Evaluation of the epidemiological impact of harm reduction programs on HIV in Vietnam

2010

THE UNIVERSITY OF NEW SOUTH WALES

JOINT UNITED NATIONS PROGRAMME ON HIV/AIDS

UNHCR UNICEF WFP UNDP UNFPA UNODC ILO UNESCO WHO WORLD BANK

PEMA Partnership for EpideMic Analysis

Acknowledgements

This report is a joint product of

- the Vietnam Administration for HIV/AIDS Control;
- UNAIDS;
- World Bank;
- University of New South Wales;
- Partnership for Epidemic Analysis;

and was carried out in a collaboration between UNAIDS, the World Bank Office in Hanoi, and the Global HIV/AIDS network of the World Bank in Washington DC, USA.

The authors wish to thank

- Dr. Nguyen Thanh Long, Director of Viet Nam Administration for HIV/AIDS Prevention and Control (VAAC), for guidance and support;
- The Viet Nam study team, consisting of senior researchers
    - Dr. Phan Thu Huong, Viet Nam Administration for HIV/AIDS Prevention and Control (VAAC),
    - Dr. Nguyen Minh Tam, Viet Nam Administration for HIV/AIDS Prevention and Control (VAAC),
    - Dr. Le Cu Linh, Hanoi School of Public Health,
    - Dr. Nguyen Anh Tuan, the National Institute of Hygiene and Epidemiology (NIHE);
- The Viet Nam National data collation team:
    - Mr. Le Tong Giang, Viet Nam Administration for HIV/AIDS Prevention and Control (VAAC),
    - Dr. Pham Duy Quang, Viet Nam Administration for HIV/AIDS Prevention and Control (VAAC),
    - Dr. Do Thai Hung, Pasteur Institute in Nha Trang,
    - Mr. Tran Xuan Bach, Hanoi Medical University;
- Colleagues from Provincial AIDS Centers from the provinces that were included in the evaluation of the epidemiological impact of harm reduction programs, and members of

the Viet Nam National Strategic Information and Monitoring and Evaluation Technical Working Group (in particular FHI and Abt Associates) for their support and provision of data;

- Dr. David Wilson and Ms. Nguyen Thi Mai both from The World Bank, and Dr. Vladanka Andreeva and Dr. Cam Anh Nguyen, from the Joint United Nations Programme on HIV/AIDS (UNAIDS) in Vietnam for their assistance with coordination of communication with stakeholders in Vietnam, and collaboration across the project including the approach, interpretation of data, and presentation of this report.

The research of this report was conducted by a team of investigators.

Partnership for Epidemic Analysis

Dr. Virginia Loo, independent consultant

- Conducted the review of intervention coverage, ecological analyses, and contributed to preparation of the report.

The University of New South Wales, Sydney, Australia

Dr. David Wilson, Dr. Lei Zhang

- Led the mathematical modeling analyses and preparation of the report.

Dr. Rosie Thein, Dr. Richard Gray, and Ms. Amy Kwon

- Provided technical modeling support, conducted literature reviews, and compiled parameters for the mathematical modeling.

Ms. Louisa Wright

- Copyedited the report.

Contents

Executive summary

Vietnam's HIV epidemic is concentrated, both in specific behavioral sub-populations and geographic regions. The key populations at higher risk for HIV infection in Vietnam are female sex workers (FSW) and their clients; injecting drug users (IDU); and men who have sex with men (MSM). Vietnam identified harm reduction interventions for IDU and FSW as a key component of its last 5-year National HIV strategy 2004-2009. Harm reduction interventions aim to reduce the dominant behavioral risk factors that facilitate transmission of HIV in Vietnam, namely, sharing injecting equipment and engaging in unprotected sex. The main service components of harm reduction for these groups include the distribution of free sterile needle-syringes and condoms and providing behavior change communication through peer educator-based outreach. As the next phase of programming is planned and resources allocated, it is important to assess the achievements of previous programs aimed at minimizing risk of infection in terms of coverage and epidemiological impact.

Objectives and approach

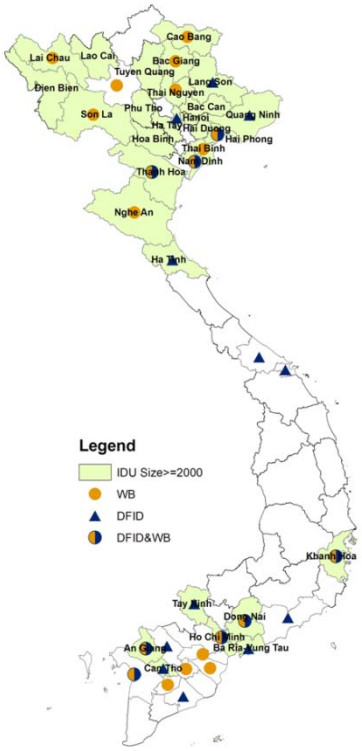
This impact assessment study has the following objectives:

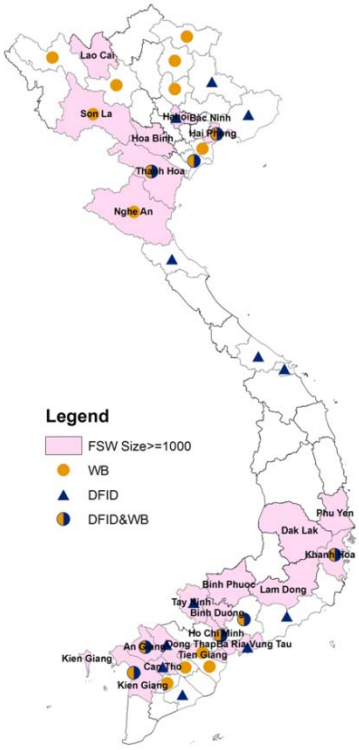
- To examine coverage of harm reduction interventions in Vietnam among IDU and FSW (programs targeted for MSM were not examined) from 2004-2009;
- To understand the HIV transmission dynamics in Vietnam and to estimate the extent to which harm reduction interventions among core groups have contributed towards epidemiological trends and reduced HIV transmission in Vietnam during the 2004-2009 strategy.

The primary geographic unit of analysis for program coverage and likely impact was province level. Through ecological analysis and epidemic modeling, the assessment explored the plausibility of intervention impact on epidemic trajectories. By estimating the likely number of infections averted compared with coverage levels, the effectiveness of programs across the country could also be used to predict the expected impact of introducing new programs or further expanding existing programs.

Assessment of program coverage

Harm reduction interventions for IDU and FSW have been in place at limited scale in some provinces since 2001. Large-scale harm reduction programs in 32 provinces receiving U.K. Department for International Development (DFID) and/or World Bank (WB) support began in 2004/5 and are the primary subject of this assessment (see maps below). Interventions for MSM have been implemented in some areas, but are not at the same scale or formality as for IDU and FSW, and program monitoring data are not available. The impact of MSM interventions is not assessed in this study.





Assessment of program coverage concluded that:

- All but four provinces, of 32 provinces assessed, have nearly or more than 2000 IDUs or 1000 FSWs.
- Nine provinces without DFID or WB support had more than 2000 IDUs and nine had more than 1000 FSWs (seven of these provinces have both large numbers of IDUs and FSWs).
- These numbers provide a strong case for expanding harm reduction interventions to more

areas.

Even in provinces which have harm reduction interventions, there is room to expand coverage. The most reliable and consistently available indicators of program coverage across provinces and the assessment time period were free commodity distribution. It was found that:

- Levels of needle-syringe and condom distribution increased substantially over the 5 year period, 2005-2009.
- According to WB project targets of 240 condoms per FSW per year and 200 sterile needle-syringes per IDU per year,
    - 12 of 32 provinces exceeded levels of "good coverage" for FSW interventions;
    - 7 of 32 provinces exceeded levels of "good coverage" for IDU interventions.

The following table shows provinces with the largest numbers of IDU and FSW along with the highest annual level of commodity distribution achieved by the programs during 2005-2009.

	Estimated IDU size (2008)	**Estimated HIV prevalence among IDUs (2005 HSS)**	**N/S per IDU (year*)**	**Estimated FSW size (2008)**	**Estimated HIV prevalence among FSWs (2005 HSS)**	**Condoms per FSW (year*)**
HCMC	34,000	47%	16 (2008)	30,000	12%	28 (2009)
Hanoi	37,900	28%	113 (2008)	4800	13%	210 (2008)
Son La	28,000	NA	5 (2009)	1100	NA	59 (2009)
Bac Giang	8636	11%	58 (2008)	800	1%	218 (2009)
Hai Phong	8300	58%	**203** (2008)	3000	25%	**750** (2008)
Thanh Hoa	8200	26%	**251** (2008)	1500	7%	**500** (2007)
Nghe An	6700	34%	65 (2008)	1400	7%	**270** (2009)
Lang Son	6000	29%	124 (2008)	300	4%	**777** (2007)
Tay Ninh	2800	NA	82 (2008)	3000	NA	29 (2009)
An Giang	2200	26%	106 (2008)	2400	9%	**286** (2009)

* the year in which the highest level of per-capita condom distribution was achieved. Numbers in bold indicate that WB project targets of 240 condoms per FSW per year or 200 needle-syringes per IDU per year were achieved.

Ecological results

Ecological analysis assessed whether high levels of commodity distribution was reflected in declining or stabilizing trends in HIV prevalence:

- Sentinel surveillance data suggested that in almost all provinces HIV prevalence trends among IDU began declining prior to 2005.
    - Thus, it was not surprising that in 12 of 19 provinces with sufficient data, relatively high levels of per capita needle-syringe distribution (i.e. >100 needle-syringes per IDU) corresponded with stable or declining prevalence trends among IDU.
- There was a weak relationship between commodity distribution and impact on epidemic trends among FSW.
    - In eight of 15 provinces with sufficient data, high condom distribution and a continued low/stable HIV prevalence trend was observed.
    - In several provinces, declining or stable HIV prevalence trends were observed despite low levels of commodity distribution.

Epidemic trajectories naturally have dynamic profiles. Therefore, purely examining trends in prevalence is insufficient for assessing the success of programs. Due to the complex interactions and background factors associated with epidemic and behavioral trends, epidemic modeling can be valuable to understand the underlying transmission dynamics of HIV in each province and evaluate the true extent to which the harm reduction programs have contributed to mitigating the spread of infection.

Modeling results

A standard population-level mathematical transmission model was developed to describe HIV epidemics in Vietnam. The Vietnam HIV Model (VHM) was developed in a manner to be specifically customized to represent the unique situation in Vietnam and to evaluate harm reduction programs that have been implemented. Provincial models were developed for: HCMC, Hanoi, Hai Phong, Da Nang, An Giang, Can Tho, and Dien Bien. Provinces were selected

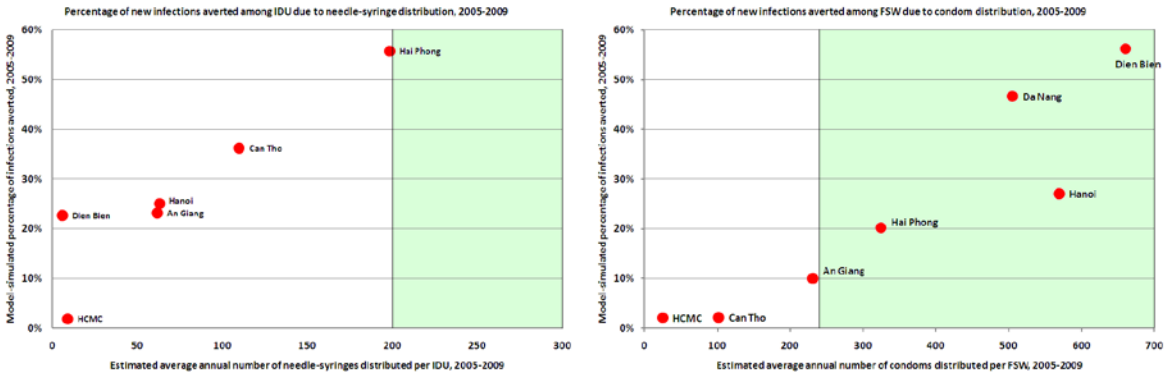
based on which had sufficient biological, behavioral, and program data. These seven provinces represent a wide variety of epidemic contexts, geographic distribution, and types of intervention support.

The VHM was designed to fit observed behavioral and program coverage data simultaneously to biological data. It assumed that increasing commodity distribution would lead to a decrease in the number of shared injections or unprotected commercial sex acts:

- Despite program data indicating large increases in commodity distribution, behavioral trends measured through two rounds of IBBS (2005/6, 2009/10) have been disappointing.
    - In all but one province included in the modeling analyses, there was an increase in reported sharing of needle-syringes among IDU in 2009 compared to 2005.
    - Assuming reliability and representativeness of data, this trend suggests that there may have been other external factors influencing engagement in risk behaviors.
    - To indirectly account for any underlying behavioral risk patterns, the VHM relied primarily on program coverage data to determine how much additional unprotected sex and sharing of injecting equipment would likely have occurred without the availability of needle-syringes and condoms distributed by the programs. The potential numbers of infections averted were then calculated.

The modeling results from seven provinces suggest that harm reduction programs:

- Averted between 2-56% of infections among both IDU and FSW, depending on the level of program coverage achieved.
- Due to prevention of infections in the population groups directly targeted with the harm reduction programs, chains of transmission to other population groups have been reduced by averting up to 39% of infections (in Hai Phong).



Based on the results of modeling evaluations across seven provinces over the period 2004/5-2009 (figures above), generalizations can be made about future program levels.

- ***If program coverage targets (>200 needle-syringes per IDU and >240 condoms per FSW) are reached, it can be expected that more than 50% of infections among IDU and more than 20% of infections among FSW would likely be averted.***

Limitations of the analysis

All aspects of these analyses are dependent on the use of existing data. Many of the data sources used have some issues of data quality or completeness that influence the confidence with which the results are presented. The main report and technical annexes explore issues of data quality and their implications on the assessment results in more detail. However, it is useful to note that the size estimates of FSW and IDU, program coverage data as well as biological trend data have wide margins of uncertainty, which would be important to address to allow more robust assessment of intervention effects in the next phase of the national strategy.

Recommendations

Although harm reduction programs have been introduced in numerous provinces of Vietnam for the purposes of reducing sharing rates and decreasing unprotected sex, these risk behaviors still occur at levels that facilitate moderately high levels of HIV transmission. Harm reduction programs that distribute free needle-syringes and condoms are immensely valuable and have been shown in this report to be effective in mitigating epidemics. Given that many provinces have not yet reached their targets of 'good' coverage, and the majority of FSW and vast majority of IDU report that they are not being reached by the peer educators with free needle-syringes and condoms, there is still need for expansion of programs coverage. For example, only two of the eight provinces with more than 6000 IDU have distribution levels exceeding 150 needles/syringes per person; and 13 provinces have more than 1000 IDU and/or FSW and no large-scale harm reduction services in place. Concerted scale-up of services is required in HCMC due to the large numbers of people at higher HIV risk.

Summaries of specific recommendations from this report include:

- *Improve data collection and analysis of size estimation of key populations at higher risk for HIV infection (e.g., IDU, FSW, MSM), as well as for the male clients of FSW, program monitoring statistics, and sentinel surveillance.*
- *Introduce harm reduction programs in all provinces with large numbers of IDU and/or FSW and improve levels of coverage within provinces with programs, giving highest priority to regions with greatest numbers of key populations at higher risk of HIV infection*
- *Establish national guidance on the package of services, quality standards, and coverage targets for harm reduction services*
- *Conduct operational research to understand technical efficiency and why implementation works in some regions*
- *Strengthen training and supervision of peer educators to improve coverage of individuals and distribute commodities efficiently.*

Introduction and background

Since the mid-1990s, HIV epidemics have occurred among specific sub-populations, leading to a concentrated epidemic in Vietnam. The government of Vietnam and its key development partners recognize HIV as a major health and development threat and have marshaled increased national and international resources to contain the epidemic. One of the country's greatest challenges is to ensure the additional financing available enables Vietnam to mount a cost-effective, evidence-based, well-evaluated and prioritized HIV response.

The key population groups at risk in Vietnam's concentrated HIV epidemic are female sex workers (FSW) and their clients; injecting drug users (IDU); and men who have sex with men (MSM). Sentinel surveillance data for these groups have been collected since the early 1990s and suggest that HIV remains relatively low among most groups of FSW, but has increased relatively rapidly over the past two decades in most provinces with a visible population of IDU. Infections among IDU account for approximately 60% of reported HIV cases but they indirectly contribute to an even larger percentage, through overlapping networks among IDU who pay for sex and FSW who inject, as well as secondary infections to other population groups. More recently, sentinel surveillance data from numerous provinces suggests that some HIV epidemics appear to have declined or stabilized; however, this is not consistent across all regions. Although sentinel surveillance is not conducted among populations of MSM, recent exploration of the rates of HIV in this group through integrated behavioral and biological surveys (IBBS) suggest the existence of high-risk behaviors in this segment of the population. In 2005/2006, HIV prevalence among MSM in Ha Noi and Ho Chi Minh City (HCMC) was 9% and 5% respectively. According to the UNAIDS/WHO estimates and projections program models (2007 EPP report, published in 2009), HIV prevalence in the general population aged 15-49 was estimated to be 0.43% in 2009. By 2007, there were an estimated 293,000 people living with HIV in Vietnam.

HIV prevalence is highest in Vietnam's two economic hubs; specifically, the Haiphong-Hanoi corridor of the Red River delta and the Mekong delta, including HCMC, which alone has approximately one-quarter of Vietnam's reported HIV infections. Thus, Vietnam's epidemic is

highly concentrated, both in specific behavioral sub-populations and geographic regions.

Vietnam's HIV response

Vietnam has implemented two medium-term plans, the first from 1993 to 2000; and then its first national strategy was developed in 2004. The strategy, which emphasizes policy reform, capacity building, coordination, surveillance, prevention, and treatment and care, provides development partners with a clear policy framework within which to work. It is due to be updated in 2010/11 to provide direction for a renewed implementation phase.

Domestic and international resources to control HIV have grown significantly in recent years, from approximately US$5 million in 2000, to over US$66.3 million in 2007. According to the National AIDS spending study, conducted for the 2010 UNGASS country report:

- Bilateral donors contributed the largest share, at 66.5% of total AIDS spending. The U.S. Government, primarily through CDC and USAID, supported national, provincial, district and civil society capacity building, advocacy, surveillance, voluntary counseling and testing and behavior change communication. The U.K. Department for International Development (DFID) funded a national condom social marketing program (with the German Government) and from 2004 to 2009, supported harm reduction activities in 21 provinces.
- The international development banks (Asian Development Bank and the World Bank) contributed nearly 12% of total AIDS spending. ADB programs included capacity building and behavior change communication. The WB originally funded harm reduction activities for IDU and FSW in 20 provinces, expanding to ten more provinces in 2010 as part of a consolidated WB/DFID harm reduction program.
- United Nations agencies, coordinated by the Joint UN Programme on HIVAIDS (UNAIDS), contributed about 4.5% of AIDS spending. Much of these funds supported national and decentralized capacity building initiatives to manage and implement HIV programming.
- The Global Fund for AIDS, TB, and Malaria (GFATM) contributed 3.5% of total AIDS spending, financing HIV prevention and AIDS treatment programs in 20 provinces.

Approximately 13% of HIV/AIDS spending comes from government budgets (approximately 9.5% through central funds and 2.5% through provincial budgets) and the rest from external sources.

Given the concentrated nature of the epidemic, the National AIDS Control Strategy prioritizes the speed, scale and coverage of harm reduction interventions. As the current phase of programming is ending, assessing the achievements in coverage is a critical measure of the effectiveness of the response and the ability to effectively utilize available resources. In particular, matching high levels of coverage to areas where there are large populations of IDU, FSW and clients is critical in a diverse epidemic.

Achievements of the program

Notwithstanding these challenges, Vietnam has had notable success in its response to the HIV epidemic, including focused policies and programs to address vulnerability among FSW and clients, MSM, and IDU. For example, political barriers hindering effective HIV responses have been progressively overcome by stronger commitment of the government through the development of the National Strategy on HIV/AIDS Prevention and Control in Viet Nam and the Law on Prevention and Control of HIV/AIDS, Decree 108. As a result, a comprehensive range of HIV services including needle and syringe programs and methadone maintenance therapy can now be implemented and expanded. A single national executing and coordinating body has been established while multisectoral cooperation and coordination is to be further strengthened. A national monitoring and evaluation framework has been developed, including establishment of ambitious coverage targets for harm reduction, and routine HIV reporting systems. Resources have also been mobilized to provide care for people living with HIV/AIDS (PLHIV) and treatment for those with AIDS.

Rationale and objectives of the current study

While there are initial indications from sentinel surveillance data and epidemic models (EPP) that HIV epidemics may have begun to stabilize among some populations of injecting drug users

and sex workers, there have been no rigorous studies of the extent to which the harm reduction interventions that form the foundation of the national program have directly contributed to these trends. The Vietnam Administration for HIV/AIDS Control (VAAC) and its development partners wish to assess the likely impact of harm reduction interventions in the country thus far and determine whether resources are being used effectively. Experiences from the past six years of implementation should also inform future implementation, management and evaluation of harm reduction interventions. This study examines program coverage and also conducts analyses based on all available surveillance and programmatic data, in conjunction with a sophistical mathematical model designed for this evaluation exercise, to estimate the effectiveness of the programs across a number of Vietnamese provinces. The findings and recommendations of this study will be used to inform the prevention strategy for the next 10 years.

The impact assessment study has the following objectives:

- To examine coverage of harm reduction interventions in Vietnam among IDU and FSW[1];
- To elucidate HIV transmission dynamics in Vietnam, including a description of regional differences within Vietnam, and to demonstrate to what extent implementation of harm reduction interventions among core groups in Vietnam have contributed towards epidemiological trends and reduced HIV transmission in Vietnam.

Impact assessment approach

To meet these objectives, the impact assessment has been divided into three main areas:

1. Review the intervention history and intensity of harm reduction programs from 2004/5 to 2009 is conducted:

- By the key populations at higher risk for HIV infection (e.g., IDU, FSW);
- By geographic area;

[1] Although MSM are recognized to be an important group for prevention interventions, during the study period of the assessment, formal programming for MSM was not being implemented in most areas to the same scale as for IDU and FSW. Consequently, reliable program data for capturing these activities were not available for the analysis.

- By intervention partner.

2. Plausibility of intervention impact on epidemic trajectories is explored through ecological analysis of the:

- Timing of intervention versus changes in epidemic trajectory;
- Relationship between intensity of intervention and changes in HIV prevalence trends.

3. Estimation of the likely epidemiological impact of the harm reduction programs is assessed through epidemic modeling by:

- Comparing the current scenario with expected epidemic trajectories if the programs were not implemented (e.g. estimating infections averted)
- According to (i) program data on units distributed and (ii) changes in risk-related behavior;
- By key populations at higher risk for HIV infection (estimating direct and indirect prevention of infections);
- In areas of different intervention intensity or epidemic conditions.

By estimating the likely number of infections averted compared with coverage levels, the effectiveness of programs across the country can be used to predict the expected impact of introducing new programs or further expansion of existing programs. Estimations of infections averted can also be used to derive a gross measure of cost-effectiveness which can be compared to other programs and interventions from the region. The results from these analyses are synthesized to form the basis of recommendations for improving the scale-up, scope, and quality of interventions in the future.

Methodology

Scope of the assessment

In Vietnam, harm reduction programs offer a variety of prevention services for both IDU and FSW. However, there is no national guideline defining the basic package of services that should be included in a harm reduction for either group. Through discussion with program managers and review of progress reports and implementation plans, a list of services was compiled that appears to be common to the harm reduction programs implemented (i.e. supported by WB and DFID) (see Table 1). This list is consistent with regional best practices for services considered to be effective prevention interventions for most-at-risk populations.

Table 1: Package of services for harm reduction programs included in the WB/DFID program in Viet Nam

IDU	FSW
o Needle/syringe distribution	o Condom distribution
o Condom distribution	o Peer outreach
o Peer outreach	o Mapping
o Mapping	o Interpersonal behavior change communication
o Interpersonal behavior change communication	o Drop-in Centers
o Drop-in centers	o Advocacy (provincial and/or local levels
o Advocacy (Provincial and/or local levels)	o STI clinic services (screening and/or syndromic management)
o Oral substitution therapy (Methadone) and drug detoxification	

FSW who also inject drugs have access to a combination of services relevant to both FSW and IDU. In some provinces, the same peer educators conduct outreach and commodity distribution

to both FSW and IDU. The degree of coverage of specific components of the package varies considerably between provinces that provide harm reduction programs. The services listed in Table 1 are considered as part of the impact assessment. Services such as VCT, basic care and support or treatment, mass media education, and large scale condom social marketing, are not explicitly included in the assessment of impact.

In addition to harm reduction services provided in community settings, some populations are managed in 05 and 06 Centers.[2] Individuals may be placed in these centers for durations of between a few weeks to several years. In each province the policy and enforcement of the ordinance authorizing 05/06 Centers varies resulting in different proportions of IDU and FSW who are in the community compared to who are in the centers. Conditions related to risk behavior and HIV epidemiology in the 05/06 Centers are different to those in the community. Consequently, the proportion of key populations at higher risk found in the centers and the duration of stay can greatly influence transmission dynamics in these groups overall. Estimates of the size of the populations of IDU and FSW are also influenced by the proportion of these groups actively managed in the centers, those who are managed in the community, and those who attempt to stay hidden from local authorities.

Together, DFID and the World Bank fund the largest scale harm reduction program activities in Vietnam. Both programs channel funds through the Vietnam government, which implements the program at the provincial level, overseen by the Provincial AIDS committee. At both the central and provincial level, a specific harm reduction management structure has been established. In addition to Provincial AIDS committee staff, teams to support the field work and outreach staff include program managers as well as monitoring and evaluation specialists, financial, and administrative staff. Harm reduction programs are in place in 12 provinces funded by the World Bank, 13 provinces funded by DFID, and eight provinces where both donors fund activities (see Figure 1 in the following chapter). In jointly-supported provinces, the program

[2] Under the Ordinance on Administrative Violations 04/2008/PL-UBTVQH12, drug use and sex work are administrative violations and result in detention for up to two years in centers managed by the Ministry of Labor, Invalids and Social Affairs (MOLISA). These centers are referred to as 05 Centers for female sex workers and 06 Centers for drug users.

avoids overlaps through clear designation about which donor funds activities at the district or commune level.

In addition to the WB and DFID activities, the US government also funds peer outreach activities and condom distribution through a program called Life-GAP. No needles and syringes are distributed as part of this program, although behavior change counseling does occur with IDU populations. The US government programs currently span 29 provinces, scaled up from four provinces in 2001 and reaching a peak of 40 provinces in 2005. Many of the provinces targeted by these programs are the same as those in which there are WB and/or DFID programs.

The impact assessment associated with this report reviews the WB and DFID harm reduction program over the period of 2004/5 to 2009. However, harm reduction was in place for some time before this in selected large provinces such as HCMC, Hanoi, and Hai Phong. The WB and DFID projects began in 2004 but did not reach full implementation until late 2005/early 2006. The DFID project ended in 2009 and much of the DFID-supported commodity distribution and outreach through peer educators were phased out completely by the middle of the year.

Although increasingly recognized as an important population requiring harm reduction services, the prevention services for MSM over the period covered in this impact assessment consisted of small scale add-ons to existing harm reduction programs. Due to a lack of specific program data, the mathematical models included MSM as an important aspect of provincial transmission dynamics but the contribution of harm reduction services on the epidemic trajectory of this group could not be assessed.

Use of existing data

The impact assessment relied heavily on collation of existing data from available documents, reports, and data files. Some of the key data sources include results from sentinel surveillance sites, integrated biological and/or behavioral surveys conducted among IDU, FSW, and MSM in selected provinces, population size estimates of IDU and FSW provided by MOLISA, and program monitoring data from the harm reduction programs.

Other efforts were made to collate the epidemiologic and program data relevant to the HIV epidemic in Vietnam recently or during the same time period as the current assessment. This includes a project to produce the estimates and projections program (EPP) indicators, conducted under the leadership of VAAC, with technical support from NIHE, FHI, WHO and UNAIDS, as well as a coordinated effort by VAAC, NIHE, FHI, PEPFAR and UNAIDS to increase data triangulation capacity in-country. These efforts, particularly the production of estimates and projections, have involved substantial efforts to review the quality of various data sources and to develop consensus around appropriate adjustment and correction factors to develop an understanding of the epidemic which is more realistic. Participants in this consensus process at both central and provincial levels have included individuals involved with the primary data collection and persons with experience implementing harm reduction programs and working with IDU, FSW, and MSM. In addition, international consultants with surveillance and modeling expertise from the region have facilitated these discussions and helped the group decide on the final inputs used in the EPP models.

To make best use of these extensive discussions, the impact assessment of this study reviewed the primary published reports and data of specific studies, as well as the notes and final synthesized inputs. Interviews with key individuals in the Vietnam EPP exercise were critical to better understanding of how these data and the resulting figures should be interpreted and used in the present exercise.

Given the importance of understanding and interpreting the existing data sources, the impact assessment team consulted with research institutes and provincial level program managers to verify information, particularly with respect to the population size estimates and program monitoring data available. A detailed description of the primary and secondary data sources available and their strengths and limitations are provided in a technical annex to this report.

Protocol development and implementation process

The terms of reference and study protocol were developed, reviewed and approved by the Viet Nam National Strategic Information and Monitoring and Evaluation Technical Working Group, chaired by the VAAC. VAAC convened a senior advisory group for the study, approved the selection of international consultants and appointed a team of national consultants, representing north, south and central regions. After an initial review of available data, the study team prepared a more detailed approach for the analysis and modeling. This was presented to the advisory group and the larger monitoring and evaluation technical working group for feedback and input. Preliminary results of the ecological analysis and tables of input parameters for the modeling were shared in a third meeting of the senior advisory group and the monitoring and evaluation technical working group, as well as with provincial level representatives for further inputs, corrections, and comments. A fourth meeting of the monitoring and evaluation technical working group was convened to review the final results of the impact assessment, before completion of the final written report.

Team Composition

This impact assessment team was led by the VAAC Monitoring & Evaluation and Harm Reduction Departments and included three components:

- A senior study team, consisting of senior researchers from VAAC, the Hanoi School of Public Health, the National Institute of Health and Epidemics (NIHE), WB and UNAIDS,

- National data collation team to support the gathering and verification of data sources which could be used in the impact assessment. Members were selected to allow broad geographic coverage: a member of the VAAC M&E department covering the Northern provinces, a researcher with the HCMC Pasteur Institute covering the Southern provinces, and a researcher with the Nha Trang Pasteur Institute covering the Central region.
- A team of international consultants with expertise in surveillance, epidemiology and modeling to support the more in-depth analysis and interpretation of findings.

The results of the impact assessment are provided in the following two chapters. The first results chapter reviews the intervention coverage over time at the provincial level, as well as the surveillance trends and their correlation, providing ecologic plausibility for the effect of harm reduction on the epidemic. The second results chapter describes the findings of the Vietnam epidemiological transmission model developed for this study, including the estimated number of infections averted in selected provinces, which may be attributable to the intervention. Each chapter begins with a short description of the specific analytic method used to address the key study objectives. Greater technical detail on each analysis is provided in the Technical Annexes.

Review of intervention coverage and associations with sentinel surveillance data

This chapter presents the analytical method and results of the history of scale-up and intensity of harm reduction programs for IDU and FSW in Vietnam. Correlations in intervention coverage and epidemiological trends among IDU and FSW are also examined ecologically.

Analytical approach

The primary unit of analysis was province, which is consistent with the structure in which the responsibility for management and implementation of harm reduction programming rests. At a gross level, the adequacy of the response is determined by whether the provinces with large numbers of FSW and IDU have harm reduction programs in place. If resources are insufficient to place harm reduction services in all areas where there is need, provinces with greater vulnerability should be prioritized in terms of the resources available for implementing programs. The next level of analysis considers whether the level of coverage is adequate within provinces where harm reduction exists, in order to meet the demand.

Service coverage can be measured in multiple ways, but only a few indicators are the focus of this assessment. The set of indicators used in the analyses was determined by the availability of reliable program monitoring data throughout the time period of the assessment in the provinces with harm reduction activities. These key indicators include:[3]

- The number of free distribution condoms given out each year;
- The number of free needle and syringe units (N/S) given out each year.

[3] The number of outreach contacts made to FSW and IDU is included as a core indicator of the harm reduction program. However, these data are less complete and are more difficult to collect in a standardized manner, making it difficult to interpret and compare as a measure of scaled-up service.

In many provinces, the number of districts and communes with harm reduction programs for FSW or IDU each year and the number of peer educators hired in each year are available. These data are used to look at whether increased distribution of commodities is consistent with geographic expansion of services and staffing for outreach services.

Ideally the adequacy of scale-up is defined according to the distribution and size of the beneficiary population in the province and their need for commodities. For example, harm reduction services in one province may cover only six of 15 districts, but determining whether this constitutes good coverage depends on whether there are IDU and FSW in sizeable numbers in more than six of those districts, and whether the six districts covered by programs are consistent with the six districts with the largest number of IDU or FSW. For the most part this level of detail, e.g. size estimates for IDU and FSW at district or commune level and the listing of specific districts/communes where services are present, was not available for the impact assessment. Instead, the numbers of commodities distributed at the provincial level are compared to the estimated size of the IDU and FSW in the province. The resulting values, the number of condoms per FSW distributed annually and the numbers of needles/syringes per IDU annually, are compared to the estimated number of risk acts, or need.

The current standard for condom need used by the WB harm reduction programs is 20 condoms per month per FSW or 240 per year. There is no specific standard for the number of needle-syringes to be distributed per month per IDU. But guidance from UNAIDS/WHO on target setting for IDU prevention interventions suggest that a threshold of 200 needle-syringes per IDU per year is considered very good. The data on average numbers of injections and commercial sex acts per month are available from survey data, such as the IBBS. In Table 2 the range of results from four rounds of survey data is presented. These numbers fluctuate greatly from year to year, suggesting some uncertainty in the reliability of this measurement. In general, the free condom and needle-syringe distribution targets used in this analysis represent a moderate, achievable level of meeting expected need, provided need is calculated from

behavioral data.

Table 2: Estimated % of acts covered by condom and needle/syringe distribution targets

	An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Ha Noi	HCMC	Quanh Ninh
Karaoke-based SW								
Estimated # commercial acts per year*	824-1002	360-1125	252-1125	244-1002	626-2304	827-1256	629-1840	318-1125
% acts covered by 240 condoms per year	19-29%	21-67%	21-95%	24-98%	10-38%	19-29%	13-38%	21-75%
Street-based SW								
Estimated # commercial acts per year*	708-1450	837-1572	551-1036	659-1450	297-1858	420-1316	621-3164	435-1450
% acts covered by 240 condoms per year	17-34%	15-29%	23-44%	17-36%	13-81%	18-57%	8-39%	17-55%
People who inject drugs								
Estimated # injections per year*	326-637	586-756	173-456	236-843	540-1004	491-981	860-926	562-714
% acts covered by 200 N/S per year	31-61%	26-34%	44-116%	24-85%	20-37%	20-41%	22-23%	28-36%

*Estimated number of sex acts and injections come from behavioral surveys conducted in selected provinces in 2000, 2002, 2005, and 2009. Values presented are the low and high value among the results from the four time points. Note that in these surveys, street-based sex workers and karaoke-based sex workers are sampled separately. However, in the current analysis these groups are treated as a combined group of FSW.

All aspects of this analysis depend heavily on the population size estimates of the FSW and IDU populations as key inputs for assessing whether the response is adequate and appropriate for the level of need in each province. Although there are several sources of population size estimation data, many uncertainties remain about the true size of each key population at higher risk. For the quantitative part of this analysis a set of consensus adjusted population size estimates for IDU and FSW, as used in the EPP 2007 analyses, were used. This provides some consistency between other efforts of data synthesis and modeling already adopted in country as well as by the epidemic modeling component of this impact assessment. Technical Annex 1

provides a discussion of the data sources available for the population size estimates and impact assessment.

Peer educators do not focus exclusively on members of their own peer group, and free condoms are distributed to both IDU and FSW. However, due to lack of more detailed information, the following simplifications are made about the program monitoring data used to measure the response:

- FSW peer educators conduct outreach to other FSW and IDU peer educators conduct outreach to other IDU;
- All free distribution is given out through peer educators and free condoms are given primarily to FSW.

More detailed examination of the strengths and limitations of the program monitoring data used in these analyses are provided in Technical Annex 1. Given the lack of information to adjust the data, these analyses are suggestive of the levels of coverage but are subject to some imprecision.

The pattern of scale-up of services in each province is then compared to the crude trends in the HIV prevalence of the relevant risk group, given by sentinel surveillance data, to assess plausibility in the impact of the intervention on changing transmission dynamics. The provinces are classified roughly into four groupings, each for IDU and FSW, as shown in Table 3.

Table 3: Classifications for coverage-epidemiology trends

IDU	Declining/ stable prevalence trend	Increasing prevalence trend	**FSW**	Declining/ stable prevalence trend	Increasing prevalence trend
High/ adequate coverage	I	II	High/adequate coverage	I	II
Low Coverage	III	IV	Low Coverage	III	IV

Provinces which are categorized in the upper left cell (I) for each table must be further assessed in terms of the timing of harm reduction reaching substantial scale compared to inflection points in the HIV prevalence trends. If data indicates provinces are categorized in groups II or III then it suggests either there are other factors impacting the trajectory of the epidemic or that the measures of program coverage and/or HIV prevalence may be unreliable.

Key Results

1. Are harm reduction interventions in the provinces with large numbers of IDU and FSW?

Overall, 32 provinces received either DFID or WB support for harm reduction over the period of 2004-2009.[4] The median number of IDU in each province was 1800, while the median number of FSW was 700. All of these provinces, receiving WB and/or DFID financial support, have greater than 2000 IDU or 1000 FSW, except for three: Ben Tre, Hau Giang, and Vinh Long. Large

[4] Although the WB and DFID programs are the largest donor supported harm reduction programs, prevention activities have been growing in other provinces. In 2009, eight provinces that do not have programs supported by the WB or DFID reported distributing more than 10,000 N/S to IDU and 38 provinces reported distributing more than 10,000 free condoms. However, because reliable and complete program monitoring data were not available for the entire assessment period from these provinces, they were not included in this assessment.

numbers of IDU and FSW are also estimated to exist in provinces without the support from harm reduction interventions from WB and DFID. Eighteen provinces have more than 2000 IDU[5] while nine provinces have more than 1000 FSW; of these, seven provinces have both large numbers of IDU and FSW, suggesting a strong case for the need to introduce harm reduction interventions (see Figure 1). This suggests there is further need for scaling up harm reduction services in a number of provinces. However, current harm reduction interventions appear to generally be in appropriate places, i.e. provinces with large populations of FSW and/or IDU.

