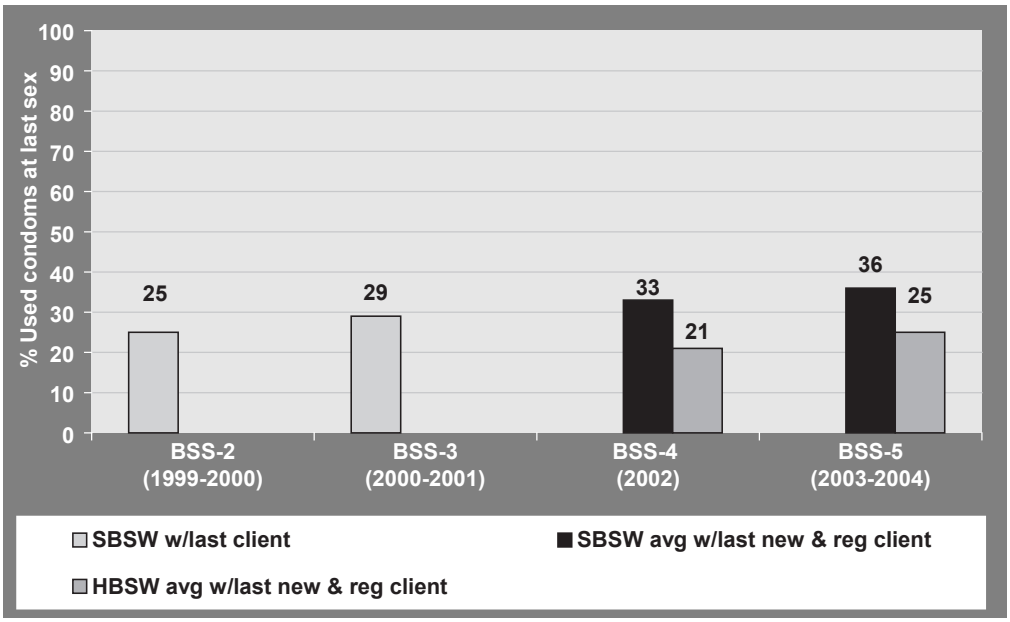
The majority of street-based sex workers reported seeking clients 4 to 5 days of the week in Dhaka City in surveys, and an average of 11 to 18 clients per week in BSS (**Table 3C**) [7, 14, 31]. There is little hard data on casual and residence-based sex workers, but based on a situation assessment of this group in Dhaka [36], it was assumed that their client numbers and working frequency are around the same or less than street-based sex workers. For the AEM low frequency sex worker group the inputs used were that they worked 5 days a week and had 2 clients a day.

Condom Use

Condom use by the two categories of sex workers was derived from behavioral surveillance data from 1999 (BSS2) to 2004 (BSS5) (**Figure 9**) [5-7, 14]. The AEM input used for HBSW from 1980 to 2002 was 21%, which was the Dhaka BSS4 (2002) value for average condom use with new and regular clients. This increased to 25% the next year in BSS5, and that value was used from 2003 onwards as the input (**Tables 3B and 3C**).

Similarly for the SBSW group, the AEM inputs were taken from the BSS trend: 25% from 1980-2000, 29% in 2001, 33% in 2002, and 36% in 2003.

Figure 9: Behavioral surveillance trends in condom use of Hotel and Street-based Female Sex Workers in Central-A



Condom use measured in BSS rounds 2 and 3 is not strictly comparable with rounds 4 and 5, which are comparable. HBSW: Hotel-based sex workers; SBSW: Street-based sex workers.

6.2.2 Clients of Sex Workers

Population Size

When the Dhaka City Baseline was originally developed in 2005, there were no nationally representative data on the proportion of general population adult males who are clients of sex workers. The literature survey yielded some studies from which the proportion of men who had non-marital sex in the previous year, including with FSW, was found to be from 6-12% [37-41]. Considering these data, for the national size estimation the proportion of men who visited sex workers was assumed to be 6-10%. Thus for AEM, 10% of the adult men (15-49 years) in Dhaka City were assumed to be clients for the entire projection time period (**Tables 2 and 3D**). This assumption has subsequently been validated by a recently completed Male Reproductive Health Survey (MRHS) done by ICDDR,B. A nationally representative sample of men were directly queried on their sexual partners, and an average of 10% in Dhaka reported having sex with a female sex worker in the previous year [42].

The fraction of circumcised males was determined based on Census reports of the percent of Muslim population for the years 1980 to 2001 (**Table 3D**) [28].

Duration

For the AEM men are assumed to be active clients of sex workers for the time interval from sexual debut to marriage. From data from the last two rounds of behavioral surveillance (among truckers, rickshaw pullers, students, and IDU) [7, 14], and a cross-sectional population survey of men dwelling in slums in Dhaka [41], the average age at first sex was estimated to be 18 years. The average age of marriage for males is 25.3 years according to the Population Census trends since 1980 [28]. Thus, the average duration of being a client of sex workers was estimated to be 7 years for AEM (**Tables 2 and 3D**).

6.2.3 Casual Sex

Population Size

Information on the percent of adult men with casual sex partners in the previous year was extremely limited. In one study 3% of men living in slums in Dhaka reported "affairs", and in another study 12% of unmarried men in the Chittagong area said they were having non-marital sex [37, 41]. In the BSS4 of men in bridging populations like rickshaw pullers and truckers, and of students, 26 - 39% in Dhaka reported having sex with girlfriends in the previous year [7]. Based on these few available studies, it was estimated for AEM that 8% of men (15-49 years) in the general population may have casual sex (**Table 3E**). Again this value has now been validated by the MRHS [42].

Behavioral surveillance among truckers and rickshaw pullers indicated that the average number of casual partners per year was no more than one [7], but there was no data available on the number of sex contacts per year. According to the MRSH, men in Dhaka (53 respondents) had an average of 1.6 casual partners the previous year, and reported an average of 5 casual sex contacts per year [42]. Despite the small sample, for lack of any better information this value was used as the input for AEM (**Table 3E**).

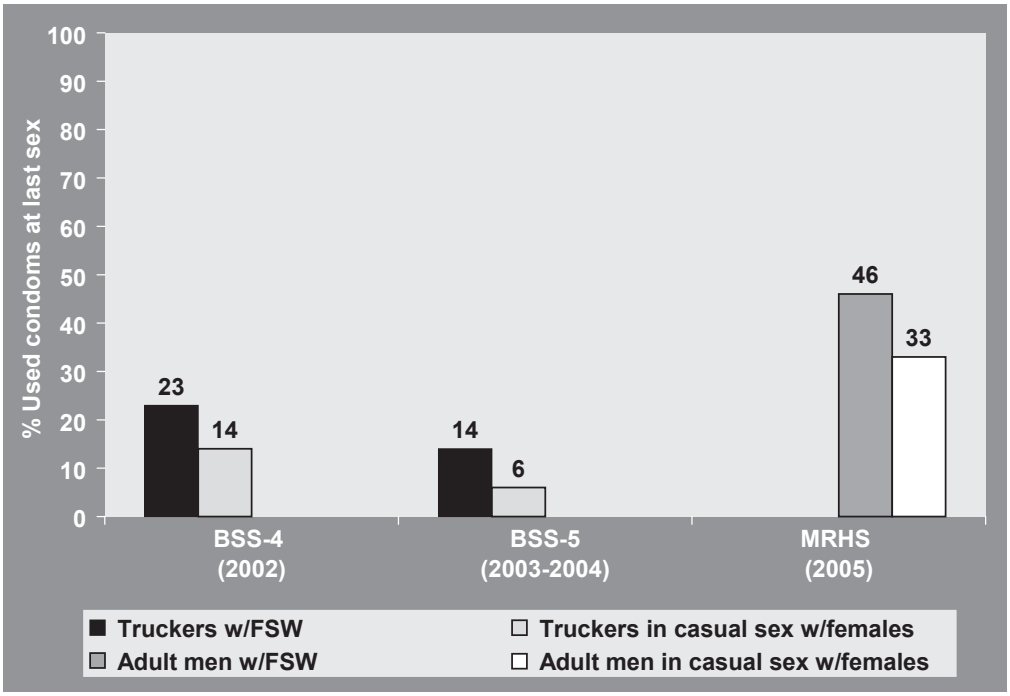
Bangladesh is a fairly conservative society where research surveys on sexual or reproductive health and risk are often conducted only among married women and even then, detailed sexual behavior questions are not asked due to the social taboos. Only two studies were found at this time that pertained to non-marital sexual activity of women in the general population. In a cross-sectional survey of female clients attending a basic healthcare clinic, 0.2% of the women admitted to having an affair [38], which is probably a minimum estimate given the social desirability bias. In the other survey of slum men mentioned previously [41], 3% had affairs with women - who were presumably not sex workers. For AEM the percent women having casual sex per year were estimated as 3% (**Table 3E**), which is less than half the proportion of men.

Condom Use in Casual Sex

According to the MRHS, 46% of the men in Dhaka (115 sampled) reported condom use with FSW at last sex, as shown in **Figure 10** [42], which is about three times the average last time condom use reported by truckers in the BSS (23% of 352 men sampled in BSS4, 2002; and 14% of 378 men sampled in BSS-5, 2003-2004) [7, 14]. It is also higher than what was reported by FSW in BSS5 (the value used for commercial sex in AEM, see **Table 3** and **Figure 9**).

Similarly, the condom use of men in Dhaka (100 respondents) with female friends/relatives/neighbors in the MRHS (33%, **Figure 10**) was also about three times the average reported by truckers with girlfriends/non-commercial female partners (14% of 187 men sampled in BSS4; and 6% of 246 men sampled in BSS-5). Thus for the AEM input for condom use with casual partners, the MRHS value was adjusted down by a factor of three, taking into account the fact that more men were sampled by BSS and hence it may be more representative, and entered as 11% for the years 1980-2020 (**Table 3E**).

Figure 10: Behavioral trends for condom use of adult males in Dhaka at last commercial sex with female sex workers, and with casual female partners



FSW: Female Sex Workers

6.2.4 Marital Sex

It was assumed that the frequency of marital sex was once a week (**Table 3F**). The Bangladesh Demographic and Health Surveys 1999-2000 and 2004 yielded figures on the trends in contraceptive condom use among married partners that were used as the AEM inputs, which ranged from 1% in 1980 to 4% from 1996 onwards (**Table 3F**) [30, 43].

6.2.5 Injection Drug Users

Population Size

The first major study with a focus on HIV vulnerability and drug use in the country was the NASROB (National Assessment of the Situation and Response to Opioid/Opiate use in Bangladesh), conducted in late 2001 [44]. NASROB found that besides heroin smokers, the majority of the study districts (19/24) had drug injectors. It also documented the changes in drug use patterns over the years, whereby there was a movement in the late '70s away from the exclusive use of cannabis, opium, and alcohol to increasing ingestion of codeine-containing cough syrup in the early '80s, and the introduction of heroin smoking in the mid-eighties. By the 1990s injection drug use had become more common among drug users in Dhaka, and Rajshahi in the north [45, 46]. Now, the evidence gathered over the years from the national behavioral surveillance and other assessments clearly indicates that injection of drugs has been steadily increasing since then [12, 47]. Injection drug use in Bangladesh tends to be more common among street drug users, who primarily inject pethidine and buprenorphine, although injecting 'cocktails' of various drugs and other substances mixed together is common [44, 48].

Information was collected for the national size estimation of at-risk groups on the number of IDU in Dhaka City. The maximum number of street-based and other IDU in 2003 was estimated to be 8000 men, which is 0.4% of the adult male population. This proportion was used in AEM for the years 2000 and onward (**Table 2**).

Estimates of the proportion of men who injected in earlier years were made based on the drug use trends described above (**Table 4A**), and NASROB data that estimated there were 2700 IDU in Dhaka region in 2001. Thus, the size of the IDU population in Dhaka City between 1990 and 2000 was assumed to be about 25% of the NASROB size

estimate, 675 IDU, i.e., 0.06% of adult males. In the '80s when injection drug use was uncommon, it was assumed that there might have been about 250 IDU in Dhaka (0.03% adult males), which is roughly 10% of the NASROB estimate.