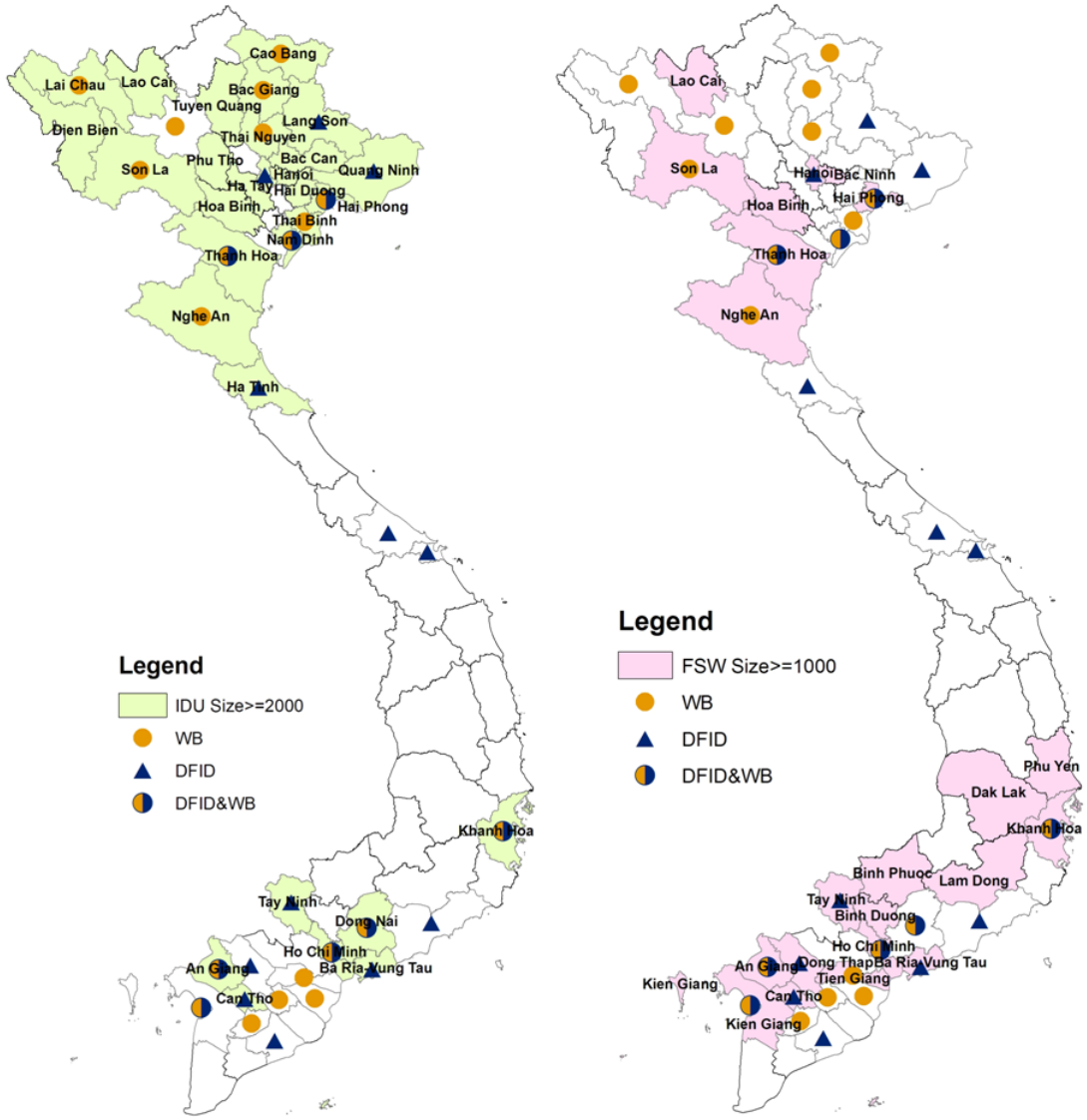


Figure 1: Map of Vietnam indicating provinces with harm reduction programs sponsored by WB/DFID, color-coded according to IDU and FSW population sizes

[5] Data from two provinces, Bac Lieu and Ha Nam, do not appear to be reliable.

2. How adequate is coverage of harm reduction programming in provinces with interventions?

Overall, the average number of condoms and needles/syringes distributed rose steadily between 2004/5 and 2008 (Figure 2). Condom distribution increased to a much higher level than needle/syringe distribution. For most provinces the largest increases in per capita commodity distribution occurred between 2007 and 2008. The numbers reported in 2009 dropped substantially in most provinces, due to the discontinuation of DFID-supported projects in early 2009.[6]

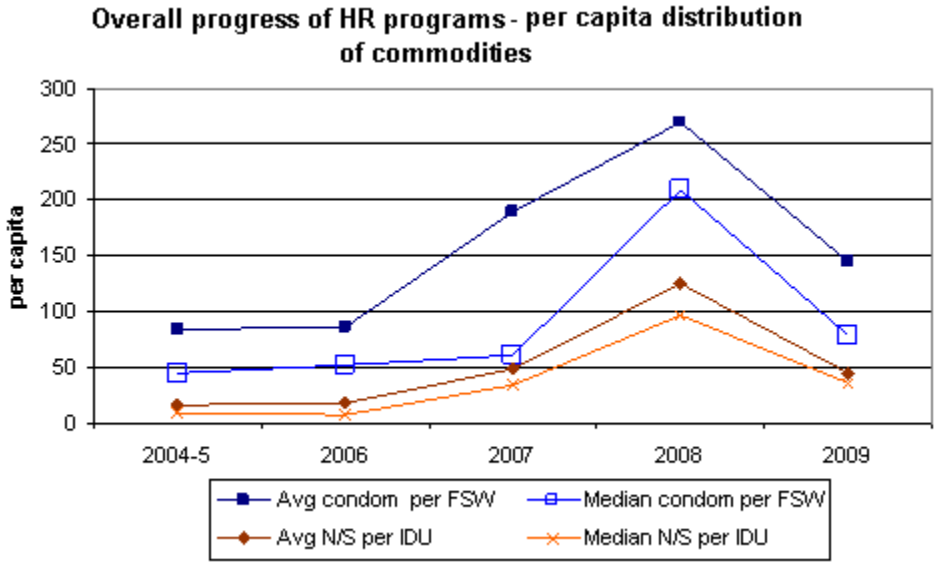


Figure 2: Estimated per-capita distribution of condoms and needle-syringe units over time, 2004-2009, for 32 provinces with WB or DFID supported harm reduction programs

In general, DFID supported provinces scaled-up distribution of condoms sooner than WB supported provinces, which is consistent with the staggered start of the respective projects. By 2008, the level of condom distribution was similar in both DFID- and WB-supported provinces (Figure 3).

[6] Since that time, the WB project has consolidated with the DFID project and initiated the second phase of its work, and in many provinces has filled the temporary gap left by DFID.

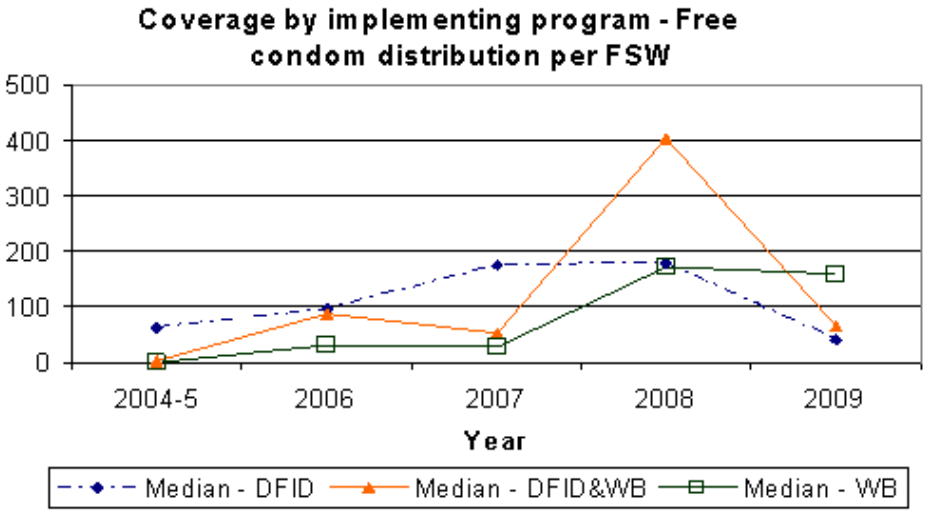


Figure 3: Estimated annual per-capita distribution of condoms to FSW, 2004-2009, grouped by whether provinces had DFID and/or WB harm reduction program

The presence of both projects in the same province did not seem to enhance the level of free commodity distribution. A similar pattern in distribution of needles/syringes per IDU was observed, in which distribution in WB-supported provinces was lower than in those provinces supported by DFID, and did not exceed the levels of coverage achieved by DFID-supported provinces until 2009, when the DFID project ended (Figure 4).

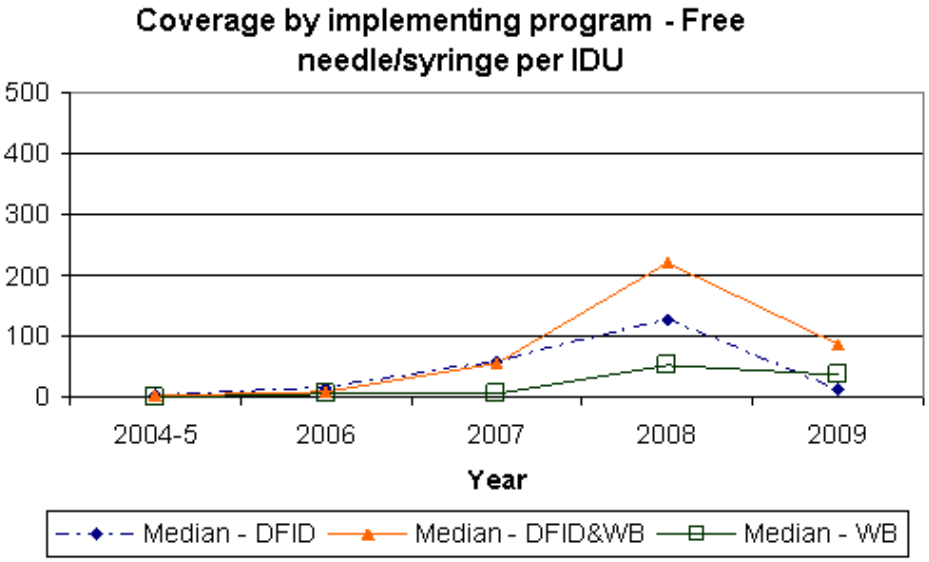


Figure 4: Estimated annual per-capita distribution of needle-syringes to IDU, 2004-2009, grouped by whether provinces had DFID and/or WB harm reduction program

With respect to assessing commodity distribution against the WB targets (Table 2), five of 12 DFID-only supported provinces, four of the eight jointly supported provinces, and three of the 12 WB-supported provinces exceeded condom distribution of 240 per FSW by 2008. It is worth noting that in some provinces supported by DFID, the numbers of condoms distributed per FSW greatly exceeded the 240 program target. In four DFID-only supported provinces (Binh Thuan, Ha Tinh, Lang Son, Soc Trang) and four jointly supported provinces (Dong Nai, Hai Phong, Nam Dinh, and Thah Hoa) the per capita number of free condoms distributed exceeded 500 per FSW per year.

These large numbers and outliers in condom distribution could suggest inaccuracy in the size estimates of the population, inaccuracy in the program monitoring data, or high levels of wastage of commodities distributed. For example, Hai Phong reported 750 condoms per FSW per year in 2008; however program monitoring data for this province fluctuates greatly, showing 13 condoms per FSW per year in 2007 and 19 condoms per FSW per year in 2009. Furthermore, the number of peer educators dropped from 82 to 60 between 2006 and 2007 and remained at these levels in 2008. This suggests that program coverage measures in Hai Phong are not reliable. Condom distribution numbers in Ha Tinh were rounded to the nearest 10,000, suggesting that data are not based on specific counts. And in Dong Nai, the condom distribution numbers in 2007 were reported to be 800 per FSW per year, but only nine FSW peer educators were working during this time, suggesting more than 8500 condoms distributed by each peer educator per month. In any case, the assessment of coverage in these provinces may not be reliable for assessing impact and conclusions should be drawn carefully.

A smaller number of provinces achieved high levels of needle-syringe distribution per IDU. Seven of the 32 donor supported provinces distributed more than 200 needle-syringes per IDU per year; all seven of these provinces had total or partial DFID support. Only two provinces with WB-only support (Yen Bai and Vinh Long) distributed more than 100 needle-syringes per IDU in a given year.

From a country perspective, it is useful to examine whether areas of high levels of commodity distribution coincide with provinces where the numbers of FSW and IDU are the largest or

where HIV prevalence has already been measured at high levels among these populations. For example, HCMC has the largest size of FSW and IDU, but relatively low levels of per capita condom (84 per FSW in 2009) and needle-syringe distribution (32 per IDU in 2008). Over time, free commodity distribution in HCMC has increased steadily, but this low level of coverage reflects the challenges of reaching such a large population, and understanding how best to achieve coverage with a large array of service providers. In contrast, Hanoi appears to have achieved much higher levels of condom and needle-syringe distribution despite its large numbers of FSW and IDU. Saturated coverage in provinces with the largest concentrations of FSW and IDU may be an important strategy for prioritizing management and resource allocation as harm reduction programming continues to scale-up. Factors which allow some provinces (e.g. Hai Phong and Thanh Hoa) to distribute greater numbers of needle-syringes to large numbers of IDU may be helpful for increasing coverage in other critical provinces.

Table 4 provides a summary of the levels of coverage of the provinces (that have harm reduction programs) with more than 6000 IDU or 2000 FSW.

Assessing the levels of achievement in per capita distribution of commodities depends heavily on the choice of the estimated size of FSW or IDU populations. These populations are hidden, mobile, and continually changing, which makes it difficult to ascertain a reliable measure of size. The set of population size estimates used in this analysis are derived from the consensus of technical experts adjusting the size of MOLISA-based estimates. The results of per capita coverage used the upper estimates of population size as the denominator. If the low population size estimates were used, then a much larger proportion of provinces would seem to exceed the 240 condoms per capita per year and many more provinces would also have distributed more than 200 needle-syringes per IDU. At the same time, using these lower numbers for population size estimates also results in unexpectedly high levels of commodity distribution, which appear unrealistic. For example, more than a third of the provinces would have distributed more than 1000 condoms per FSW estimated per year. It may be more likely that the actual population size estimate lies between these two extremes. Using the high population size estimates provides a more conservative and measured assessment of program achievements. But until more reliable and robust size estimates become available, it is difficult

to come to a definitive conclusion.

Table 4: Estimated per-capita distribution of needle-syringes and condoms to IDU and sex workers.

	Estimated IDU size (2008)	N/S per IDU (year*)	Estimated FSW size (2008)	Condom per FSW (year*)
HCMC	34,000	16 (2008)	30,000	28 (2009)
Hanoi	37,900	113 (2008)	4800	210 (2008)
Son La	28,000	5 (2009)	1100	59 (2009)
Bac Giang	8636	58 (2008)	800	218 (2009)
Hai Phong	8300	**203** (2008)	3000	**750** (2008)
Thanh Hoa	8200	**251** (2008)	1500	**500** (2007)
Nghe An	6700	65 (2008)	1400	**270** (2009)
Lang Son	6000	124 (2008)	300	**777** (2007)
Tay Ninh	2800	82 (2008)	3000	29 (2009)
An Giang	2200	106 (2008)	2400	**286** (2009)

*the year in which the highest level of per capita condom distribution was achieved.
Provinces are in order of the largest IDU populations. Bold numbers highlight those provinces where distribution exceeded the target. Cells shaded in grey indicate provinces with less than 6000 IDU or 2000 FSW.

Another issue to consider in interpreting per capita calculations of needle-syringe distribution is the stability of the population size. For example, calculations of per capita needle-syringe distribution in HCMC are further complicated due to a change in the policy for detention of IDU in 06 Centers, which resulted in large numbers of IDU being released into the community over the time period of the assessment. Size estimates of IDU, forming the denominator of the per capita estimates, were taken from 2008 data and do not reflect a growing IDU population.

These large fluctuations in the size of the IDU population that need services in the community may also be present in other provinces.

3. How consistent are levels of program coverage with trends in HIV prevalence among FSW and IDU?

Baseline HIV prevalence: Among FSW, sentinel surveillance results suggest that in a majority of provinces where data are available, HIV prevalence remains low to moderate (i.e. below or near 5%). In Dong Nai, Nghe An and Binh Duong raw sentinel surveillance measures have exceeded 5% more than once. In large cities such as Hanoi, HCMC, An Giang, and Can Tho HIV prevalence among FSW ranges between 10 and 20% and is even higher in Hai Phong.

Among IDU, HIV prevalence levels are generally considerably higher than for FSW, ranging between 20 and 40%. However, in Dong Thap and Thua Thien Hue, HIV prevalence among IDU remains relatively moderate, at around 10% or below. The crude prevalence trends among IDU fluctuate substantially over time, and are more likely to reflect the difficulty in obtaining systematic, comparable samples over time, rather than representing actual fluctuations in prevalence among the IDU group. Nonetheless, in some provinces steep declines in HIV prevalence have been measured from sentinel surveillance among IDU, often starting in 2001 or 2003.

Comparing trends in HIV prevalence to timing of program coverage scale-up: There are 18 provinces for which there are both sentinel surveillance trend data and program coverage estimates (a further 10 provinces have harm reduction programs but insufficient data to assess whether there is evidence for a relationship between program coverage and impact on the HIV epidemic because of unreliability of biological trends). In eight provinces, more than 200 condoms per FSW were distributed for free by the end of the 2009 and a declining or low/stable HIV prevalence trend was observed (Table 5). This is consistent with the notion that condom distribution helped to maintain stable HIV prevalence among FSW. However, provincial patterns suggest only a weak association between high condom distribution and positive effects on the HIV prevalence trend.

In five provinces low/stable prevalence trends remained, despite much lower levels of condom distribution. In two provinces, including HCMC, HIV prevalence trends declined despite low condom distribution. Some explanations for this inconsistency in pattern include that size estimates for FSW in these provinces are too high, that FSW who have particularly high risk for HIV transmission/acquisition are well targeted and benefiting from either free condom distribution or socially marketed condoms, or that a larger proportion of condoms used during paid sex are purchased by clients of sex workers. Despite high levels of condom distribution in Binh Thuan and Hai Phong, the sentinel surveillance data showed slight increases in HIV prevalence measured among FSW. As discussed in the previous section, per capita condom distribution is relatively high in these two provinces, suggesting that some data for calculating this indicator may be unreliable and condom coverage may not be as high as program data suggest.

Table 5: Categorization of provinces according to levels of per-capita condom distribution among FSW compared with HIV prevalence trends.

Annual program distribution level	HIV prevalence trend		
	Declining	**Low/Stable**	**Increasing**
>500 condoms per FSW		Nam Dinh (1185) Lang Son (777) Ha Tinh (718) Soc Trang (638)	Binh Thuan (1150) Hai Phong (750)
200-500 condoms per FSW	An Giang (286)	Vinh Long (327) Bac Giang (218) Hanoi (208)	
<200 condoms per FSW	Quanh Ninh (165) HCMC (28)	Da Nang (187) Kien Giang (154) Thua Thien – Hue (117) Ba-Ria Vung Tau (68) Can Tho (68)	Thai Nguyen (50)

Insufficient information: Dong Nai, Tay Ninh, Dong Thap, Ben Tre, Cao Bang, Lai Chau, Nghe An, Son La, Khah Hoa, Thanh Hoa. The colored text indicates provinces for which the trend in prevalence precedes the increase in program coverage. Values in parenthesis indicate the highest level of condom distribution per FSW per year measured.

The correlation between HIV prevalence trends and commodity distribution is stronger among IDU than for FSW. Twelve of the 19 provinces with sufficient data show relatively high levels of

per capita needle-syringe distribution (i.e. >100 needle-syringes per IDU) and corresponding stable or declining prevalence trends. While these patterns are consistent, many of the provinces in this grouping observed declines in prevalence prior to the scale-up of interventions and commodity distribution (highlighted in the table in red). Five provinces show similar declines or stabilization in trends with less than 100 needle-syringes distributed per IDU. Thanh Hoa shows continually increasing HIV prevalence trends despite more than 250 needle-syringes distributed per IDU in 2008.

Table 6: Categorization of provinces according to levels of per-capita needle-syringe distribution among IDU compared with HIV prevalence trends. (

Annual program distribution level	HIV prevalence trend		
	Declining	**Stable**	**Increasing**
>200 needle-syringes per IDU	Nam Dinh (315) Kien Giang (292) Soc Trang (234) Hai Phong (203)	Can Tho (246)	Thanh Hoa (251)
100-200 needle-syringes per IDU	Vinh Long (133) Binh Thuan (129) Lang Son (124) Hanoi (113)	Ha Tinh (153) Thua Thien-Hue (107) An Giang (106)	
<100 needle-syringes per IDU	Khanh Hoa (90) Ba-Ria Vung Tau (79)	Nghe An (65) Bac Giang (58) HCMC (16)	Thai Nguyen (81)

Not enough information: Quanh Ninh, Dong Nai, Tay Ninh, Dong Thap, Ben Tre, Cao Bang, Hau Giang, Lai Chau, Son La, Yen Bai, An Giang, Da Nang. The colored text indicates provinces for which the trend in prevalence precedes the increase in program coverage. Values in parenthesis indicate the highest level of N/S distribution per IDU per year measured)

Overall, the ecological analysis of the effect of commodity distribution in HIV prevalence trends is mixed. This is partly due to both the general declines/stable HIV prevalence trends observed among FSW and IDU, which often began prior to 2006. It could also be due to instability in both the measures of HIV prevalence trends through sentinel surveillance as well as in the calculation of per capita commodity distribution. The ecological association between commodity distribution and prevalence trends is stronger for IDU populations that for FSW.

The weaker relationship between free condom distribution and prevalence trends among FSW may be due to the large number of socially marketed condoms available in many provinces. According to the DFID project final report, more than 170 million condoms were distributed through social marketing in the 21 project provinces between 2005 and 2008, which is 30 times the volume distributed free through peer educators. However, not all of these socially marketed condoms were targeted for HIV or STI prevention, i.e. for high risk sex acts. Condom social marketing data for some provinces is available from the VAAC central database and may reflect the portion targeted for use during commercial sex acts. These data suggest that the number of socially marketed condoms sold may have resulted in total condom numbers which were two to five times higher than the number of reported free condoms distributed. This includes several provinces where low free per capita distribution was reported but declines in prevalence were observed among FSW in sentinel surveillance data (i.e. in An Giang, Quanh Ninh, and HCMC). These data also suggest that when free distribution of condoms first scaled up in 2004/5 that in a few provinces the volume of socially marketed condom sales dropped significantly (e.g. Quanh Ninh, Soc Trang, HCMC, Hai Phong). These patterns suggest some caution in how free distribution of condoms are rolled out in provinces with a history of strong condom social marketing, to avoid the cannibalization of a market for condoms which people are willing to pay for.

One of the limitations to using per capita commodity distribution as a measure of program coverage is that it is not sensitive to the actual number of IDU or FSW who may be reached by free distribution. The impact on the epidemic may be quite different if a large number of commodities reached a few people, compared to the same number distributed to a large proportion. Data from the 2009 IBBS survey indicates that overall 47% of FSW and 15% of IDU reported being reached by HIV prevention interventions. These relatively low levels of coverage suggest that even if high levels of commodities are distributed, a large number of key populations at higher risk for HIV infection may not benefit from these services. These data suggest that the coverage of key populations at higher risk as measured by per capita commodity distribution could over-estimate the potential impact made on reducing HIV transmission.

The risk behavior and size of the network among key populations are also diverse. This has implications for disproportionate transmission risks for different people. Future analysis may consider further segmenting the population of key populations into higher-risk and lower-risk groups, and considering levels of coverage and per capita commodity distribution among these subgroups to better assess its effect on the epidemic.

Mathematical modeling to evaluate the epidemiological impact of harm reduction programs

Methods

A standard population-level mathematical transmission model [1] was developed to describe HIV epidemics in Vietnam. The Vietnam HIV Model (VHM) was developed in a manner to be specifically customized to represent the unique situation in Vietnam and to evaluate harm reduction programs that have been implemented. The VHM accounts for various population groups at risk of HIV infection (Figure 5) and the different extents of HIV infection in these groups. Change in categorization of people in the model is incorporated through rates in which people from one population group may transition to be represented by another population group (e.g. 'Male IDUs' may stop injecting and become 'General males' or vice-versa); see Technical Annex 3 for details. The VHM describes sexual and injecting related transmission of HIV. Sexual mixing occurs across population groups and the model ensures conservation of partnerships; that is, the total number of partnerships that general males have with general females is equivalent to the total number of partnerships that general females have with general males, when adjusted across dynamic population sizes.

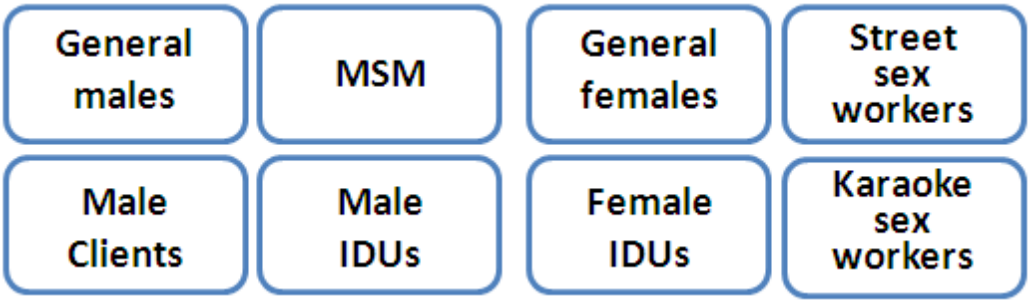


Figure 5: Population groups included in the VHM

The VHM describes the changes over time in the epidemics as a whole and among each population group. For each population group, the VHM:

- tracks the rate at which uninfected people become infected with HIV;
- differentiates between people who have been diagnosed with their infection through HIV testing and those for whom it remains unrecognized;
- tracks the rate of disease progression to late-stage infection and treatment-eligibility and subsequently the number of people who receive antiretroviral therapy.

These stages are illustrated in Figure 6.

Each disease stage is associated with a different viral load and hence a different level of infectiousness [2-3]. Effective antiretroviral therapy (ART) substantially improves survival rates and decreases the likelihood of transmitting the virus (by 92% on average [4-5]). Although this is dependent on the level of adherence to therapy [6-7], adherence levels of individuals and their impact on viral suppression are not explicitly modeled but the average population-level impact of treatment is included [8-10].

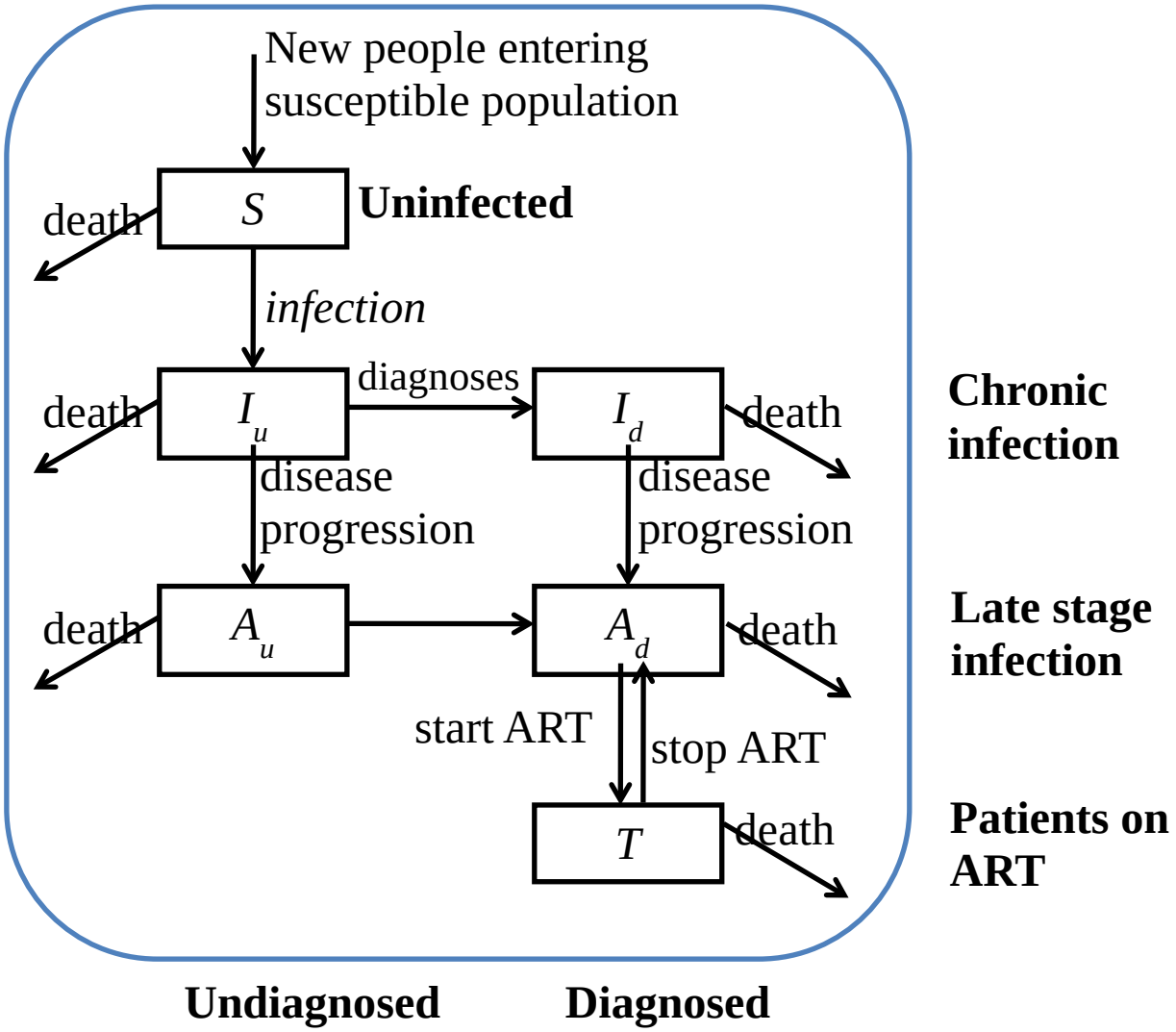


Figure 6: Schematic diagram of the structure of the natural history of infection in the VHM

Mathematical description of VHM

Mathematically, the VHM is described by 48 ordinary differential equations, one for each of the eight population group (Figure 5) multiplied by one for each of the six disease states (Figure 6); the equations are developed according to standard disease modeling [1] and are presented in Technical Annex 2.

The annual per-capita risk of acquiring HIV infection per uninfected person in each population group, known as the 'force of infection', estimates the average rate of infection through both sexual and intravenous transmissions. Sexual transmission risk depends on:

- the number of people in each HIV-infected stage (that is, the prevalence of infection in the population of partners)
- the average number of casual and regular homosexual and heterosexual partnerships per person
- the average frequency of sexual acts per partnership
- the proportion of these acts in which condoms are used, and
- the efficacy of condoms.

The stage of infection (chronic, AIDS/late stage, or on treatment) for the HIV-positive partner in a serodiscordant couple also influences transmission risk due to different levels of infectiousness in each infection stage.

Intravenous transmission risk depends on:

- the number of injecting partners per person per year
- frequency of injecting per year
- frequency of sharing injecting equipment
- percentage of shared syringes that are cleaned before re-use, and
- the efficacy of cleaning injecting equipment.

Mathematically, the force of infection is expressed by standard mathematical risk equations that combine the specific risk behaviors and their frequencies with biological risk probabilities per exposure event and the epidemiology of chance of contact with infected partners to quantify the average per-capita risk of acquiring infection for a given person in each of the defined population groups. These calculations are carried out dynamically to track the evolution of epidemic trajectories. The mathematical equations for the force of infection have been described in detail elsewhere [11] and we also present them in Technical Annex 2.

Provinces evaluated with the VHM

In consultation with partners at the Vietnam Administration of HIV/AIDS Control (VAAC), the Vietnam Strategic Information and Monitoring and Evaluation Technical Working Group, UNAIDS Vietnam, the World Bank, and other stakeholders, available epidemiological, behavioral and program-specific data were reviewed in order to determine which Vietnamese provinces would be applied to the VHM. The selection criterion was that provinces would be included if data were availability on program distribution and key risk-related behavior before and after the implementation of the programs (with minimal requirement of condom usage and syringe sharing rates), as well as population size estimates. Based on this, it was decided that the VHM would be applied to evaluate the harm reduction programs carried out in An Giang, Can Tho, Dien Bien, Hai Phong, Ha Noi and HCMC (Figure 7).

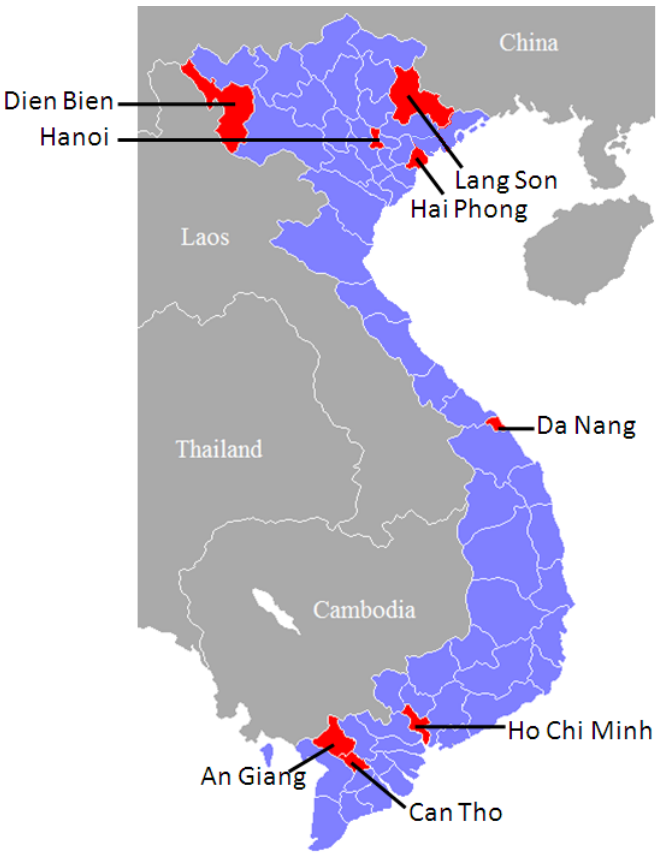


Figure 7: Map of the Vietnamese provinces evaluated by the VHM

The provinces selected include the five largest metropolitan areas in Vietnam (HCMC, Hanoi, Hai Phong, Can Tho and Da Nang) and represent a diverse set of epidemic contexts and geographic regions. For example, mega-cities such as HCMC and Hanoi, as well as Hai Phong,

comprise large portions of the IDU and FSW population. An Giang and Can Tho have moderate sized key populations at higher risk for HIV infection of about equal size. However, in Can Tho the IDU epidemic appears to have flattened at a high saturation point, and in An Giang declines in HIV prevalence are seen among IDU sentinel surveillance. Dien Bien is believed to have very high numbers of IDU at high levels of prevalence, but fairly small FSW populations at moderate to low prevalence. Da Nang appears to have a relatively low level epidemic with small to moderate sized key populations at higher risk. Seven of the eight provinces are supported by US government prevention funds. Can Tho, Da Nang and Ha Noi had DFID but no WB program support for harm reduction. An Giang, Hai Phong, and HCMC have both DFID- and WB-supported programs. Dien Bien relies primarily on national program support for harm reduction but received international donor support for needle/syringe distribution beginning in 2008 from the Australian government.

An extensive search was conducted of the published and grey literature, as well as unpublished data available from the Vietnam Data Triangulation Team, in order to inform the VHM evaluation of the harm reduction programs. A complete list of all model inputs and parameters used in the VHM for each province is provided in Technical Annex 3; this also contains a list of province-independent biological and clinical parameters that were used by the model. The main sources of province-specific data were:

- 2000 HIV/AIDS Behavioral Surveillance Survey (2000 BSS) [1];
- 2002 Baseline Survey Report [2];
- 2005 HIV/STI Integrated Biological and Behavioral Surveillance (2005-2006 IBBS) [3];
- 2005 Vietnam Population and AIDS Indicator Survey (VPAIS) [4];
- 2007 MOLISA Data for population size estimates [5], consistent with the ecological analyses;
- Sentinel Surveillance Data from across all provinces.

All provinces included in the modeling analysis had unique epidemiology of prevalence trends, population size distributions, and some behavioral factors. Data were generally available for the most important risk-related factors for each specific province; where data were not available

for a particular parameter for a specific region, parameter values are assumed based on averages across other provinces or other comparable settings (see Technical Annex 4 for detailed information on all data, assumptions and inputs used in all provinces). Biological parameters (e.g. the probability of HIV transmission per discordant sexual act and the rate of disease progression) were assumed to be the same across all provinces. Strengths and weaknesses of the data available for use in the VHM are discussed in Technical Annex 3.

Uncertainty/sensitivity analysis

The VHM was programmed using the Matlab (2009b, Mathworks, MA) computer language and solved numerically. Due to large confidence intervals in data and to account for intrinsic heterogeneity that exists between behaviors, epidemiology and biology of different groups of people, a range of plausible values for each parameter was defined rather than using point estimates. Where only point estimates were available from data, an uncertainty range of ±25% of the best value was assumed to account for possible distribution in the parameter value. Specific values and ranges used for each parameter and their sources are provided in Technical Annex 2. To translate the uncertainty in input data into uncertainty in the model output, Latin hypercube sampling [12-14], an efficient type of stratified Monte Carlo sampling, along with Monte Carlo filtering [15-16], was used to sample 100 parameter sets from the large parameter space (using the SaSAT software [14]). The VHM was run once for each set of parameter values, as an uncertainty analysis. This process enabled the VHM to expose the extent of uncertainty that exists in available data. In order to determine the factors of greatest importance for yielding variation in model outputs, sensitivity analyses were also carried out using the SaSAT software [14].

Optimization procedure to reconcile all data sources

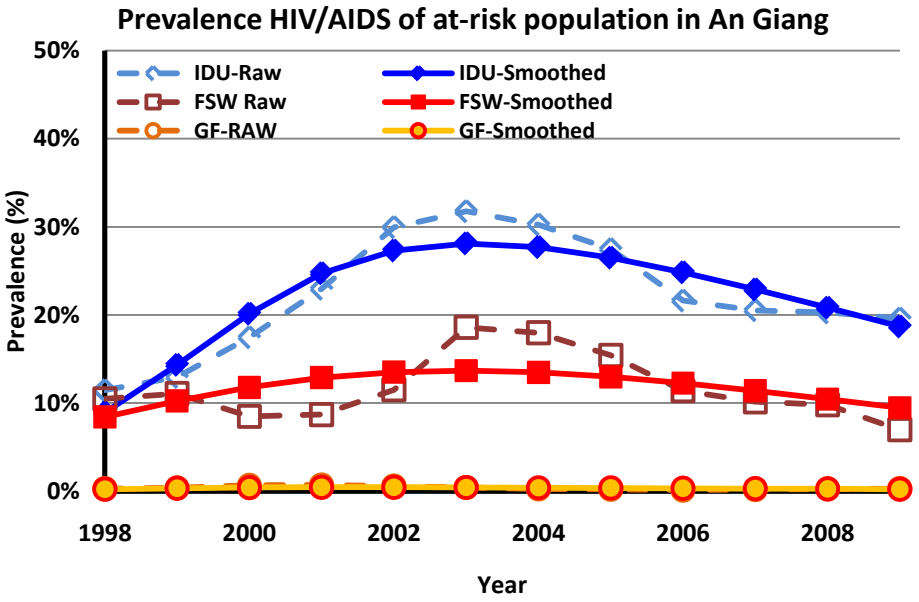
Another unique feature of the VHM was the incorporation of formal optimization procedures around the numerical solvers of the ordinary differential equations. Most epidemic models do not include this component but its relatively innovative inclusion in this study provides more rigor and robustness of the modeling results. A rationale for this feature is as follows. Essentially, mathematical models incorporate a large variety of epidemiological, behavioral,

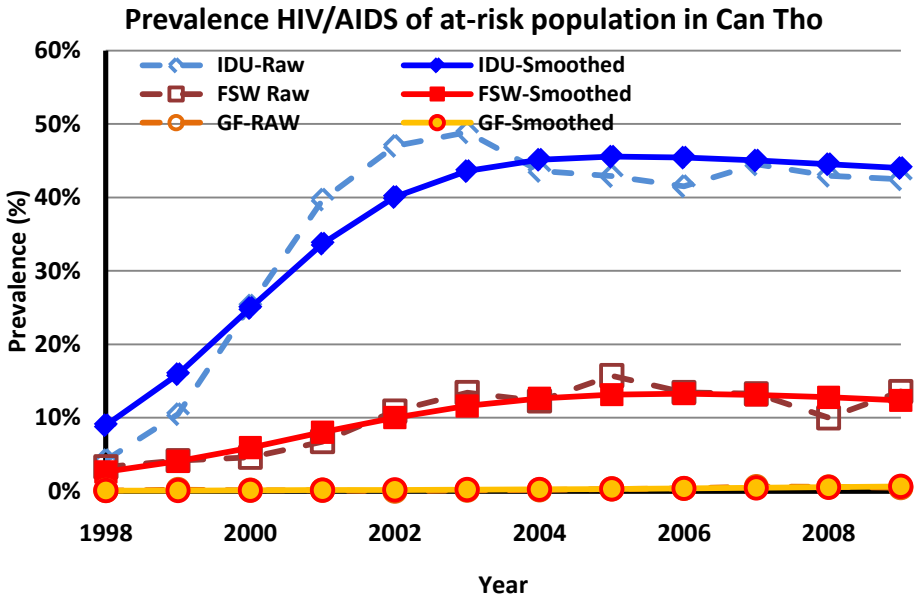
biological, clinical and social data sources into a single mechanistic framework that examines how all of these factors interact and together contribute to the observed epidemic. However, due to uncertainties, inaccuracies or heterogeneity in survey data or large complexity in the interacting factors, the large number of parameter values may not seem to be consistent when viewed as an interacting whole (e.g. if condom use increases by a certain amount in a sample of a given population group then calculations would yield estimates of change in prevalence but this might not be precisely how prevalence was observed to change). Given the uncertainty around all parameter values, within confidence intervals or plausible bounds provided by empirical evidence, the optimization procedure determines how all the complex parameters can be reconciled together to produce the observed epidemiology by finding values within each confidence interval for all interacting factors. Further details of this mathematical routine and an example are provided in Technical Annex 2 along with model results from the calibration and optimization procedures over 100 model simulations that represent past epidemic trends among all population subgroups. It should be noted that any systematic changes in underlying base populations need to be captured through empirical surveys and sociological studies and not the optimization routine.

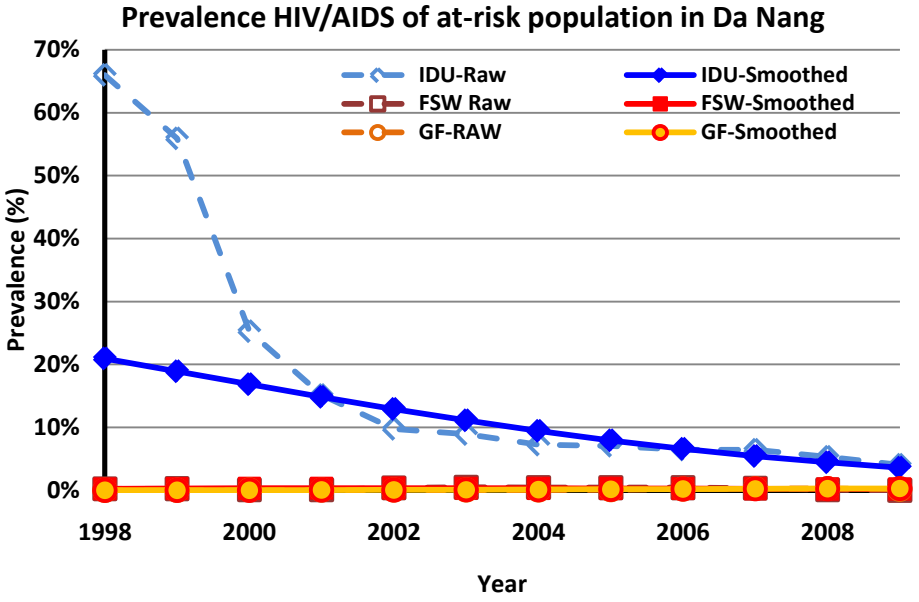
Population data used in model calibration

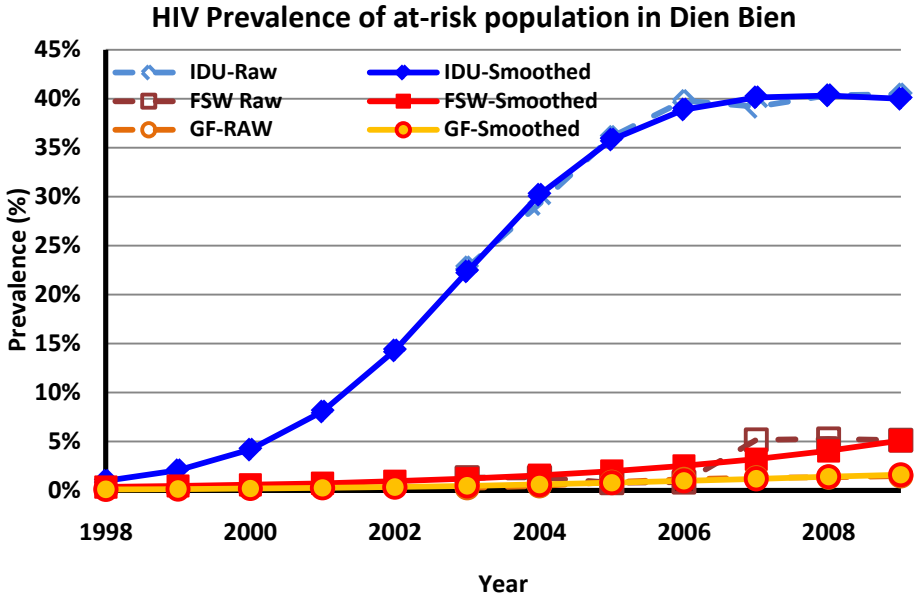
The VHM was calibrated through the optimization routine to reflect available data on the prevalence of HIV among various at-risk population groups. The calibration process also ensured consistency with data on the numbers of people who initiated ART and general consistency with the numbers of HIV diagnoses and reported AIDS cases in each province, acknowledging that reported cases are likely to be highly under-reported. Sentinel surveillance data provided annual raw estimates of HIV prevalence among key population groups (FSW, IDU, and ANC). Smooth prevalence curves were obtained by inputting a three-yearly running average of the raw data for each year into the UNAIDS Estimations and Projections Package (EPP 2007 R10). These estimates were similar to the official prevalence outputs published for Vietnam but were produced independently from the official reported EPP values. This procedure was carried out in order to obtain smooth epidemic trajectories rather than base

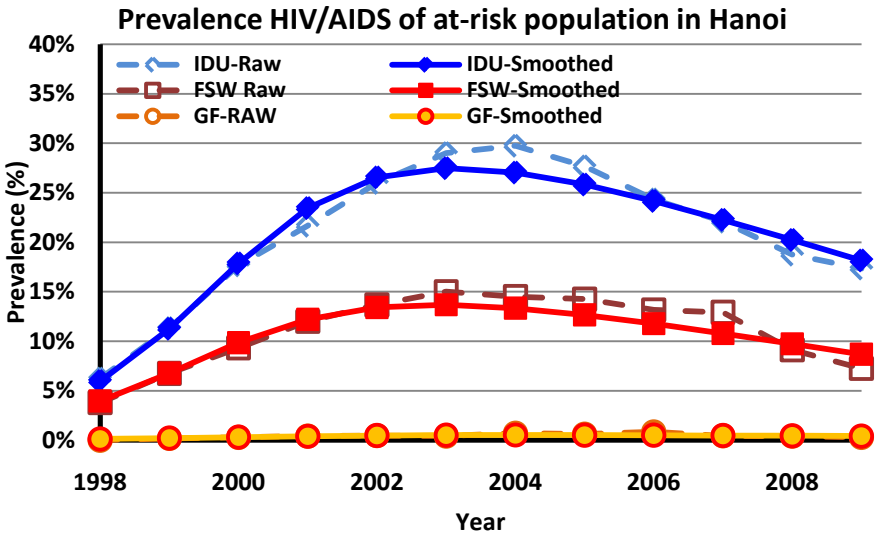
estimations on sampling ‘blips’ that cause jumps in trends. Comparisons of the input (three-year running averages) and output prevalence data from EPP are shown in Figure 8. The VHM was calibrated to reflect the prevalence curves generated as outputs from EPP among each population group.

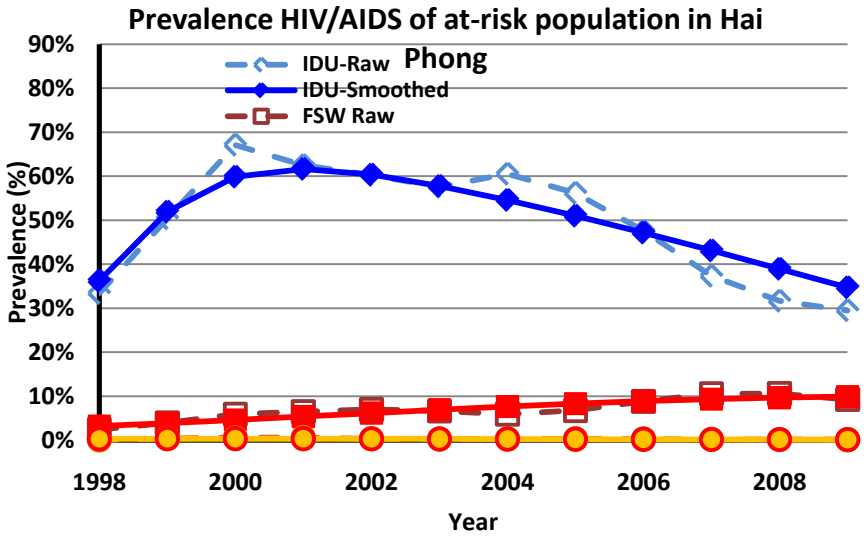

Prevalence HIV/AIDS of at-risk population in An Giang
IDU-Raw
IDU-Smoothed
FSW Raw
FSW-Smoothed
GF-RAW
GF-Smoothed
Prevalence (%)
50%
40%
30%
20%
10%
0%
1998
2000
2002
2004
2006
2008
Year


Prevalence HIV/AIDS of at-risk population in Can Tho
IDU-Raw
IDU-Smoothed
FSW Raw
FSW-Smoothed
GF-RAW
GF-Smoothed
Prevalence (%)
60%
50%
40%
30%
20%
10%
0%
1998
2000
2002
2004
2006
2008
Year


Prevalence HIV/AIDS of at-risk population in Da Nang
IDU-Raw
IDU-Smoothed
FSW Raw
FSW-Smoothed
GF-RAW
GF-Smoothed
Prevalence (%)
70%
60%
50%
40%
30%
20%
10%
0%
1998
2000
2002
2004
2006
2008
Year


HIV Prevalence of at-risk population in Dien Bien
IDU-Raw
IDU-Smoothed
FSW Raw
FSW-Smoothed
GF-RAW
GF-Smoothed
Prevalence (%)
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
1998
2000
2002
2004
2006
2008
Year





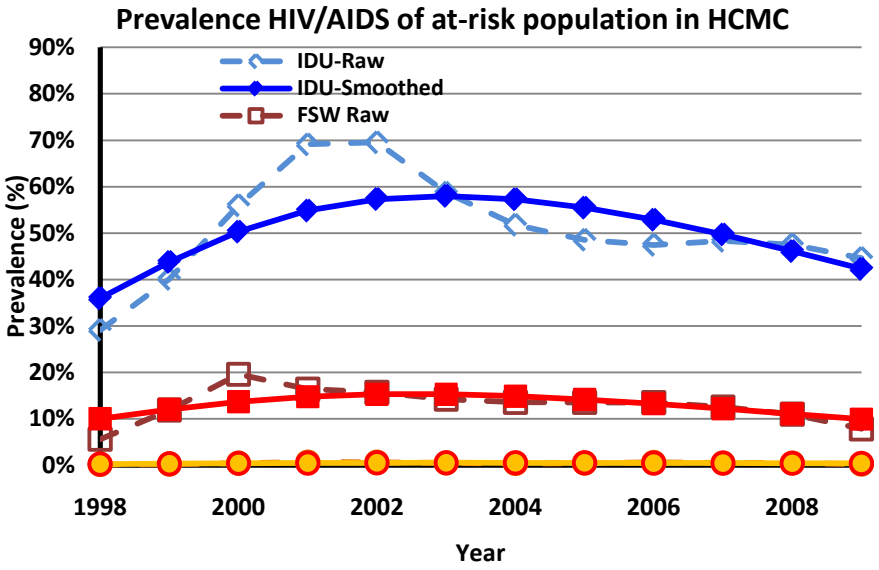
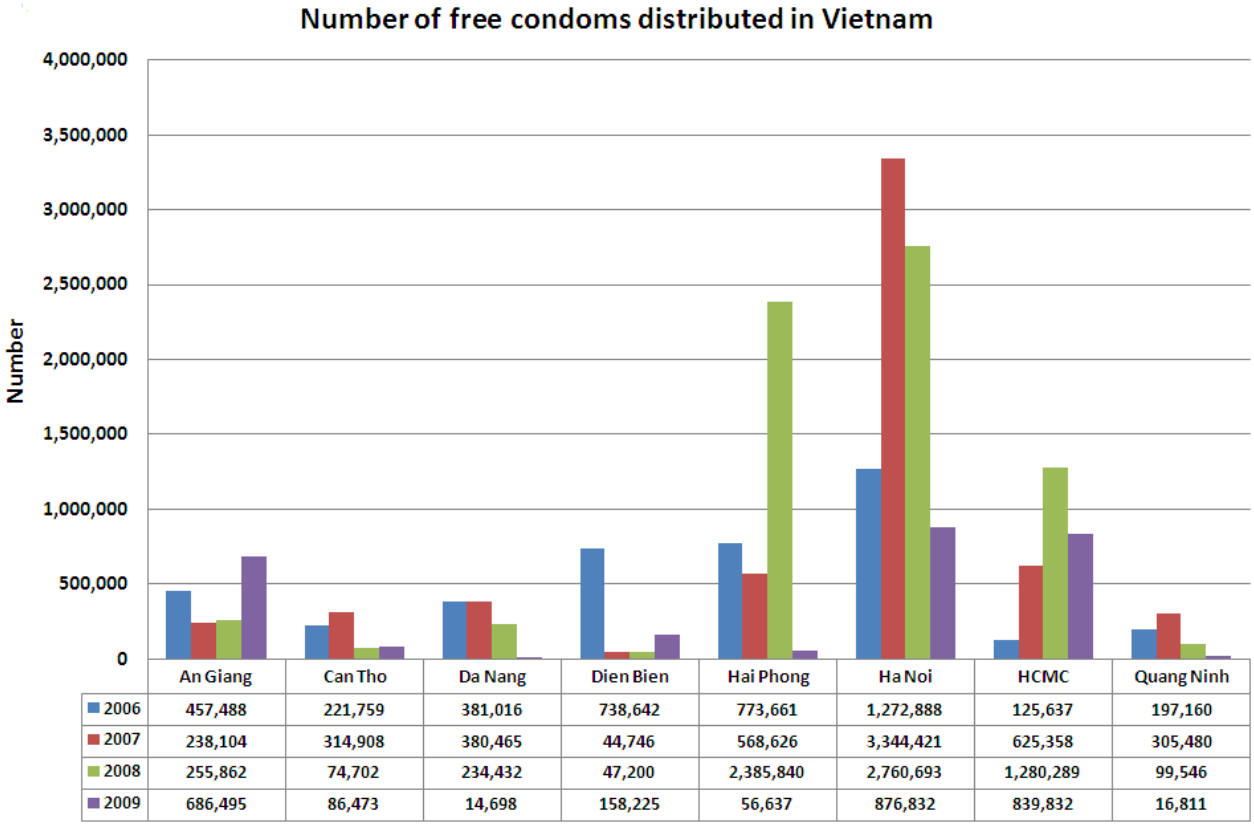


Figure 8: HIV prevalence of specific at-risk populations estimated from 3-year running averages of MOLISA data and smoothed prevalence curves fitted with EPP, independent of official EPP estimates.

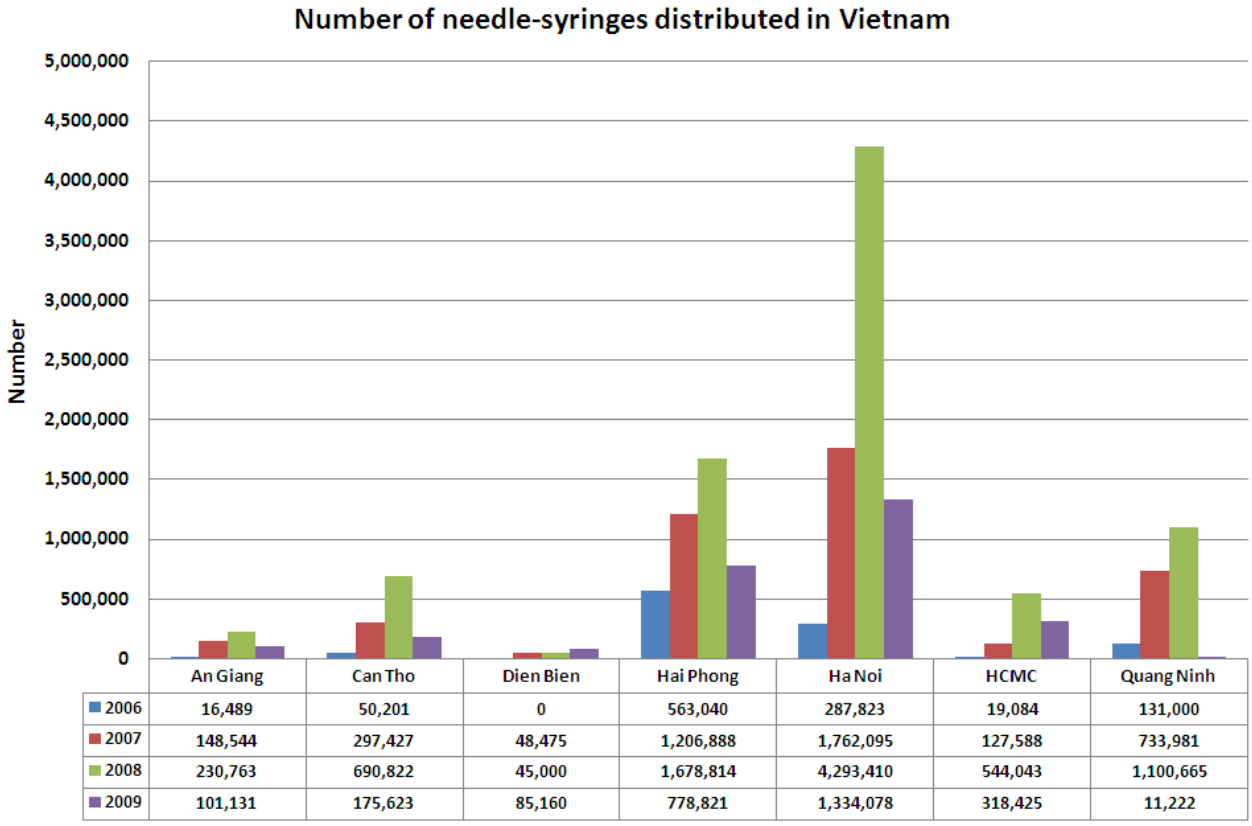
Harm reduction intervention data

The calibrated VHM for each province was used to evaluate the impact of harm reduction programs in the period 2005-2009. Most harm reduction programs in Vietnam were implemented by multiple organizations in different provinces. Intervention data for the total number of free condoms distributed and total number of free needle-syringes distributed in each province were collated across implementation partners (Figure 9, Figure 10).



	An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Ha Noi	HCMC	Quang Ninh
2006	457,488	221,759	381,016	738,642	773,661	1,272,888	125,637	197,160
2007	238,104	314,908	380,465	44,746	568,626	3,344,421	625,358	305,480
2008	255,862	74,702	234,432	47,200	2,385,840	2,760,693	1,280,289	99,546
2009	686,495	86,473	14,698	158,225	56,637	876,832	839,832	16,811

Figure 9: Number of free condoms distributed through harm reduction programs among Vietnamese provinces



	An Giang	Can Tho	Dien Bien	Hai Phong	Ha Noi	HCMC	Quang Ninh
2006	16,489	50,201	0	563,040	287,823	19,084	131,000
2007	148,544	297,427	48,475	1,206,888	1,762,095	127,588	733,981
2008	230,763	690,822	45,000	1,678,814	4,293,410	544,043	1,100,665
2009	101,131	175,623	85,160	778,821	1,334,078	318,425	11,222

Figure 10: Number of syringes distributed through harm reduction programs among Vietnamese provinces

Evaluating the impact of harm reduction programs

In order to evaluate the epidemiological impact of the harm reduction programs it is necessary to understand how behavior has changed due to the programs. That is, the programs can act to reduce HIV transmissions if they resulted in an increase in the number or proportion of sexual acts in which condoms were used or a reduction in the number of injections with shared injecting equipment; thus, data before and after the initiation of the intervention is required and ideally there would be a series of time points. However, it must also be acknowledged that cross-sectional surveys conducted, at intervals of several years, with sampling from a mobile and marginalized population may result in the sampling of non-comparable populations. Other forms of selection, recall, and social desirability biases may also occur in survey of most at risk population. Therefore, trends observed in behavioral and biological data should be interpreted with appropriate caution. In some cases, levels of risk behavior measured in the IBBS surveys

increased over time or did not change. Indeed, in all but one province included in the modeling analyses, there was an increase in reported sharing of needle-syringes among IDU in 2009 compared to 2005. Assuming reliability and representativeness of data, this trend suggests that there may have been other external factors influencing engagement in risk behaviors, independent of the intervention. It is likely that many competing external factors influence behavior related to HIV risk. To indirectly account for any underlying behavioral risk patterns, the VHM relied primarily on program coverage data to determine how much additional unprotected sex and sharing of injecting equipment would likely have occurred without the availability of needle-syringes and condoms distributed by the programs.

Approach to evaluate impact of programs: Calculate how risk behavior (frequency of syringe sharing and unprotected sex) would likely have been different in the absence of the distribution of condoms and needle-syringes, assuming the total number of injecting/sexual events is unchanged. Here, a mathematical relationship informs how sharing rates/condom usage change with the total number of needle-syringes/condoms distributed to the population (see Technical Annex 2). The VHM is simulated under observed behavior-epidemiological trends and according to levels of risk behavior that would have been expected had the harm reduction programs not distributed condoms and needle-syringes. The difference in the outcomes of these simulations determines the overall impact of the programs. A schematic diagram of this approach is in Figure 11.

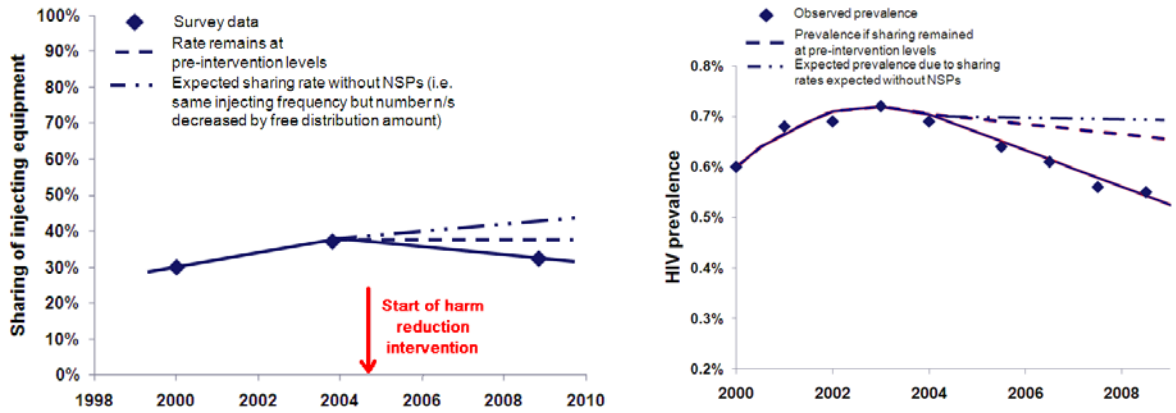


Figure 11: Schematic diagram of behavioral trends and corresponding change in prevalence trajectories

HIV is transmitted due to risky behavior such as unprotected sex or sharing of injecting equipment. Effective public health programs should result in a decrease in indicators associated with these risk-related behaviors and such change should demonstrate the primary impact of the interventions. However, indicators for levels of risk behavior can be influenced by many circumstances beyond the specific public health interventions. Furthermore, trends in risk-behavior indicators can be biased by many (identifiable and unidentifiable) external factors. Consequently, if observed risk behavior indicators increase then it cannot be concluded that the programs have or have not been effective in influencing some positive change. Indeed, the distribution of needle-syringes and condoms that are effectively used in place of sharing of injecting equipment or engaging in unprotected sex, that would have taken place without the availability of this equipment, can only result in some reductions in HIV transmission. In the current study we apply both approaches of investigating (i) observed behavior change and (ii) the expected influence on behavior of distribution of needle-syringes/condoms, on HIV trajectories. The analysis measures the estimated number of infections averted in the primary target population group as well as the number of secondary infections averted in other population groups due to reductions in transmission in the primary group. The model describes mixing between eight population groups (Figure 5). The secondary impact of harm reduction programs for each population group is shown in the results. For example, primary infections averted among FSW should have a flow-on effect to male clients of FSW and then to general females who have sexual partnerships with male clients of FSW, ultimately also to other general males who partner with general females and to MSM. Evaluation of secondary infections averted incorporates the 'transmission chain' among all eight population groups.

Results

The VHM was applied to the province-specific data of each of the eight modeled provinces and fit to the epidemic trajectories overall and by specific population groups at risk (see Technical Annex 2 for specific values of parameters used in each province). For each province, the number and percentage of averted infections among IDU/FSW (i.e. primary infections) and the total population (i.e. secondary infections) were estimated based on the program coverage levels. The number of infections in the total population is based on the sum of all infections occurring from 2005-2009 among the eight population groups included in the model. Although, no harm reduction program was evaluated for the MSM population, estimates of the number of infections occurring among this group are also presented to indicate the relative urgency of implementing prevention interventions for MSM in different provinces.

The following sections review the results from each province, providing some insights from the modeling about the explanations for the level of effects observed. When reviewing these figures it is important to note that changes in incidence trends, for any epidemic, due to prevention programs may not be clearly reflected in prevalence trends; this is especially true in established epidemics with low mortality rates where the bulk of infections comprising prevalence are long standing infections.

An Giang

Smoothed epidemic curves show that the inflection point of the HIV prevalence trends in An Giang occurred prior to the assessment period. Trends in IBBS behavioral data suggest that needles sharing increased from 29 to 44% over this period. Evaluation of the harm reduction programs in An Giang by the VHM indicated that if the interventions had not been implemented, little difference would have been observed in the trajectories of prevalence in most population groups (Figure 12). This is due, in part because intervention scale-up in terms of condom distribution was very low (~40 condoms per FSW per year), except in 2009. Distribution of needle-syringes has likely reduced the prevalence among injecting drug users to a greater, but still only moderate, degree. This level of effect also reflects the moderate distribution of needle-syringes which was almost 0 in the first two years of the program, and increased to 100 needle-syringes per IDU per year in 2008, before dropping back down to less than 50. Projected epidemic curves among the MSM population appear to be increasing since 2006. The expected numbers of primary and secondary infections averted due to harm reduction programs calculated by VHM are presented in Figure 13.

Model trajectories of HIV prevalence among population groups in An Giang

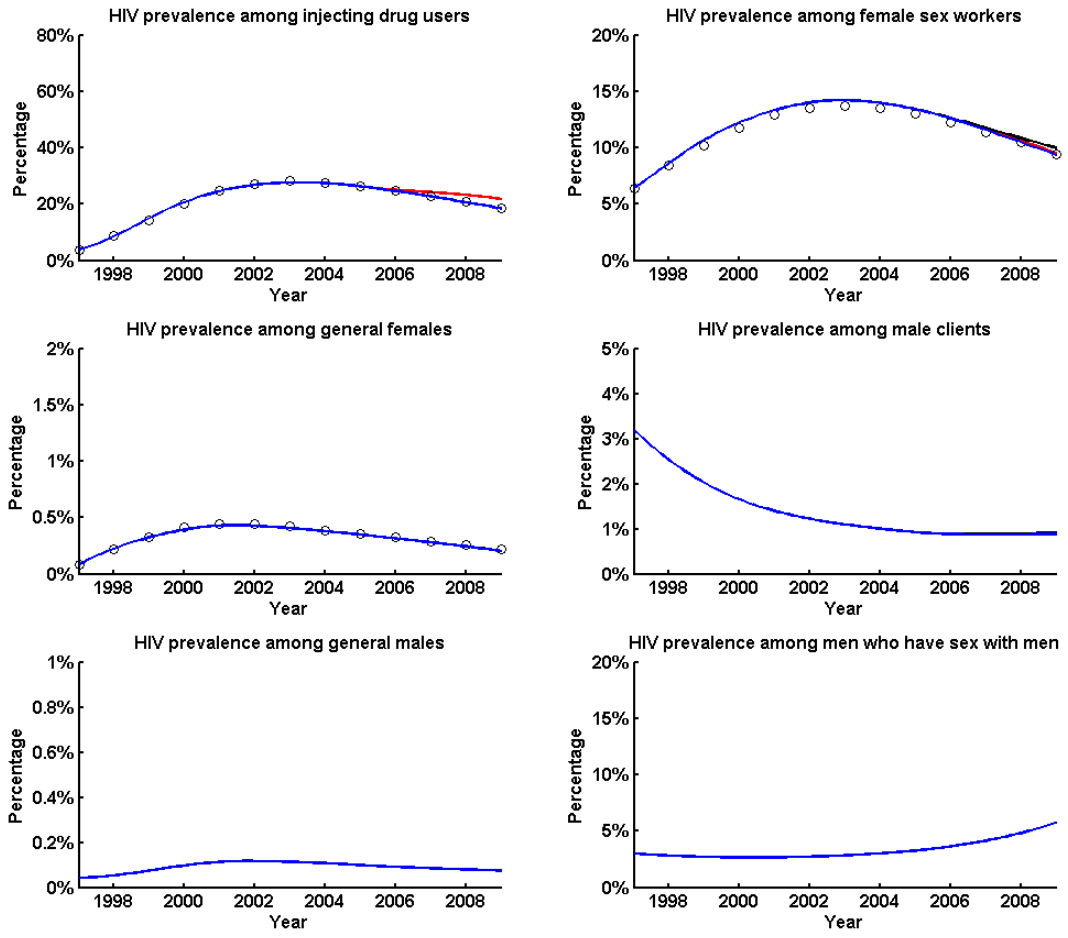


Figure 12: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in An Giang. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

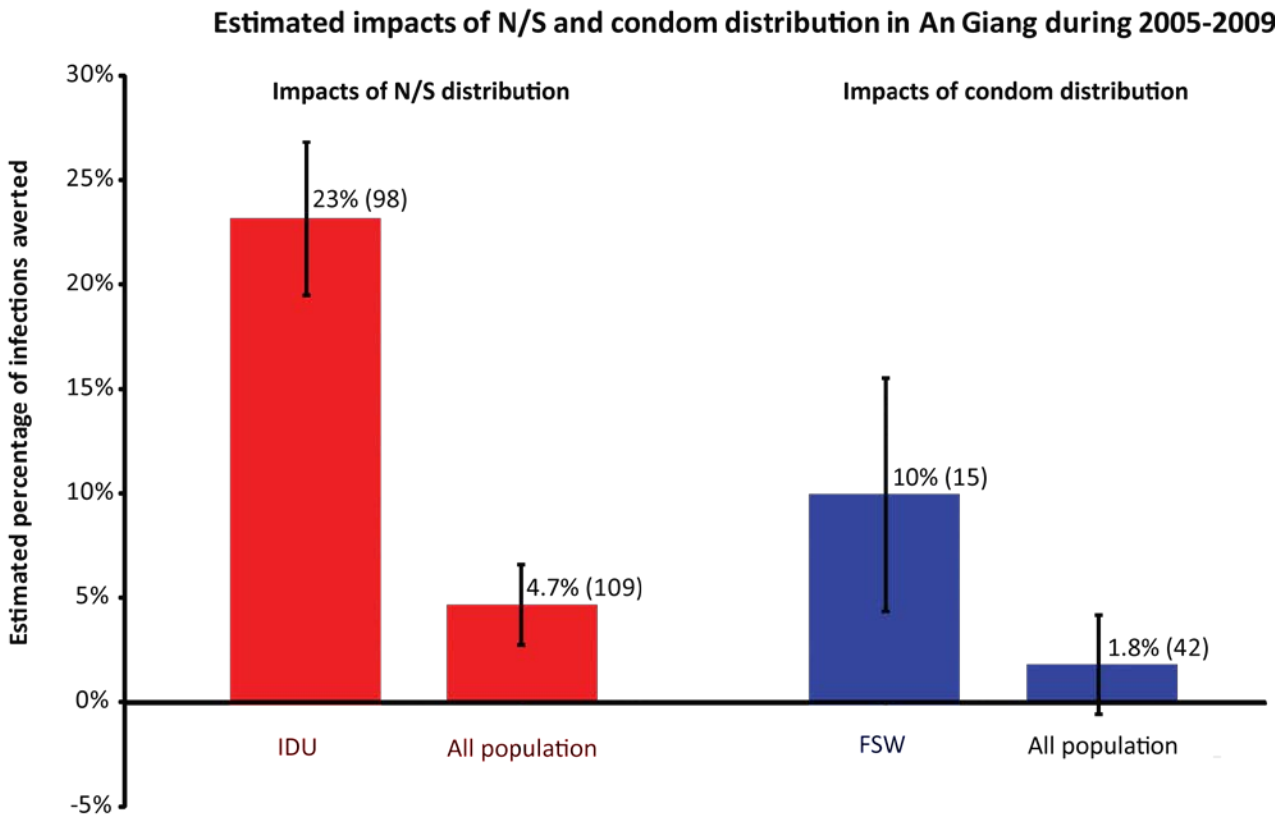


Figure 13: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for An Giang. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Distribution of needles-syringes among IDU in An Giang were estimated to avert 98 infections (23% of infections) among IDU, and another 11 infections from other population groups (4.7% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in An Giang were estimated to avert 15 infections (10%) among sex workers and a further 27 'onward' infections, primarily among clients and regular partners of clients.
- Moderate levels of averted infections are predominantly the result of low-to-medium program coverage; the average number of needle-syringes distributed per IDU was much lower than the target threshold and while the average number of condoms per sex worker approached the target, it was not achieved over the full term of the intervention.

Can Tho

Epidemic trends in Can Tho suggest a mature epidemic among both IDU and FSW, which reached its peak just prior to the assessment period. Trends in behavioral data in this province showed increasing sharing of injecting equipment and reduction in condom use between IBBS rounds. Needle-syringe distribution in this province has been moderately high, reaching greater than 100 needle-syringes per IDU in 2007 and almost 250 per IDU in 2008. Evaluation of the harm reduction programs in Can Tho by the VHM indicated that if the needle-syringe interventions had not been implemented there could well have been a further significant rise in prevalence, and a large absolute number of new infections among injecting drug users and this would have had a flow-on effect to female sex workers and to a small degree among other females (Figure 14). Condom distribution has had little effect on prevalence, in part because levels of distribution were fairly low (average of ~50 condoms per FSW per year). Rapidly escalating prevalence projected among MSM in this province also underscores a missed opportunity for averting infections among this group through prevention interventions. The VHM was used to calculate the expected number of primary and secondary infections averted due to harm reduction programs (see Figure 15).