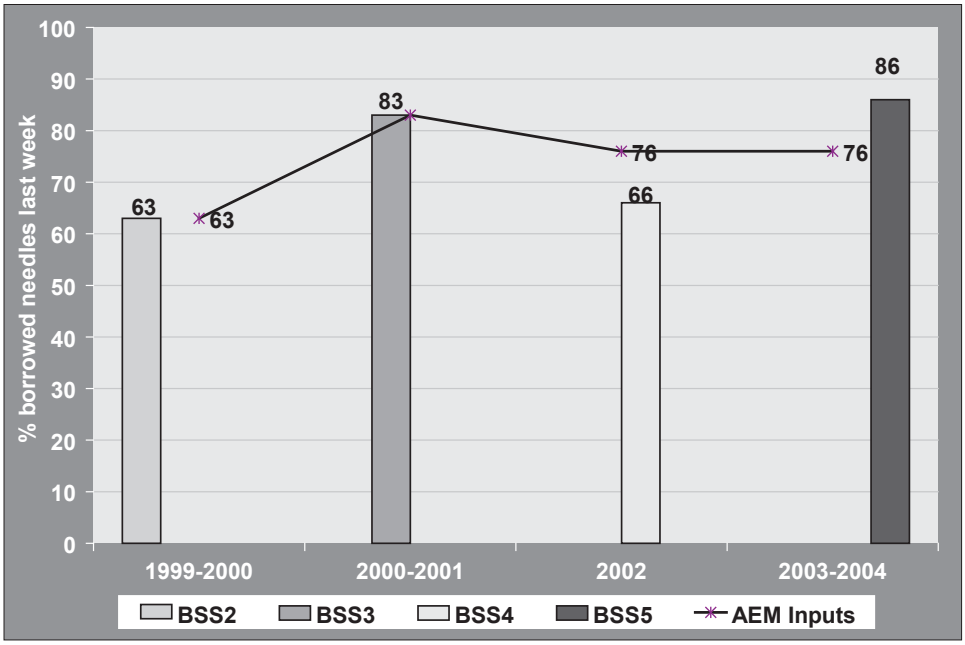
Current knowledge and behavioral surveys indicate that females hardly use injection drugs [7, 12, 14, 45], although now some institutions working with or researching drug users are finding increasing levels among women who are the partners of male injectors and among FSW [49][50] . Combining information from interventions and studies in Dhaka and its surrounding areas, there may be about 200 to 300 injecting female sex workers overall. This low number will probably not contribute significantly to HIV transmission and hence was not considered at this time as a separate group for AEM.

Injecting Behaviors

AEM inputs on IDU injecting and sexual behaviors were mainly obtained from the 2nd to 5th rounds of BSS (1999-2000, 2000-2001, 2002, 2003-2004), reinforced with the results from NASROB [5-7, 14, 44]. A cohort of IDU in Dhaka is being studied by ICDDR,B, and this research might better inform the AEM inputs later.

All the surveys show that high proportions of IDU in Dhaka City lend and borrow needles and injecting equipment. The real risk for HIV transmission is borrowing used needles from others; hence only the data on borrowing of injecting equipment in the previous week was used for AEM. There is quite a fluctuation in the BSS trend in the reported borrowing of needles and/or syringes over the last week, as shown in **Figure 11**. The percent sharing was entered in AEM as 63% for the years 1980 up to 2000 (BSS2), and increased to 83% for 2001 (BSS3). Since it was decided to generate the AEM projection based on conservative assessments of risk behavior, instead of using the high BSS5 value, the average of BSS4 and BSS5 values, 76% borrowing of needles, was used for the years 2002 onwards (**Table 4A** and **Figure 11**).

Figure 11: Behavioral surveillance trends for proportions of injection drug users in Central-A who borrowed needles or injecting equipment in the previous week and the corresponding Asian Epidemic Model inputs



IDU: Injection Drug Users; AEM: Asian Epidemic Model

Drug users in Dhaka City inject about 2.5 times a day, and there has not been much variation in this frequency over the years of surveillance [4-7, 14]. The average duration of the drug injection habit by users was estimated to be 8 years from the fourth surveillance information on the proportion of IDU who have injected for a year or less (**Table 4A**) [7, 12].

There is no concrete data at present on the size or mechanics of IDU sharing networks in the country. It was assumed for AEM that about half the drug injectors in Dhaka City were in high-risk networks in 1980 when injection drug use

was not so common, while 75% were from 1995 onwards since 25% IDU reported not sharing in the previous week (**Table 4A**) [6, 7, 14]. Also at that time the use of injection drugs picked up, and HIV case-reporting started to increase [51]. Values for the years between 1980 and 1995 were generated by linear interpolation.

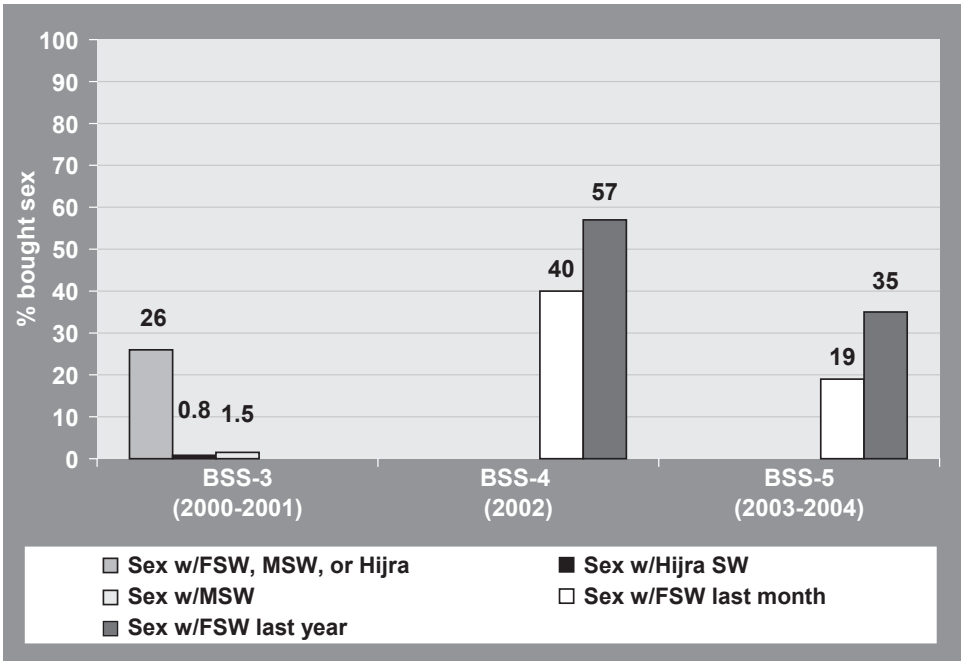
The fraction of injections shared among those IDU who do share needles is one of the determinants of HIV spread considered in the AEM. This was not directly queried in the behavioral surveillances, but approximate values were derived from other IDU responses in the BSS3 to BSS5 (2000-2001, 2002, 2003-2004) databases. In BSS3 there were direct questions on the number of times each respondent injected in the previous week, and on the number of times in the previous week each IDU had used a needle or syringe after someone else used it. Thus the percentage of shared injections could be computed directly as 51%. The BSS4 and 5 questionnaires were changed so that questions were framed in a way that did not elicit quantitative responses, therefore, the values for proportion of shared injections had to be derived more indirectly from those data (calculation details are provided in [29]). The results were that IDU shared about 79% and 62% of the injections they had taken in the previous week in BSS4 and BSS5, respectively. Since the BSS3 value was obtained more directly from the questionnaire, and in the interests of generating a conservative Dhaka Baseline, the input used for AEM from 1980-2020 was that IDU who share, do so half the time (50% shared injections, **Table 4A**).

As there was no local information available, IDU mortality was set at 1 in a 100, and the sharing to non-sharing movement per year was entered as 10% (**Table 4A**) as per the default AEM Baseline [16].

Sexual Risk Behaviors

Behavioral surveillance in 2000-2001 found that 26% of IDU in Dhaka reported buying sex from female, male or hijra commercial partners in the last month [6]. In response to separate questions, only 0.8% and 1.5% of the IDU respondents reported commercial sex with a Hijra or a male partner in the last month, respectively, indicating that the majority of commercial sex was with female sex workers (**Figure 12**). Surveillance the next year in BSS4 found 40% and 57% of IDU reported sex with FSW in the previous month and previous year, respectively [7], which decreased in BSS5 to 19% and 35%, respectively [14]. Taking into account this recent downward trend, and in the interests of "low-balling" the epidemic in AEM, it was decided to set the proportion as 26% IDU visiting FSW for the whole projection time period as in BSS2 (**Table 4B**), which is also the rough average from BSS5.

Figure 12: Behavioral Surveillance trends for proportions of injection drug users in Central-A that bought sex from female sex workers in the last month and last year

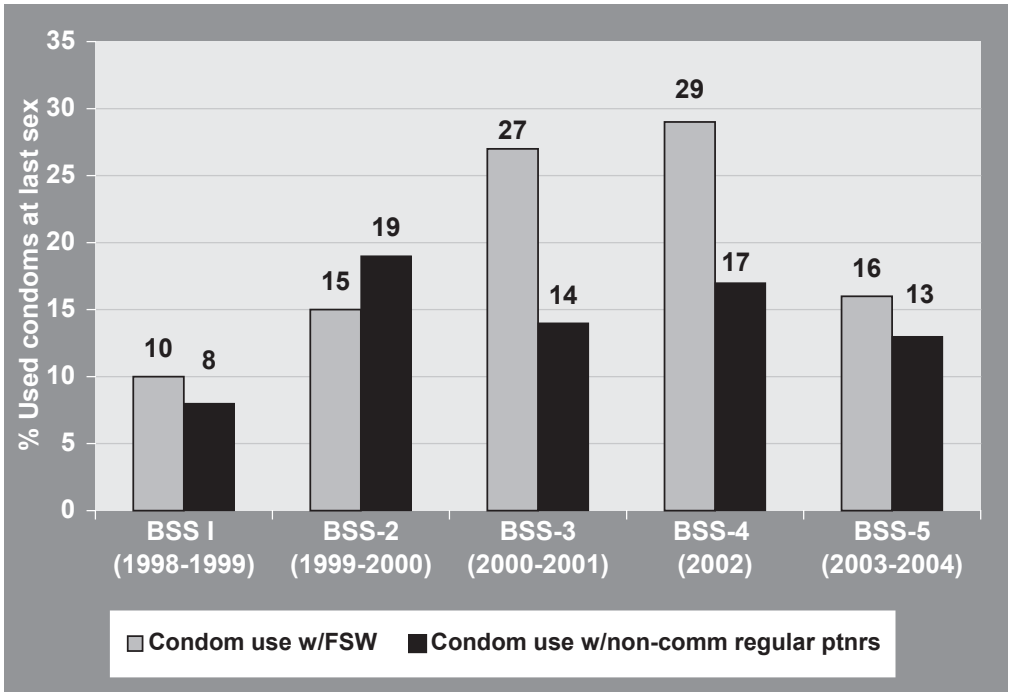


BSS3 is the proportion of Injection Drug Users (IDU) reporting commercial sex overall last month, i.e., with female (FSW), male (MSW) or Hijra sex workers (Hijra SW)

Condom Use with Commercial Sex Partners

The proportion of IDU who used condoms with female sex workers was input in the AEM as per the increasing trend observed in behavioral surveillance up to 2002 as 10% for 1980-1999, 15% for 2000, 27% for 2001, and then 29% for 2002 onwards (**Table 4B and Figure 13**). BSS5 data that indicates that the condom trend may be declining among IDU (16% at last sex) [14, 17] was not used in order to be consistent with a conservative baseline projection, and because there was no other supporting evidence that the decline would continue into the future. There was no information regarding different levels of condom use with high and low frequency FSW and so the same values were used for both categories.

Figure 13: Behavioral Surveillance trends for proportions of injection drug users in Central-A that reported condom use at last sex with female sex workers and non-commercial and/or regular partners



IDU: Injection Drug Users; FSW: Female Sex Workers; non-comm: non-commercial; ptnrs: partners.
Condom use at last sex is only strictly comparable in BSS4 and BSS5, because in earlier rounds it was measured differently.
IDU condom use in commercial sex in BSS1 is with sex workers, not specific male or female; in BSS3 it is with commercial partners overall, i.e., female, male or Hijra sex workers.
IDU condom use in non-commercial sex in BSS1 is with non-commercial partners; BSS2 is with non-commercial partners excluding wives; BSS3 is with non-commercial partners including wives, and BSS4 and 5 are with regular partners including wives.

Sexual Frequency and Condom Use with Regular Partners

In BSS3 injectors in Dhaka reported a mean of one regular, non-commercial partner (including wife) in the previous month [6], but there was no data on frequency of sex with that partner. In BSS5 injectors reported an average of 7 sex acts per month with regular sex partners [14], but there was no other data against which to validate this fairly high frequency. Therefore, the frequency of IDU contacts with their regular partners, which are generally wives based on the surveillance demographic data [7, 14], was assumed to be about 0.25 per month as per the AEM Asia defaults (**Table 4B**).

As for condom use with FSW, the trend from BSS of IDU condom use with non-commercial or regular partners (**Figure 13**) was used for the AEM inputs as follows: 8% for 1980-1999, 19% for 2000, 14% for 2001, and then 17% for 2002 onwards (**Table 4B**). Again, this downplays the fact that the condom trend may be declining based on BSS5 data (13%) [14].

6.2.6 Males who have sex with males

Population Size

The percent of men in Bangladesh who engage in same-sex sexual behavior was unknown until recently, and like many other countries there is denial in many quarters about the existence of this group. The national size estimation of MSM and MSW in Bangladesh was one of the weaker estimates due to the lack of information. Data was available from the two major MSM and MSW HIV prevention interventions in 4 districts of the country regarding contacts with their target group through meetings and outreach at cruising sites. This included Dhaka City, where approximately 15,000 MSM had been contacted. From this information an estimate was made that 0.9% of the Dhaka adult male population at any time may actively engage in cruising for male-to-male sex.

In the MRHS an average of 2% of the men surveyed in Dhaka households said they had had sex with men in the previous year [42]. However, behaviors as well as the transmission frequency influence the projected spread of HIV in the AEM. Behavioral surveillance of MSM and MSW was among men encountered at cruising sites located through peer outreach workers from the interventions. Hence it is possible that behaviors elicited through BSS are more representative of the 0.9% high-risk MSM identified through interventions, rather than describing the behavior of all 2% of men who have sex with men in Dhaka according to the MRHS. For this reason the decision was made that for the Dhaka Baseline Scenario 1% of men should be considered to have the behaviors used as inputs to AEM (**Tables 2 and 5A**).

Since there is no definite information on the ratio of MSW to MSM, it was assumed that the ratio is probably about 1 sex worker for every 25 men who buy sex, resulting in 0.04% of adult males in Dhaka City working as male sex workers (**Tables 2 and 5C**).

Duration

Based on anecdotal information it was assumed for the Baseline AEM model that the average duration of active male same sex behavior might be 20 years (**Table 5A**). This was explored further by sensitivity analysis and was seen not to affect the HIV prevalence in this group much if varied between 10 and 25 years.

From BSS data it was estimated that MSW are in the sex work profession for about 8 years. However based on the advice of experts who felt this was too long a duration, this was modified for the AEM input to 6 years [52][53]. It was assumed that the shift between male same sex sexual behavior and being a male sex worker was low and input as 1% in AEM.

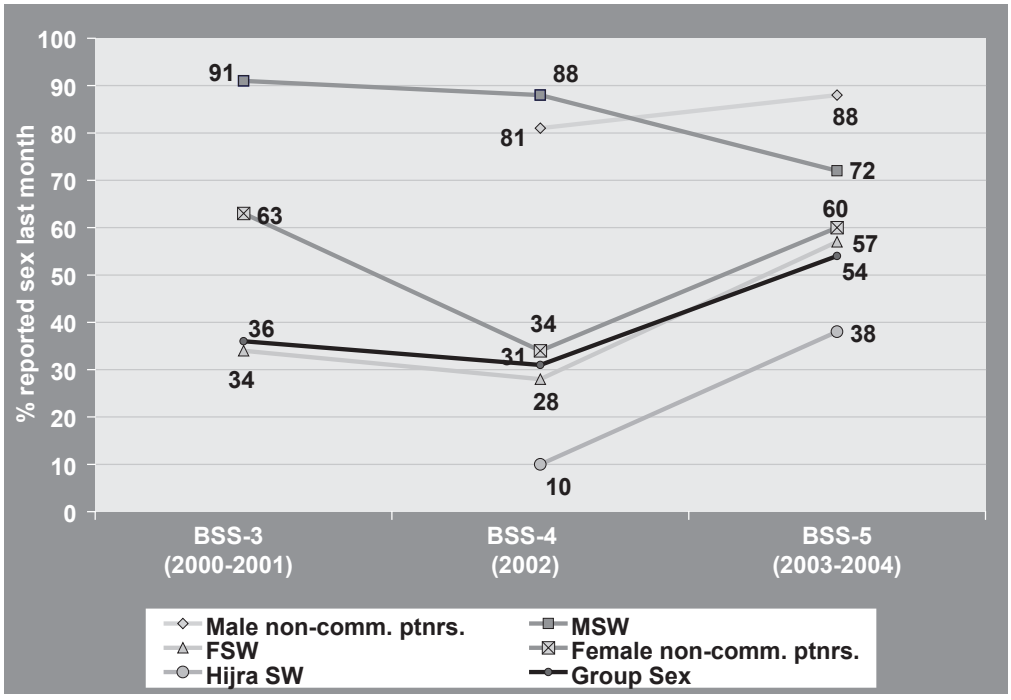
Sexual Behavior

A high proportion of MSM and MSW surveyed in Bangladesh are sexually active with different types of partners. They have male lovers, and buy sex from male, as well as hijra (transgender) sex workers [54-56]. Like some other Asian countries, their own sense of identity or societal and religious pressures result in a high percentage of them getting married, and they also have girlfriends and visit female sex workers. In the fourth round of surveillance in 2002, 88% of MSM in Dhaka reported anal sex with male sex workers in the previous month alone, and 90% MSW reported new clients in the previous week [7]. Hence, for AEM 100% of MSM and MSW was input as having had anal sex in the previous year (**Table 5A**).

The frequency of anal sex in the previous week for MSM was estimated to be at least once, since in BSS4 (2002) they reported an average of 7 partners in the previous month, which included an average of 3.4 commercial male partners, 0.2 Hijra sex workers, and 2.4 non-commercial partners [7]. MSW reported a mean of 9.5 clients, new and regular, in the previous week, and hence their frequency of anal sex per week was estimated to be about 9, assuming they had anal sex with each client (**Table 5C**).

There was a discrepancy in the behavioral surveillance trend data regarding the proportion of MSM reporting sex with different kinds of partners (**Figure 14**). It was observed that there was an increase by a factor of 2 between rounds 4 and 5 in the percentage reporting sex with FSW (28 to 57%) and female non-commercial partners (34 to 60%), and group sex (31 to 54%), while there was a four-fold increase in the percentage reporting sex with hijra sex workers (10 to 38%) [7, 14]. The proportion reporting male non-commercial partners increased a little from 81 to 88%, while those having bought sex from males decreased from 88 to 72%. It is unlikely there were such significant changes in sexual activity with females and Hijras in just one year; possibly there might have been other factors responsible for this effect. Behavioral surveillance did rely on peer outreach workers from MSM and MSW interventions to access these populations for interviews and that might be one source of bias.

Figure 14: Behavioral Surveillance trends for proportions of non-sex worker men who have sex with men in Central-A that reported sex in the last month with different types of partners

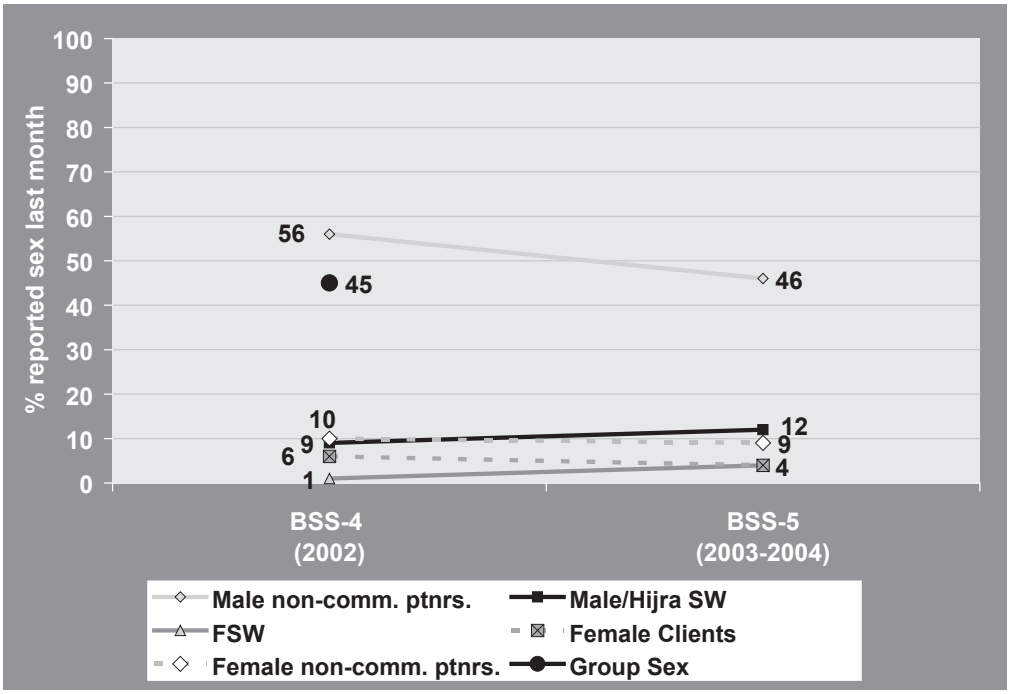


BSS: Behavioral Surveillance Survey; MSM: Men who have Sex with Men; Male non-comm ptnrs: Male non-commercial partners; MSW: Male Sex Workers;
FSW: Female Sex Workers; Female non-comm ptnrs: Female non-commercial partners; Hijra SW: Hijra Sex Workers.

In the interests of trying to keep the Dhaka Baseline Scenario as conservative as possible, the BSS3 values [6] were used as inputs for the percent reporting sex with male (91%) and female sex workers (34%) for the years 1980-2001, and the BSS4 values [7] for the years 2002-2020 (88% and 28%, respectively, **Table 5B**). The proportion MSM with non-commercial female partners was set at 47% for the entire projection time period, which reflected the average percent who were married over the rounds of surveillance (**Table 5A**) [6] [7, 14].

For MSW the trends in those reporting sex with different kinds of partners during behavioral surveillance were more plausible than for MSM (**Figure 15**). For the years 1980-2000, the BSS4 value of 1% MSW having sex with female sex workers was used as the AEM input, and for 2003-2020 the input was the BSS5 value of 4% (**Table 5C**). The proportion MSW with other female partners was input as 10% for 1980-2020, which corresponds to the percent that reported sex with female non-commercial partners in BSS4 and BSS5, and also the average percent that were married [7, 14].

Figure 15: Behavioral Surveillance trends for proportions of Male Sex Workers in Central-A that reported sex in the last month with different types of partners

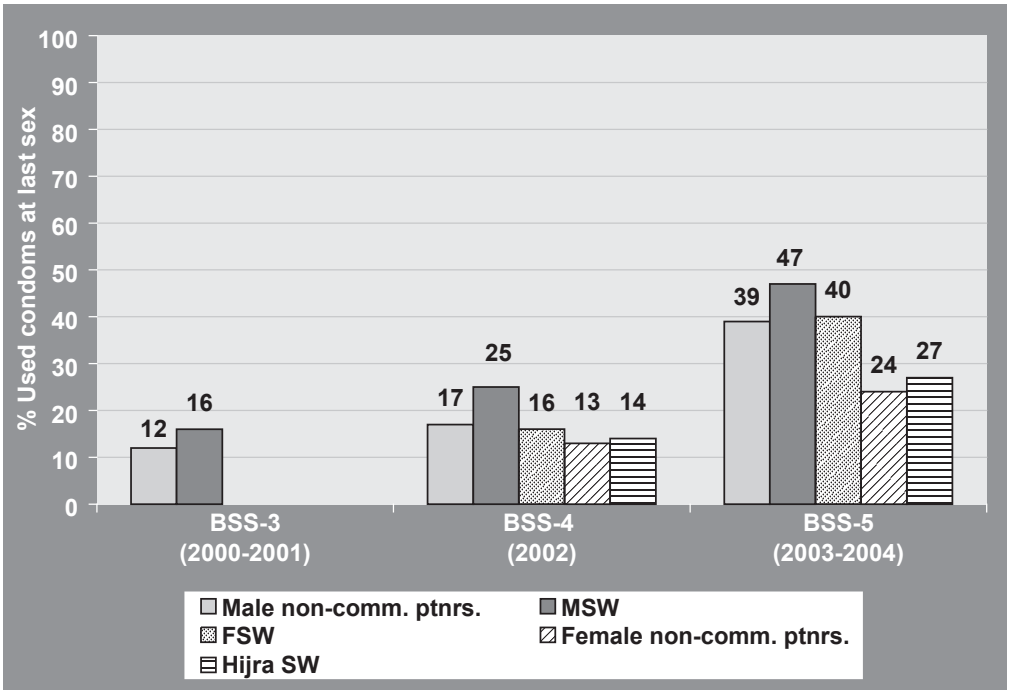


BSS: Behavioral Surveillance Survey; MSW: Male Sex Workers; Male non-comm ptnrs: Male non-commercial partners; Male/Hijra SW: Male or Hijra Sex Workers; FSW: Female Sex Workers; Female non-comm ptnrs: Female non-commercial partners.