Model trajectories of HIV prevalence among population groups in Can Tho

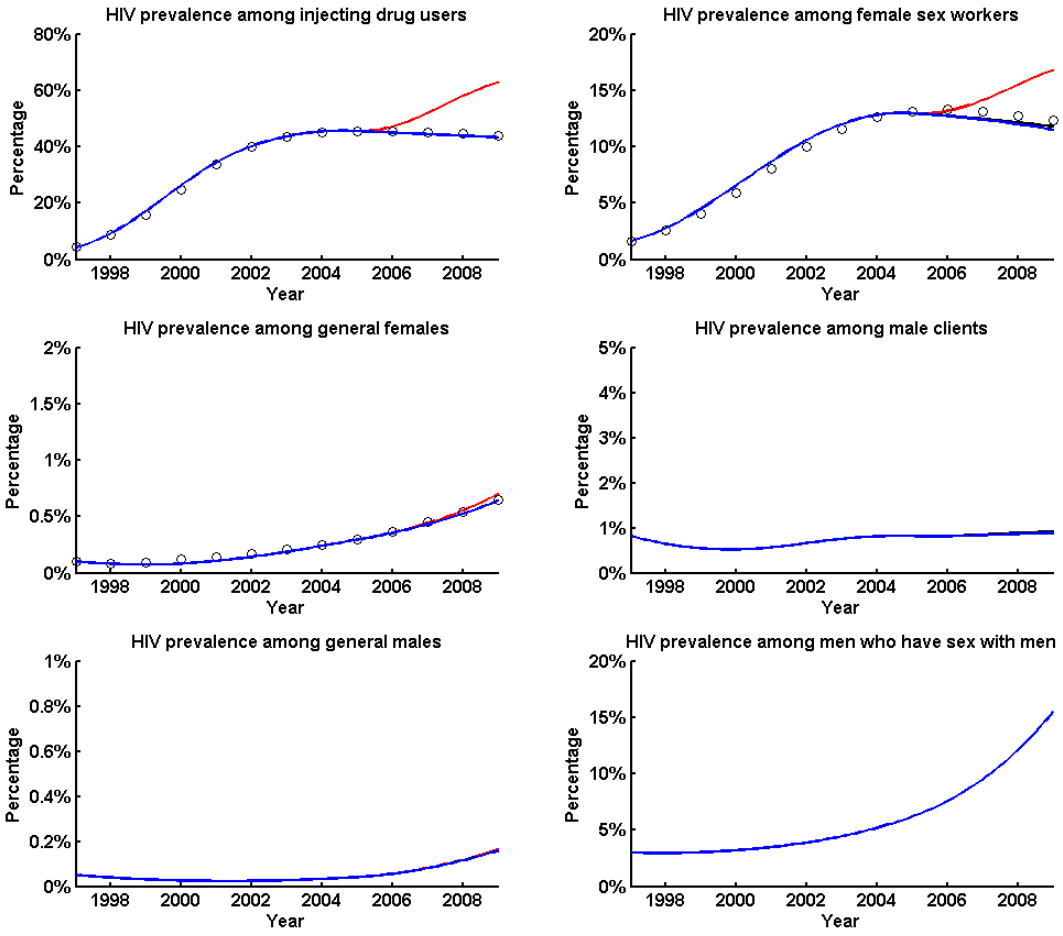


Figure 14: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Can Tho. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

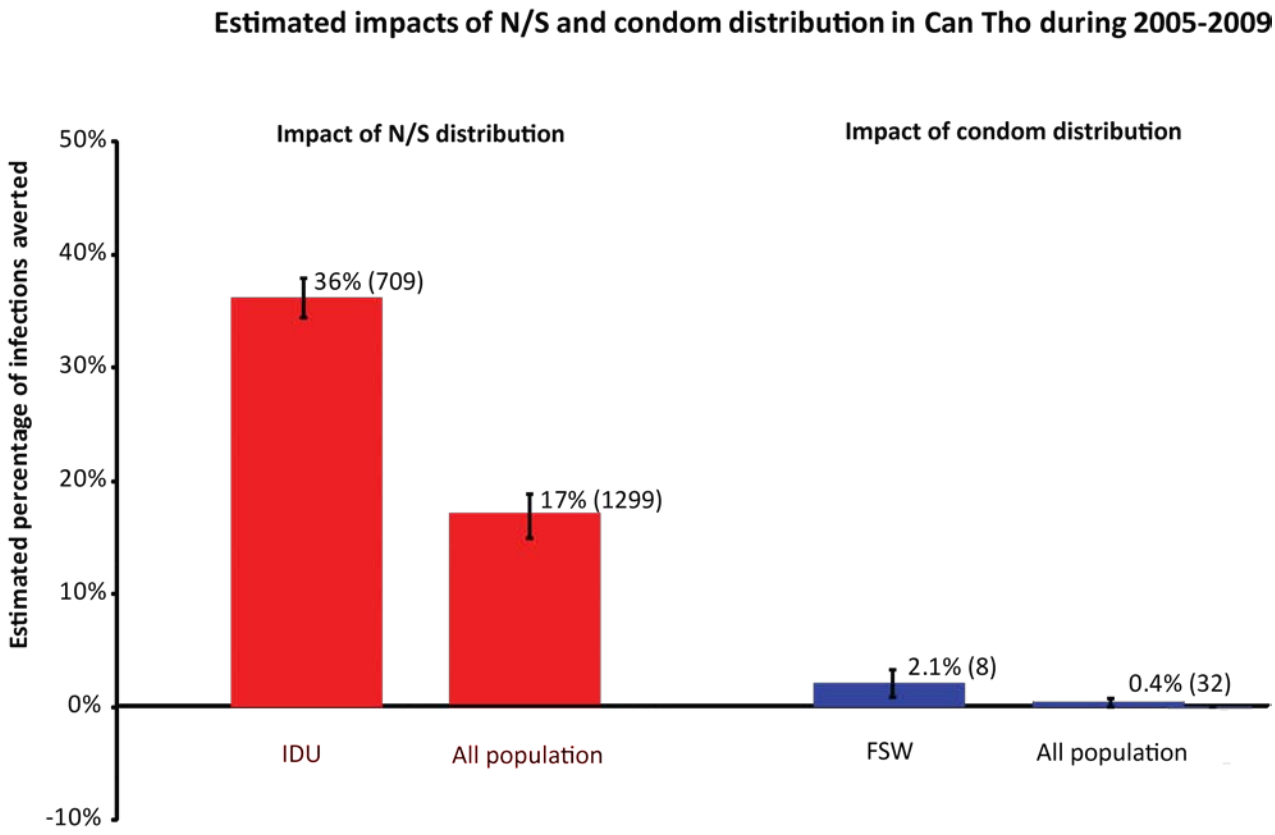


Figure 15: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Can Tho. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Distribution of needles-syringes among IDU in Can Tho were estimated to avert 709 infections (36% of infections) among IDU; and another 590 infections from other population groups (17% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in Can Tho were estimated to avert 8 infections (2%) among sex workers and a further 24 'onward' infections, primarily among clients and regular partners of clients.
- Moderate levels of averted infections are predominantly the result of low-to-medium program coverage; the average number of needle-syringes distributed per IDU was approximately half the target threshold and the average number of condoms per sex worker

was less than half the target level.

Da Nang

Compared to other provinces in the modeling exercise, Da Nang's epidemic trajectory appeared to have greatly declined among IDU and remained very low among FSW. As expected, evaluation of the harm reduction programs in Da Nang by the VHM indicated that the interventions had negligible impact on prevalence trends (Figure 16). The lack of IDU harm reduction programs in Da Nang and small-scale FSW interventions suggests other factors in place which have prevented the spread of HIV in this province. Mild increases in prevalence are projected for the MSM population and it may be useful for programs to explore whether there is a need of intervention among this group. The expected numbers of primary and secondary infections averted due to harm reduction programs calculated by VHM are presented in Figure 17.

Model trajectories of HIV prevalence among population groups in Da Nang

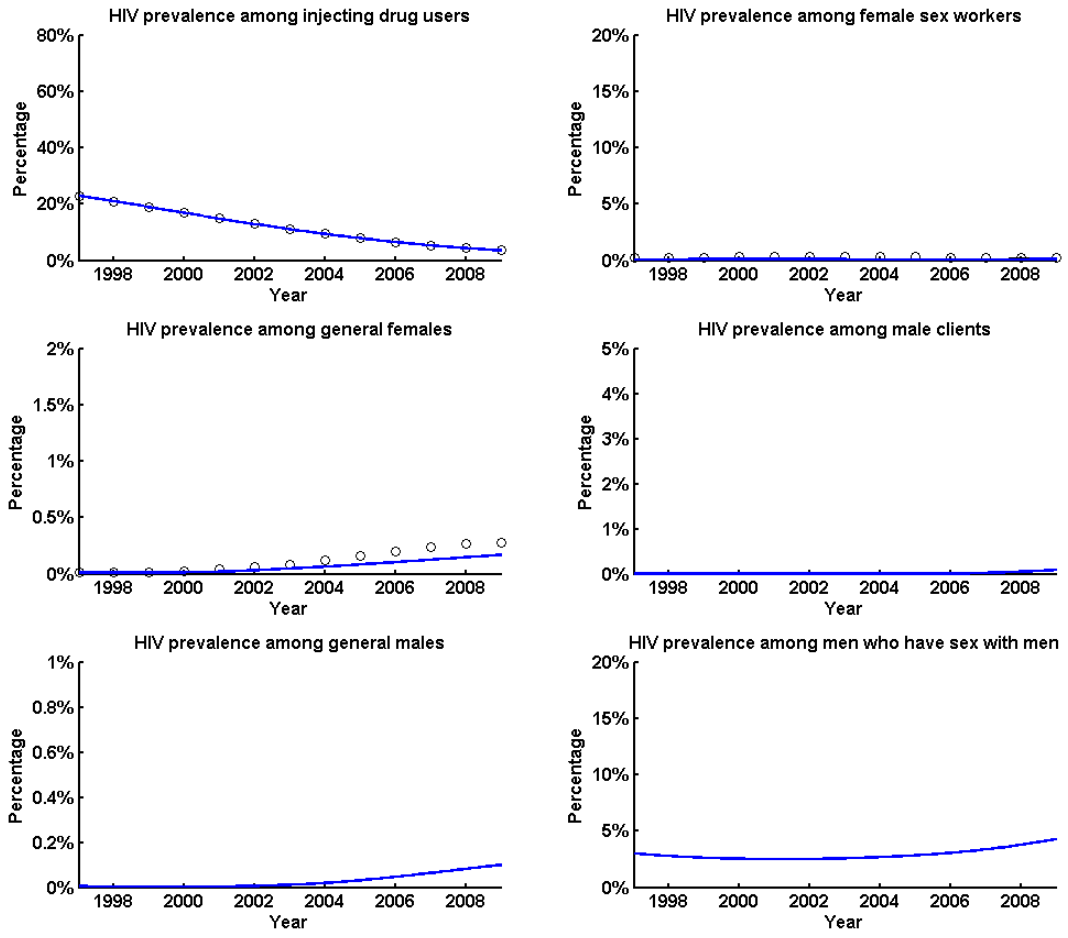


Figure 16: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Da Nang. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

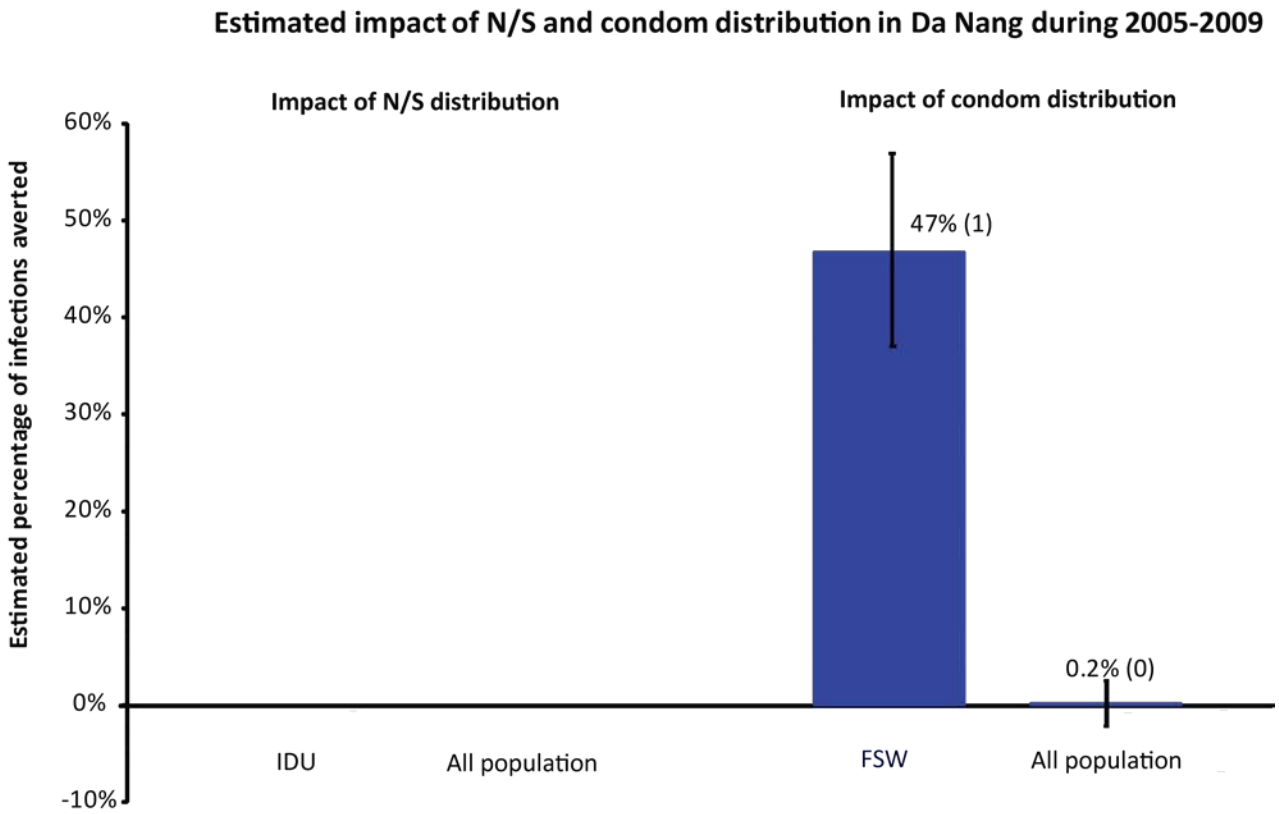


Figure 17: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Da Nang. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Needle-syringe programs were not implemented in Da Nang over 2005-2009, so the effect of program was not measurable.
- Distribution of condoms among sex workers in Da Nang was estimated to avert 1 infection (~47%) among sex workers and no noticeable 'onward' effect to other population groups.
- There are relatively small numbers of IDUs and FSWs at moderately low risk of HIV infection. Nil-to-little program coverage in Da Nang for IDUs could be increased; the coverage of condoms over the small number of FSWs appears to be adequate.

Dien Bien

Despite its relatively small size, very large numbers of IDU are reported to be in Dien Bien. Epidemic curves suggest that the IDU epidemic lagged behind most of the other provinces. The small population of FSW in Dien Bien appears to have experienced low but increasing prevalence of HIV over the period of the assessment. Interventions in Dien Bien have been supported primarily by the government, with a late influx of international donor support for needle-syringe programs in 2008. Evaluation of the harm reduction programs in Dien Bien by the VHM indicated that if the needle-syringe interventions had not been implemented there could have been a moderate increase in prevalence among injecting drug users, rather than stabilization, and this would have had a flow-on effect of higher prevalence among the general female population (Figure 18). Similarly, appropriate levels of condom distribution to the relatively small population of FSW has likely reduced the extent of rise in prevalence in this group and had a secondary impact on their male clients. The curve for MSM remains low and stable for Dien Bien compared to other provinces; this is due to less risk behavior and mixing compared to other regions (based on available behavioral data on mixing within and between population groups and the optimization-reconciliation routine). The expected numbers of primary and secondary infections averted due to harm reduction programs as calculated by VHM are in Figure 19.

Model trajectories of HIV prevalence among population groups in Dien Bien

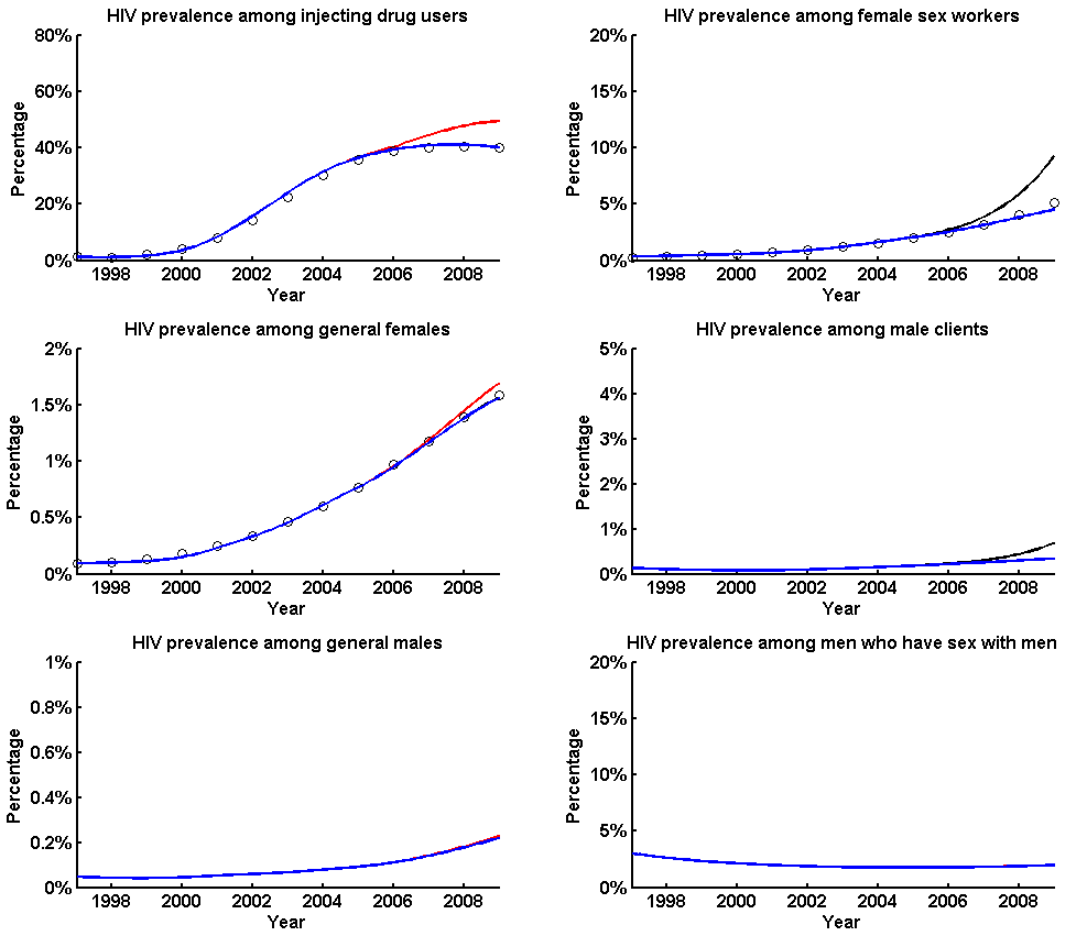


Figure 18: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Dien Bien. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

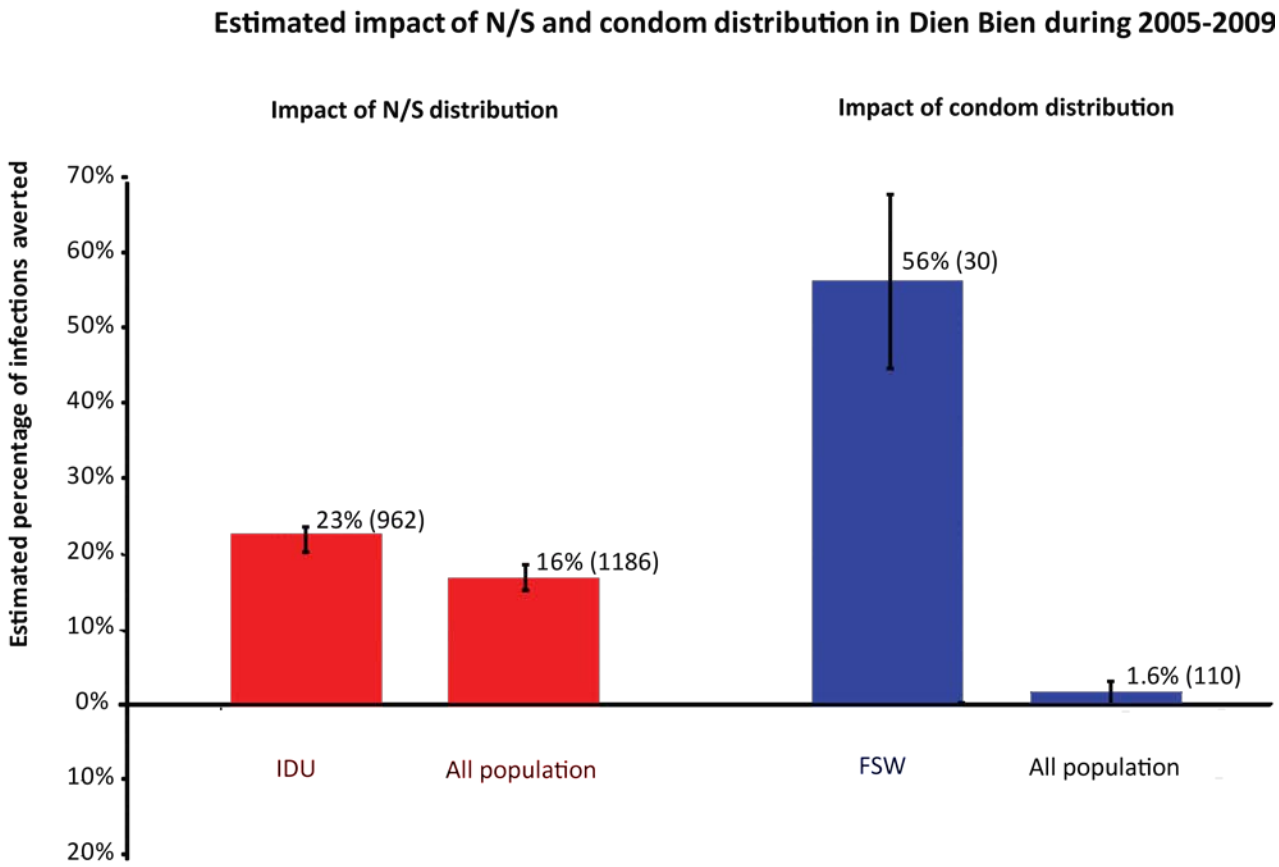


Figure 19: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Dien Bien. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Distribution of needle-syringes among IDU in Dien Bien were estimated to avert 962 infections (23% of infections) among IDU; and another 224 infections from other population groups (16% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in Dien Bien were estimated to avert 30 infections (56%) among sex workers and a further 80 'onward' infections, primarily among clients and regular partners of clients.
- Coverage among IDU was very low over the period 2005-2009. The moderate reduction in infections is mainly due to the IDU population size. It is important for coverage of needle-syringes among IDU to increase in Dien Bien. Coverage of condoms among FSWs is relatively

high. This has facilitated large success in preventing infections among sex workers. Despite this, behavioral trends need to be addressed.

Hai Phong

Epidemic curves in Hai Phong suggest that it has one of the older and most severe epidemics among IDU, and a steadily increasing epidemic among FSW. Long recognized as an important center of HIV epidemics in Vietnam, interventions in Hai Phong have also been in place prior to the establishment of the WB/DFID interventions. In Hai Phong, levels of sharing among IDU rose slightly despite steady increases in levels of needle-syringe distribution. Evaluation of the harm reduction programs in Hai Phong by the VHM indicated that if the needle-syringe interventions had not been implemented there could well have been a further significant rise in prevalence among injecting drug users and there could also have been a rise in prevalence among female sex workers if condom interventions were not implemented (Figure 20). The extent of potential increase among injecting drug users was produced with the same routine as for other provinces but is perceived as relatively high. This could be due to the IDU population size in Hai Phong or interactions of various factors that changed over time. However, the data sources for Hai Phong were found to be more inconsistent than for most other provinces in the model reconciliation, suggesting that caution should be taken in interpreting results. Only a subset of model simulations could be used to reconcile sampled parameters from distributions of data and these simulations were used to produce the Hai Phong results. For this reason, the model results for Hai Phong are not as robust as for other provinces. The simulations of programs in Hai Phong had little observable impact on secondary infections. This is due to little mixing between population groups, as informed by available data and the reconciliation routine. The VHM was used to calculate the expected number of primary and secondary infections averted due to harm reduction programs (see Figure 21).

Model trajectories of HIV prevalence among population groups in Hai Phong

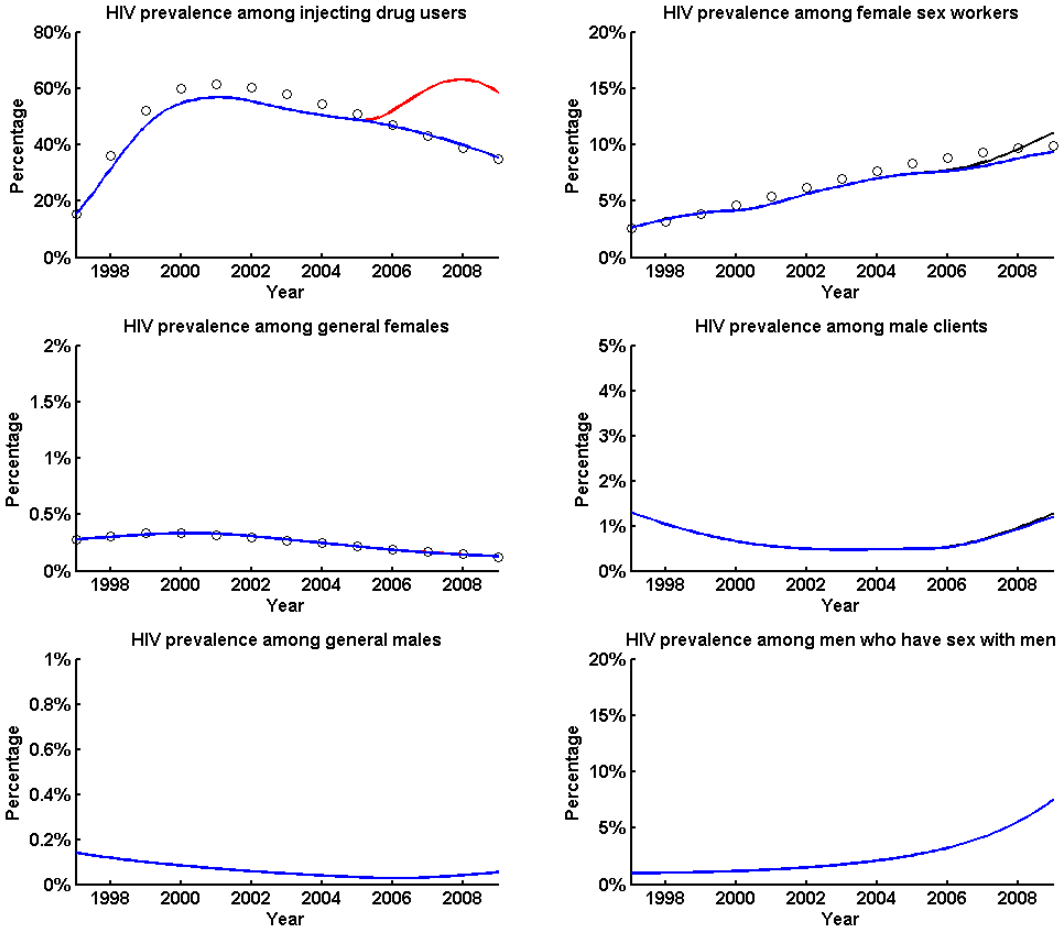


Figure 20: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Hai Phong. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

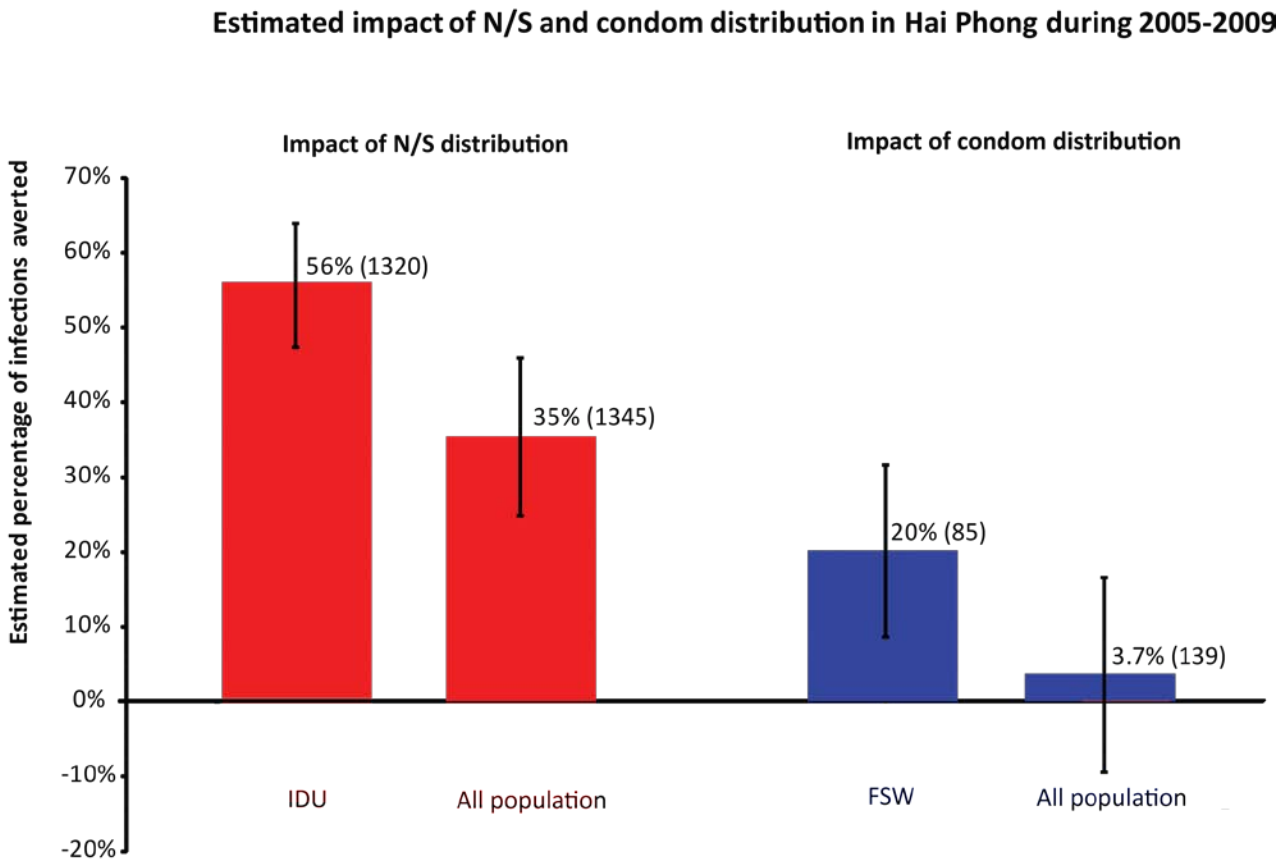


Figure 21: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Hai Phong. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Distribution of needles-syringes among IDU in Hai Phong were estimated to avert 1320 infections (56% of infections) among IDU; and another 25 infections from other population groups (25% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in Hai Phong were estimated to avert 85 infections (20%) among sex workers and a further 54 'onward' infections, primarily among clients and regular partners of clients.
- Coverage among IDUs reached the WB target over the period 2005-2009 and is the main reason for the relatively large success. However, sharing rates among IDU have still not declined adequately. Coverage of condoms among FSW was erratic over the assessment

period, but may have led to increased condom use and reductions in new infections.

Ha Noi

Ha Noi, like HCMC, represents a disproportionately large number of IDU for the country overall. Yet it has historically had a much more moderate IDU epidemic compared to many other large urban regions. The FSW epidemic in Hanoi has been relatively severe but appeared to have peaked several years before the start of WB/DFID interventions. Ha Noi has also benefited from interventions prior to 2004/5.

Over the assessment period higher rates of needle sharing and lower levels of condom use were reported in the IBBS, despite moderate levels of commodity distribution. Evaluation of the harm reduction programs in Ha Noi by the VHM indicated that if the needle-syringe interventions had not been implemented there could have been a moderate increase in prevalence among injecting drug users, rather than a small decline, and this would have had also resulted in slightly higher prevalence among the population of female sex workers (Figure 22). Similarly, condom distribution has likely reduced the prevalence among female sex workers, from stable levels to a decreasing trend. The VHM was used to calculate the expected number of primary and secondary infections averted due to harm reduction programs (see Figure 23).

Model trajectories of HIV prevalence among population groups in Ha Noi

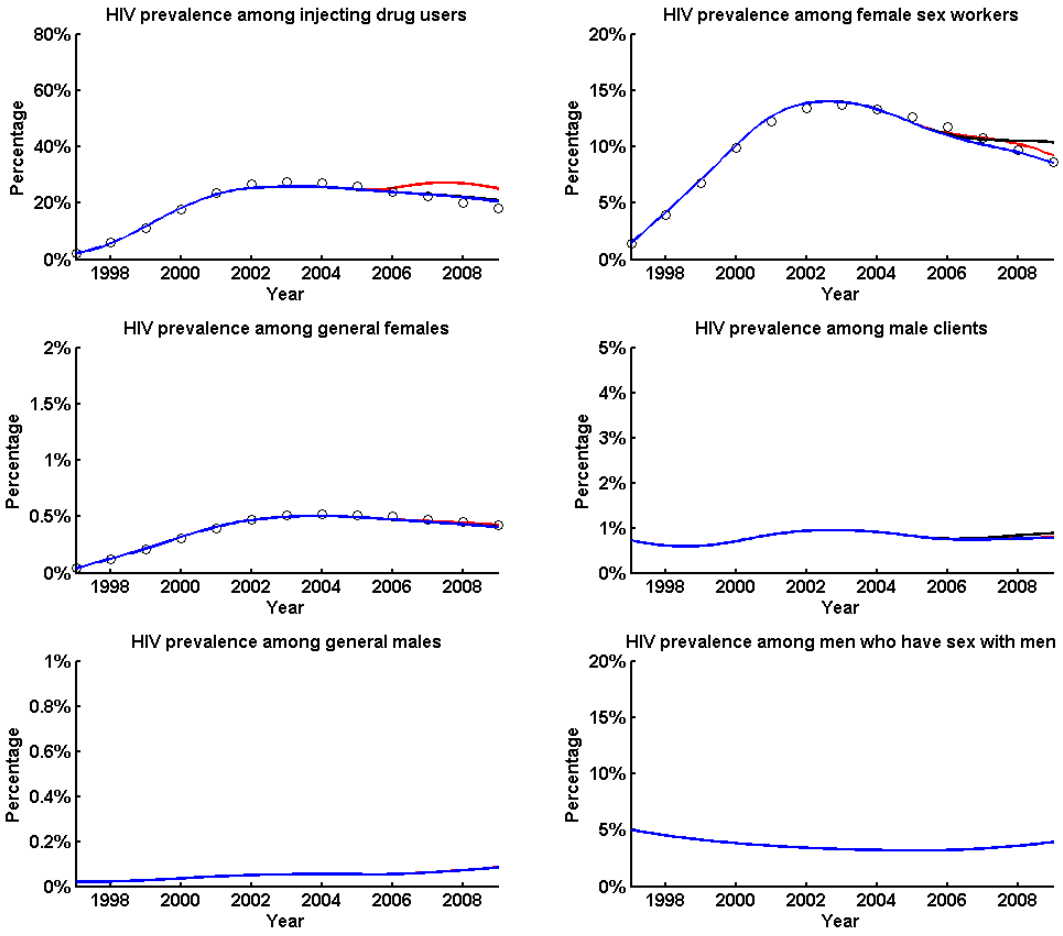


Figure 22: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Ha Noi. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

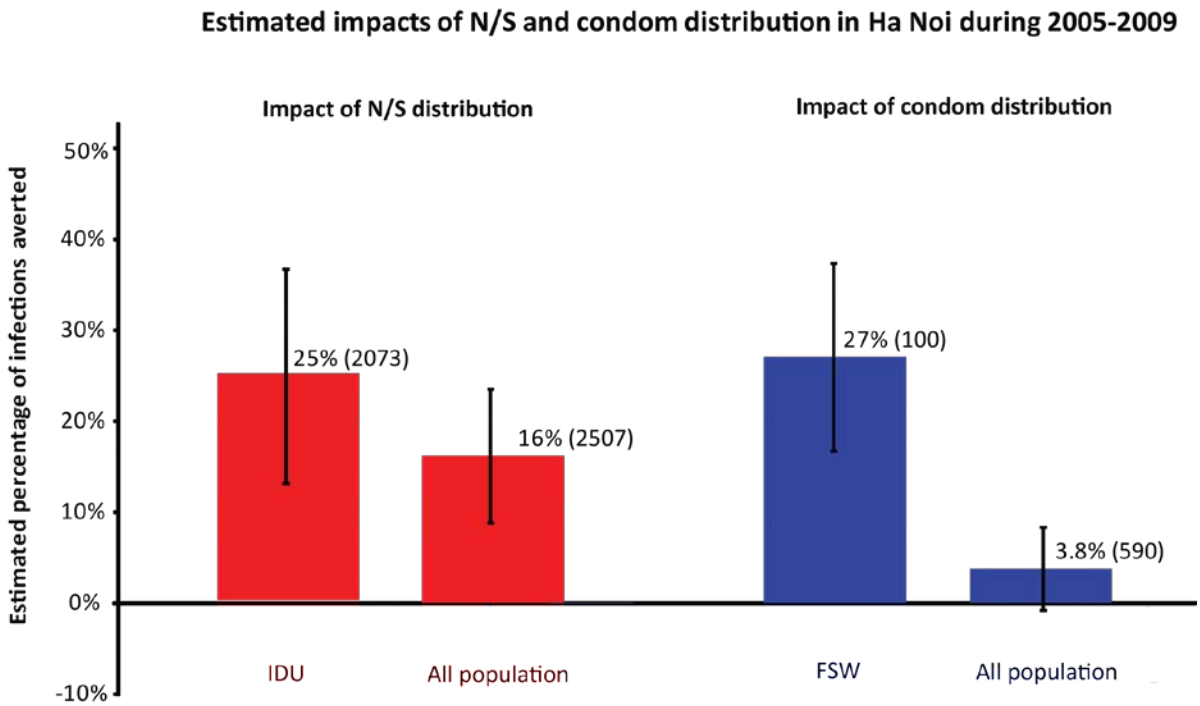


Figure 23: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Ha Noi. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Distribution of needle-syringes among IDU in Ha Noi were estimated to avert 2073 infections (25% of infections) among IDU; and another 434 infections from other population groups (16% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in Ha Noi were estimated to avert 100 infections (27%) among sex workers and a further 490 'onward' infections, primarily among clients and regular partners of clients.
- The relatively large numbers of 'onward' infections to other population groups is highly suggestive of large mixing between FSWs and the rest of the population; specifically, a relatively large male client population that has increased sexual activity with other groups. Coverage of needle-syringes among IDUs is moderately low and should be increased substantially. However, coverage of condoms among FSW is moderately high, contributing to reductions in new infections.

Ho Chi Minh City

In terms of the size of key populations at higher risk for HIV and levels of HIV prevalence among these groups, HCMC has the largest potential for harm reduction to contribute to averted infections. During the assessment period sharing rates did not increase, although levels of condom use reported in the IBBS decreased. Very low levels of per capita commodity distribution were reported in HCMC. Based on these low coverage levels, evaluation of the harm reduction programs in Ho Chi Minh City by the VHM indicated that if the interventions had not been implemented, little difference would have been observed in the trajectories of prevalence in any population group (Figure 24). The optimization routine resulted in suggestions that the HIV trajectory among MSM has increased steeply in recent years. This was found to be the consequence of transmission chains and mixing patterns among all population groups and is consistent with increases in other male population groups. Surveillance activities are required to confirm or invalidate the magnitude and trend of prevalence among MSM in HCMC. The VHM was used to calculate the expected number of primary and secondary infections averted due to harm reduction programs (see Figure 25).