Condom Use

As seen among other groups in Bangladesh, MSM also often do not use condoms (**Figure 16**). Condom use as reported in the BSS3 (2000-2001) was 12% at last sex with male, female and Hijra non-commercial partners [6], in the fourth behavioral surveillance it was 17% for last anal sex with other MSM, which improved to 39% by BSS5 [7, 14]. In AEM for condom use with other MSM the BSS3 value of 12% with non-commercial partners was used for 1980 to 2001, the BSS4 value of 17% with other MSM was input for 2002, and the BSS5 value of 39% from 2003 onwards (**Table 5A**).

Figure 16: Behavioral Surveillance trends for proportions of non-sex worker men who have sex with men in Central-A that reported condom use at last sex with different types of partners



BSS: Behavioral Surveillance Survey; MSM: Men who have Sex with Men; Male non-comm ptnrs: Male non-commercial partners; MSW: Male Sex Workers; FSW: Female Sex Workers; Female non-comm ptnrs: Female non-commercial partners; Hijra SW: Hijra Sex Workers. Condom use at last sex is only strictly comparable in BSS4 and BSS5, because in earlier rounds it was measured differently. Condom use in BSS3 is with non-commercial partners overall, i.e., female, male or Hijra sex workers;

For MSM in Dhaka the mean condom coverage rate for the last penetrative sex act when buying sex was 16% in BSS3 [6]. In BSS4 and BSS5 the proportions of MSM reporting condom use in last anal sex with MSW were 25% and 47%, respectively (**Figure 16**) [7, 14]. For the AEM Dhaka Baseline the BSS3 value of 16% condom use was used for 1980 to 2001 and the BSS4 value of 25% for 2002 onwards (**Table 5B**). Since the condom usage indicators could have a significant effect on the dynamics of HIV infection among MSM, their effects were explored further through building alternate AEM scenarios in which condom use was varied (Report on scenarios is in preparation)

About the same proportion of MSM that used condoms with male non-commercial partners (at last sex) did so with FSW (16% and 40% in BSS4 and 5, respectively, **Figure 16**) [7, 14]. For the AEM Dhaka Baseline, the BSS4 value was used with both high and low frequency FSW for 1980-2020 (**Table 5B**), to correspond with using the BSS4 value for the proportion visiting FSW.

6.3 Inputs on Sexually Transmitted Infections

It is now well established that the presence of sexually transmitted infections (STI), especially ulcerative ones, increases the transmission of HIV [57-59]. Hence the prevalence of any STI in the different sub-populations over the years is an important input in the AEM (prevalence of any STI). There was very limited trend information available on STI in Bangladesh. Nevertheless, appropriate assumptions were made based on the data described below to generate inputs that would be most likely representative of the situation in Dhaka City (**Table 2**). STI levels among FSW can have a significant effect on HIV transmission in the country; hence their effects were also explored further through building alternate AEM scenarios in which the prevalence was varied (see Section 8).

6.3.1 Female Sex Workers

In the one published study found [60], the prevalence of "any STI' measured among a sample of 400 hotel-based sex workers was considered too high (63%) to generate a conservative Dhaka Baseline. Instead, the prevalence of Gonorrhea (40%) was used as the input for 1980-2002 (**Table 3B**), which was decreased to 30% from 2005 onwards after seeking an expert opinion [61], and also based on the generally decreasing trend in syphilis observed by HIV surveillance [9].

There is one published study that measured the prevalence of any STI to be 84% among the street-based sex workers surveyed (269 speculum samples) [62], but again this was considered too high to use. From the published studies and the HSS, SBSW have higher syphilis prevalence (32.7% total and 9.7% active syphilis, HSS5) than HBSW (8.5% total and 4.5% active syphilis, HSS5). From several ad-hoc STI studies available, HBSW and SBSW have about the same GC prevalence (an average of 36.7% for SBSW from 4 studies versus 35.8% from the HBSW study) [60, 62-65]. But a higher proportion of HBSW were diagnosed with Chlamydia than SBSW (43.5% vs. 25%, respectively) [60, 62].

On the other hand, the low frequency sex workers category in the Dhaka Baseline also includes casual and residence-based sex workers, who it was assumed probably have less STI, since they have fewer clients [36]. Street-based sex workers reported higher condom use than HBSW in behavioral surveillance, and an upward trend in consistent condom use between 2002 and 2003 [7, 14]. In addition, HBSW have more exposure to HIV and STI as they have about twice the frequency of sex. Taking into account all the information mentioned on low frequency sex workers, the prevalence of any STI for AEM was set at three-quarters the value used for hotel-based sex workers, i.e., 30% for the years 1980 to 2002, and 23% for 2005 onwards, with a proportional increase in STI for the years 2003 and 2004. (**Table 3C**)

6.3.2 Adults Males and Females

Information on STI prevalence among adult men in the country is limited to three population surveys: a study of rural men, a survey of men in Dhaka slums, and a third survey of emigrating workers [41, 66, 67]. There are more community and clinic-based studies on STI among married women in rural areas and in Dhaka [38, 41, 66, 68-74].

The Demographic Health Survey 2004 found that 2% of men who had ever had sex reported having had a STI in the preceding 12 months [30]. Synthesizing all this data, especially the Dhaka studies, and considering the opinion of local experts that STI prevalence is going down due to improved services and awareness [75][76], the prevalence of any STI among the general population was made 5% in 1980, 3% in 1997 [73], and then 2% from 2004 onwards. Values for the years between were generated by linear interpolation (**Table 3F**).

The STI age distribution of males and females was set as in the AEM Thailand Baseline Scenario, as there was no data available for Bangladesh [16].

6.3.3 Men who have Sex with Men

There is virtually no information available on anal or urethral STI among MSM, including MSW. In addition, many experts feel that there is limited training in the country in detecting these diseases among men [77]. There is data from the HSS on the prevalence of syphilis among MSW and MSM. Active syphilis prevalence according to the fifth surveillance (2003-2004) was 1.5% in MSM, and among MSW was 6% [8]. From the limited information and data from other countries in Asia [78], STI prevalence was finally set to 10% for rectal STI among MSW, and among non-sex worker MSM to the same as the general adult population for urethral STI (5% decreasing to 2%), and 1% for anal STI (**Tables 5A and C**).

6.4 HIV Prevalence

The low prevalence of HIV among key at-risk populations has been measured every year since 1998 by the national HSS [4-7, 9, 14]. The values for the AEM shown in **Table 7** were entered based on the HSS for at-risk groups in Central City A, and from ad hoc studies on prevalence among adult males and females [38, 41, 67-69, 79-82].

6.5 Epidemic Parameters

6.5.1 Epidemic start years

In the AEM the start years of the heterosexual, injecting, and homosexual epidemics are entered. According to the start years specified in the model one HIV infection is introduced into the appropriate sub-population to initiate transmission. For countries that already have HIV epidemics the start year inputs can be adjusted in the AEM comparison screen to optimize the fit between the projected HIV curves for each population and the observed prevalence inputs.

For the Dhaka Baseline Scenario model HIV was introduced into the heterosexual, IDU and MSM populations in the year 2003. This was because national HIV surveillance measured a significant increase in HIV prevalence from 2.7% to 4% among IDU in Dhaka City between 2001 and 2002, and a prevalence of 8.9% in one area in 2003 [6-8]. However, as mentioned before since the Dhaka Baseline cannot be fit to observed prevalence trends, it is not yet clear what the exact start year of the HIV epidemic will be, therefore in the results shown the years are labeled starting from Year 0 when HIV was introduced into the different sub-populations.

6.5.2 Transmission parameters and cofactors

Based upon a review of the parameters which fit the national epidemic in Thailand [16], and values reported in the scientific literature [83, 84], the HIV transmission probabilities chosen were as given below:

- Male-to-female transmission rate of 0.002
- Ratio for male-to-female to female-to-male transmission of 3.0
- Male-to-male transmission rate of 0.005
- Per needle stick transmission rate of 0.00425
- The STD cofactors applied were set at relatively low values of 20 for men, 10 for women and 2 for male-to-male transmission, to minimize the impact of STDs [85-89].
- A circumcision cofactor of 3.0 was used to account for its protective effect [90-96].

6.5.3 Infection Progressions

The progression from HIV to AIDS and from AIDS to death among adults and children was entered as per the default UNAIDS values as there is no specific data available as yet in low prevalence Bangladesh. Among adults on average 5% of those infected are assumed to develop AIDS, with the progression from infection to AIDS being an average of 8 years, and the survival from AIDS to death of 1 year (UNAIDS median survival from infection to death is 9.4 years for women and 8.6 years for men). For children the UNAIDS value for median survival is 3 years. Mother-to-child transmission of HIV is considered in the AEM, with corresponding input needs. Since the Dhaka Baseline is just a scenario projection, the results for infections among children have not been considered, and anyway default inputs were used (details are provided in [29]). The age-specific fertility rates **(Table 6)** were taken from the Demographic Health Survey 2004.

7. Results of the AEM Dhaka Baseline Scenario

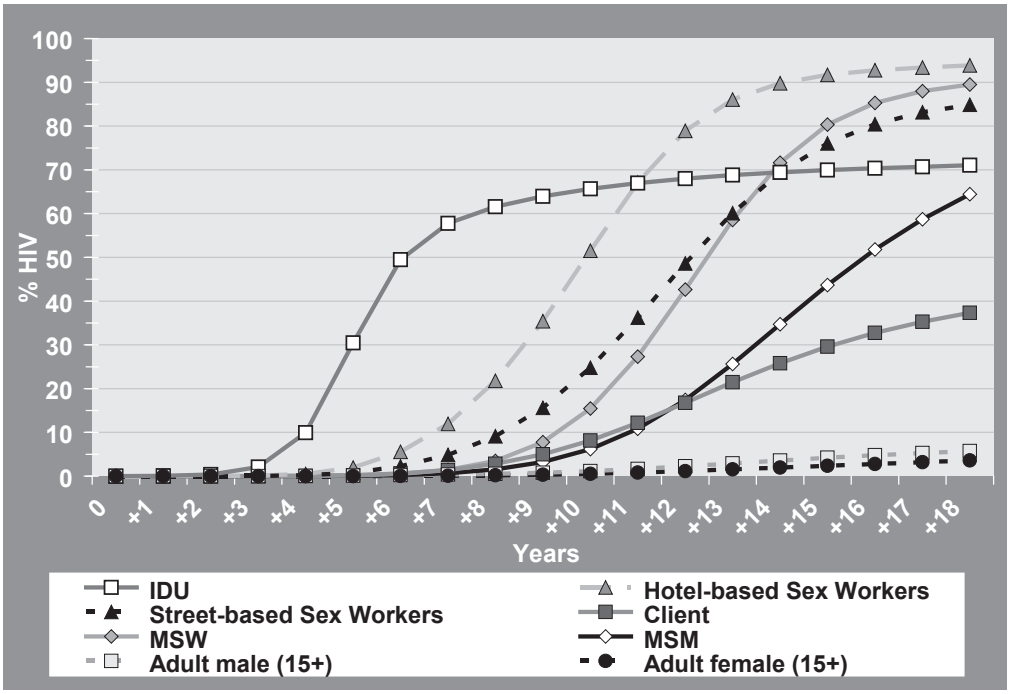
In this section the Dhaka Baseline Scenario is presented, its implications discussed, and the relationships among the various sub-epidemics in different sub-populations is described. The key sub-populations considered that will be discussed are street-based IDU, MSM, MSW, hotel-based and street-based (and other) FSW, clients of FSW, and low-risk adult men and women.