Model trajectories of HIV prevalence among population groups in Ho Chi Minh City

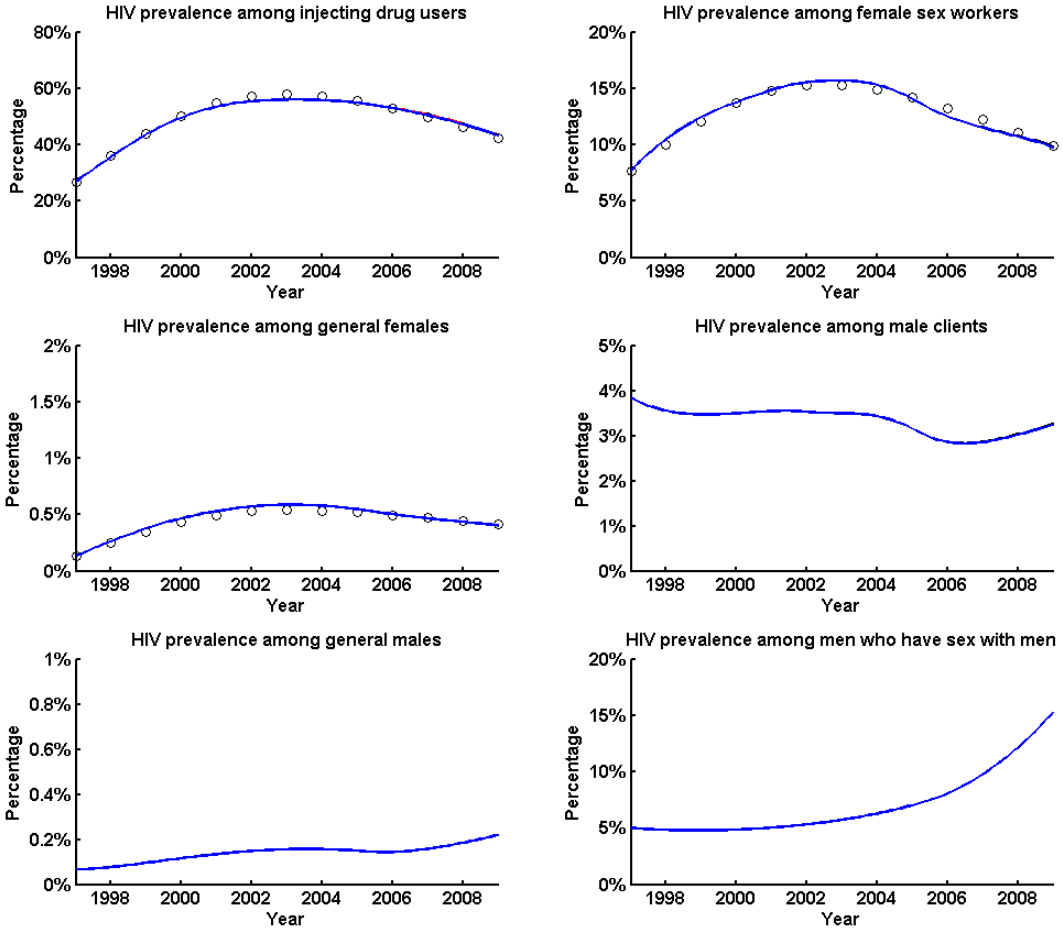


Figure 24: Trajectories of HIV prevalence among IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in HCMC. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation, the red and black curves represent VHM-simulated trajectories under the scenarios that needle-syringes and condoms were not distributed, respectively.

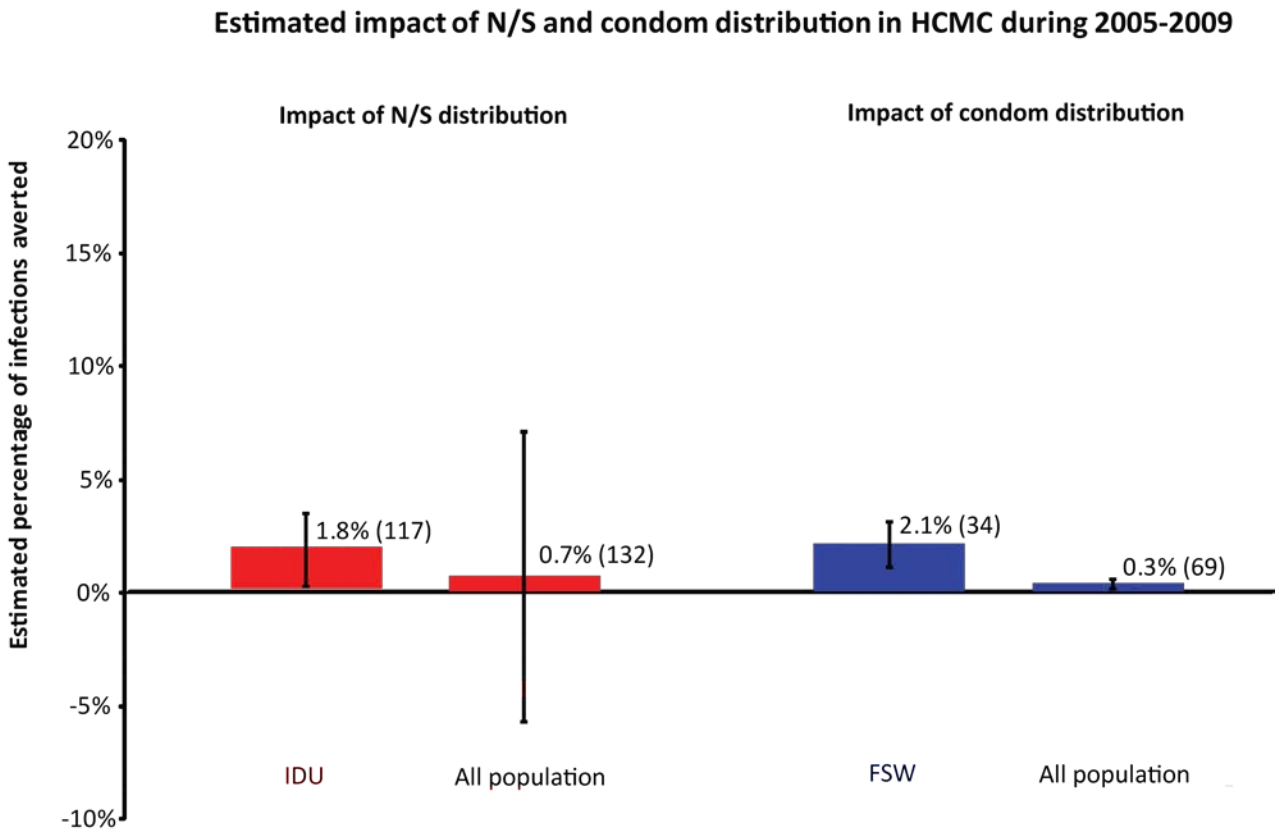


Figure 25: Estimated percentage of infections averted (number of cases averted) over the five-year period, 2005-2009, among IDU, FSW and the entire population based on simulations of the VHM for Ho Chi Minh City. Estimates are based on comparison of the observed HIV epidemic trajectory with the simulated trajectory according to expected risk behavior without distribution of needle-syringes/condoms over the period 2005-2009. Error bars refer to standard deviation of model outputs.

- Given the size of the IDU population in HCMC, even low levels of distribution of needles-syringes among IDUs in HCMC were estimated to avert 117 infections (2% of infections) among IDU; and another 15 infections from other population groups (0.7% of all infections in the total population) between 2005-2009.
- Distribution of condoms among sex workers in HCMC were estimated to avert 34 infections (2%) among sex workers and a further 35 'onward' infections, primarily among clients and regular partners of clients.
- The coverage of harm reduction programs in HCMC has been extremely low. They must increase for both IDUs and FSWs if there is to be a substantial decrease in new infections.

Sensitivity analyses

All parameters of the VHM were defined a distribution of values to account for confidence intervals in data and uncertainty in values. One hundred sets of values from the multi-dimensional parameter space were sampled, across all parameters, and used in the VHM to produce 100 different model outcomes trajectories. Sensitivity analyses, conducted in the calibration process and using the SaSAT software [14], identified the most sensitive parameters giving rise to the variation in model outcomes. The following is a list of the parameters which were consistently the most important for influencing epidemic trajectories (roughly in order of relative importance):

- Population size of all population groups, especially IDU, FSW and MSM;
- Biological transmission probability for male-to-female and female-to-male sexual exposure;
- Annual number of injections per IDU;
- Frequency of sharing injecting equipment by IDU;
- Frequency of commercial sexual acts by FSW;
- Number of regular non-commercial sexual partners for FSW;
- Condom usage in commercial sexual partnerships.

Factors that are not included in this list still have influence on the transmission dynamics of HIV epidemics, but to a smaller degree. The factors included in this list should be prioritized in accuracy of data collection for assessing their values and trends over time and they should also be prioritized in public health interventions. The sensitivity analysis identified frequency of sharing injecting equipment and condom use with FSW, which are the key factors targeted by the harm reduction programs in Vietnam. These factors are clearly the ones that have greatest potential for change. This indicates that existing public health programs are focused on appropriate targets. Underlying biological transmission probabilities cannot be affected,

however, the presence of other sexually transmissible infections (STIs) may act to increase transmission rates and thus targeting other STIs may be a potential intervention. But the most feasible way to decrease STI incidence is to promote condom use, which is already a direct priority target. Any epidemiological analysis requires accurate estimation of appropriate denominators, specifically, the size of the populations most-at-risk of infection. It is important that such estimates are made more accurate for future evaluation exercises.

Overview of modeled impact of programs versus coverage

To assess the impact of the harm reduction programs across Vietnam we investigated the model-simulated impact of the programs (with respect to the percentage of infections averted among target population groups) versus the average coverage of the programs (with respect to the number of units distributed per target person). In Figure 26 the estimated percentage of infections averted among injecting drug users in each province over the five year period, 2005-2009, is shown versus the estimated average annual number of needle-syringes distributed per IDU per year over this period.

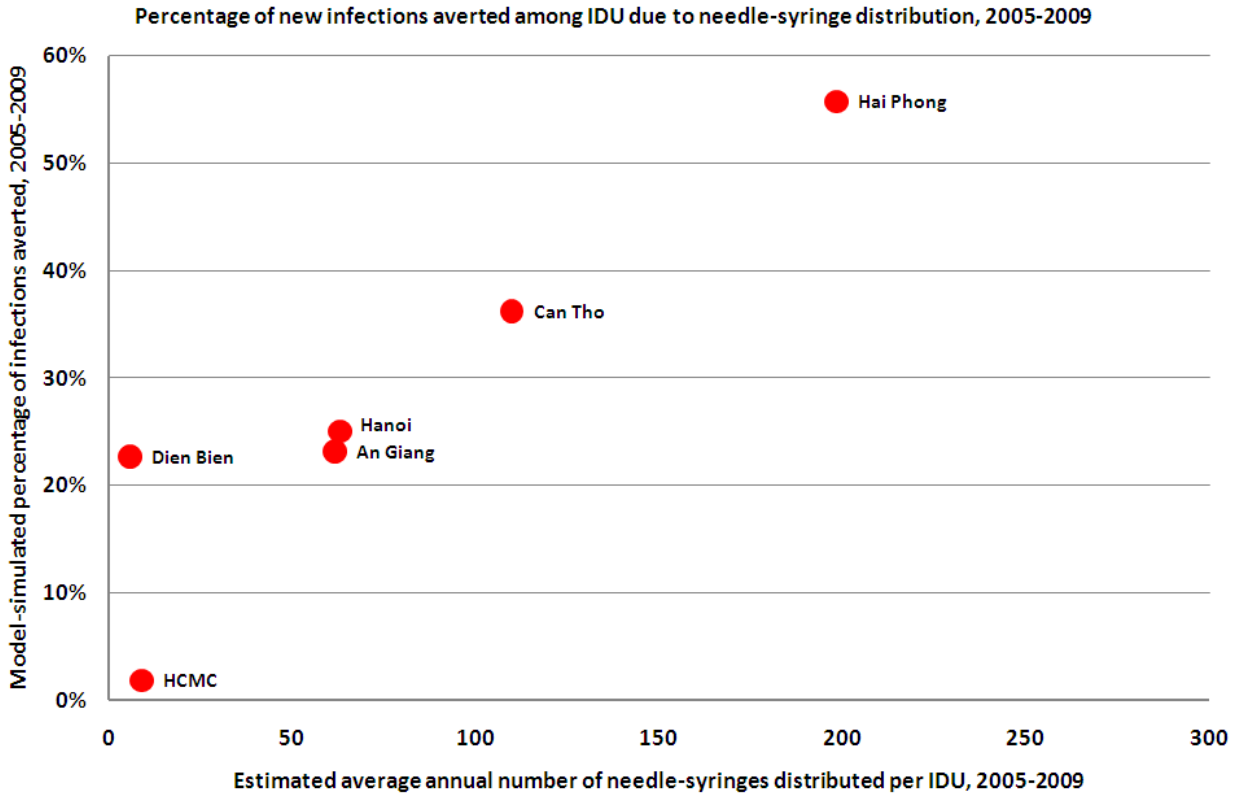


Figure 26: Scatterplot of the results from analyses across all provinces of model-simulated percentage of infections averted among IDU versus average number of needle-syringes distributed per IDU according to expected risk behavior without distribution of needle-syringes over the period 2005-2009.

In Figure 27, the estimated percentage of infections averted among female sex workers in each province over the five-year period, 2005-2009, is shown versus the estimated average number of condoms distributed per FSW per year over this period.

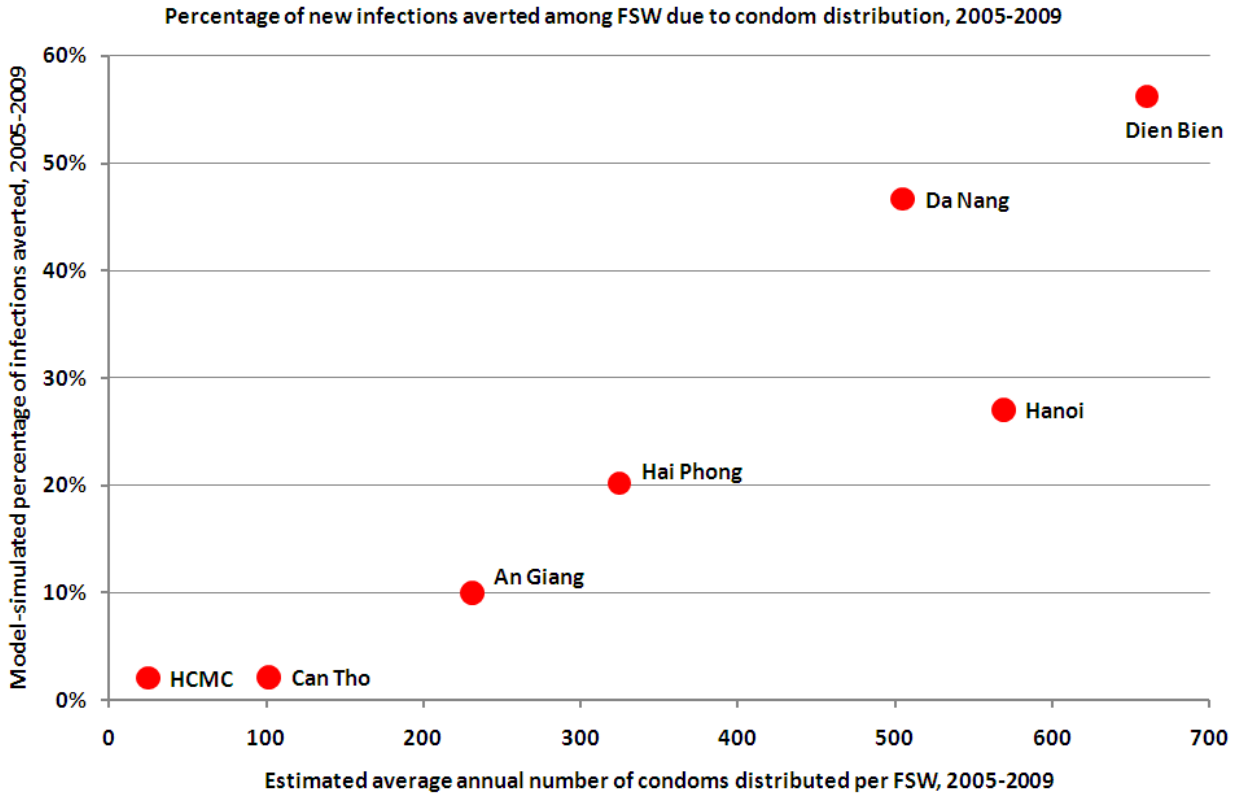
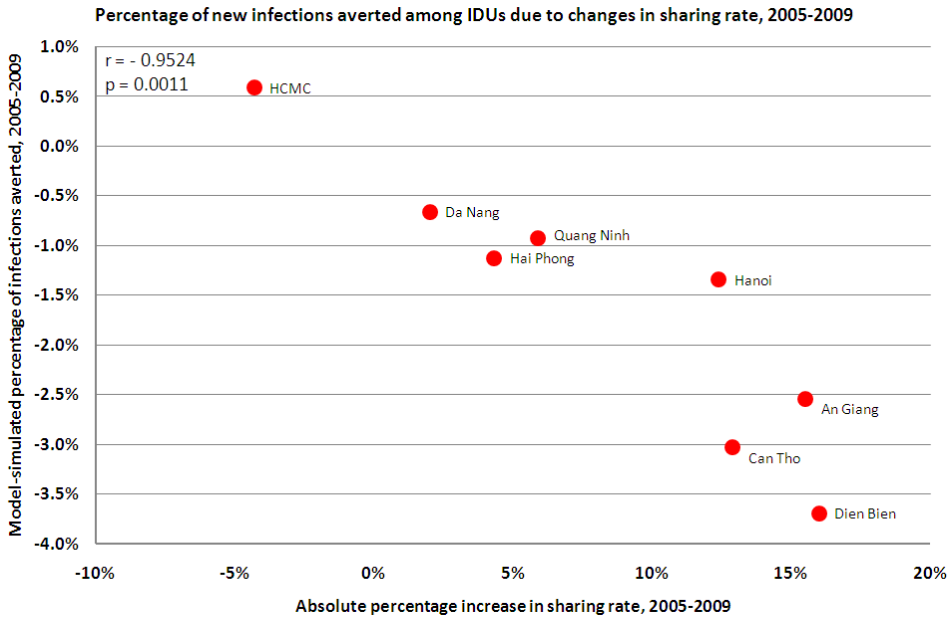


Figure 27: Scatterplot of the results from analyses across all provinces of model-simulated percentage of infections averted among FSW versus average number of condoms distributed per FSW according to expected risk behavior without distribution of condoms over the period 2005-2009.

In Figure 28, the estimated percentage of infections averted among injecting drug users and female sex workers in each province over the five-year period, 2005-2009, is shown versus the percentage change in sharing injecting equipment and condom use, respectively. Condom use among sex workers is measured in surveys for regular and casual clients and regular and casual non-clients. The average percentage change from 2005 to 2009 for each province is included in Figure 28(b).

(a)



(b)

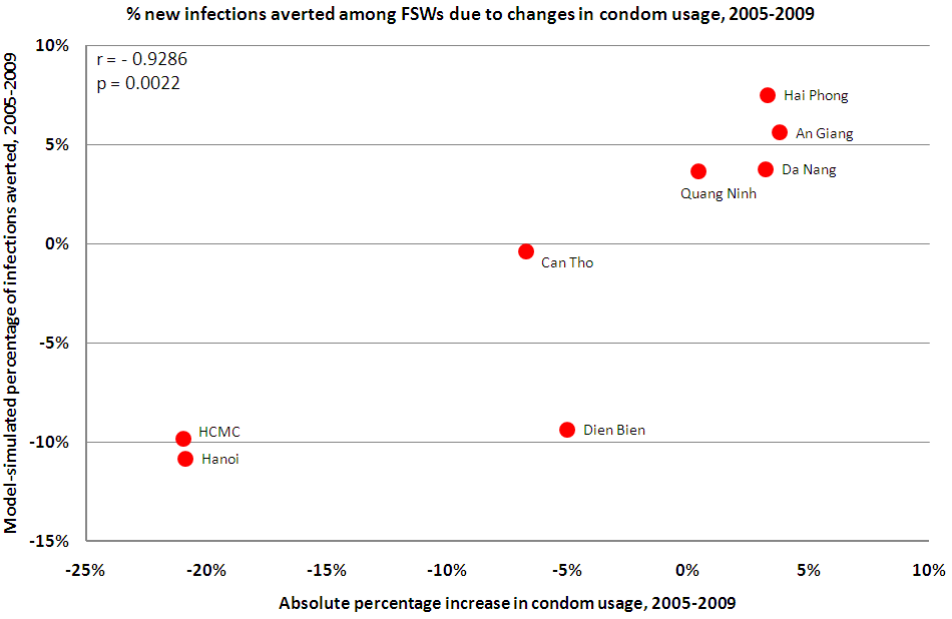


Figure 28: Scatterplot of the results from analyses across all provinces of model-simulated percentage of infections averted among (a) FSW and (b) IDU, versus absolute percentage change from 2005-2009 in needle-syringe sharing rates and condom usage respectively

Summary of results

Table 7 compares the estimated impact of harm reduction programs of IDU and FSW in each province where the VHM was applied. Provinces are ordered according to the estimated size of the IDU population to indicate the relative importance of each province to the overall national epidemic. These results suggest that moderate-to-high levels of commodity distribution by IDU harm reduction programs can result in one-quarter to one-third of infections averted among IDU. This can translate to sizeable absolute numbers of infections averted, particularly when considering downstream infections in the overall population, such as to regular partners and other key populations at higher risk. The factors most associated with greater numbers of secondary infections are behavioral risk variables (specifically, the number of potential exposure events; that is, shared injections). Similar proportions of infections averted due to good coverage of FSW harm reduction programs are also observed, however, the relatively low numbers of FSW and lower levels of HIV prevalence in these groups, suggest smaller numbers of absolute infections averted. The factors most associated with greater numbers of secondary infections are behavioral risk variables (specifically, the number of potential exposure events; that is, acts of unprotected sex and number of different sexual partners).

Harm reduction programs targeted for preventing infections among IDU and FSW can lead to secondary infections averted among other population groups. This is due to migration and mixing between groups. It is common for MSM in Vietnam to also have sex with females (see Technical Annex 3, 2005-2006 IBBS report (Table 37, page 69 [3]). As such, infections prevented in females results in reductions in prevalence among the pool of partners of many MSM. Further, infections prevented among males who inject or are clients of sex workers and are also bisexual can lead to further secondary infections among MSM.

Extrapolating the results of this study to other provinces where harm reduction interventions were implemented will provide a broader view of the likely level of impact the national harm reduction program has made on the overall epidemic in Vietnam.

Table 7: Summary of results

Province	IDU size #	HIV prevalence ##	Program coverage	% infections averted (N) due to n/s distribution		FSW size #	HIV prevalence ##	Program coverage	% infections averted (N) due to condom distribution	
				In IDU	In Total				In FSW	In Total
HCMC	34,000	47%	Low	1.8% (117)	0.7% (132)	30,000	12%	Low	2.1% (34)	0.3% (69)
Ha Noi	37,900	28%	Med	25% (2073)	16% (2507)	4800	13%	Med	27% (100)	3.8% (590)
Dien Bien	9300	42%	None-Low	23% (962)	16% (1186)	400	2%	-	56% (30)	1.6% (110)
Hai Phong	8300	58%	High	56% (1320)	35% (1345)	3000	25%	Med	20% (85)	3.7% (139)
Can Tho	2800	38%	High	36% (709)	17% (1299)	2100	9%	Low	2.1% (8)	0.4% (32)
An Giang	2200	26%	Med	23% (98)	4.7% (109)	2400	9%	Low	10% (15)	1.8% (42)
Da Nang	2000	6%	None	0	0	800	0%	Med	47% (1)	0.2% (0)

#: EPP inputs- high
##: 2005 HSS

Model limitations

The Vietnam HIV Model was newly developed for this study to evaluate the impact of harm reduction programs in Vietnam. The mathematical constructs that underpin the model are similar to standard disease transmission models, such as the Asian Epidemic Model, and models developed by other leading international modeling groups. Strengths of the VHM include its construction for the purpose of utilizing all available data source in Vietnam, representing the unique population groups and epidemic profiles in Vietnam, extensive data collation and review of model inputs for each province, the model-fitting optimization routine incorporated around a dynamic transmission epidemic model and application to numerous provinces covering different geographical regions, epidemics, and program coverage levels. However, limitations of the model include the following points:

- The VHM assumes that new people enter the population and others leave the population (e.g. due to death or mobility) but the total number of people in each population group is constant. Changes in population sizes influences estimates of program coverage and can magnify or dilute the magnitude of results.
- The structure of the model assumes the mutual exclusivity of risk behavior among individuals over a given time period. For example, men who inject are assumed not to be paying for sex or having sex with men during the period in which they are injecting. This limits the overlap in transmission networks between groups which may contribute greatly to the trajectory of the epidemic and number of 'secondary infections' occurring. However, the model incorporates the major routes of transmission and is more detailed than comparable models. This structure is unlikely to have largely influenced the results of this study.
- The model also considers the impact of harm reduction programs for IDU separately from the impact of programs for FSW. However, in epidemics where the two groups share sexual or injecting networks, the effect of interventions occurring simultaneously may have a synergistic effect which is not accounted for. This was done in order to provide clear assessment of the value of each program. However, the potential synergistic effect can be explored by the model in future analyses.

- The use of average values of parameters for each model simulation. The model could not account for the large heterogeneity that exists within risk groups, for example, wide distributions in behaviors such as number of sexual partners or injecting frequency. Uncertainty bounds around best average values were used to account for some of the differences that exist in the population but outlying attributes of core groups of individuals and other important features of sexual or injecting networks (like concurrency of partnerships) cannot be accommodated by population-level models such as the VHM.
- Mixing patterns between risk groups in the VHM may not be representative of real mixing networks. The model includes a group of men who have sex with men but it assumes that they also have sex with women at a given average sexual activity. The model does not separate men who only have sex with men from those who have sex with both men and women.
- The VHM did not represent trends over time in precise values of estimated behavioral or biological parameters; it was found that data could not be directly reconciled together. To overcome this, an optimization routine was developed to ensure all model input values remained within confidence/uncertainty bounds and directly fit to past biological trends. While the trends in uncertainty bounds represent trends in indicators over time, sampled parameter values for a single run of the model may deviate considerably within the bounds.
- The VHM was applied to a number of provinces in Vietnam. Where province-specific data were available, they were used as model inputs. However, other data may exist that were not known or accessible. Data were also not available for all variables for all provinces. Data from other provinces, or even other countries, were used to fill in gaps for provinces without similar data.
- Differences in survey methods, demographics of recruited participants, and quality of data that informed the VHM were not adjusted in any formal manner other than including confidence limits or uncertainty bounds around best estimates.
- Some model limitations can be addressed through improved quantity and quality of future data collection. Priority data requirements are listed in the Recommendations chapter.

Synthesis of findings and recommendations

Female sex workers (FSWs) and their clients and injecting drug users (IDUs) have been the focus of harm reduction programs in Vietnam implemented over the period of the last National HIV Strategy, 2004-2009. This study assessed the effectiveness of efforts to distribute needle-syringes and condoms and changing risk behavior to reduce sharing of injecting equipment and engaging in unprotected sex so that HIV transmission rates would decline. Analysis of program placement and coverage determined that harm reduction programs are generally established in appropriate places; that is, provinces with large populations of FSW and/or IDU. However, there are some provinces in which there also exist relatively large numbers of IDU and FSW but without the support of harm reduction interventions. This suggests the need to introduce harm reduction interventions in new regions. Data from the 2009 IBBS indicates that 47% of FSW and 15% of IDU reported being reached by HIV prevention interventions. Therefore, more effective targeting of programs is also required to reach a greater proportion of the population most at risk.

While levels of commodity distribution scaled up significantly during the assessment period, an ecological analysis investigating the correlation between commodity distribution and HIV prevalence trends is mixed. This is mainly due to natural epidemic dynamics such that general declines and/or stable HIV prevalence trends were observed among FSW and IDU prior to the introduction of harm reduction programs. Overall, behavioral trends have been disappointing over the past few years. In all but one province included in the modeling analyses, there was an increase in sharing of needle-syringes among IDUs in the 2009 IBBS compared to levels reported in the 2005 IBBS (Figure 28). Where no programs were implemented, increased needle-syringe sharing and some decrease in condom use was observed; for example, there was no formal needle-syringe program established in the province of Da Nang and rates of sharing of injecting equipment increased over the period 2005-2009. This is strongly supportive of the position that external socio-cultural factors may have influenced background trends towards more risky behavior independent of the programs and therefore the harm reduction programs have the challenge of attempting to reverse trends that are tending in directions of increased HIV transmission. Where there has been moderate or large program coverage, relatively modest

change in risk behavior occurred, suggesting that the programs have possibly combated a systematic background increase in risk. Furthermore, model-assumed increases in sharing rates that would have occurred without needle-syringe programs led to estimated percentage of infections averted that are very strongly correlated with program coverage (Figure 26). These results are highly supportive of the large benefit of the harm reduction programs and indicate that higher program coverage will lead to larger relative benefit in reducing infections. Even where there was small program coverage, of approximately 5-10 needle-syringes per IDU in HCMC for example, there were reductions in potential IDU infections (an estimated 2-5% reduction in HCMC). The modeling analyses provide evidence that the harm reduction programs have assisted to mitigate what could well have been greater incidence. At a population level, the effect of the harm reduction programs may not yet be largely noticeable but they have reduced the number of incident infections by a moderate level that is in support of the epidemiological value of the programs. Incidence would have been substantially greater without the number of needle-syringes being available to IDU to reduce the need to share injecting equipment. The modeling results suggest that the programs have potentially averted between two and 55% of infections depending on coverage levels (Figure 26).

There was also a strong correlation between the estimated percentage of infections averted among FSW and program coverage when adjusting for the expected condom use without the condom distribution programs (Figure 27). Overall, it is estimated that the distribution of condoms have reduced the potential number of infections among FSWs by between two and 57% (Figure 27).

Results from modeling vary in quality between different provinces. Hanoi is a good example of the impact of the harm reduction programs for which data are of relatively good quality and there is high confidence in model-based results. Medium-level coverage of both condoms and needle-syringes resulted in an aversion of an estimated 25% of IDU infections (or just over 2000 primary cases) and 27% of FSW infections (~100 cases). Furthermore, due to prevention of these infections in the population groups directly targeted with the harm reduction programs, chains of transmission to other population groups have been reduced. It was estimated that infections averted among IDU and FSW led to an additional ~800 secondary infections averted from other

population groups. However, some of the behavior change has negated some of the effect (sharing of injecting equipment to a small degree but more from decreased condom use among certain partner types).

The routes of HIV transmission and their relative efficiency are well-known. Simple biomedical interventions are available and are inexpensive for preventing transmission of HIV. In Vietnam, sharing of injecting equipment and unprotected sex between discordant sexual partners are the major routes of HIV transmission. Access to sterile injecting equipment, such that all new injections are with a new needle-syringe, and universal effective use of condoms should stop new transmissions. Harm reduction programs have been introduced in numerous provinces of Vietnam for the purposes of reducing sharing rates and decreasing unprotected sex. However, these risk behaviors still occur at levels that facilitate moderately high levels of HIV transmission. It is important to reduce rates of sharing of injecting equipment and unprotected sex. To this end, harm reduction programs that freely distribute needle-syringes and condoms are immensely valuable.

The results of this study support the need for a range of evidence-based public health responses to prevent both primary and secondary HIV transmissions. These include biomedical and behavioral prevention interventions which target injecting and sexual risk behaviors. Needle-syringe distribution and methadone maintenance treatment (MMT) are known interventions for targeting injecting behavior. Interventions designed to encourage frequent testing, early uptake of antiretroviral treatment, and educational campaigns may also be effective. Currently, HIV prevalence trends are generally decreasing across Vietnam, mainly due to the natural epidemic dynamics and assisted by harm reduction programs. Thus, deaths rates of HIV-infected people exceed rates at which people become newly infected with HIV. Increases in antiretroviral treatment in Vietnam should reverse AIDS-defining conditions and prevent HIV/AIDS-related mortality, eventually leading to the number of deaths among HIV-infected people reducing below the number of new infections. Prevalence trends are then expected to rise even if prevention efforts substantially reduce the number of new infections. Thus, it is important to implement systems for monitoring new infections and not purely prevalence in the evaluation of prevention strategies.

Harm reduction programs which distribute needle-syringes and condoms are important for HIV prevention. Current gaps in coverage continue to sustain the epidemic. The results of this study offer strong supportive evidence of the epidemiological benefits associated with expanding these harm reduction services. This should also include the establishment of programs in settings where there is demand and where they currently do not exist, and considering alternative ways of supplying clean injecting equipment and condoms, such as extending hours of distribution, removing legal and political impediments, and making needle-syringe and condom dispensing machines available. Scaling up the distribution of sterile needle-syringes and condoms could result in significant reductions in HIV transmission, averting considerable morbidity and mortality.

Recommendations of priority data requirements for future analyses

Below is a list of variables for which the VHM is most sensitive. These factors are likely to be the most important indicators for any epidemiological evaluation study and for assessing program coverage. It is recommended that these variables be prioritized in future data collected to ensure accuracy and representativeness of population groups. It is also recommended that data collection be carried out in a systematic manner, on a regular basis, with consistent methods in order for trends and comparisons to be appropriately made.

Population size estimates. Almost all epidemiological measures and planning public health responses are reliant on accurate knowledge of the denominator of the total number of people at risk in the population. However, population size estimates in any setting are often inaccurate or not known. Size estimates of at-risk populations, particularly IDU and FSW, were the most important factor in the analysis of this study. The set of population size estimates used in this analysis are derived from the consensus of technical experts adjusting the size of MOLISA-based estimates. Upper estimates of population size were used. To facilitate planning of appropriate coverage of harm reduction programs and conducting evaluation and epidemiological studies, it is important to obtain empirically-based estimates of sizes of at-risk populations in as much detail and as accurately as possible. It is recommended that a systematic approach be taken to calculate population size estimates of at-risk populations, with priority in provinces with greatest HIV prevalence and differentiating between different urban-rural geographical locations.

Incidence and prevalence of an infection are the most important epidemiological measures for understanding the transmission and extent of disease in a population. While incidence estimates are ideal for understanding trends in new infections and the direct impact of prevention strategies, it is difficult and costly to perform routinely. Prevalence provides an understanding of the extent of existing infection in a population. Determining the cross-sectional positivity rate among a sampled group of people representative of the population of interest is a common method for estimating prevalence. Such study-based measurements are often fraught with

participation biases and not representative of the population group of interest, and also do not allow generalization of the results for other regions. Prevalence data used in this study are based on estimates from sentinel surveillance sites; however, they are consistently lower than the prevalence estimates from IBBS reports. It is important for these estimates to be reconciled by adjusting for the different population groups sampled from each study to achieve a consistent estimate that is representative of the broader population. This study uses EPP-smoothed prevalence data from the sentinel surveillance sites to calculate levels and trends in incidence across all population groups, with assumed mortality, disease progression and mixing rates.

With the recent scale-up of antiretroviral treatment in Vietnam, HIV/AIDS-related mortality rates should have declined. With sufficient scale-up of treatment and effective management of HIV-infected patients, the prevalence of HIV should not decline but may increase. Consequently, surrogate indicators of incident infections would become a more important epidemiological marker than prevalence and methods for incidence estimates should be explored.

The number of needle-syringes and condoms distributed are the most obvious indicators of the magnitude of harm reduction programs. The number of units distributed from year to year can vary considerably and the reliability of such data is questionable. It is important to identify all sources of needle-syringes and condom distribution, collect data in an efficient but reliable manner for provincial and national reporting. The number of units obtained from commercial means – outside the harm reduction programs – is believed to be greater than those distributed through the programs. There are not data to support this or provide estimates of the magnitude of units in circulation. Understanding the frequency of use of new needle-syringes and condoms accessed by individuals in the population, and mapping it against frequency of sharing injecting equipment and unprotected sex, is the most important exercise for understanding harm reduction programs in terms of their coverage and effect on modifying risk behavior.

Examine differential coverage. Due to police detention, forced detoxification and re-education in Treatment, Education & Social Labor Centers (TESLCs), some IDU are reluctant to access harm

reduction programs. There is large diversity in coverage of programs across the population. It is important to determine the percentage of IDU and FSW who have access to the harm reduction programs and commercial sites where needle-syringes and condoms can be obtained easily. The analyses in this study assumed accessibility is proportional to average coverage levels (commodities distributed divided by number of people in the population) but stratifying population groups further by extent of program coverage and/or accessibility to commodities may yield significantly different results and provide further information to assist in targeting programs.

The frequency of unprotected sex with casual, regular or commercial partners is the most important variable for quantifying the likelihood of HIV acquisition from sexual exposure. While survey questions around 'consistent condom use' and 'condom use at last act' are useful indicators for the extent of condom use, the total number of unprotected sex acts is the most useful measure of one's risk. Multiplying the estimated number of total (protected and unprotected) acts by the proportion of people who reported use of a condom during their last act, as a surrogate marker for the proportion of all acts in which condoms are used, is currently one of the best methods available for quantifying unprotected sex. However, this can be improved upon. Further differentiation of number of unprotected sex acts by knowledge about the partner's HIV status (HIV-negative, HIV-positive, and unknown) as well as more information about the type of sexual acts (penile-vaginal/penile-anal, with or without ejaculation) would also increase accuracy of modeling estimates and provide more precise indicators of specific risk factors associated with the spread of HIV.

The frequency of receptive sharing of needle-syringes is the most important variable for quantifying the likelihood of HIV acquisition from injecting exposure. While survey questions such as 'have you shared injecting equipment in the last three months?' are useful indicators for the extent of sharing needle-syringes, the total absolute number of receptively shared needle-syringes is the most useful measure of one's risk. Obtaining more precise estimates of the number of times an average injector uses a needle-syringe after another IDU has used it would

be a valuable indicator. Differentiating between rates of sharing needle-syringes, spoons, and tourniquets is important as well as understanding sharing rates not only in terms of the proportion of IDUs who share but the proportion of their injections in which they receptive share injecting equipment. Estimates of the number of people with whom IDUs share and knowledge of the HIV status of these partners would also be useful indicators.