A projection of the HIV epidemic potential in Dhaka City Corporation was prepared with the transmission parameters described previously, based on the current size estimates and behavioral risk patterns of the groups as derived in the previous section and outlined in **Table 2**. The Dhaka Baseline Scenario only describes what is likely to happen if the risk behaviors measured by the BSS and other studies continue into the future with little change.

7.1 HIV Prevalence Projections

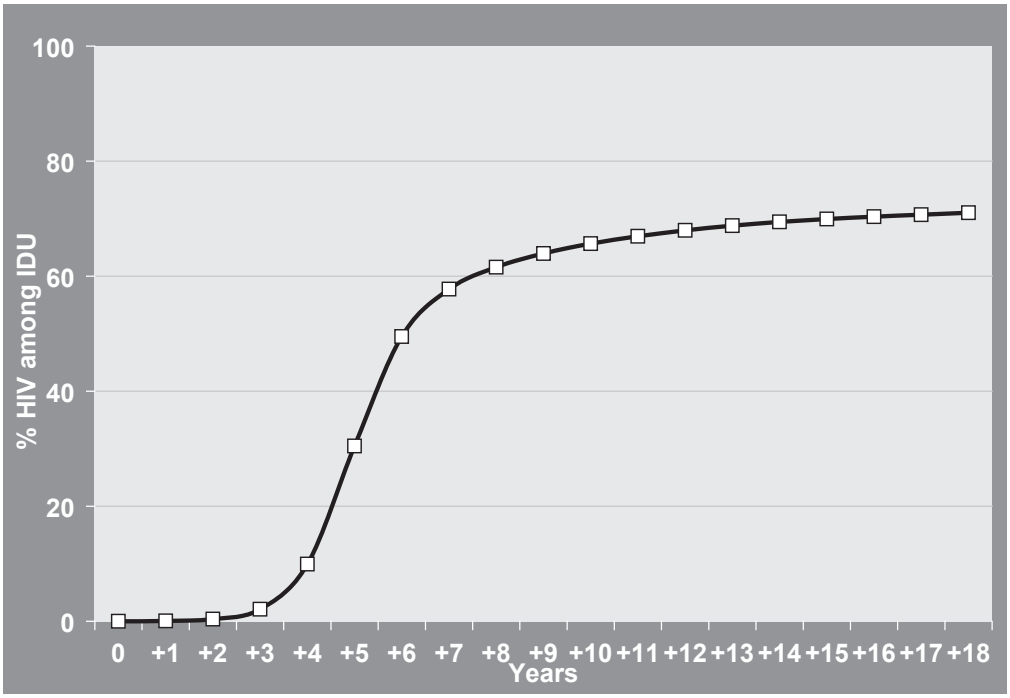
The projected HIV prevalence over time when one HIV infection was introduced into each vulnerable population in Year 0 is shown in **Figure 17**. As mentioned before, since the Dhaka Baseline cannot be fit to observed prevalence trends, it is not yet clear what the exact start year of the HIV epidemic will be, therefore the years are labeled based on the passage of time after HIV was introduced into the different sub-populations in Year 0.

Figure 17: Projections of HIV prevalence in the different at-risk populations considered in the Dhaka Baseline Scenario



The epidemic starts with explosive growth of HIV among IDU, reaching a high prevalence in just a few years, as shown in **Figure 18**. Three years after the introduction of HIV, prevalence has grown to just 2 percent, but then it increases explosively in the next 2 years to 30 percent by Year 5, and finally stabilizes at a level above 70%.

Figure 18: The Dhaka Baseline Scenario: the rise in HIV begins with a rapid rise of HIV prevalence among injections drug users



This pattern is completely consistent with trends in HIV infection observed in IDU populations in other countries in Asia, i.e., after a period of low prevalence HIV rises dramatically and plateaus at an extremely high level [24, 25, 97]. The rapid rise results from the high number of injections per day (about 2.5) [7, 44, 48]. The ultimate level is determined by factors such as the levels of needle-sharing among IDU and the characteristics of their sharing networks, and the turnover in the IDU population. The level above 70 percent obtained in the Dhaka Baseline is quite possible given that according to BSS about three-quarters of injectors used borrowed needles in the previous week, the majority were assumed to be in high risk networks (75%), and it was estimated that those IDU who share needles or injecting equipment do so about half the time [6, 7, 14].

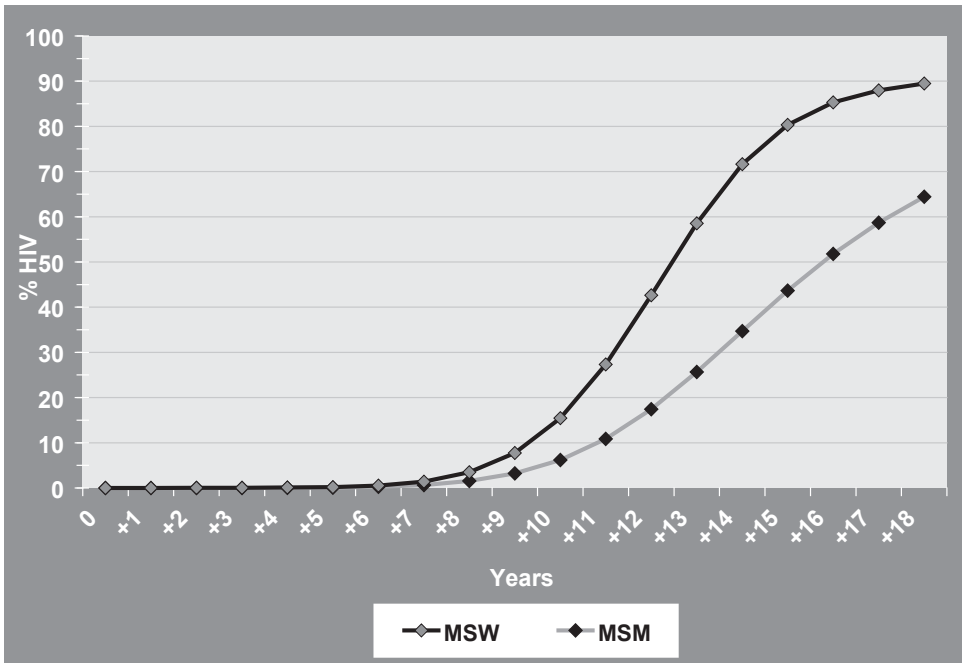
Surveys have found repeatedly that drug injectors in Dhaka are not an isolated population. They interact with other sub-populations through sexual, injecting and other networks [12]; for example, 26% of IDU reported visits to FSW. Hence, the growth of HIV prevalence in IDU 'seeds' the sex work epidemic. The heterosexual epidemic becomes apparent in the Baseline Scenario approximately 2 to 3 years after the IDU epidemic is apparent (**Figure 19**). Prevalence first increases rapidly among HBSW, followed soon after by a sharp rise in prevalence among the street-based and casual sex workers group. HIV prevalence in HBSW reaches 94 percent by the time it starts stabilizing at the end of the projection, while it reaches 85 percent in SBSW. After HIV infection spreads to FSW, prevalence grows steadily over the next 10 years among the clients of sex workers until it is more than 35 percent.

Figure 19: The Dhaka Baseline Scenario: the interlinked injection and commercial sex epidemics

The high HIV prevalence among sex workers in this scenario deserves comment. As mentioned previously, behavioral studies show that FSW in Dhaka City have many more clients per night than sex workers in many parts of Asia. They have low condom use (**Table 2 and Figure 9**) - consistent condom use is less than 5 percent for most groups surveyed - and they have high levels of STDs, all of which facilitate rapid HIV transmission. HBSW are often very mobile, working at one hotel for one week and then moving on to another hotel (or city) the next week [13]. They also tend to stay in sex work for 7 to 8 years on average, which is longer than in many other countries in Asia [16, 26]. These factors working together allow their HIV prevalence to grow quite high.

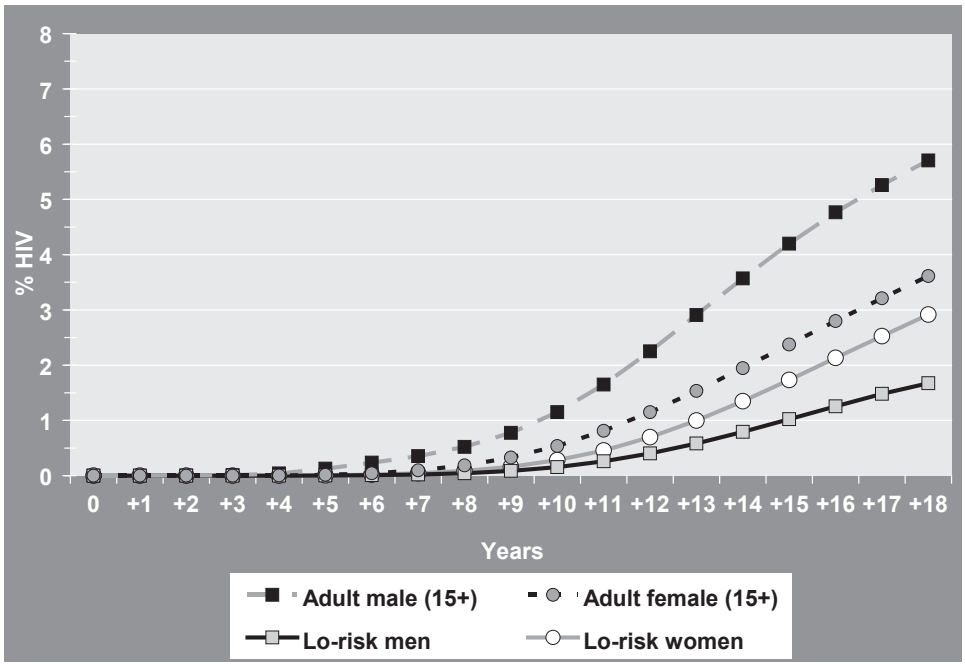
Infection may spread to MSM and MSW through sexual networks in Dhaka, although among those in BSS5 who used drugs other than alcohol in the previous year (3%), a considerable proportion (75%) injected them [14]. Despite trying to generate a conservative baseline by using BSS4 data inputs as described previously, HIV prevalence in MSW reaches saturation at almost 90%, and is at 64% by the end of the projection among MSM and still growing (**Figure 20**). Once again data from BSS support this scenario. Almost all MSM and MSW surveyed at cruising sites engage in anal sex. Eighty eight percent of the MSM reported they bought sex from male sex workers, and MSW reported an average of 9 clients per week. MSM only use condoms with MSW one-quarter of the time, and even less with female sex workers (16 percent), and consistent condom use with MSW is in the 5 to 10 percent range. Hence, it is not surprising that these groups stabilize at such high prevalence since the probability of HIV infection through anal sex is high (set in the model at 1 per 200 sexual acts).

Figure 20: The Dhaka Baseline Scenario: HIV prevalence in MSM and MSW grows to high levels



Largely because of clients, prevalence among adult males in Dhaka will surpass 1 percent about 6 years after IDU prevalence shoots up, and stabilizes at around 6 percent by the end of the projection (**Figure 21**). These men are bound to then infect their wives, resulting in a more gradually growing epidemic among women. All the other male risk groups, including MSM, also report regular and casual female partners. Thus, HIV prevalence in low-risk women reaches more than 1% about 3 years after adult men, and plateaus at approximately 3%, while adult women overall (i.e. including FSW) reaches 4% HIV prevalence.