Key recommendations

Improve data collection and analysis of size estimation of key populations at higher risk for HIV infection (e.g., IDU, FSW, MSM), as well as for the male clients of FSW, program monitoring statistics, and sentinel surveillance

Indicators that accurately measure the extent of the HIV epidemic (population size denominators, prevalence and incidence) and are representative of the underlying population are essential. This needs to be combined with accurate data on the extent of program implementation (number of units distributed, number of peer educators, information about the network accessing the programs and subgroups that do not access the programs). Trends in behavioral risk factors are the links between epidemiology and program interventions. Measuring specific variables that are direct indicators of exposure to HIV (frequency of unprotected sex and frequency of receptive sharing of needle-syringes) is important for future evaluation of the success of public health programs. It is also recommended that data collection be carried out in a systematic manner, on a regular basis, with consistent methods in order for trends and comparisons to be appropriately made. Data that should be prioritized are listed above in the *Priority data requirements for future analyses* section.

Introduce harm reduction programs in all provinces with large numbers of IDU and/or FSW and improve levels of coverage within provinces with programs, giving highest priority to regions with greatest numbers of key populations at higher risk of HIV infection

Although harm reduction programs have been introduced in numerous provinces of Vietnam, key

risk behaviors still occur at levels that facilitate moderately high levels of HIV transmission. Harm reduction programs that distribute free needle-syringes and condoms are immensely valuable and have been shown in this report to be effective in mitigating epidemics. This analysis identified provinces with large numbers of IDU and/or FSW experiencing HIV epidemics, but as yet, no large-scale harm reduction programs. For example, 13 provinces have more than 1000 IDU and/or FSW and no large-scale harm reduction services are in place. There is a strong case for the need to introduce harm reduction interventions in these regions, informed by experiences of success in other provinces but tailored to the environment of each location. Even in the absence of an established HIV epidemic, it is important to introduce these programs in order to prevent epidemics emerging. Some important provinces, with large numbers of IDU, continue to have relatively moderate levels of coverage. Only two of the eight provinces with more than 6000 IDU have distribution levels exceeding 150 needle-syringes per person. Importantly, given the large contribution HCMC makes to the overall population of key populations at higher risk for HIV in the country, low levels of program coverage in HCMC suggests that national-level epidemic impact requires concerted scale-up of services in this province.

Establish national guidance on the package of services, quality standards, and coverage targets for harm reduction services

There are currently no national standards as to the minimum package of harm reduction services, no specific quality standards or targets for distribution of needle-syringes and condoms. Without this national guidance it is challenging to conduct an impact assessment across provinces which use standardized measures to compare or summarize program achievements at the end of a 5-year implementation period, much less to conduct ongoing program monitoring and management during the implementation period. Recent survey data suggest that even in provinces with harm reduction programs, the majority of intended beneficiaries do not have access to these programs. Thus, it is important to ensure greater coverage among all IDU and FSW networks. It is also important to increase the volume of commodities distributed. If program coverage exceeds target thresholds of 200 needle-syringes per IDU and 240 condoms per FSW, then it can be expected that more than 50% of infections among IDU and more than 20% of

infections among FSW would likely be averted; substantial changes in epidemiological trends would be observed. The target of 200 needle-syringes per IDU per year is consistent with UNAIDS/WHO guidance for achieving high coverage for IDU interventions [17]. The target of 240 condoms per FSW per year is likely to be lower than the 60% of risk acts proposed to be necessary to maintain low or declining trends in HIV prevalence. However, socially marketed condoms play an important role in meeting the need for condoms and it is important to clarify the proportion of need which free distribution of condoms is intended to comprise.

Conduct operational research to understand technical efficiency and why implementation works in some regions

This analysis demonstrated variability in impact across different provinces despite similar harm reduction programs being implemented in all areas. It was shown that coverage levels were very strongly associated with the epidemiological success of the interventions. It is recommended that factors giving rise to the success or failure in each setting be determined. Coverage, in terms of the number of units of needle-syringes/condoms per IDU/FSW, is an appropriate outcome indicator for the programs but understanding how implementation can be improved to reach high coverage levels is essential. Therefore, it is recommended that *implementation science studies* be conducted (i.e., studies to understand technical efficiency of different models of service implementation) and studies to understand the 'why' of impact (i.e. *management science studies*).

Strengthen training and supervision of peer educators to improve coverage of individuals and distribute commodities efficiently

Achieving high levels of program coverage is dependent on sufficient training for program implementers (peer educators). This includes techniques for contacting individuals on a regular basis, distributing sufficient numbers of commodities to each individual and accompanying commodity distribution with effective behavior change communication. Good training will also

depend on establishing and reinforcing national norms and quality standards for peer educator outreach activities.

References

1. Anderson, R.M. and R.M. May, *Infectious Diseases of Humans: Dynamics and Control*. 1991, NY: Oxford University Press.
2. Quinn, T.C., et al., *Viral load and heterosexual transmission of human immunodeficiency virus type 1. Rakai Project Study Group.* N Engl J Med, 2000. **342**(13): p. 921-9.
3. Wilson, D.P., et al., *Relation between HIV viral load and infectiousness: a model-based analysis.* Lancet, 2008. **372**(9635): p. 314-20.
4. Donnell, D., et al., *Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: a prospective cohort analysis.* Lancet, 2010. **375**(9731): p. 2092-8.
5. Attia, S., et al., *Sexual transmission of HIV according to viral load and antiretroviral therapy: systematic review and meta-analysis.* AIDS, 2009. **23**(11): p. 1397-404.
6. King, M.S., S.C. Brun, and D.J. Kempf, *Relationship between adherence and the development of resistance in antiretroviral-naive, HIV-1-infected patients receiving lopinavir/ritonavir or nelfinavir.* J Infect Dis, 2005. **191**(12): p. 2046-52.
7. Wood, E., et al., *Effect of medication adherence on survival of HIV-infected adults who start highly active antiretroviral therapy when the CD4+ cell count is 0.200 to 0.350 x 10(9) cells/L.* Ann Intern Med, 2003. **139**(10): p. 810-6.
8. Maggiolo, F., et al., *Effect of adherence to HAART on virologic outcome and on the selection of resistance-conferring mutations in NNRTI- or PI-treated patients.* HIV Clin Trials, 2007. **8**(5): p. 282-92.
9. Phillips, A.N., et al., *Long term probability of detection of HIV-1 drug resistance after starting antiretroviral therapy in routine clinical practice.* Aids, 2005. **19**(5): p. 487-94.
10. Phillips, A.N., et al., *Risk of extensive virological failure to the three original antiretroviral drug classes over long-term follow-up from the start of therapy in patients with HIV infection: an observational cohort study.* Lancet, 2007. **370**(9603): p. 1923-8.
11. Kwon, J.A., et al., *The impact of needle and syringe programs on HIV and HCV transmissions in injecting drug users in Australia: a model-based analysis.* J Acquir Immune Defic Syndr, 2009. **51**(4): p. 462-469.
12. Iman, R.L., J.C. Helton, and J.E. Campbell, *An Approach To Sensitivity Analysis Of Computer-Models .1. Introduction, Input Variable Selection And Preliminary Variable Assessment.* Journal Of Quality Technology, 1981. **13**(3): p. 174.
13. Iman, R.L., J.C. Helton, and J.E. Campbell, *An approach to sensitivity analysis of computer-models .2. Ranking of input variables, response-surface validation, distribution effect and technique synopsis.* Journal of Quality Technology, 1981. **13**(4): p. 232.
14. Hoare, A., D.G. Regan, and D.P. Wilson, *Sampling and sensitivity analyses tools (SaSAT) for computational modelling.* Theor Biol Med Model, 2008. **5**: p. 4.
15. Rose, K.A., et al., *Parameter sensitivities, monte carlo filtering, and model forecasting under uncertainty.* Journal of Forecasting, 1991. **10**: p. 117-133.
16. Fedra, K., G. Van Straten, and M.B. Beck, *Uncertainty and arbitrariness in ecosystems modeling: A lake modeling example.* Ecological Modelling, 1981. **13**: p. 87-110.
17. *Joint United Nations Programme on HIV/AIDS & World Health Organization. Technical Guide for countries to set targets for universal access to HIV prevention, treatment and care for injecting drug users* 2009.
18. Rottingen, J.A. and G.P. Garnett, *The epidemiological and control implications of HIV transmission probabilities within partnerships.* Sex Transm Dis, 2002. **29**(12): p. 818-27.
19. Kaplan, E.H., *Modeling HIV infectivity: must sex acts be counted?* J Acquir Immune Defic Syndr, 1990. **3**(1): p. 55-61.
20. Kerr, T., et al., *Syringe sharing and HIV incidence among injection drug users and increased access to sterile syringes.* Am J Public Health. **100**(8): p. 1449-53.

21. Zamani, S., et al., *Needle and syringe sharing practices among injecting drug users in Tehran: a comparison of two neighborhoods, one with and one without a needle and syringe program.* AIDS Behav. **14**(4): p. 885-90.
22. MacDonald, M.A., et al., *Hepatitis C virus antibody prevalence among injecting drug users at selected needle and syringe programs in Australia, 1995-1997. Collaboration of Australian NSPs.* Med J Aust, 2000. **172**(2): p. 57-61.
23. Donoghoe, M.C., et al., *Changes in HIV risk behaviour in clients of syringe-exchange schemes in England and Scotland.* AIDS, 1989. **3**(5): p. 267-72.
24. Bluthenthal, R.N., et al., *The effect of syringe exchange use on high-risk injection drug users: a cohort study.* AIDS, 2000. **14**(5): p. 605-11.
25. Broadhead, R.S., Y. van Hulst, and D.D. Heckathorn, *The impact of a needle exchange's closure.* Public Health Rep, 1999. **114**(5): p. 439-47.
26. Durex, *Global Sex Survey 2005*. 2005.
27. Nguyen, N.T., et al., *Clients of female sex workers as a bridging population in Vietnam.* AIDS Behav, 2009. **13**(5): p. 881-91.
28. National Institute of Hygiene and Epidemiology, *HIV/STI Integrated Biological and Behavioral Surveillance, Vietnam 2008*. 2008, National Institute of Hygiene and Epidemiology: Hanoi.
29. Nguyen, T.A., et al., *Prevalence and risk factors associated with HIV infection among men having sex with men in Ho Chi Minh City, Vietnam.* AIDS Behav, 2008. **12**(3): p. 476-82.
30. Boily, M.C., et al., *Heterosexual risk of HIV-1 infection per sexual act: systematic review and meta-analysis of observational studies.* Lancet Infect Dis, 2009. **9**(2): p. 118-129.
31. Pedraza, M.A., et al., *Heterosexual transmission of HIV-1 is associated with high plasma viral load levels and a positive viral isolation in the infected partner.* J Acquir Immune Defic Syndr, 1999. **21**(2): p. 120-5.
32. Deschamps, M.M., et al., *Heterosexual transmission of HIV in Haiti.* Ann Intern Med, 1996. **125**(4): p. 324-30.
33. Siddiqui, N.S., et al., *No seroconversions among steady sex partners of methadone-maintained HIV-1-seropositive injecting drug users in New York City.* AIDS, 1992. **6**(12): p. 1529-33.
34. Longini, I.M., Jr., et al., *Statistical analysis of the stages of HIV infection using a Markov model.* Stat Med, 1989. **8**(7): p. 831-43.
35. Jin, F., et al., *Per-contact probability of HIV transmission in homosexual men in Sydney in the post HAART era.* AIDS, 2009. **In Press**.
36. Kaplan, E.H. and E. O'Keefe, *Let the needles do the talking! Evaluating the New Haven needle exchange.* Interfaces, 1993. **23**(1): p. 7-26.
37. Hudgens, M.G., et al., *Subtype-specific transmission probabilities for human immunodeficiency virus type 1 among injecting drug users in Bangkok, Thailand.* Am J Epidemiol, 2002. **155**(2): p. 159-68.
38. Henderson, D.K., et al., *Risk for occupational transmission of human immunodeficiency virus type 1 (HIV-1) associated with clinical exposures. A prospective evaluation.* Ann Intern Med, 1990. **113**(10): p. 740-6.
39. Cavalcante, N.J., et al., *Risk of health care professionals acquiring HIV infection in Latin America.* AIDS Care, 1991. **3**(3): p. 311-6.
40. Gerberding, J.L., *Incidence and prevalence of human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and cytomegalovirus among health care personnel at risk for blood exposure: final report from a longitudinal study.* J Infect Dis, 1994. **170**(6): p. 1410-7.
41. Ippolito, G., V. Puro, and G. De Carli, *The risk of occupational human immunodeficiency virus infection in health care workers. Italian Multicenter Study. The Italian Study Group on Occupational Risk of HIV infection.* Arch Intern Med, 1993. **153**(12): p. 1451-8.
42. Nelsing, S., T.L. Nielsen, and J.O. Nielsen, *Occupational exposure to human immunodeficiency virus among health care workers in a Danish hospital.* J Infect Dis, 1994. **169**(2): p. 478.

43. Tokars, J.I., et al., *Surveillance of HIV infection and zidovudine use among health care workers after occupational exposure to HIV-infected blood. The CDC Cooperative Needlestick Surveillance Group*. Ann Intern Med, 1993. **118**(12): p. 913-9.
44. Davis, K.R. and S.C. Weller, *The effectiveness of condoms in reducing heterosexual transmission of HIV*. Fam Plann Perspect, 1999. **31**(6): p. 272-9.
45. Fitch, J.T., et al., *Condom effectiveness: factors that influence risk reduction.* Sex Transm Dis, 2002. **29**(12): p. 811-7.
46. Pinkerton, S.D. and P.R. Abramson, *Effectiveness of condoms in preventing HIV transmission.* Soc Sci Med, 1997. **44**(9): p. 1303-12.
47. Weller, S. and K. Davis, *Condom effectiveness in reducing heterosexual HIV transmission.* Cochrane Database Syst Rev, 2002(1): p. CD003255.
48. Weller, S.C., *A meta-analysis of condom effectiveness in reducing sexually transmitted HIV*. Soc Sci Med, 1993. **36**(12): p. 1635-44.
49. Abdala, N., et al., *Can HIV-1-Contaminated Syringes Be Disinfected? Implications for Transmission Among Injection Drug Users.* JAIDS Journal of Acquired Immune Deficiency Syndromes, 2001. **28**(5): p. 487-494.
50. Siegel, J., M. Weinstein, and H. Fineberg, *Bleach programs for preventing AIDS among iv drug users: modeling the impact of HIV prevalence.* Am J Public Health, 1991. **81**(10): p. 1273-1279.
51. Ritchers J, *HIV/AIDS, Hepatitis C & Related Diseases in Australia: Annual Report of Behaviour National Centre in HIV Social Research*. 2006, University of New South Wales.
52. Smith, C.J., et al., *The rate of viral rebound after attainment of an HIV load <50 copies/mL according to specific antiretroviral drugs in use: results from a multicenter cohort study.* J Infect Dis, 2005. **192**(8): p. 1387-97.
53. Bonnet, F., et al., *Causes of death among HIV-infected patients in the era of highly active antiretroviral therapy, Bordeaux, France, 1998-1999.* HIV Med, 2002. **3**(3): p. 195-9.
54. Keiser, O., et al., *All cause mortality in the Swiss HIV Cohort Study from 1990 to 2001 in comparison with the Swiss population.* AIDS, 2004. **18**(13): p. 1835-43.
55. Krentz, H.B., G. Kliewer, and M.J. Gill, *Changing mortality rates and causes of death for HIV-infected individuals living in Southern Alberta, Canada from 1984 to 2003.* HIV Med, 2005. **6**(2): p. 99-106.
56. Lewden, C., et al., *Factors associated with mortality in human immunodeficiency virus type 1-infected adults initiating protease inhibitor-containing therapy: role of education level and of early transaminase level elevation (APROCO-ANRS EP11 study). The Antiproteases Cohorte Agence Nationale de Recherches sur le SIDA EP 11 study*. J Infect Dis, 2002. **186**(5): p. 710-4.
57. Petoumenos, K. and M.G. Law, *Risk factors and causes of death in the Australian HIV Observational Database*. Sex Health, 2006. **3**(2): p. 103-12.
58. Ledergerber, B., et al., *Predictors of trend in CD4-positive T-cell count and mortality among HIV-1-infected individuals with virological failure to all three antiretroviral-drug classes.* Lancet, 2004. **364**(9428): p. 51-62.
59. Smith, C., et al., *Causes of death in the D:A:D study-initial results*. 2008.
60. Colette Smith, et al., *Causes of death in the D:A:D study-initial results*. 2008.
61. Donoghoe, M.C., K.A. Dolan, and G.V. Stimson, *Life-style factors and social circumstances of syringe sharing in injecting drug users.* Br J Addict, 1992. **87**(7): p. 993-1003.
62. McKeganey, N., et al., *The preparedness to share injecting equipment: an analysis using vignettes.* Addiction, 1995. **90**(9): p. 1253-60.

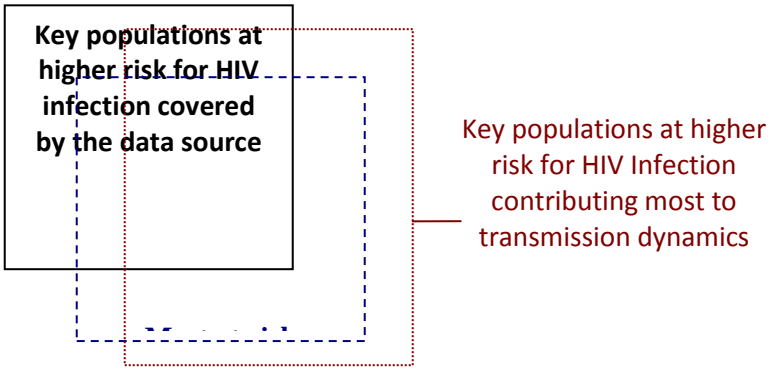
Technical Annex 1: Review of data sources

This annex reviews the sources of data used for the analyses presented in this impact assessment and describes the considerations given to data quality and representativeness.

Populations of interest to the impact assessment

Evaluating the best use of different data sources for the impact assessment requires a clear definition of the population each source relates to and how this overlaps with the population considered to be both epidemiologically and programmatically relevant.

Ideal scenario: High degree of overlap between population for which data is available and data needed



The impact assessment focuses on the outcomes of Vietnam's harm reduction interventions, which are targeted toward female sex workers (FSW) and injecting drug users (IDU),. But to the extent that clients of sex workers and MSM also play an important role in transmission dynamics, these groups are also described. Some key challenges in measuring impact lies in the difficulty in both identifying and characterizing key populations at higher risk for HIV infection. These groups are generally hard to reach due to their marginalized status in country. Surveys conducted among key populations at higher risk in Vietnam also suggest they are diverse within their own groups, representing a range of risk intensity and vulnerabilities. Risk characteristics, including frequency

of injecting or numbers of clients, as well as socio-demographic variables such as age and level of income vary greatly between and within provinces. For the purpose of the impact assessment, the population definitions used for these analyses follow the definitions used by the harm reduction programs.

Injecting drug users: This group includes those who are currently injecting (i.e. who require a supply of sterile injecting equipment. Injecting drug users may be male or female. The proportion of female IDU is difficult to estimate in different regions of the country And many female IDU are believed to be either sexual partners of male IDU and/or engaged in selling sex.

The impact assessment considers both IDU who reside in the community as well as those who may be held in Treatment, Education & Social Labor Centres (TESLCs) (i.e. 06 Centers) by the Department of Labor, Invalids, and Social Affairs (DoLISA). Detention centers include those with a history of both injecting and non-injecting drug use and serve as settings for detoxification. As such, drug use within these facilities is clandestine and sterile injecting equipment is not readily available. The level of detainment activity of DoLISA (i.e. the percentage of IDU who are in detention centers vs. in the community) varies from province to province, depending on the both the socio-political climate locally, available resources, and perception of severity of the drug user problem. Persons held in TESLCs may stay for a few months or up to several years. Individuals who are released from TESLCs may or may not relapse and resume injection drug use practices. And persons held in 06 Centers may or may not be residents of the province in which the detention center is located, so that upon release they may or may not remain in the local community.

Female sex workers: There are multiple venues from which women may sell sex in exchange for money. In Vietnam, the most common venues for soliciting clients are street-based locations or entertainment establishments such as karaoke bars, restaurants, and massage parlors. The latter type is often described as indirect sex work, and in Vietnam is commonly referred to as karaoke-based sex workers. These women get paid a regular wage for working in the establishment, and the money earned by selling sex is not the sole or primary source of income. Not all women who work in these types of establishments may sell sex. There is some belief that women who work in establishments and sell sex generally earn more income and take fewer clients, and therefore

may be at lower risk than FSW who solicit clients on the streets. However, there remains some diversity in behavior within these groups and a fluid boundary between street-based and karaoke/entertainment-based sex workers in many areas. TESLCs for female sex workers (i.e. 05 Centers) are also maintained by DoLISA. The policy for detention of sex workers differs from those of IDU. The duration of detention is usually shorter and women who solicit in street-based venues are more likely to be detained than those who solicit clients from an entertainment establishment.

Male clients of female sex workers: According to epidemic modeling conducted in the region, male clients of FSW are a critical group for understanding the potential for spread of HIV in Asian countries. Buying sex is thought to be a common practice in most parts of Asia, in part due to the relatively small percentage of general females who engage in casual, extra-marital sexual activity. The potential size of the male client of FSW population and the large proportion who have vulnerable spouses often represent the populations with the largest numbers of HIV infections identified. At present, most harm reduction interventions in Vietnam do not directly address male clients of FSW. Instead, behavior change, communication and availability of condoms to FSW are intended to have the largest impact on reducing risk through commercial sex work. However, large-scale condom social marketing and some effort to focus prevention efforts among potential male clients found at solicitation points have been undertaken by the government and its partners. For impact assessment, the contribution of male clients of FSW have been accounted for in epidemic modeling, but less so in the direct assessment of program coverage.

Men who have sex with men: In the last few years, increasing attention has been given to the contribution of anal sex among males to the spread of HIV in Asian epidemics. However, except for large cities such as HCMC, Ha Noi and Hai Phong, harm reduction interventions for MSM have only just begun in most provinces. The MSM group, similar to the clients of FSW, has been considered in the impact assessment in terms of the potential contribution to the overall trajectory of the epidemic, rather than in terms of what degree harm reduction interventions may have reduced or slowed transmission among this group. As with all MARP, the MSM population encompasses a group of very diverse behaviors, from those who sell sex to male

clients, or those with large numbers of often anonymous male partners, to men who have occasional or intermittent sexual experiences with other men, but who are well integrated in the general population, having wives and living with their families. The segment of the MSM population most relevant to understanding the HIV epidemic are those with higher risk profiles, i.e. who have frequent anal sex with multiple male partners. This higher risk group is often characterized as those who are venue-based, i.e. those who seek sex partners at venues/cruising points.

Temporal element to defining populations at risk: As these populations are defined in part by the risk behavior they engage in, it is important to recognize that this identity contains a temporal element. For example, someone who injected drugs a year ago may or may no longer inject today, next month, or several years from now. At different points of the analyses, slightly different temporal definitions may be used. For example, the population relevant for assessing program coverage includes those who engaged in risk behaviors at the time of the intervention (i.e. those who would benefit from behavior change communication or commodities to support safe behaviors). However, for the purposes of transmission dynamics, both those who are actively engaged in risk behavior as well as those who may have previously been infected but who no longer engage in risk behavior may be important to consider when estimating the number of infections occurring in a given time period.

There are four main types of data on key populations at higher risk for HIV infection used for the impact assessment[7]:

1) Population size estimates

2) HIV prevalence

[7] In addition to data sources on MARP, the epidemic modeling component of the assessment utilizes other sources of survey data which characterize the underlying general population in an effort to project the larger impact of the harm reduction program, including the prevention of downstream infections among regular partners of most-at-risk populations.

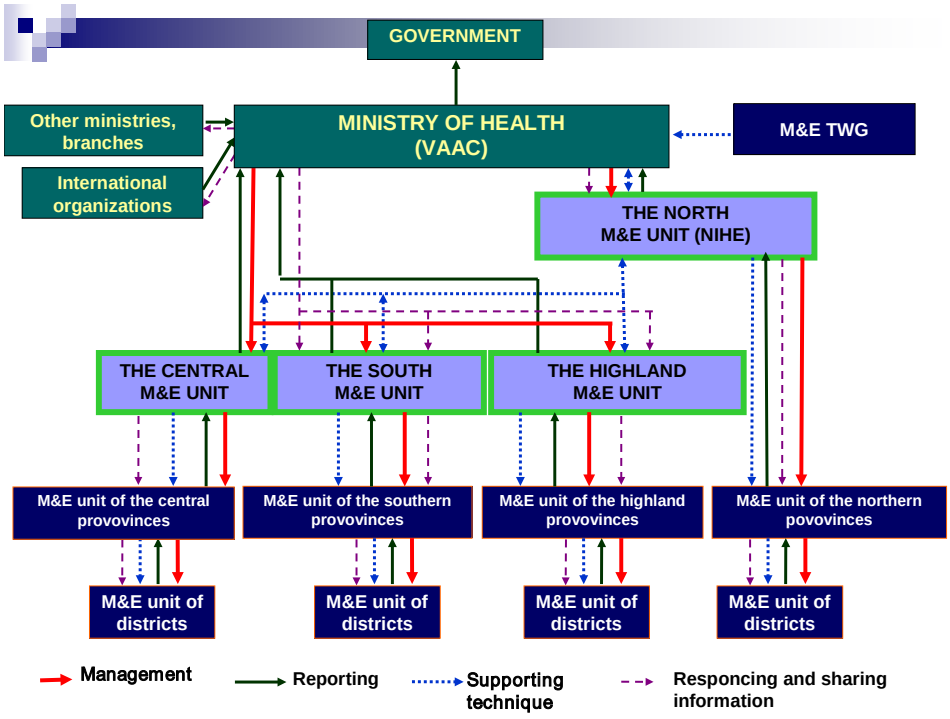
3) Behavioral risk factor/patterns of behavior

4) Service utilization / delivery data

The data sources available for each of these types of data and for each key population at higher risk for HIV are detailed in the following section.

Institutions involved in supporting data collection:

The data used for this impact assessment comes from multiple sources managed by different partner organizations and departments within the government. The figure below illustrates the flow of data and units responsible for coordinating M&E data within the VAAC. To the extent that the VAAC is the national authority for AIDS control, then routine monitoring data, surveillance data, and special study data should be accessible at the central level. However, in practice, some interventions are managed by central management units funded by international donors and have resulted in separate parallel streams of reporting. Strong efforts over the last two years have been made by the government and its development partners to strengthen and harmonize the M&E system, under the commitment to the 'Three Ones'. This effort is manifest in Decision 28, which enforces a single reporting format and central database for routine program monitoring. Data quality and completeness is considered to have improved under this decision. However, this also implies some issues of data quality through the period being assessed which must be accounted for in the interpretation of the results.



The following sections provide more detailed discussion about different sources of data and the strengths and limitations of each, which influenced decisions on which data should be used and how it was analyzed.

Size estimates of most-at-risk populations

The size of the most-at-risk population is a critical input to understanding the scale and speed of the spread of HIV currently and in the future. In concentrated epidemics, such as the one found in most provinces of Vietnam, the key populations at higher risk for HIV infection are those described earlier: IDU, FSW and their clients, and MSM.

These populations tend to be very fluid, with individuals both joining and leaving the key populations at higher risk for HIV over time. These reasons may be due to factors at the individual level (e.g. aging, personal/familial level of income, etc.) or social-environmental level (e.g. change in drug prices, shift in population or labor markets). Consequently, the size of the population is difficult to quantify and may be continuously changing in unanticipated ways. When interpreting size estimates data from different sources and different time periods, it can be difficult to assess whether changes in size estimates relate to the uncertainty inherent in size estimation, differences in the methods of measurement, or growth/shrinkage in the size of the

populations themselves.

Summary of available data sources from different years for each key population at higher risk for HIV**:**

	IDU	**FSW**	**MSM**	**Clients of FSW**
MOLISA/DOLISA	2004-2008	2004-2008	NA	NA
Program mapping	2008	2008	NA	NA
Estimates through expert consensus (i.e. EPP inputs)	2007,2009 EPP	2007,2009 EPP	2007,2009 EPP	2007-2009 EPP
Vietnam Population and AIDS indicator survey	NA	NA	NA	2005
Selected source of data for the impact assessment analyses	**2009 EPP inputs through expert consensus**			

DoLISA/MOLISA size estimates: For IDU and FSW, official sources of size estimates come from the MOLISA/DOLISA, the government agency given responsibility for enforcing the laws against illicit drug use and solicitation of sex. Data from MOLISA include the number of IDU or FSW who have been registered by the agency at any point and are believed to still be alive. This number is often referred to as the 'registered' number. Some IDU/FSW counted as registered live in the community while others are still in a detention center. A subset of the registered number of IDU are those who are actively 'managed' by MOLISA, this includes people who are still in the detention center or who are living in the catchment area of the local DOLISA office which registered them and have not moved elsewhere or died. Data from MOLISA do not distinguish between those who inject and do not inject.

Data on the number 'registered' by MOLISA were available from 2004-2008 for both FSW and IDU. The concentration of IDU in different provinces ranges considerably when taking the MOLISA data and calculating it as a percentage of the total adult male population. These

differences may reflect the true variation in distribution of the population as well as different rates of detention practiced by DoLISA in different provinces. The figures on size also vary from year to year, without consistent patterns, e.g. from 2007-2008 the size of the IDU population increased substantially (i.e. by more than a third) in 11/65 provinces; and decreased substantially in 12 provinces. Between 2004 and 2008, the size of the IDU population fluctuated by more than 100% between the smallest and largest estimate of size over the period in more than a third of provinces.

Some of the difficulties in interpreting the MOLISA data for IDU include the likelihood that IDU in the community try to avoid detention and have an incentive to remain hidden from the authorities, making the proportion who do not come into contact with the MOLISA system, difficult to apportion. In HCMC during the period of 2005-2007, a large-scale effort to identify and detain IDU in 06 Centers was enacted. However, the policy of detainment changed in 2007 resulting in a large-scale release of IDU back to the community. This release of IDU from the detention centers would not have shown up as a large fluctuation in the number of 'registered' IDU; however, they would impact the expected number of IDU who could be covered through outreach and change the potential transmission dynamics during this period. There is insufficient information to interpret whether changes in the numbers registered are associated with changes in detention practices, or whether the proportion of drug users who inject has changed over time in different areas. More corroborating information is also needed about the rate of relapse among those who are released from detention or the rate of death among IDU included in the registers.

MOLISA data are believed to severely underestimate the size of the FSW population, due to the much less attention paid to managing or rehabilitating sex workers compared to drug users. The size of the FSW population, according to MOLISA, is one tenth the size of the IDU population. Nonetheless, the size estimates provided by MOLISA fluctuates for FSW to a similar degree as for IDU.

Program Estimates: Size estimates based on mapping exercises conducted by harm reduction intervention programs provide alternative data for the estimated size of IDU, FSW populations in provinces with WB- or DFID-supported prevention programs. These estimates are based on the

numbers of beneficiaries encountered by peer educators and outreach staff during field activities. At the time of the impact assessment, a standardized method for program-based size estimates was not in place. This makes it difficult to evaluate the reliability of the data provided from these estimates. However, the general method suggests that the completeness of the size estimates depends heavily on the level of geographic coverage of outreach activities in the province (i.e. whether outreach services offered in all districts/communes where key populations at higher risk for HIV are located) and the rapport the intervention has with beneficiary community (i.e. key populations at higher risk are likely to remain hidden to outreach staff, due to a lack of trust in the program). Experience from other countries in the region suggests that program mapping data may often overestimate the size of the key populations at higher risk o infection, due to the lack of unique identifiers used for counting, the inability to account for mobility of the population and the double counting of individuals who frequent more than one location where outreach services are provided. This has been a more severe problem in highly urban areas with high population density areas, making it difficult to track individuals' mobility between sites in close proximity to each other.

In almost all provinces with both data sources, the program-based size estimates are larger, often by several times, than the size estimates of the MOLISA data. This is particularly true for the estimated size of the FSW population

Vietnam Population and AIDS indicator survey: This general population household survey of adults (aged >15 years) conducted in 2005, provides some information about the proportion of male respondents who have bought sex in the last year. The survey included a limited number of sites including (Hai Phong, Ha Noi, and HCMC), and the proportion ranged from 0.2-1.1% of respondents. This figure is considerably lower than many other countries in the region and is believed to be under estimated due to social desirability bias.

Consensus adjusted population size estimates: Due to the limitations of the direct size estimation data available through MOLISA or intervention programs, substantial efforts have been made to adopt adjusted population size estimates of IDU, FSW, and MSM for the purpose of epidemic modeling and projections of the burden of disease. Using these estimates helps to maintain consistency with approaches adopted for other types of epidemic modeling and projections

being conducted in country. Differences in the outputs of these analyses reflect differences in modeling or analytic approaches rather than differences in the data inputs.

These adjusted figures have been developed in recent years through consultation with an in-country Strategic Information and Monitoring & Evaluation Technical Working Group (i.e. VAAC, NIHE, UNAIDS, WHO, FHI, USG) and international (East West Center) technical experts for the purpose of producing official national estimates for the burden of disease, through the Estimates and Projections Package (EPP). The following adjustments have been made for IDU population size estimates:

a) applying a correction factor of 0.85 to the MOLISA 'registered' drug user figures in each province, which includes both community and detained individuals, then

b) applying a further correction factor of 2X as the group estimated 50% of current IDU have not been included in the MOLISA system.

For sex workers, the overall number of FSW included in the MOLISA figures is multiplied by 3X to account for the proportion of FSW who are not captured by MOLISA.

For male clients of FSW, the proportion of adult males (i.e. men >15 years old) who bought sex recently is estimated to be between five (low) and 10 (high) % in all provinces.

For MSM, 0.5-1.5% of the adult male population (i.e. men <15 years old) are assumed to have had a male sexual partner (in the last year?) in all provinces except in Hanoi and HCMC, where the population proportion is estimated at 1-3%.

The magnitude of the adjustments used for the size estimates of all key populations at higher risk for HIV are not based on referenced, country-specific data, but reflects consensus on the best estimates of local and international technical experts. The population proportions applied for MSM and male clients of FSW figures are consistent with those used in the region.

Selection of data source for population size estimates: Due to the difficulty in obtaining specific local information on the reliability of the direct size estimates and in verifying the assumptions made about the adjusted factors on a province by province basis, the team has chosen to use the

consensus population size estimates used for the most recent round, 2009, of the estimates and projections program (EPP).

HIV prevalence

The impact of a prevention intervention is measured most directly through changes in the number of new infections which occur over the period of the intervention. However, most impact evaluations of HIV prevention interventions must rely on measures of HIV prevalence, due to the nascent state of development of HIV incidence assays. Trends in HIV prevalence are examined both directly as well as used as inputs in mathematical models to assess whether changes in prevalence and potentially incidence are attributable to the intervention.

Interpreting trends in HIV prevalence as a proxy for incidence trends is complex due to the difficulty in distinguishing factors which may influence the duration of infection (e.g. access to care and treatment to prolong survival) from factors related to actual changes in disease transmission. However, biological trends among key populations at higher risk for HIV are difficult to interpret due to the challenges in obtaining consistent, comparable samples of these hidden and highly mobile groups. Interpreting a prevalence trend also depends on whether the population under study is believed to be closed, dynamically stable, or changing in size and composition. For these reasons, the review of data quality and representativeness of these data sources are critical issues in determining the reliability of results of the impact assessment.

HIV Sentinel surveillance: Vietnam is one of the few countries in the world to have an extensive, long-standing system of sentinel surveillance for most-at-risk populations, specifically IDU and FSW. Data in some provinces are available since 1994, and since 2001 more than 40 provinces have had sentinel surveillance data for these groups. Sentinel surveillance systems are designed to provide reliable measures of trend for a particular location, which is useful for determining whether an epidemic is emerging, growing, stabilizing or declining, but is not intended to be representative of the population in a particular geographic area. To produce reliable trends, sentinel surveillance sites must adhere to strict protocols of sequential sampling, where eligible

individuals are neither incentivized nor coerced into participating. Under ideal circumstances, HIV testing would be unlinked and anonymous using leftover blood specimens which are collected routinely for the provision of other clinical services, such as regular syphilis screening.

The Vietnam sentinel surveillance system for IDU and FSW operate under different protocols which divide the sample of each province in half, to obtain samples from the community and from those currently in a detention center. The actual process of recruitment in each setting varies and is prone to selection bias by local teams responsible for the surveillance activities. Reviews of the quality of sentinel surveillance data conducted by the expert groups preparing inputs for EPP in 2003, 2005, and 2007, identified a number of quality issues with sentinel surveillance data in some provinces, resulting in exclusion of data from some provinces from analysis. In 2005, the protocol for sentinel surveillance was revised by VAAC to update and enforce stricter standards. This change in protocol was accompanied by more resources and technical support from regional institutions such as NIHE, HCMC – Pasteur Institute, and Nha Trang – Pasteur Institute, to strengthen implementation. Some improvements in the quality of sentinel surveillance data have been recognized recently by local experts, however, the reliability of HIV prevalence prior to the start and in the early phase of large scale harm reduction programs is difficult to determine.

Integrated biological and behavioral survey (IBBS): In many countries with concentrated epidemics, IBBS of key populations have been introduced as an important component of HIV surveillance. These surveys employ probability sampling methods designed to accommodate the challenges faced in obtaining representative samples of these groups, of which to make either biological and behavioral inferences. The two most common approaches for sampling used are time location cluster sampling (TLS) and respondent driven sampling (RDS).

Time location cluster sampling is appropriate for populations which congregate in public locations, but are generally mobile (e.g. female sex workers and some types of injecting drug users). To obtain a representative sample of key populations at higher risk for HIV through TLS depends on the development of an updated and comprehensive listing of all types of locations/venues where the relevant key populations congregate. This type of listing is often difficult to develop and requires the support of the local key populations at higher risk for HIV

community and other groups who are familiar with the local situation such as intervention staff. This may result in a bias toward inclusion of locations or key populations at higher risk for HIV infection which are reached or more familiar to the interventions.

Respondent driven sampling is a method which does not require the development of a sampling frame, but relies on the existing social network structure within a population to recruit a representative sample. This method has been successful in many countries especially with MSM and IDU populations, as well as some types of FSW populations. The design of the survey depends on a fixed survey location where respondents are willing to come after being recruited by peers/friends who have already participated and a system of dual incentives for respondents to participate and recruit others. The representativeness of the survey depends heavily on the convenience on the location of the fixed site, the appropriateness of the incentive, and the completeness of the social network. Bias may result if key populations from only the area close to the fixed survey site, or if incentives are too high or low, resulting in selectivity in the process of recruitment. A poorly networked group will result in low participation and skew the sample according to the characteristics and social network of the initial seeds selected to start the survey. Due to the limited participation of the survey team in the process of sampling/recruitment, it is difficult to assess the introduction of these types of biases or measure the degree to which groups are represented.

In Vietnam, an IBBS has been conducted in a number of provinces by two main research institutes: NIHE and HCMC – PI, with technical support from FHI While TLS sampling methods were used in Vietnam in 2000 and 2002, the IBBS conducted in 2005-6 in 7 provinces represents the first round of surveys including a biological marker for HIV and including RDS approaches for some populations and sites. The second round of IBBS was conducted in 2009-2010 in 10 provinces and provides a critical second time-point with which to assess the trends in HIV prevalence in selected provinces over the time period of the intervention being evaluated.