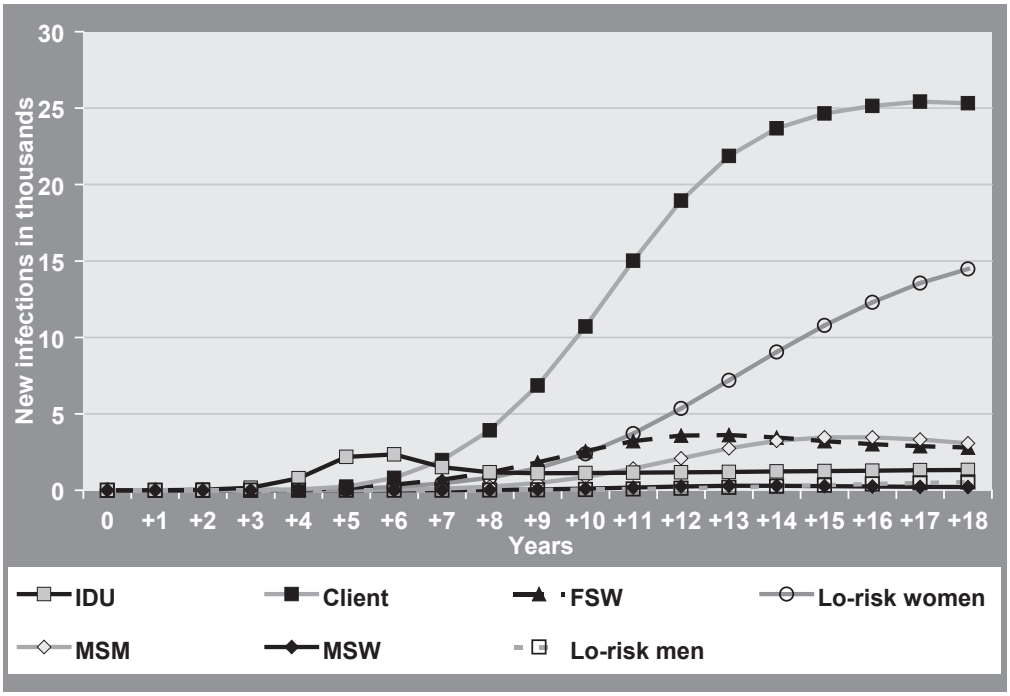
Figure 21: The Dhaka Baseline Scenario: increasing prevalence among low-risk men and women



7.2 New HIV Infections

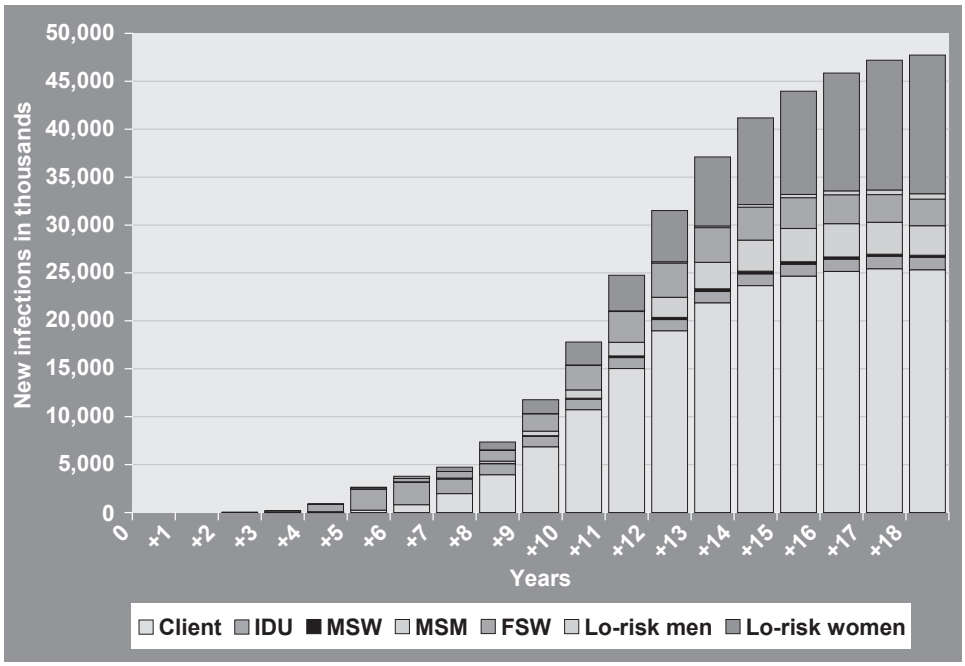
In the AEM Dhaka Baseline new infections among different sub-populations influence the epidemic over the projection period (**Figure 22**). IDU are critically important in the first five years of the epidemic, but by the eighth year clients of FSW dominate new infections. By the tenth year a growing number of new infections start to occur in the low-risk women who are the wives of infected clients of sex workers (**Table 8**).

Figure 22: New infections among the different sub-populations over time in the Dhaka Baseline Scenario



The rapid growth of HIV among the adult male and female populations, and the relative contribution of each risk group are clearer from the proportions of the new infections among the different populations as shown in **Figure 23.** It is clear that the real potential for a substantial HIV epidemic is in heterosexual populations. This is because the sizes of the populations categorized as IDU, MSM and MSW are limited (0.4%, 1%, and 0.04% of adult males in Dhaka, respectively), whereas according to the estimates made for the AEM from the national size estimation and other research, 0.9 percent of women in Dhaka are FSW, and 10 percent of men are clients of these women (approximately 13,250 sex workers and more than 250,000 clients in 2006), for an estimated 7 years at least. Most of these clients are married or will be in the future, creating significant HIV risk for their wives, which leads to increasing proportions of infected low-risk women as the epidemic progresses.

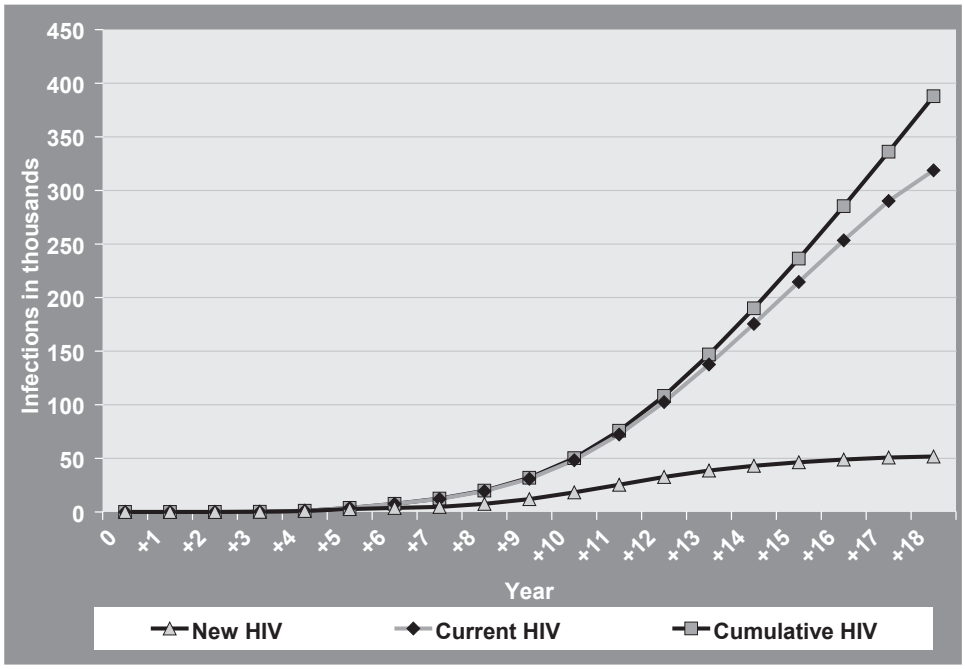
Figure 23: The relative contribution to new infections of the different sub-populations in the Dhaka Baseline Scenario



7.3 Cumulative HIV Infections

Five years after the increase in IDU prevalence is apparent, the model estimates that there will be over 50,000 cumulative HIV infections in Dhaka City Corporation (**Figure 24**). This will include around 18,000 new infections and 48,000 current infections (**Table 8**). By the end of the projection there are an estimated 400,000 cumulative HIV infections in Dhaka City, which would constitute a huge social and economic burden for Bangladesh.

Figure 24: Current, new, and cumulative infections in the Dhaka Baseline Scenario projection



8. Sensitivity Analyses

When there was insufficient data, or when information was not validated through multiple sources, assumptions were made for some of the AEM inputs. To test the validity of these assumptions, and ensure that these inputs did not significantly affect the findings, extensive sensitivity analyses were conducted, i.e., the effect on the AEM of the Dhaka Baseline Scenario of varying the concerned inputs across a reasonable range was examined, keeping all other indicators constant.

The following inputs for which assumptions were made in the model were varied across the indicated ranges, with the final Dhaka Baseline Scenario inputs in parentheses:

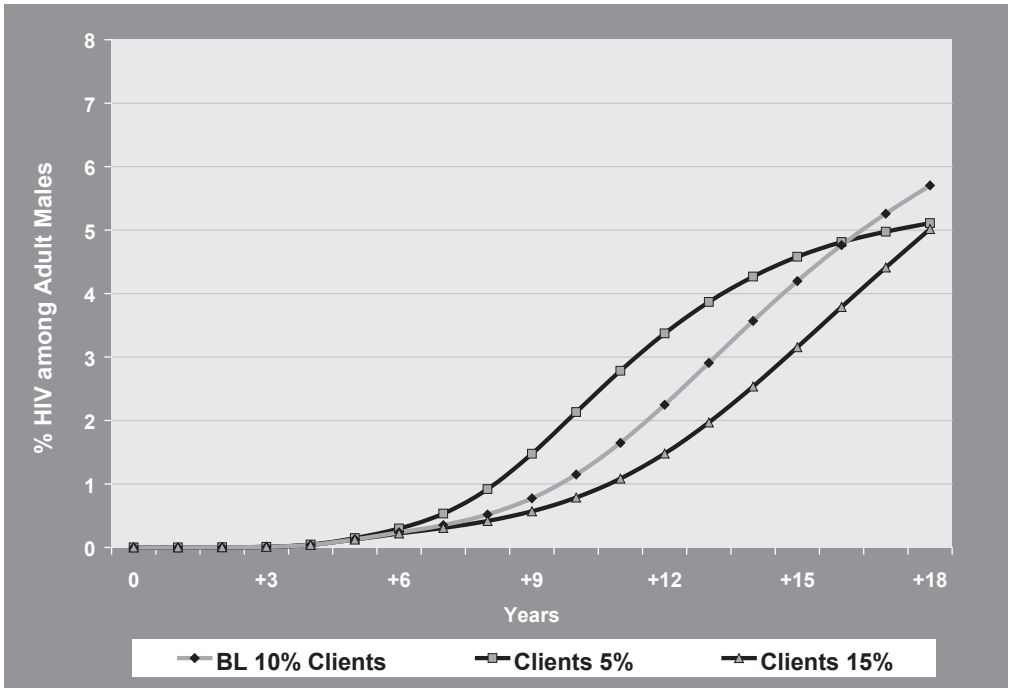
- Proportion of IDU in high-risk sharing networks: 50%, 60%, 75% (Baseline), 80%, 90%;
- Fractions of injections shared by those IDU who share: 33%, 50% (Baseline), 62%, 75%, 80%.
- Client percentages: 5%, 10% (Baseline), 15%;
- Higher and lower STI levels for HBSW: 15%, 30% (Baseline), 60%;
- Male STD cofactors: 10, 20 (Baseline), 30;
- Impact of circumcision: 2.0, 3.0 (Baseline), 4.0;
- Impact of fraction circumcised: 0, 50%, 90% (Baseline);
- Duration of male same-sex behavior: 10, 20 (Baseline), 25 years;
- Transmission parameters were varied between the values:
  - needle-sharing 0.003 to 0.006; (Baseline 0.00425)
  - male to female 0.001 to 0.002 (Baseline 0.002)
  - male to male 0.01 to 0.005 (Baseline 0.005)

The qualitative finding that Bangladesh faces a significant HIV epidemic in Dhaka in the near future was found to be quite robust against the variations tested in the transmission parameters, STD levels, the level of risk behaviors, and the other key inputs. In all cases, the main effect of these parameters on the final projection is to start the HIV increase among adult males a couple of years earlier or later, or to increase or decrease the overall level of infection within a range of 3 to 10 percent.

The results of the sensitivity analyses are briefly listed below:

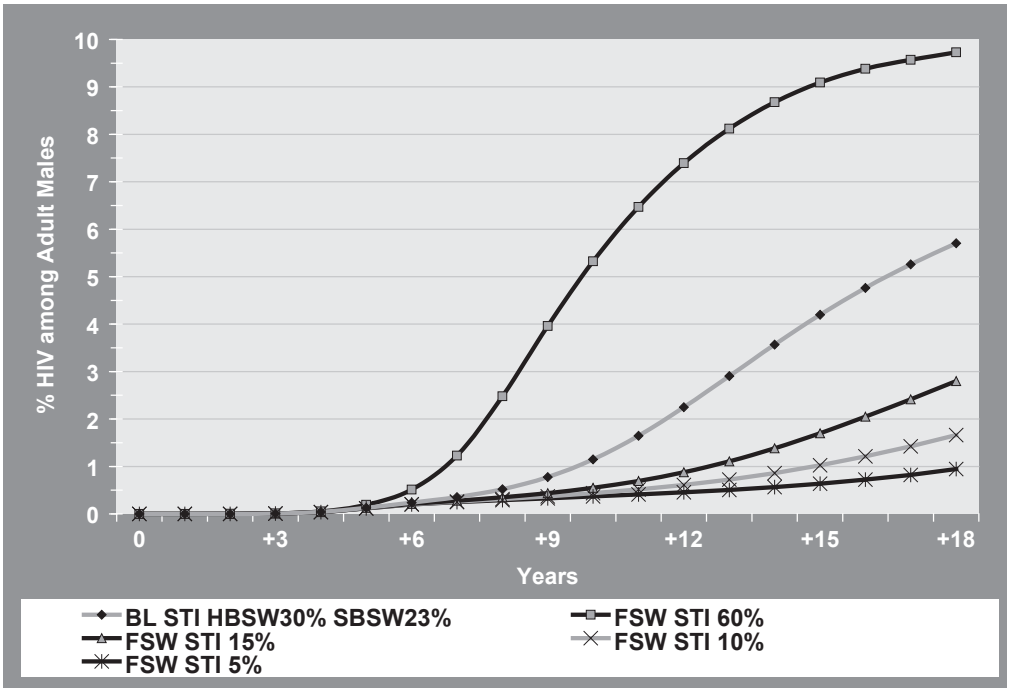
- Both the proportion of IDU in high risk networks and the fraction of injections shared had a minimal impact on the ultimate adult male HIV prevalence by 2020, but the latter can affect the rate of increase in prevalence. If the IDU borrowing needles do so for only a third of their injections, then the increase in HIV among adult males and IDU is delayed by 2 years.
- If 90% of IDU are in high risk networks, then the overall IDU prevalence reaches 81%, but if only half of them are, then HIV increases to 52% among IDU. The fraction of injections shared had less impact on HIV among IDU; it varied from 67 to 74 percent as the fraction was increased from one-third to three-quarters injections shared.
- With a smaller pool of 5% clients visiting FSW, HIV infection in males was accelerated by a year, but the prevalence was already starting to level off at 5% (**Figure 25**). With 15% male clients, the increase in HIV happened a year later, but while the shape of the curve was similar to the baseline, by the end of the projection the prevalence was slightly lower.

Figure 25 : Projected HIV Prevalence among adult males by proportion of adult males having sexual intercourse with FSW



- The Dhaka Baseline was most sensitive to the level of STI among FSW. Halving or doubling the HBSW STI input to 15% or 60% resulted in delaying or expediting the rise in adult male HIV prevalence by 2 years, reaching 3% or 10% HIV among males, respectively, by the end of the projection (**Figure 26**). Prevalence among FSW was obviously sensitive to this input and varied from about 60 to 95% as STI varied from 15 to 60%.

Figure 26 : Projected HIV Prevalence among adult males by STI prevalence rates among FSW



- Changing the male STD cofactor to 10 or 30 resulted in a minus or plus 2 percent change, respectively, in adult male prevalence by the end of the projection.
- Varying the male circumcision cofactor had minimal effect on the male prevalence. However, changing the proportion of males circumcised from 90% to none, or to 50%, resulted in an increase of male prevalence to 10% and 8%, respectively.
- Decreasing the duration of males having sex with other males to 10 years still resulted in high prevalence among MSM, but the saturation level decreased by 8 percent. Increasing duration to 25 years led to a 2 percent higher prevalence than the baseline.

9. Data Limitations

In the process of compiling and synthesizing data to meet the numerous behavioral inputs for the Dhaka Baseline Scenario model, several gaps and weakness were found, and these can impact on the accuracy of the model to various degrees as described above. The main data gaps that have been encountered while building the Dhaka Baseline Scenario with the AEM are briefly described below.

- One of the biggest data gaps for understanding the impact of HIV in Bangladesh is related to the STI information. The national HIV serological surveillance has been monitoring the prevalence of syphilis among high-risk groups as a supporting indicator of sexual risk, which provides some useful information for the last six years. But there is no dedicated STI surveillance system for any of the groups most likely to be HIV infected or among antenatal women. Military conscripts are not routinely monitored for STI, so there is no large database on young men. Information on STI prevalence in general population men and FSW is limited to 2-3 population surveys as described previously. There are more STI studies on married women in rural and urban (Dhaka slums) areas. Overall there are no clear trends to use for AEM for the prevalence of "any STI" among general population males and females, nor is there knowledge on STI age distribution among them. The same is true for male and female sex workers.

- Some of the at-risk population sizes may be underestimated from the data, and the national size estimation exercise acknowledged that 'hidden' populations like non-cruising networks of MSM and non-street-based IDU could have been underestimated, as could residence-based sex workers. This would affect contributions of these sub-populations to the epidemic and the model. It is known that returnee migrants constitute the largest proportion of the officially reported HIV and AIDS cases, but they are not considered in this version of AEM.

- There is insufficient trend data on most of the behavioral indicators required as inputs for the AEM, especially for the years from 1980 to 2000. The Dhaka Baseline Scenario is now based largely on indicators derived from the national BSS which is comparable only for the last two rounds in 2002 and 2003-2004.

- While most of the populations surveyed by BSS were accessed through random time-location sampling, the MSM and MSW at cruising sites were reached through peer-educators from particular interventions. Hence it is unclear how representative the resulting behavioral indicators are of the larger population of MSM. For the AEM the high-risk behavioral inputs of the surveyed MSM were applied to 1 percent of adult men, which is half the proportion who reported male-to-male sex in the last year in the Male Reproductive Health household survey. The Dhaka Baseline should be updated with the results of the recently conducted survey among MSM using the Respondent Driven Sampling method (ICDDR,B) to locate participants, as it might have elicited more representative behaviors.

- For the present Dhaka Baseline Scenario the BBS only supplied information on Dhaka City Corporation from the latest Population Census for the year 2001 broken down by age and sex, and projections were made for the other years from the supplied data. Therefore, for the AEM for Dhaka City to be accepted by the government possibly a formal linkage with the BBS is needed in order to access population projections directly from their database.

Considering the uncertainties in some of the AEM inputs, it is clear that there is an need for better behavioral data in Bangladesh as there are still unknowns. Cross-validation of the behavioral data used, and updating of the model projections as new research resources and further rounds of BSS become available is needed. However as described, the most uncertain indicators were all tested by sensitivity analyses in the AEM and the qualitative finding that there will be a significant epidemic in Dhaka City was largely unchanged.

10. Implications and Suggestions for an Effective Response

The Asian Epidemic Model scenarios presented here all suggest that if the currently recorded risk behaviors found in Dhaka City continue, a substantial HIV epidemic is anticipated. In the absence of stronger prevention efforts than exist today, HIV infections will rise in all the at-risk populations in the city and affect the general population as well, so that adult HIV prevalence approaches 5 percent. Ten years after HIV is introduced, it is estimated that there will be about 20,000 new adult infections, and over 50,000 cumulative HIV infections in Dhaka City, and this could progress if unchecked to around 400,000 cumulative infections over the next 10 years. In a country like Bangladesh this would be a severe epidemic, which would have a huge impact on the country in terms of human and economic costs; and constitute a burden that is likely to be unmanageable given its level of development and financial resources.

According to the projections produced with the AEM, HIV will first increase rapidly, over the space of a few years, to high prevalence levels among drug injectors, who then seed major epidemics in the other risk populations. However, the real potential for spread to low-risk women in the population is through infection from men who are clients of female sex workers, generally their own husbands. *Although various risk populations will influence the epidemic over time, overall men, especially clients, will dominate the epidemic in terms of absolute proportions of new infections.*

The real danger in the heterosexual situation depicted here is that 5 years after HIV in IDU increases, prevalence in sex workers will just start to exceed 20 percent, while prevalence in pregnant women will remain below 0.2 percent. This may not attract serious attention from policymakers and others within the country considering other priorities in public health and other areas. Because no surveillance exists for male populations, the 1 percent in males will remain completely unobserved, as will the rapid growth of HIV among men in Dhaka to 6 percent in the next five years.

It is difficult to assess why if the potential for such an extensive epidemic exists, it has not happened yet. Possibly HIV has not yet been introduced widely in the country into the right networks of risk [98]. In other Asian countries a common pattern observed in IDU epidemics is a long period of low prevalence followed by a sudden rapid increase in infections [24]. Bangladesh may be poised to follow the same dynamics, now that HIV is just beginning to reach epidemic proportions in certain areas of Dhaka City among men who use unclean needles to inject drugs [9, 17, 99]. In simulation models the transmission of HIV in IDU needle-sharing networks is probabilistic, and can show great variability in starting times in non-shooting gallery situations such as Dhaka [100].

In addition, 90 percent of the population in Bangladesh is Muslim [28], thus the large majority of men are probably circumcised, which confers some protection. Large-scale randomized trials in Africa have now been declared to show conclusively that circumcised men have a lower risk of HIV infection than uncircumcised men [91-95]. However, circumcision only slows down the transmission of HIV, it does not prevent HIV. If the slow epidemic start in Bangladesh is due to circumcision and a lag until HIV spreads enough in injection-sharing networks, neither will protect forever in the absence of stronger prevention efforts.

In the process of compiling and synthesizing data to meet the behavioral inputs for the Dhaka Baseline Scenario model, several gaps and weakness were found as described, and these can certainly impact on the accuracy of the model to various degrees. The most uncertain indicators were all tested by sensitivity analyses in the AEM. The qualitative finding that there will be a significant epidemic in Dhaka City is quite robust across allowable ranges of key behavioral and modeling parameters that affect the progress of HIV transmission. However, there is an urgent need for cross-validation of the behavioral data in Bangladesh with results from new population studies and more

rounds of BSS. The AEM is not intended to be a static tool, but needs to be updated as new data emerges, so that it keeps being improved to better reflect the ground situation. The aim of the A^2 project is to build the in-country technical capacity to do this.

It is unclear how the Dhaka Baseline reflects on the nature of the epidemic nationally, but in a densely populated country like Bangladesh it is likely that an HIV epidemic would spread out from there, given the level of internal migration for employment to the capital city, and the mobility of female sex workers and drug injectors. *A clear message from the Dhaka Baseline Scenario is that HIV spread in Bangladesh will remain focused throughout the epidemic in the higher risk populations, and hence, the prevention focus must remain on them.*

Surveillance data from a number of other Asian countries shows that IDU epidemics are often followed by an epidemic of HIV among sex workers and clients [24]. Simulations using the AEM have shown that IDU epidemics in Asia tend to precipitate the heterosexual population epidemic, and the latter grows to larger magnitudes [25, 97]. Thus the majority of resources should remain directed at the higher risk populations in which new infections occur. The experiences of other countries have shown that effective harm reduction and demand reduction programs for IDU can control the start of an epidemic spread through needle sharing. This will buy precious time to strengthen prevention programs for clients and sex workers, who will be the bulk of the Bangladeshi HIV epidemic.

Condoms can substantially reduce the risk of anal sex and sex work - their effectiveness has been repeatedly proven on a global scale in affected communities. Hence extensive and intensive efforts to reduce the number of men visiting sex workers and actively promote the use of condoms in all non-marital sexual relations, especially in those between clients and sex workers should be promoted. There must also be a major push to encourage men who have sex with men to use condoms with both male and female sexual partners.

Other programs and general awareness campaigns could focus on reducing levels of higher risk behaviors among the population at large and higher risk youth, or reducing the stigma and discrimination that interfere with mounting effective prevention programs.

Finally, the Dhaka Baseline Scenario indicates that once the prevalence starts going up among at-risk populations, the spread of HIV will be rapid. Therefore there must be no delay in efforts to overcome the numerous societal and policy barriers to effective prevention programs that still exist, and to achieve the level of coverage that will have an impact.

Bangladesh still has the chance to make the right choices to stop a large-scale HIV epidemic before it starts, or if it starts to quickly reverse its course. But that can only happen by acknowledging the urgency of doing so, and putting resources where they will have the greatest impact in stopping or slowing the HIV epidemic. A failure to take this challenge seriously now will lead to intolerable losses in the future.