Table of sites and populations covered in each round of IBBS.

	IBBS Round I (2005-6)	IBBS Round II (2009-10)
Hanoi	IDU, SSW, KSW, MSM*	IDU, SSW, VSW, MSM
Hai Phong	IDU, SSW, KSW	IDU, SSW, VSW, MSM
Quang Ninh	IDU*, SSW*, KSW	IDU, SSW, VSW,
Da Nang	IDU, SSW*, KSW*	IDU, SSW, VSW,
HCMC	IDU, SSW*, KSW, MSM*	IDU, SSW, VSW, MSM
Can Tho	IDU, SSW*, KSW*	IDU, SSW, VSW, MSM
An Giang	IDU, SSW*, KSW*	IDU, SSW, VSW,

*indicates cluster samples where all key populations at higher risk identified at the clusters were included, i.e. "take all" approach was used. SSW – Street based sex workers; KSW – Karaoke bar based sex workers; VSW- Venue based sex workers

The sampling methodology used in the first round of IBBS for IDU in all provinces except for Hai Phong and An Giang was RDS and all the other samples were conducted using time location cluster sampling. The sex worker sample was divided into two groups: street based sex workers (SSW) and karaoke bar sex workers (KSW), the latter group representing a large portion of the sex workers working in entertainment establishments, i.e. indirect sex workers. The separate samples reflected differences in the venues appropriate for sampling as well as the belief that these groups had distinct risk and socio demographic profiles.

The target sample size for IDU and both FSW groups was 300 per site, per group, while for MSM the sample size target was 400. In five of the seven SSW samples, three of the seven KSW samples, and both MSM samples, an insufficient numbers of eligible respondents could be found at the clusters to take a random sample. Instead the survey teams selected all relevant key populations at higher risk for HIV infection found at all clusters identified. The need to adopt a take all method in provinces where the size of the FSW population was expected to be large (e.g. HCMC, Can Tho, and An Giang, where the FSW population is greater than 1000), suggests some potential problem in the ability of the survey team to obtain an unbiased sample. Similarly, it is

surprising that in large metropolitan areas, the sample of MSM required a take-all approach. Given the large estimated size of the MSM population in these cities, the MSM included in the sample may represent a skewed subset of visible MSM found in a limited number of known cruising points.

The eligibility criterion for inclusion in the survey for IDU and FSW was being over 18 years of age.MSM who were 15 years and older were eligible for inclusion. IDU were eligible if they injected in the last month, while FSW had to have sold sex in the last month. Women were classified as SSW rather than KSW, if they primarily solicited clients from street venues, even if they occasionally sold sex from establishments when trying to evade detention. MSM were eligible for the survey if they had sex with another man in the last 12 months.

For the HIV prevalence measure, blood specimens were obtained from all respondents consenting to participate. The testing algorithm used one rapid test and two ELISA tests for confirmation. Testing was conducted by provincial preventive medicine labs using standardized protocols and employing certified lab technicians. No problems with test results from central level quality assurance procedures were reported in the IBBS final report.

Other surveys with biological markers: Since 2002, a number of surveys among key populations at higher risk for HIV infection and general population have been conducted by the HCMC – Pasteur Institute in provinces under their purview in the southern region of Vietnam. These surveys have employed TLS for FSW, IDU, and trucker populations, and stratified sampling for more general population groups such as youth.

	FSW (TLS)	**IDU (TLS)**	**MSM (RDS)**	**Other**
Sóc Trăng	2002, 2008*	2002, 2004, 2006		2002: Truck drivers; students; Youth 2004, 2006: Youth
Bình Dương	2002	2002		2002: Truck drivers; Youth
Bình Phước	2002	2002		2002: Truck drivers; Youth

Long An	2002	2002		2002: Truck drivers; Youth
Đồng Tháp	20002, 2004	2002, 2004		2002, 2004: Male youth
An Giang	2002. 2004, 2008*	2002, 2004	2010	2002, 2004: Male youth; 2006: Minority groups; 2007: peasant;
Kiên Giang	2002, 2004	2002, 2004		2002, 2004: Male youth; 2006: Minority groups; 2007: peasant, Fishermen
Tiền Giang, Bến Tre, Vĩnh Long (combined)	2006, 2008*			
Kiên Giang, Hậu Giang	2007			
Vĩnh Long		2007		
Bến Tre		2008		
Vũng Tàu		2008		
Đồng Nai				General population (2008)
Hậu Giang				General population (2008)
Vĩnh Long				General population (2008)

*combined sample across three provinces in 2008 (Total N=300)

These surveys provide useful measures of the HIV prevalence in the population at the time. However, the approach to using TLS was relatively new in 2002 and the methodology has been improved over time, generating what are believed to be more representative samples in the later years of the survey. Due to shifts in the methodology, trends from the five provinces/sites with data from two or more time points among the same risk groups, are not always easy to interpret, although are indicative of the trajectory of the epidemic in these southern provinces prior to the

scale-up of harm reduction programs.

Consensus adjusted HIV prevalence numbers: Similar to the consensus process for adjusting the population size estimates, technical experts developing the inputs for the EPP process have also made adjustments to HIV prevalence data from sentinel surveillance the first round of the IBBS. This process includes excluding sentinel surveillance points deemed to be highly biased or skewed in sampling, and adjusting the sentinel surveillance data to reflect the prevalence of the key populations at higher risk for hiv infection in the community (i.e. not in detention centers). Where IBBS data are available, this data point is used for the 2005 time point. In most cases, the EPP input trend is similar to the trend given by raw sentinel surveillance; however, in a few key groups and sites, the trajectory of the epidemic becomes quite different in the most recent period. While great efforts have been made to document the adjustments made for use in EPP, in some cases, it is not possible to determine how final HIV prevalence estimates were arrived at for use in EPP in 2007 or 2009.

Selection of data sources for HIV prevalence trends: Data from the raw sentinel surveillance are used to describe qualitative trends in prevalence measured in different provinces. These gross trends are then compared to the trends in program coverage indicators to determine if the results are generally consistent with the idea that increasing program coverage is associated with a declining or stabilizing HIV prevalence trends over a similar (slightly staggered) period. When looking at the HIV prevalence trends with the coverage data in ecological analysis, the general trajectory of the epidemic is more important to consider than the specific value of prevalence. Given that there is some missing information about the adjustments applied by the consensus prevalence estimates, raw data were thought to be more straightforward to use for this first application.

For the purposes of epidemic modeling, sentinel surveillance data were used after being smoothed by putting three year running averages as inputs in the 2007 version of the EPP software.. The resulting curves are similar but not identical to those projected in the official 2007 EPP report (published in 2009).

Behavioral Risk Factors

Measures of behavioral risk are primarily used in the epidemic modeling to better fit the predicted effect of interventions on risk behaviors, which ultimately change the transmission of HIV in the populations being studied. These behaviors include the frequency of risk taking (e.g. numbers of clients, numbers of anal sex partners, and numbers of injections per day, week or month), the frequency of exposure to regular partners, and the adoption of safer behaviors (e.g. condom use, sterile needle/syringe use; cleaning of injecting equipment). In addition to risk profile data, these surveys also contain important socio-demographic characteristics of the population and their exposure or interaction with harm reduction interventions.

Due to the use of existing data sources, most behavioral risk factor data were obtained from published reports, slide presentations shared with the M&E technical working group, and other spreadsheets of data collated for other data triangulation activities ongoing in the country (e.g. A2 – Asian Epidemic Modeling, Data Triangulation Capacity Building project). In many cases these reports or existing data tables may not have analyzed the survey questions in the format most useful for the epidemic models. Although the study team advisory group for the impact assessment suggested that collaborators make raw data files available for reanalysis, these raw data sets were not available in time to complete the report. Where necessary, the data provided in tables were transformed into useful parameter values through formulae detailed in Annex 4.

In addition to the IBBS and other surveys conducted by HCMC – Pasteur Institute and Abt, there are a number of important behavioral surveys of FSW and IDU as well as the general population.

End line evaluation surveys of the WB and DFID harm reduction program: At the close of the DFID project and at the end point of the first phase of the WB harm reduction projects, a set of behavioral surveys were conducted in selected provinces where each donor supported program was active. The sampling design for the WB allowed for province specific estimates of a few core behavioral indicators, in nine provinces for IDU[8], six provinces for FSW[9], and two provinces for general adult population[10]. In the DFID project area, behavioral estimates were available for six provinces for IDU[11] and seven provinces for FSW[12]. To avoid survey fatigue in a province, in

[8] Son La, Cao Bang, Lai Chau, Thai Nguyen, Bac Giang, Nam Dinh, Thanh Hoa, Ben Tre, Vinh Long
[9] Kien Giang, Tien Giang, Ben Tre, Hau Giang, Vinh Long, An Giang
[10] Thanh Hoa, Dong Nai
[11] Ha Noi, Hai Phong, Quang Ninh, HCMC, Can Tho, and An Giang

provinces where both DFID- and WB-supported programs, only one project selected the province for evaluation surveys. The exception to this was An Giang province, which was surveyed in both the WB and DFID evaluation surveys as well as for IBBS.

A type of TLS was used to select the sample for both projects' evaluation surveys; however the institution conducting the survey in each case did not have prior experience with this style of sampling and did not work with the organizations with greater experience conducting probability surveys of FSW and IDU (i.e. FHI, NIHE, HCMC – PI). Unlike the surveys conducted by NIHE/FHI and HCMC – PI, cluster listings were drawn from information from the NGOs rather than through mapping of hotspots for the purpose of sampling frame development. This is likely to have skewed the sample toward respondents who had some contact with the program. Because no baseline round of data were collected, it is difficult to draw a conclusion about the impact of the intervention on changes in behavior since the project start date.

VPAIS: AIDS indicator surveys, such as the one conducted in Vietnam, are general population household surveys which ask questions about HIV/AIDS knowledge, attitudes, and some information about risk behaviors, which follow international guidance using standardized instruments and have a reputation for high degree of quality control. The VPAIS was conducted in 2005 through ORC Macro, a research organization which conducts these surveys in many countries globally. The survey was funded by the US government and involved both the general statistics office (GSO) and NIHE. The sampling design allowed for point estimates at national level, for urban vs. rural areas, for three regions (North, South, Central), and four target provinces (Ha Noi, HCMC, Hai Phong,[13] and Quang Ninh).

Selected data sources for behavioral parameters: Given that epidemic modeling was conducted in eight selected provinces, all behavioral data available in each province were collated and used to develop parameter values/ranges for the province-specific models.

[12] Ha Noi, Hai Phong, Quang Ninh, Da Nang, HCMC, Can Tho, An Giang

[13] Blood specimens for an HIV prevalence measure were collected in only Hai Phong. The prevalence was 0.5% among a sample size of N=1791.

Service Utilization/ Delivery Data

Selected measures of coverage: There are multiple measures of coverage for harm reduction programs. While outreach is a key component of harm reduction programs, it is often difficult to distinguish the number of contacts made from the number of individuals who receive outreach services. Measures of coverage that count the number of contacts made may be misleading as it cannot distinguish a situation where a small group of individuals are reached daily from a broad group of individuals reached weekly or monthly. Harm reduction programs are generally more effective by saturating coverage, i.e. offering moderate level of services to a large proportion of the population of MARP. Drop-in centers are another component of programming, which provide an anchor for project visibility in an area, but may attract only a small proportion of the population who require prevention services. The effectiveness of outreach lies both in helping key populations at higher risk for HIV infection to feel empowered and motivated to adopt harm reduction practices, as well as in providing commodities needed for safe behaviors, such as condoms and sterile needles/syringes.

For the purposes of the impact assessment, the indicators felt to use the most standardized definitions and likely to be easiest to verify were:

- the number of districts and communes covered
- the number of peer educators engaged, and
- the volume of free distribution of commodities (either condoms or needle-syringes).

A central repository for routine monitoring data: The large-scale harm reduction programs in Vietnam are supported by international donors, and this results in the flow of service utilization/delivery data reported from the Provincial AIDS Centers (PAC) to the Central program management units of the donor-funded programs (i.e. WB, DFID, Life Gap), as well as being consolidated at the provincial level, across both donor programs and government-funded interventions, and transmitted to the central VAAC database.

Because responsibility for the harm reduction program shifted from the Department of

Preventive Medicine to the newly-created VAAC in 2005, it took some time to establish the current, central electronic routine monitoring data base. The early phase of the large-scale harm reduction programs of DFID and WB did not establish a set of core indicators or standardized flow of data for the first 18 months to two years of the program. While the system currently receives routine and relatively complete reporting from the PACs, some provinces continue to provide more reliable data on service utilization than others.

Data collation and verification process: Routine monitoring data were collected from both the central VAAC database as well as the central PMU of the Life Gap, WB and DFID programs for the period 2004/5 to 2008. Data from the latter part of 2004 and the full period of 2005 were consolidated as a single reporting year, as the program was in its initial phases. It was not possible to annualize these data for the purposes of comparison to subsequent years.

In many provinces, large and inconsistent patterns between the summed data reported by WB, DFID and Life Gap and the consolidated number reported by the PAC to VAAC exist in the indicators of free condom and needle-syringe distribution. For example, sometimes the sum of free condoms distributed by WB, DFID, and Life Gap combined greatly exceeded the total free condoms distributed according to the VAAC. In other cases, the VAAC-consolidated number was much higher. To resolve these inconsistencies, the team of regional data collators confirmed the unexplained differences with the M&E officers of the respective PACs between December 2009 and January 2010.

In February 2010, the 2009 routine monitoring data became available and were forwarded to the impact assessment team to incorporate into the analyses. These data were sent only from the VAAC central database and were not compared to the donor-supported program PMU records.

Technical Annex 2: Mathematical details of Vietnam HIV Model

Mathematically, the Vietnam HIV Model (VHM) is described by 48 ordinary differential equations, one for each of eight population group (Figure 5) multiplied by the number of disease states (six) tracked by the model (Figure 6); the equations are developed according to standard disease modeling frameworks [1] and their mathematical expression and description of each term is as follows:

$$\underbrace{\frac{dS}{dt}}_{\text{Rate of change in the number of uninfected people}} = \underbrace{\pi}_{\text{New people enter population}} - \underbrace{\lambda(t)S}_{\text{Per-capita rate of HIV transmission. Depends on risk-related behavior and prevalence of HIV among partners}} - \underbrace{\mu_S S}_{\text{Death rate for uninfected people}} \quad (1)$$

$$\underbrace{\frac{dI_u}{dt}}_{\text{Rate of change in the number of undiagnosed chronic-stage cases}} = \underbrace{\lambda(t)S}_{\text{Per-capita rate of HIV transmission}} - \underbrace{\gamma I_u}_{\text{Rate of disease progression from chronic infection to late stage}} - \underbrace{\eta_c I_u}_{\text{Rate of HIV diagnosis for people in chronic stage}} - \underbrace{\mu_c I_u}_{\text{Death rate for HIV-infected people in chronic stage}} \quad (2)$$

$$\underbrace{\frac{dA_u}{dt}}_{\text{Rate of change in the number of undiagnosed late-stage cases}} = \underbrace{\gamma I_u}_{\text{Rate of disease progression from chronic infection to late stage}} - \underbrace{\eta_a A_u}_{\text{Rate of HIV diagnosis for people in late stage}} - \underbrace{\mu_a A_u}_{\text{Death rate for HIV-infected people in late stage}} \quad (3)$$

$$\underbrace{\frac{dI_d}{dt}}_{\text{Rate of change in the number of diagnosed chronic-stage cases}} = \underbrace{\eta_c I_u}_{\text{Rate of HIV diagnosis for people in chronic stage}} - \underbrace{\gamma I_d}_{\text{Rate of disease progression from chronic infection to late stage}} - \underbrace{\mu_c I_d}_{\text{Death rate for HIV-infected people in chronic stage}} \quad (4)$$

$$\underbrace{\frac{dA_d}{dt}}_{\text{Rate of change in the number of diagnosed late-stage cases}} = \underbrace{\gamma I_d}_{\text{Rate of disease progression from chronic infection to late stage}} + \underbrace{\eta_a A_u}_{\text{Rate of HIV diagnosis for people in late stage}} - \underbrace{\tau A_d}_{\text{Rate of diagnosed people in late stage initiating treatment}} + \underbrace{\sigma T}_{\text{Rate of people on ART stopping treatment}} - \underbrace{\mu_a A_d}_{\text{Death rate for HIV-infected people in late stage}} \quad (5)$$

$$\underbrace{\frac{dT}{dt}}_{\text{Rate of change in the number of people on ART}} = \underbrace{\tau A_d}_{\text{Rate of diagnosed people in late stage initiating treatment}} - \underbrace{\sigma T}_{\text{Rate of people on ART stopping treatment}} - \underbrace{\mu_t T}_{\text{Death rate for people on ART}} \quad (6)$$

These differential equations describe the change in the number of people in each of these

disease states where the states are: uninfected and potentially susceptible individuals (S), HIV-infected individuals that are undiagnosed with their infection in either chronic (I_u) or AIDS/late disease stage (A_u), HIV-infected individuals that have been diagnosed with their infection and are in chronic (I_d) or AIDS/late disease stage (A_d), and those that are receiving antiretroviral treatment (T). The number of people in each compartment changes based on per-capita rates of disease progression, HIV testing, initiation of treatment, and mortality. The per-capita rate of becoming infected, or the 'force of infection', is the most important term in the system of mathematical equations. The mathematical structure of this term differs between exposure routes.

The mathematical expression for the force of infection associated with sexual behavior is based on the standard binomial formula for accumulation of risk over multiple exposures [18-19]. Separate force of infection expressions are used for casual, regular, and commercial partners and for each combination of pairings between individuals of different population groups and disease stages of the HIV-infected partner. The governing structure for each partnership type is given by:

$$\lambda(t) = cP(t)\left[1-(1-\beta)^{n(1-q)}(1-(1-\varepsilon)\beta)^{n(1-q)}\right],$$

where *c* is the average number of sexual partners, *P(t)* is the dynamic prevalence level of HIV in the pool of potential partners, β is the probability of transmission per unprotected sexual act, *n* is the frequency of sex in the given partnership, *q* is the frequency of condom use, and ε is the efficacy of condoms. The formula for calculating risk is consistent for each population group and region but the values of each of these parameters differ between groups and regions.

The mathematical expression for the force of infection associated with injecting behavior is given by:

$$\lambda(t) = \frac{nsq\delta_S\beta(1-p_c\varepsilon_c)}{m^2}\sum_{r=1}^{m-1}\binom{m}{r}P(t)^r(1-P(t))^{m-r}\frac{rm-r^2}{r+1},$$

where *n* is the average number of times an IDU injects per year, *s* is the proportion of IDUs who

share syringes and *q* is the frequency of sharing among these IDUs; the average number of people who share injecting equipment in a given sharing event is defined by *m*, δ_S is the average number of times each shared needle-syringe is used before it is disposed, *P(t)* is the dynamic prevalence level of HIV in the IDU population, β is the probability of transmission from a contaminated needle-syringe per use, p_c is the frequency of cleaning of shared injecting equipment and ε_C is the efficacy of cleaning. This expression calculates the chance of transmission occurring across all shared injecting events, incorporating different possible sizes of sharing groups (*m*) and considering the probability of receptive sharing of HIV-contaminated injecting equipment and the biological probability of transmission. The derivation of this formula has been published previously [11].

Free distribution of needle-syringes/condoms is expected to decrease sharing of injecting equipment/unprotected sex. The extent of expected change is not known from empirical data as it a hypothetical scenario. However, if it is assumed that the saturation in need for sterile injecting equipment/condoms has not been reached and greater supply would result in greater coverage then a mathematical relationship can be developed that balances the total number of units in circulation with how they were used; e.g. the total number of needle-syringes available in the population, from personal purchasing and free distribution from harm reduction programs, must equal the sum of total number of needle-syringes used in personal injections, shared injections, and units that are not used. Based on this rationale, if P needle-syringes are in circulation each year and a proportion ω of all needle-syringes are not used, then the number of needle-syringes that are used is $P(1-\omega)$. The number of needle-syringes used for individual injecting episodes among non-sharing IDUs is $\frac{nN(1-s)}{\delta_p}$, where *N* is the size of the IDU population and δ_P is the average number of times each non-shared needle-syringe is used before it is disposed. Similarly, the total number of needle-syringes used for individual injecting among all IDUs who share some of the time is $\frac{n(1-q)sN}{\delta_p}$ and the total number of syringes used

in sharing events is $\frac{nqsN}{\delta_s}$. Therefore,

$$P(1-\omega)=\frac{nN(1-s)}{\delta_p}+\frac{n(1-q)sN}{\delta_p}+\frac{nqsN}{\delta_s}=\frac{nN}{\delta_p\delta_s}\left[\delta_s-sq\left(\delta_s-\delta_p\right)\right]$$

defines a relationship between the total number of needle-syringes in circulation and the use of needle-syringes. Changes in the number of needle-syringes distributed are likely to change any, or all, of the following factors in a way that is consistent with this balancing relationship: the proportion of needle-syringes that remain unused (ω), the proportion of IDUs who share injecting equipment (*s*), the proportion of injections that are shared (q), or the average number of times each needle-syringe is used (in shared (δ_S) or individual (non-shared) injections (δ_P)). Changes to ω and δ_P will not influence transmission levels but changes to *s*, q and δ_S could potentially result in large reductions in incidence. Numerous studies from a variety of international settings have provided evidence that needle-syringe programs have been effective in reducing sharing rates (e.g. [20-25]); these studies typically report sharing rates in terms of the proportion of IDUs who share injecting equipment (*s*). Therefore, this balancing relationship was used to calculate the expected change in the sharing rate according to changes in the total number of needle-syringes distributed (i.e. if the number of needle-syringes in circulation decreased by the number freely distributed by the harm reduction programs).

Similar to the derivation of a balancing equation for needle-syringes and sharing rates, a balancing equation was derived for the number of condoms distributed in the population and average condom usage per FSW. If N_{FSW} is the total number of FSWs in the population and the average condom usage rate (specifically, the average proportion of acts in which condoms are used) is p_{condom} and the total number of condoms used by the population is C_{FSW} then the balancing equation is: $C_{FSW} = p_{condom} N_{FSW}$.

Optimization

For parameters in which there were multiple time-points, linear regression was performed and the shortest distance between the 95% confidence interval bounds was taken as the uncertainty bound to be applied in parallel to the best-fitting regression line (see Figure 29); where applicable, the uncertainty bounds of all percentage/proportion parameters were constrained to have a minimum upper bound of 5%, minimum lower bound of 0%, maximum upper bound of 100% and maximum lower bound of 95%.

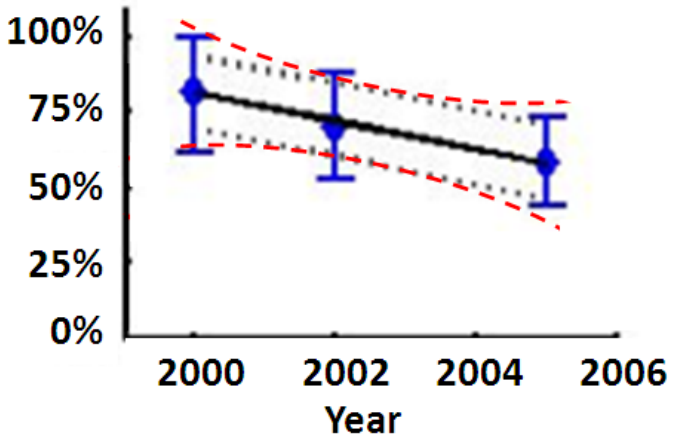


Figure 29: Example of how the uncertainty bound was devised for time-dependent parameters. The blue diamonds and error bars are the best estimates and 95% confidence intervals from reported data; the black solid line is the best-fitting linear regression line and the red curves are the 95% confidence intervals for the regression; the dashed lines represent the lines parallel to the best-fitting regression that coincide with the 95% bounds.

The VHM incorporates a large variety of different factors that interact in yielding epidemic trajectories, in the same way that many behavioral, biological, clinical and social factors contribute to epidemic trends in the real work. There are some data sources available, from different settings and population samples, to provide estimates of the interacting factors incorporated in the VHM. However, due to inaccuracies in survey data, heterogeneity, other biases or large complexity in the epidemiology, parameter values may not seem to be consistent when analyzed as a complex dynamical system of interactions. For example, many factors contribute to the time trends in prevalence among IDUs but when their measured estimates from available sources are included in quantitative calculations, they are unlikely to match exactly to

the observed prevalence trend. For the purposes of illustration, two of the most important factors associated with risk for IDUs are shown in Figure 30, namely, frequency of injecting and rates of sharing injecting equipment for the province of Can Tho. According to exact fits of the point-estimates of these factors, and all other variables that influence transmission among IDUs, model-simulated trends did not match to accepted national prevalence estimates (Figure 30). However, if model input values were allowed to have flexibility to be any value within the uncertainty bounds, a mathematical optimization procedure can ensure input values used are consistent with the confidence limits of the data and also match the national prevalence estimates (Figure 31). Thus, this procedure adjusts inputs such that they are still consistently within their confidence limits but ensures that all factors, when interacting in the model calculations, can be reconciled with prevalence estimates.

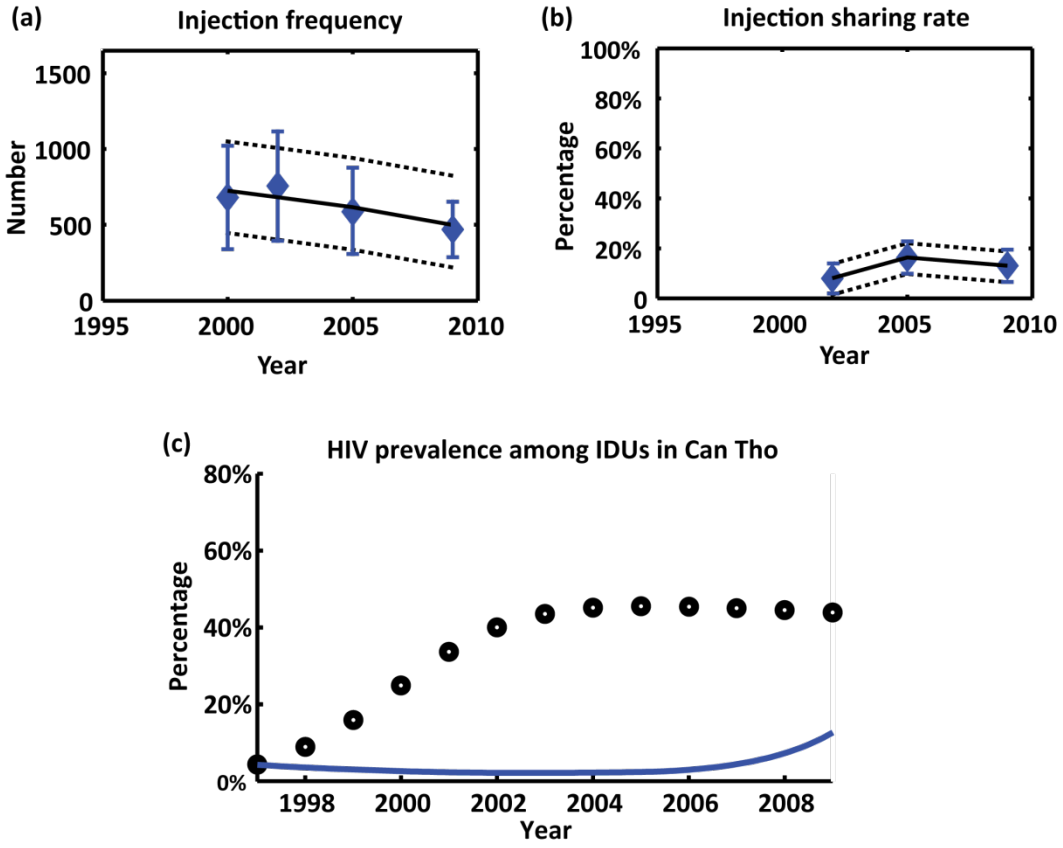


Figure 30: Survey data from Can Tho and uncertainty bounds in (a) injecting frequency and (b) injecting sharing rate, as well as (c) prevalence trends among IDUs in Can Tho. In (c) the black circles represent national consensus estimates and the blue curve represents the model-simulated trend according to exact fits of the point-estimates of all variables.

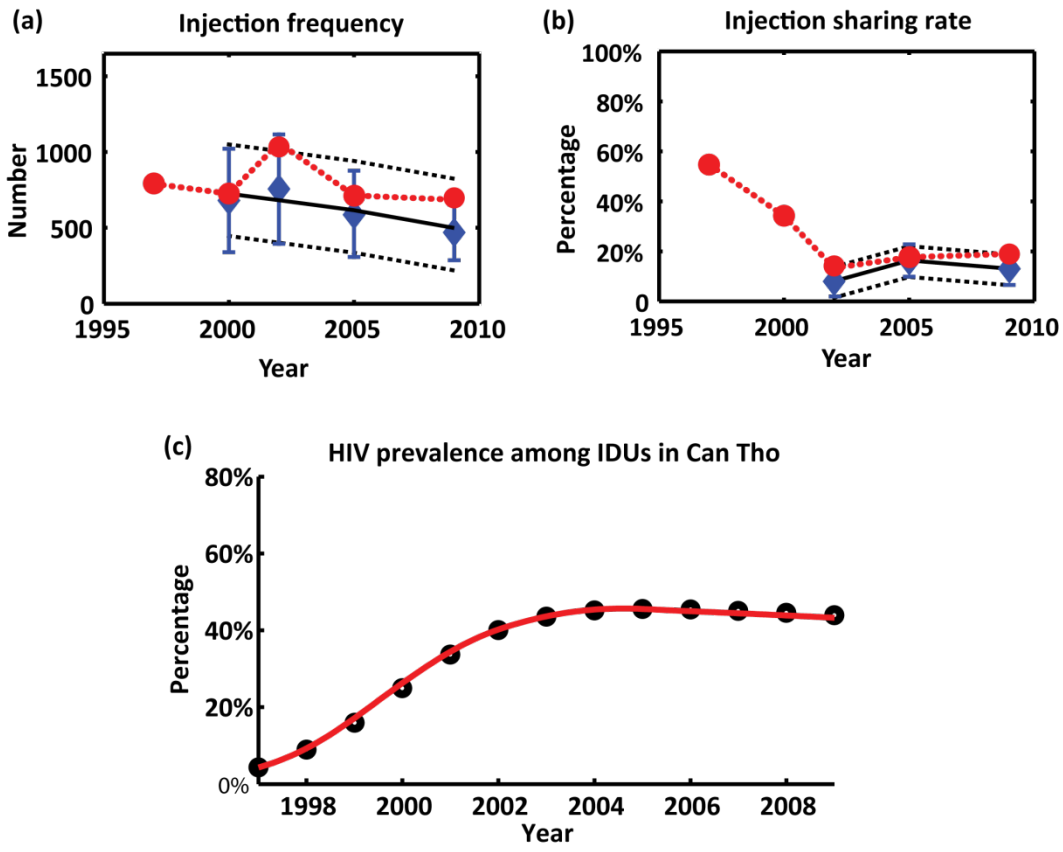


Figure 31: Survey data from Can Tho with uncertainty bounds and input values used in the model derived from the optimization procedure for (a) injecting frequency and (b) injecting sharing rate, as well as (c) prevalence trends among IDUs in Can Tho. In (c) the black circles represent national consensus estimates and the red curve represents the model-simulated trend according to optimized fits of the variables to remain within all parameter uncertainty bounds.

This relatively complex mathematical optimization routine was accomplished in the Matlab software package and consists of two major components. The first component includes a process that 'force-fits' the available epidemiological data (i.e. HIV prevalence for specific population subgroups, and numbers of HIV and AIDS diagnoses and people receiving antiretroviral therapy across all populations) to estimate the annual incidence and 'force of infection' that is required to yield these population levels. A subsequent component simultaneously optimizes the values of behavioral and biological parameters, constrained by their pre-defined confidence limits/plausible bounds while also ensuring trends are conserved, and such that they produce the required force of infection. This is carried out through a nonlinear regression routine. However,

in the event of apparent inconsistencies between behavioral, biological and epidemiological data that cannot be reconciled, the bounds on behavioral parameter values were widened until the optimization routine could achieve reconciliation between the various data sources. The parameters included in the optimization procedure were:

- Among female sex workers: the number of regular and casual sexual partners, condom usage, and the number sexual acts with both their clients and other male partners in the past 12 months;
- Among injecting drug users: the number of injections in the past 12 months, rates of sharing injecting equipment, the number of sexual partners and rates of condom usage;
- HIV transmission probabilities associated with receptive sharing of injecting equipment, and probabilities of HIV transmission for heterosexual and homosexual exposure among discordant couples.

Prevalence estimates are not available for some population groups. After the optimization procedure was completed, the model was used to infer expected prevalence levels and trends for population groups for which no data exist, capturing degrees of uncertainty as influenced by uncertainty in available data for model inputs. These model results are shown in Figure 32 for An Giang, Figure 33 for Can Tho, Figure 34 for Da Nang, Figure 35 for Dien Bien, Figure 36 for Hai Phong, Figure 37 for Ha Noi and Figure 38 for Ho Chi Minh City.