Appendix I

List of Tables

Table 1: Trends in adult male and female populations in Bangladesh derived from the Population Census 2001

Year	Males 15+	Females 15+	Age 15	
			Males	Females
1980	933,564	658,394	29,529	27,812
1981	1,038,580	732,457	32,850	30,940
1982	1,087,036	766,630	34,383	32,384
1983	1,137,752	802,398	35,987	33,895
1984	1,190,834	839,834	37,666	35,476
1985	1,246,394	879,017	39,423	37,131
1986	1,304,545	920,028	41,263	38,864
1987	1,365,409	962,953	43,188	40,677
1988	1,429,113	1,007,880	45,203	42,575
1989	1,495,790	1,054,903	47,312	44,561
1990	1,565,577	1,104,120	49,519	46,640
1991	1,638,620	1,155,634	51,830	48,816
1992	1,691,058	1,192,616	53,488	50,378
1993	1,745,174	1,230,781	55,200	51,991
1994	1,801,022	1,270,168	56,966	53,654
1995	1,858,657	1,310,815	58,789	55,371
1996	1,918,137	1,352,763	60,671	57,143
1997	1,979,520	1,396,053	62,612	58,972
1998	2,042,867	1,440,729	64,616	60,859
1999	2,108,242	1,486,834	66,684	62,807
2000	2,175,708	1,534,415	68,818	64,817
2001	2,245,334	1,583,518	71,020	66,891
2002	2,307,938	1,627,669	73,000	68,756
2003	2,372,287	1,673,051	75,036	70,673
2004	2,438,430	1,719,698	77,128	72,644
2005	2,506,417	1,767,646	79,278	74,669
2006	2,576,300	1,816,931	81,488	76,751
2007	2,648,131	1,867,590	83,760	78,891
2008	2,721,966	1,919,662	86,096	81,090
2009	2,797,858	1,973,185	88,496	83,351
2010	2,875,867	2,028,201	90,964	85,675
2011	2,956,051	2,084,750	93,500	88,064
2012	3,038,471	2,142,876	96,107	90,519
2013	3,123,188	2,202,623	98,787	93,043
2014	3,210,268	2,264,036	101,541	95,637
2015	3,299,775	2,327,161	104,372	98,304
2016	3,391,778	2,392,046	107,282	101,045
2017	3,486,346	2,458,740	110,273	103,862
2018	3,583,551	2,527,293	113,348	106,758
2019	3,683,466	2,597,758	116,508	109,735
2020	3,786,167	2,670,188	119,757	112,794

Table 2: Size estimates and Key Behavioral Inputs for High-risk Populations in the Asian Epidemic Model Dhaka Baseline Scenario

Vulnerable Population	Average Duration of Risk Behavior	Estimated Size of Population % 15-49 years adults, time period: estimated number	Key HIV-related Risk Behavior Inputs from 2003 to 2020	Sexually Transmitted Infections Prevalence Inputs from 2005 to 2020
Injection drug users	8 yrs	0.4% of adult males, 2000-2020: 7,500 street-based and 500 others	Average 2.5 injections per day; 75% in high risk networks; 76% borrowed needles last week, with 50% all injections shared; 26% sex with FSW previous month, with 29% condom use at last sex; 1 contact per month with regular partners, with 17% condom use at last sex.	Not required
Female sex workers	7 yrs hotel-based 8 yrs street-based	0.93 % of adult females, 2000-2020: 3,250 hotel-based; and 10,000 street and casual or residence-based	Hotel-based sex workers: weekly average of 5 clients per day, with 25% condom use with clients at last sex; Street and casual/residence-based sex workers: weekly average of 2 clients per day, with 36% condom use with clients at last sex.	Hotel-based sex workers: 30% Street and casual/ residence-based sex workers: 23%
Adult Males	7 yrs Clients of Female Sex Workers	10% Clients of Female Sex Workers, 1980-2020: > 250,000 males aged 15+ in 2006	90% circumcised; 10% visiting Female Sex Workers; 8% having casual sex, average 5 casual contacts per year, with 11% condom use at last casual sex; 1 contact with spouse or regular partner per week, with 4% condom use at last sex.	Adult population: 2%
Men who have sex with men	20 yrs	1% of adult males, 1980-2020: approx. 25,000 males aged 15+ years in 2006	100% anal sex in last year, with 1 anal sex contact per week; 39% condom use for last anal sex with other MSM; 88% visiting male sex workers, with 25% condom use for last anal sex with male sex workers; 28% visiting female sex workers, with 16% condom use at last sex; 47% with other female partners in last year.	Urethral STI: 2% Anal STI: 1%
Male sex workers	6 yrs	0.04% of males, 1980-2020: 1 MSW:25 MSM	100% anal sex with clients in last year, with average 9 anal sex contacts with clients per week; 4% visiting female sex workers in last year; 10% with other female partners in last year.	Anal STI: 10%

Table 3: Behavioral and STI inputs used for particular years in the AEM inputs worksheet for heterosexual populations in Dhaka City

A. Female Sex workers - General	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of females age 15-49 who are sex workers	0.61%	0.77%	0.87%	0.91%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%	0.93%
Percent of sex workers who are higher frequency	13%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%	25%
High frequency to low frequency movement each year	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
B. Hotel-based Sex Workers - Higher frequency group	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Number of clients per day - higher frequency SW	5	5	5	5	5	5	5	5	5	5	5	5
Days worked per week - higher frequency sex workers	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Percent condom use with clients - higher frequency SW	21%	21%	21%	21%	21%	21%	21%	25%	25%	25%	25%	25%
Average duration for higher frequency sex workers (years)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Percent higher frequency SW with STI	40%	40%	40%	40%	40%	40%	40%	37%	33%	30%	30%	30%
C. Street-based and Casual/Residence-based Sex Workers - Lower frequency group	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Number of clients per day - lower frequency SW	2	2	2	2	2	2	2	2	2	2	2	2
Days worked per week - lower frequency sex workers	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Percent condom use with clients - lower frequency SW	25%	25%	25%	25%	25%	29%	33%	36%	36%	36%	36%	36%
Average duration for lower frequency sex workers (years)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Percent lower frequency SW with STI	30%	30%	30%	30%	30%	30%	30%	28%	25%	23%	23%	23%
D. Clients of Female Sex Workers	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of males age 15-49 visiting sex workers in last year	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Average duration of being a client (years)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Percentage of adult males circumcised	87%	87%	88%	88%	88%	90%	90%	90%	90%	90%	90%	90%
E. Male & female casual sex (non-commercial, non-regular partner)	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percentage of males having casual sex in last year	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%	8%
Percentage of females having casual sex in last year	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%	3%
Percent condom use in casual sex	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
Average number of casual contacts in last year (male)	5	5	5	5	5	5	5	5	5	5	5	5
F. Sex with spouses or regular partners (RP)	1980	1990	1996	1999	2000	2001	2002	2003	2004	2005	2006	2007-2020
Number of sexual contacts with spouse or RP (per week)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Percent condom use with spouses or regular partners	1%	2%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Percent adult population with STI	5%	4%	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%

Table 4: Behavioral inputs used for particular years in the AEM inputs worksheet for Male Injection Drug Users in Dhaka City

A. Injecting behaviors	1980	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of adult males 15-49 years of age who inject	0.03%	0.06%	0.23%	0.40%	0.40%	0.40%	0.40%	0.40%	0.40%	0.40%	0.40%
Percent in high risk networks	50%	67%	75%	75%	75%	75%	75%	75%	75%	75%	75%
IDU mortality (additional mortality per year in percent)	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Percent of IDUs sharing	63%	63%	63%	63%	83%	76%	76%	76%	76%	76%	76%
Percent of all injections shared (by those in sharing group)	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%	50.0%
Number of injections each day	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Average duration of injecting (years)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Sharing to non-sharing movement in a year	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%
B. Sexual behaviors	1980	1990	1995	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent visiting female sex workers	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%	26%
Percent condom use with higher frequency sex workers	10%	10%	10%	15%	27%	29%	29%	29%	29%	29%	29%
Percent condom use with lower frequency sex workers	10%	10%	10%	15%	27%	29%	29%	29%	29%	29%	29%
Percent condom use with spouse or regular partner	8%	8%	8%	19%	14%	17%	17%	17%	17%	17%	17%
Number of contacts with regular partners (per week)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25

Table 5: Behavioral and STI inputs used for particular years in the AEM inputs worksheet for Male Same Sex Behaviors in Dhaka City

Men who have sex with men (MSM)										
A. Sexual behavior with non-commercial partners and STI	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of males age 15-49 engaging in same-sex behavior	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
Percent of MSM reporting anal sex in last year	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Number anal sex contacts last week (for MSM w/anal sex)	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Average duration of same-sex behavior (years)	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Percent of MSM with other female partners	47%	47%	47%	47%	47%	47%	47%	47%	47%	47%
Percent condom use in anal sex with other MSM	12%	12%	12%	12%	17%	39%	39%	39%	39%	39%
Percent MSM with urethral STI	5%	4%	3%	2%	2%	2%	2%	2%	2%	2%
Percent MSM with anal STI	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
B. Sexual behavior with commercial partners	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of MSM visiting male sex workers	91%	91%	91%	91%	88%	88%	88%	88%	88%	88%
Percent of MSM visiting female sex workers	34%	34%	34%	34%	28%	28%	28%	28%	28%	28%
Percent condom use in anal sex with male sex workers	16%	16%	16%	16%	25%	25%	25%	25%	25%	25%
Percent condom use with higher frequency female SW	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
Percent condom use with lower frequency female SW	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
C. Male sex workers (MSW)										
MSW size and duration	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of males age 15-49 who are male sex workers	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%	0.04%
Average duration of male sex work (years)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
Shifts from MSM to MSW	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Sexual behaviors and STI with clients	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent of MSW reporting anal sex with clients in last year	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Number anal sex contacts last week (for MSW w/anal sex)	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
Percent MSW with anal STI	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Female partners of MSW	1980	1990	2000	2001	2002	2003	2004	2005	2006	2007-2020
Percent MSW visiting female sex workers in last year	1%	1%	1%	1%	1%	4%	4%	4%	4%	4%
Percent MSW with other female partners in last year	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%

Table 6 : Age distributions for fertility

Age	Age-specific Fertility rate
0 - 4	0.0000
5 - 9	0.0000
10 - 14	0.0000
15 - 19	0.1440
20 - 24	0.1880
25 - 29	0.1650
30 - 34	0.0990
35 - 39	0.0440
40 - 44	0.0180
45 - 49	0.0030
50 - 54	0.0000
55 - 59	0.0000
60 - 64	0.0000
65 - 69	0.0000
70 - 74	0.0000
75 - 79	0.0000
80+	0.0000

Table 7: HIV prevalence inputs used in the worksheet for different sub-populations considered in the Asian Epidemic Model

Sub-Population	Month-year %	HIV+
Hi-frequency sex workers:	11/6/2002	0.20%
	11/30/2003	0.00%
Lo-frequency sex workers:	2/7/1999	0.00%
	5/14/2000	0.20%
	6/2/2001	0.50%
	11/6/2002	0.20%
	11/30/2002	0.20%
	5/23/2003	0.20%
Injecting drug users:	2/7/1999	2.50%
	4/14/2000	1.40%
	6/2/2001	1.70%
	11/6/2002	4.00%
	11/30/2003	4.00%
	5/23/2005	4.90%
Men who have sex with men	2/7/1999	0.20%
	5/14/2000	0.00%
	6/2/2001	0.00%
	11/6/2002	0.20%
	11/30/2003	0.00%
	5/23/2005	0.00%
Male sex workers	6/2/2001	0.00%
	11/6/2002	0.00%
	11/30/2003	0.00%
	5/23/2005	0.00%
General population males:	5/31/1996	0.20%
	2/7/1999	0.00%
	4/30/1999	0.00%
	6/2/2001	0.00%
	3/23/2002	0.00%
	11/30/2003	0.20%
	5/23/2005	0.00%
General population females:	5/31/1996	0.10%
	6/1/1999	0.00%
	4/30/1998	0.00%
	12/31/1998	0.00%
	6/1/1997	0.00%

Table 8: HIV infections in Dhaka City over the years as projected by the Asian Epidemic Model

Total Epidemic	Year 0	Year 1	Year 5	Year 10	Year 15	Year 18
New HIV infections	0	7	2,657	18,246	46,448	51,754
Current HIV infections	3	10	3,759	48,305	214,545	318,692
Cumulative HIV infections	0	7	3,789	50,186	236,432	387,792

Appendix II

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