Range of VHM simulated trajectories for An Giang

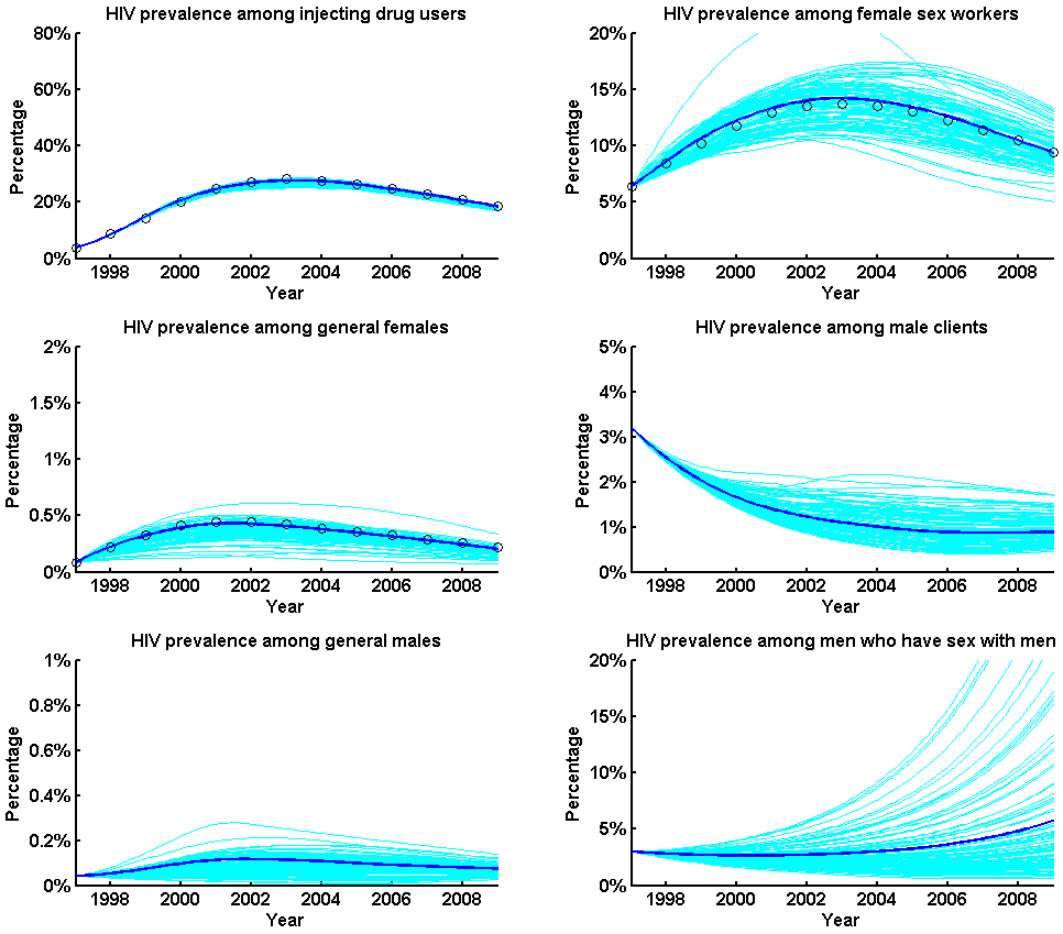


Figure 32: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in An Giang. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Can Tho

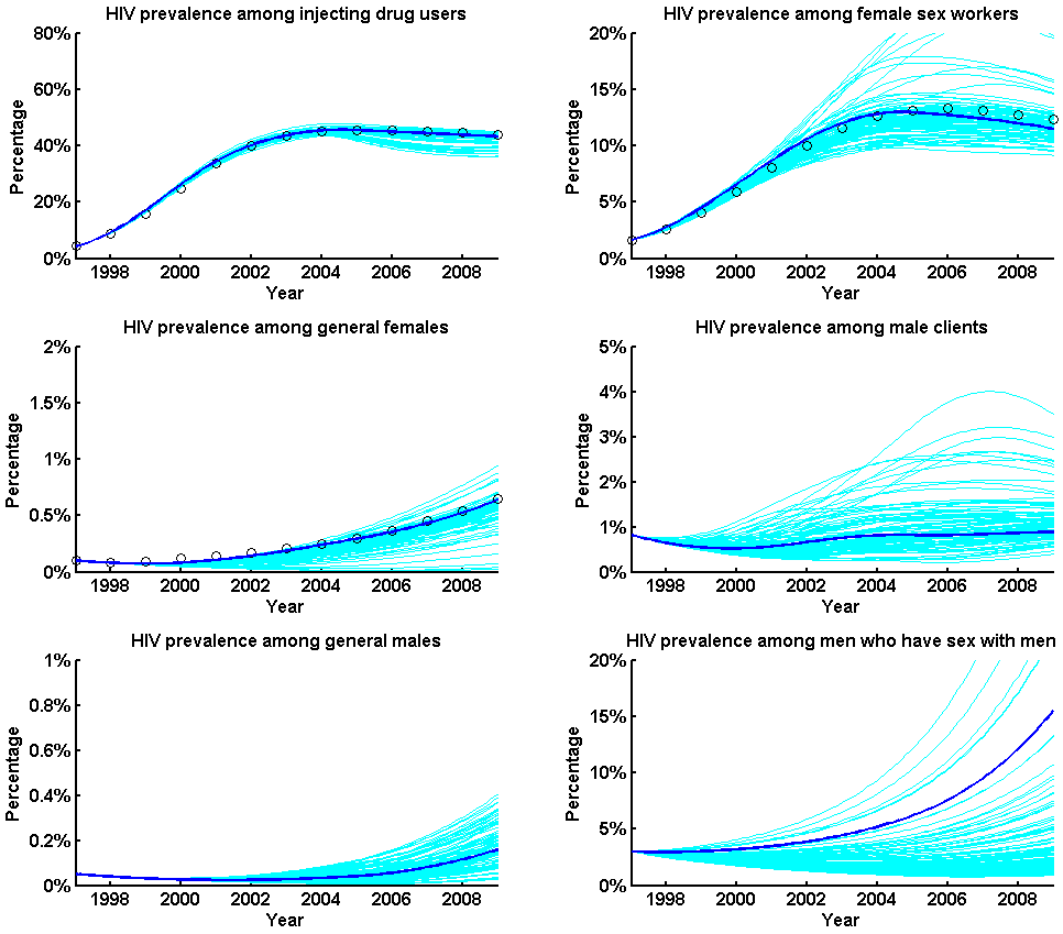


Figure 33: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Can Tho. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Da Nang

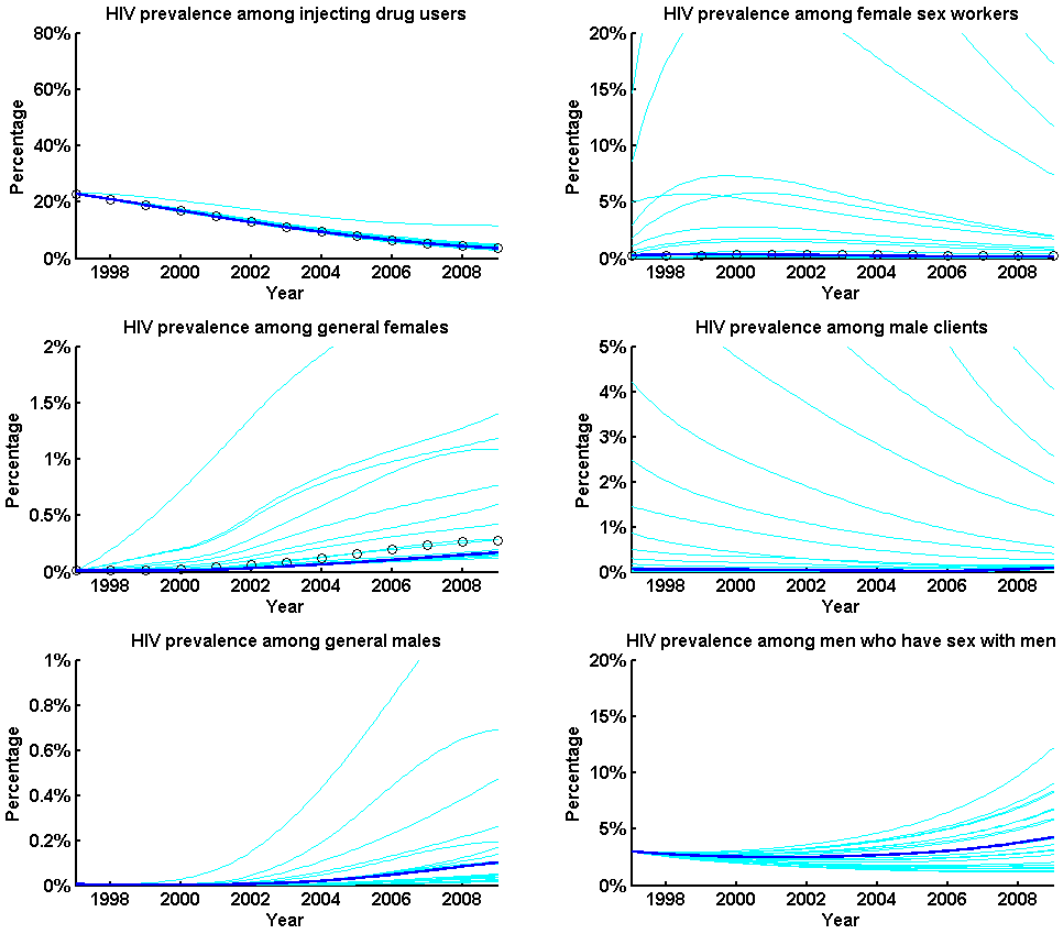


Figure 34: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Da Nang. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Dien Bien

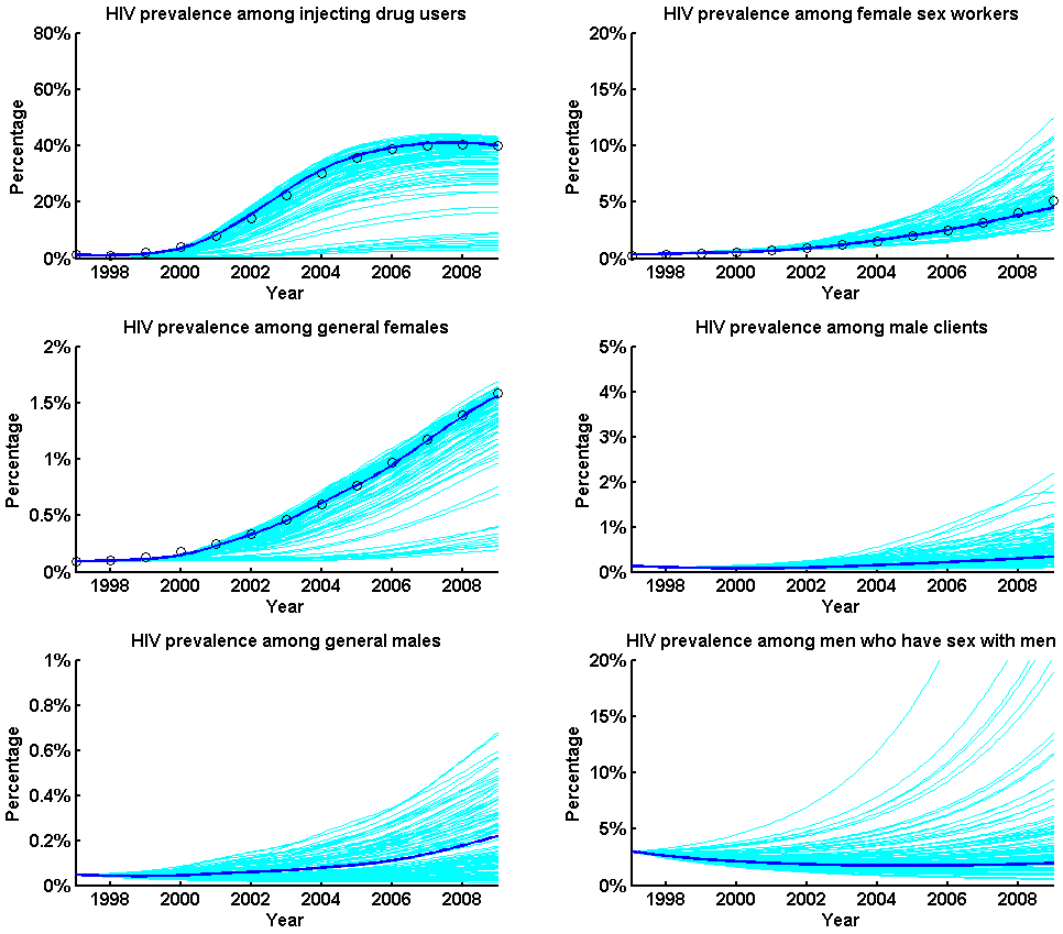


Figure 35: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Dien Bien. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Hai Phong

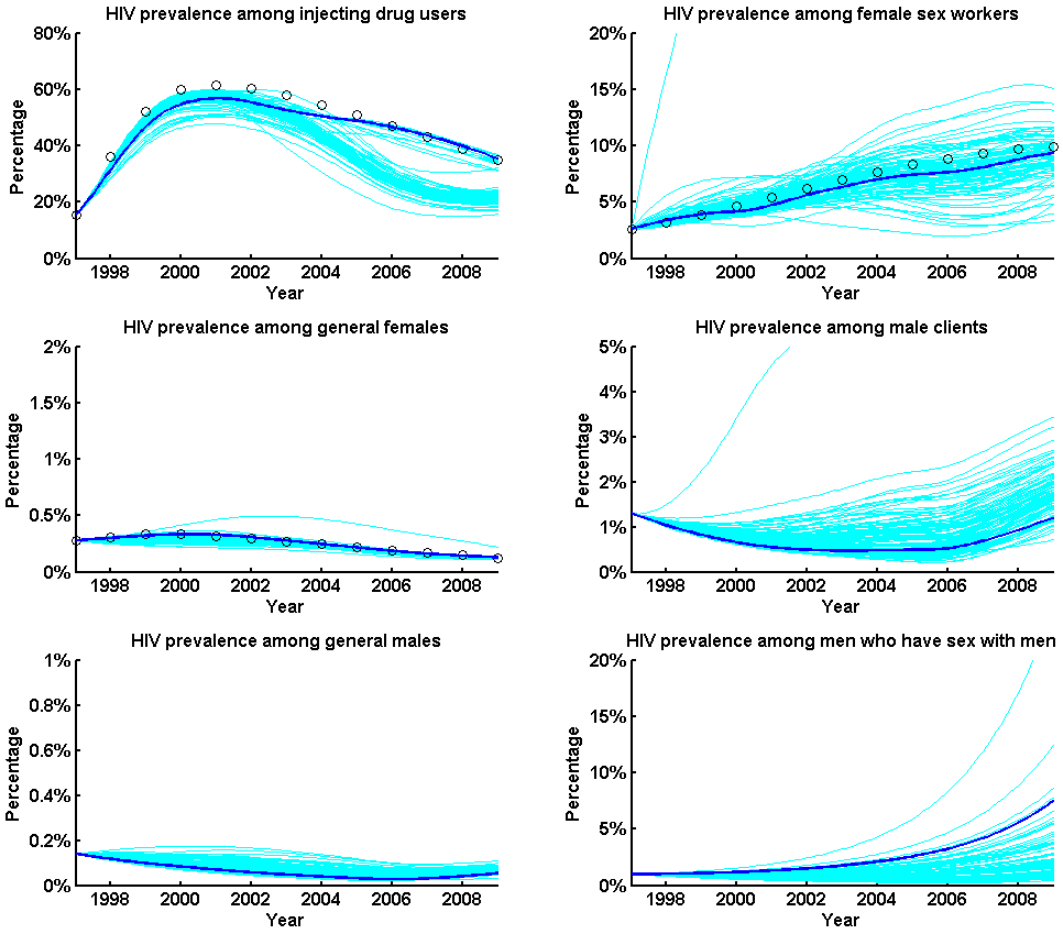


Figure 36: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Hai Phong. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Ha Noi

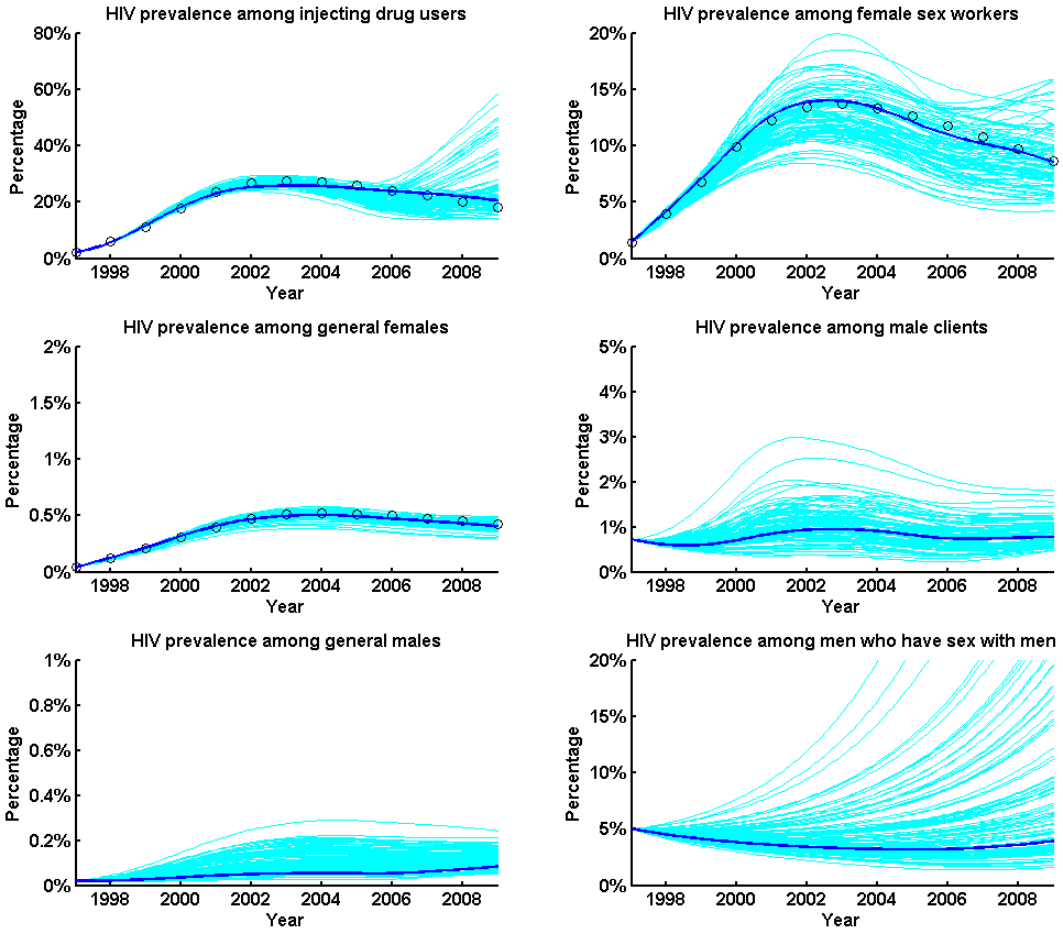


Figure 37: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in Ha Noi. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Range of VHM simulated trajectories for Ho Chi Minh City

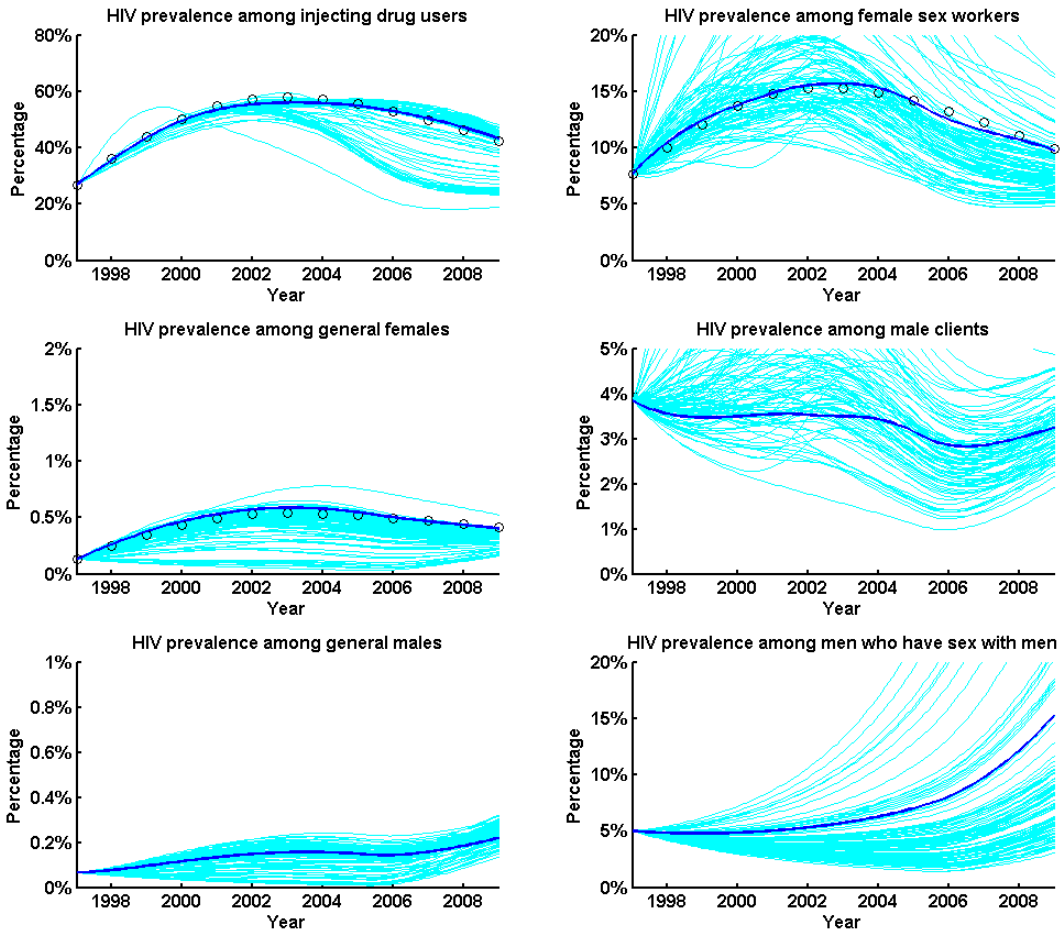


Figure 38: Prevalence of HIV among population groups of IDU, FSW, general females, male clients of FSW, general males, and men who have sex with men in HCMC. Circles represent EPP-fitted curves to available data, the dark blue curves represent the best-fitting VHM simulation and the cyan curves represent 100 VHM simulations that account for uncertainty in model input data.

Technical Annex 3: Mathematical modeling inputs

Table of inputs and parameters for evaluation of harm reduction programs in An Giang, Can Tho, Da Nang, Dien Bien, Hai Phong, Ha Noi, HCMC

Main data sources:

1. 2000 HIV/AIDS Behavioral Surveillance Survey (2000 BSS): Can Tho, Da Nang, Hai Phong, Ha Noi, HCMC [1].
2. 2002 Baseline Survey Report: An Giang, Dien Bien (Lai Chau) [2].
3. 2005 HIV/STI Integrated Biological and Behavioral Surveillance (2005-2006 IBBS): An Giang, Can Tho, Da Nang, Hai Phong, Ha Noi, HCMC [3].
4. Vietnam Population and AIDS Indicator Survey (VPAIS) 2005 [4].
5. MOLISA Data 2007 [5].
6. Sentinel Surveillance Data from all provinces.

Notes:

See the footnotes for detailed comments on the sources and derivation of all parameter estimates.

Due to uncertainty and to account for intrinsic heterogeneity in parameter values, the mathematical model samples from a range of plausible values for each parameter rather than using point estimates. The model independently samples values from each parameter with a triangular distribution of peak at the given value and a range defined by the uncertainty bound.

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Size of sexually active population (~ aged 15-49 years)	2007	1,283,000	661,000	456,000	271,000	1,052,000	1,881,000	3,615,000	p1
General Males (men who do not inject drugs, clients of female sex workers, or men who have sex with men)									m1
Proportion of overall population		50.2% minus the percentage of men who are clients, IDUs, or MSM as described in the footnote							m2
Average number of casual sexual partners per year	2005	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	m3
Average number of regular sexual partners per year	2005	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	m4
Average number of sexual acts per regular partner per year	2005	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	m5
Frequency of condom use with casual partners	2005	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	67.6% (50.7-84.5%)	m6
Frequency of condom use with regular partners	2005	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	6.1% (4.6-7.6%)	m7
Percentage tested for HIV per	2005	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	2.6%	m8

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
year		(1-5%)	(1-5%)	(1-5%)	(1-5%)	(1-5%)	(1-5%)	(1-5%)	
Male clients of female sex workers									c1
Proportion of male population	2005	0.50% (0.1-10%)	0.50% (0.1-10%)	0.50% (0.1-10%)	0.50% (0.1-10%)	1.10% (0.5-10%)	0.20% (0.1-10%)	0.30% (0.1-10%)	c2
Percentage tested for HIV per year	2005	2.6% (1-5%)	2.6% (1-5%)	2.6% (1-5%)	2.6% (1-5%)	2.6% (1-5%)	2.6% (1-5%)	2.6% (1-5%)	c3
Injecting drug users (IDUs)									i1
Population size (lower and upper estimates)	2004-2008	1634 (1,090-2,179)	1,872 (936-2,808)	1,278 (608-1,947)	6,967 (4,644-9,289)	5,942 (3,597-8,286)	26,820 (15,777-37,864)	25,573 (17,049-34,097)	i2
Proportion of IDUs that are female	2009	10% (5-15%)	10% (5-15%)	10% (5-15%)	10% (5-15%)	10% (5-15%)	10% (5-15%)	10% (5-15%)	i3
Average size of sharing group	2005	3 (2.25-3.75)	3 (2.25-3.75)	3 (2.25-3.75)	3 (2.25-3.75)	3 (2.25-3.75)	3 (2.25-3.75)	3 (2.25-3.75)	i4

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Average frequency of injecting per year	2000	562* (422-703)	681 (511-851)	192 (144-240)	562* (422-703)	540 (405-675)	491 (368-614)	906 (679-1132)	i5
	2002	326 (244-407)	756 (567-945)	375 (281-468)	236 (177-295)	917 (688-1,146)	662 (497-828)	862 (647-1,078)	
	2005	547 (411-684)	586 (440-733)	173 (130-216)	684‡ (513-855)	1,004 (753-1,255)	939 (704-1,174)	860 (645-1,075)	
	2009	637 (478-796)	688 (516-860)	456 (342-570)	843 (632-1054)	981 (736-1226)	981 (516-860)	926 (695-1158)	
Percentage of people who shared needle/syringe last month	2002	5.3% (4-6.6%)	8% (6-10%)	21.6% (16.2-27%)	25.7% (19.3-32.1%)	23.4% (17.6-29.3%)	13.7% (10.3-17.1%)	20.6% (15.5-25.8%)	i6
	2005	28.7% (21.5-35.9%)	16.3% (12.2-20.4%)	24.9% (18.7-31.1%)	17.7%† (13.3-22.1%)	6.3% (4.7-7.9%)	7.2% (5.4-9.0%)	35.4% (26.6-44.3%)	
	2009	44.2% (33.2-55.3%)	29.2% (21.9-36.5%)	26.9% (20.1-33.6%)	33.7% (25.3-42.1%)	10.6% (8.0-13.3%)	19.6% (14.7-24.5%)	31.1% (23.4-38.9%)	
Percentage of shared syringes that are cleaned		1% (0.1-10%)	1% (0.1-10%)	1% (0.1-10%)	1% (0.1-10%)	1% (0.1-10%)	1% (0.1-10%)	1% (0.1-10%)	i7
Average number of casual sexual partners per year	2000	0.10* (0.07-0.12)	0.06 (0.05-0.08)	0.3 (0.23-0.38)	0.10* (0.07-0.12)	0.09 (0.07-0.12)	0.1 (0.07-0.12)	0.12 (0.09-0.15)	i8

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2002	0.28 (0.21-0.35)	0.02 (0.01-0.03)	0.14 (0.11-0.18)	0.19 (0.14-0.24)	0.09 (0.07-0.11)	0.13 (0.09-0.16)	0.12 (0.09-0.14)	
	2005	0.34 (0.26-0.43)	0.16 (0.12-0.20)	0.27 (0.20-0.34)	0.26‡ (0.19-0.32)	0.06 (0.04-0.07)	0.39 (0.29-0.49)	0.5 (0.37-0.62)	
	2009	0.39 (0.29-0.49)	0.81 (0.61-1.01)	1.16 (0.87-1.45)	0.31 (0.23-0.39)	0.79 (0.59-0.99)	6.05 (4.54-7.56)	0.39 (0.29-0.49)	
Average number of regular sexual partners per year	2000	0.3* (0.2-0.3)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.3* (0.2-0.3)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.2 (0.1-0.3)	i9
	2002	0.3 (0.2-0.4)	0.5 (0.4-0.6)	0.6 (0.4-0.7)	0.5 (0.4-0.6)	0.5 (0.3-0.6)	0.6 (0.5-0.8)	0.4 (0.3-0.5)	
	2005	0.7 (0.6-0.9)	0.8 (0.6-1.0)	0.6 (0.5-0.8)	0.6† (0.5-0.8)	0.3 (0.2-0.4)	0.7 (0.5-0.8)	0.6 (0.5-0.8)	
	2009	1.20 (0.90-1.50)	0.76 (0.57-0.95)	1.31 (0.98-1.64)	1.05 (0.79-1.31)	0.74 (0.56-0.93)	1.31 (0.98-1.64)	1.04 (0.78-1.30)	
Average number of commercial sex partners per year	2000	0.77* (0.58-0.96)	0.11 (0.08-0.13)	0.61 (0.46-0.77)	0.77* (0.58-0.96)	0.4 (0.3-0.51)	0.92 (0.69-1.15)	0.19 (0.14-0.23)	i10
	2002	0.83 (0.62-1.03)	0.27 (0.2-0.34)	1.33 (1.0-1.66)	0.33 (0.25-0.41)	1.17 (0.88-1.46)	2.18 (1.64-2.73)	0.45 (0.34-0.57)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2005	1.3 (0.97-1.62)	0.68 (0.51-0.85)	1.07 (0.8-1.34)	0.74‡ (0.56-0.93)	0.4 (0.3-0.5)	0.54 (0.40-0.67)	0.78 (0.59-0.98)	
	2009	1.58 (1.19-1.98)	4.07 (3.05-5.09)	3.41 (2.56-4.26)	0.34 (0.26-0.43)	2.47 (1.85-3.09)	12.94 (9.71-16.2)	1.11 (0.83-1.39)	
Probability of condom use per act with casual partners	2000	46.8%* (35.1-58.5)	25% (18.8-31.3%)	62.3% (46.7-77.9%)	46.8%* (35.1-58.5)	77.3% (58-96.6%)	41.2% (30.9-51.5%)	28% (21-35%)	i11
	2002	19.3% (14.5-24.1%)	26.0%† (19.5-32.5%)	16.3% (12.2-20.4%)	33.3% (25-41.6%)	10.5% (7.9-13.1%)	40.4% (30.3-50.5%)	36.4% (27.3-45.5%)	
	2005	41.7% (31.3-52.1%)	36.7%§ (27.5-45.9%)	41.7%§ (31.3-52.1%)	51.0%‡ (38.3-63.8%)	54.6% (41-68.3%)	59.4% (44.6-74.3%)	38.4% (28.8-48%)	
	2009	56.7% (42.5-70.8%)	44.0% (33.0-55.0%)	64.9% (48.7-81.2%)	60.2% (45.2-75.3%)	100% (75.0%-100%)	78.3% (58.7-97.8%)	20.5% (15.4-25.6%)	
Frequency of condom use with regular partners	2000	31.0%* (23.3-38.8%)	22.90% (17.2-28.6%)	47.2% (35.4-59%)	31.0%* (23.3-38.8%)	39.8% (30-49.8%)	25.4% (19.1-31.8%)	19.7% (14.8-24.6%)	i12
	2002	14.3% (10.7-17.9%)	13.6% (10.2-17%)	39.3% (29.5-49.1%)	3% (2.3-3.8%)	42.5% (31.9-53.1%)	27.6% (20.7-34.5%)	24.8% (18.6-31%)	
	2005	40.0% (30-50%)	27.3% (20.5-34.1%)	31.6% (23.7-39.5%)	36.0%‡ (27.0-45.0%)	33.7% (25.3-42.1%)	32.9% (24.7-41.1%)	39.9% (30-50%)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2009	38.8% (29.1-48.5%)	34.2% (25.6-42.7%)	53.9% (40.4-67.4%)	51.8% (38.8-64.7%)	66.7% (50.0-83.3%)	61.0% (45.7-76.2%)	24.8% (18.6-31.0%)	
Frequency of condom use with commercial sex workers	2000	70.3%* (52.8-87.9%)	57.1% (42.8-71.4%)	69% (51.8-86.3%)	70.3%* (52.8-87.9%)	83.7% (62.8-100%)	82.4% (61.8-100%)	59.5% (44.6-74.4%)	i13
	2002	37.7% (28.3-47.1%)	58.5% (43.9-73.1%)	78% (58.5-97.5%)	58.1% (43.6-72.6%)	57.9% (43.4-72.4%)	70% (52.5-87.5%)	86.4% (64.8-100%)	
	2005	65.9% (49.4-82.4%)	60.7% (45.5-75.9%)	78.7% (59-98.4%)	69.3%‡ (52.0-86.6%)	83.7% (62.8-100%)	58.7% (44-73.4%)	46.6% (35-58.3%)	
	2009	81.7% (61.3-100%)	72.3% (54.2-90.4%)	82.0% (61.5-100%)	77.5% (58.1-96.9%)	91.5% (68.6-100%)	81.8% (61.4-100%)	48.3% (36.2-60.4%)	
Number of sexual acts between IDUs and regular partners per year	2009	60 (45-75)	281 (211-351)	57 (42-71)	119 (89-149)	43 (32-54)	265 (199-331)	71 (54-89)	i14
Number of sexual acts between IDUs and commercial sex workers per year	2009	50 (37-62)	112 (84-140)	47 (35-59)	84 (63-105)	21 (16-27)	263 (198-329)	46 (34-57)	i15
Number of sexual acts between IDUs and casual partners per year	2009	18 (13-22)	171 (129-214)	37 (28-46)	129 (97-161)	192 (144-240)	354 (266-443)	120 (90-150)	i16
Percentage tested for HIV per	2005	5%	5%	5%	5%	5%	5%	5%	i17

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
year		(2.6-9%)	(2.6-9.3%)	(2.6-4.9%)	(2.6-4.9%)	(2.6-29.9%)	(2.6-24.5%)	(2.6-14.3%)	
Men who have sex with men (MSM)									h1
Proportion of male population	2008	2% (1-3%)	2% (1-3%)	2% (1-3%)	2% (1-3%)	2% (1-3%)	2% (1-3%)	2% (1-3%)	h2
Average annual number of regular male sexual partners	2005	0.2 (0.15-0.25)	0.2 (0.15-0.25)	0.2 (0.15-0.25)	0.2 (0.15-0.25)	0.2 (0.15-0.25)	0.27 (0.2-0.34)	0.13 (0.1-0.17)	h3
Average number of casual male sexual partners per year	2005	26.3 (19.7-32.9)	26.3 (19.7-32.9)	26.3 (19.7-32.9)	26.3 (19.7-32.9)	26.3 (19.7-32.9)	19 (14.3-23.8)	33.6 (25-42)	h4
Average number of female sexual partners per year	2005	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	0.4 (0.3-0.5)	h5
Frequency of condom use with other MSM in last act	2005	57.4% (43-71.8%)	57.4% (43-71.8%)	57.4% (43-71.8%)	57.4% (43-71.8%)	57.4% (43-71.8%)	63.4% (47.5-79.2%)	51.4% (38.6-64.3%)	h6
	2009	60.9% (45.7-76.1%)	58.8% (44.1-73.5%)	60.9% (45.7-76.1%)	60.9% (45.7-76.1%)	69.0% (51.8-86.2%)	70.7% (53.0-88.4%)	45.3% (34.0-56.6%)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Frequency of condom use with females in last act	2005	43.9% (32.9-54.9%)	43.9% (32.9-54.9%)	43.9% (32.9-54.9%)	43.9% (32.9-54.9%)	43.9% (32.9-54.9%)	65.3% (49-81.6%)	22.5% (16.9-28.1%)	h7
	2009	63.7% (47.8-79.6%)	45.9% (34.4-57.4%)	63.7% (47.8-79.6%)	63.7% (47.8-79.6%)	67.9% (50.9-84.9%)	80% (69.0-100%)	61.1% (45.8-76.4%)	
% of MSM have had sex with a women in the past 12 months	2009	42.2% (31.7-52.8%)	46.4% (34.8-57.9%)	42.2% (31.7-52.8%)	42.2% (31.7-52.8%)	28.5% (21.4-35.6%)	48.6% (36.5-60.8%)	45.4% (34.0-56.7%)	h8
Percentage tested for HIV per year	2005	5% (2.6-15.7%)	5% (2.6-15.7%)	5% (2.6-15.7%)	5% (2.6-15.7%)	5% (2.6-15.7%)	5% (2.6-15.4%)	5% (2.6-16%)	h9
Females (general population)									f1
Proportion of population		49.8% minus the percentage of women who are (karaoke- or street-based) sex workers, or injecting drug users as described in the footnote							f2
Average number of casual sexual partners per year	2005	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	0.025 (0.019-0.031)	f3
Average number of regular sexual partners per year	2005	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	1 (0.75-1.25)	f4
Average number of sexual acts per regular partner per year	2005	87	87	87	87	87	87	87	F5

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
		(65-109)	(65-109)	(65-109)	(65-109)	(65-109)	(65-109)	(65-109)	
Percentage tested for HIV per year	2005	2.10% (0.5-5%)	2.10% (0.5-5%)	2.10% (0.5-5%)	2.10% (0.5-5%)	2.10% (0.5-5%)	2.10% (0.5-5%)	2.10% (0.5-5%)	F6
Karaoke-based sex workers (KSWs)									k1
Proportion of sex workers who are KSWs	2009	35% (26-44%)	35% (26-44%)	35% (26-44%)	35% (26-44%)	35% (26-44%)	35% (26-44%)	35% (26-44%)	k2
210 (105-315) K3	2004-2008	560 (280-840)	496 (248-743)	186 (93-279)	92 (46-138)	700 (350-1,050)	1,120 (560-1,680)	7,000 (3,500-10,500)	k3
Average number of years of selling sex	2002	2 (1.5-2.5)	2.0* (1.5-2.5)	2.0* (1.5-2.5)	2 (1.5-2.5)	2.0* (1.5-2.5)	2.0* (1.5-2.5)	2.0* (1.5-2.5)	k4
	2005	5 (3.7-6.2)	2.3 (1.7-2.8)	3.4 (2.6-4.3)	3.3† (2.5-4.1)	3.3 (2.4-4.1)	3.1 (2.3-3.9)	2.6 (2-3.3)	
	2009	3.0 (2.3-3.8)	3.1 (2.3-3.8)	4.1 (3.1-5.2)	3.7 (2.8-4.6)	3.6 (2.7-4.5)	4.9 (3.7-6.1)	4.5 (3.4-5.6)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Average number of one-time clients per year	2000	186* 140-233	24 18-30	60 45-75	186* 140-233	768 576-960	104 78-130	160 120-200	k5
	2002	140 105-175	129† 97-162	129† 97-162	52 39-65	129† 97-162	129† 97-162	129† 97-162	
	2005	133 100-166	65 49-81	47 35-58	93‡ 70-117	134 101-168	131 98-163	77 57-96	
	2009	80 60-100	97 73-121	94 71-118	122‡ 92-153	210 159-263	168 126-210	96 72-120	
Average number of regular clients per year	2000	68* 51-85	28 21-35	16 12-20	68* 51-85	128 96-160	96 72-120	140 105-175	k6
	2002	92 69-115	83† 62-103	83† 62-103	16 12-20	83† 62-103	83† 62-103	83† 62-103	
	2005	67 51-84	45 34-56	41 31-51	46‡ 34-57	41 31-52	58 43-72	46 35-58	
	2009	62 47-78	54 41-68	43 32-54	61‡ 46-76	77 58-96	76 57-95	58 44-73	
Average number of non-commercial casual sexual partners per year	2005	7.2 5.4-9.0	5.9 4.4-7.4	4.6 3.5-5.8	5.4* 4.1-6.8*	4.2 3.2-5.3	5.2 3.9-6.5	3.7 2.8-4.6	k7

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Average number of non-commercial regular sexual partners per year	2000	0.06* 0.05-0.08	0.08 0.06-0.11	0.04 0.03-0.05	0.06* 0.05-0.08	0.04 0.03-0.05	0.03 0.02-0.04	0.11 0.09-0.14	k8
	2002	0.06 0.05-0.08	0.05† 0.04-0.06	0.05† 0.04-0.06	0.04 0.03-0.05	0.05† 0.04-0.06	0.05† 0.04-0.06	0.05† 0.04-0.06	
	2005	0.16 0.12-0.20	0.14 0.11-0.18	0.14 0.11-0.18	0.19‡ 0.14-0.24	0.21 0.16-0.26	0.21 0.16-0.26	0.12 0.09-0.14	
	2009	0.57 0.43-0.71	0.65 0.49-0.81	0.49 0.37-0.61	0.57‡ 0.43-0.71	0.40 0.30-0.50	0.54 0.41-0.68	0.50 0.38-0.63	
Average number of sexual acts per regular client per year	2005	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	k9
Average number of sexual acts per non-commercial regular Sexual partner per year	2005	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	k10
	2009	62 (47-78)	80 (60-100)	66 (50-83)	71 (53-89)	65 (49-81)	118 (88-147)	60 (45-75)	
Frequency of condom use with one-time clients	2000	92.0%* (69-100%)	96.0% (72-100%)	97.5% (73.1-100%)	92.0%* (69-100%)	95.1% (71.3-100%)	89.6% (67.2-100%)	81.8% (61.4-100%)	k11
	2002	73.7% (55.3-92.1%)	79.5%† (59.6-99.4%)	79.5%† (59.6-99.4%)	85.30% (64-100%)	79.5%† (59.6-99.4%)	79.5%† (59.6-99.4%)	79.5%† (59.6-99.4%)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2005	94.4% (70.8-100%)	99.2% (74.4-100%)	90.6%* (68-100%)	95.9%‡ (71.9-100%)	96.7% (72.5-100%)	97.9% (73.4-100%)	96.1% (72.1-100%)	
	2009	97.9% (73.5-100%)	98.3% (73.7-100%)	100% (75.0-100%)	91.8%‡ (68.9-100%)	98.0% (73.5-100%)	82.3% (62.1-100%)	77.3% (58.0-96.6%)	
Frequency of condom use with regular clients	2000	83.1%* (62.3-100%)	93.3% (70-100%)	94% (70.5-100%)	83.1%* (62.3-100%)	85.5% (64.1-100%)	78.3% (58.7-97.9%)	64.3% (48.2-80.4%)	k12
	2002	62.8% (47.1-78.5%)	64.8%† (48.6-80.9%)	64.8%† (48.6-80.9%)	66.7% (50-83.4%)	64.8%† (48.6-80.9%)	64.8%† (48.6-80.9%)	64.8%† (48.6-80.9%)	
	2005	86.1% (64.6-100%)	98.4% (73.8-100%)	94.9% (71.2-100%)	90.0%‡ (67.5-100%)	91.3% (68.5-100%)	92.1% (69.1-100%)	90.9% (68.2-100%)	
	2009	94.0% (70.5-100%)	88.4% (66.3-100%)	97.0% (72.6-100%)	85.7% (64.3-100%)	95.6% (71.7-100%)	73.4% (55.3-92.1%)	65.6% (49.2-82.0%)	
Frequency of condom use with non-commercial casual partners	2000	48.6%* (36.5-60.8%)	76.3% (57.2-95.4%)	71.9% (53.9-89.9%)	48.6%* (36.5-60.8%)	46.8% (35.1-58.5%)	33.5% (25.1-41.9%)	14.6% (11-18.3%)	k13
	2005	54.8% (41.1-68.4%)	22.5% (16.9-28.2%)	36.8% (27.6-46%)	36.8%† (27.6-45.9%)	34.5% (25.8-43.1%)	36.6% (27.5-45.8%)	29% (21.7-36.2%)	
Frequency of condom use with non-commercial regular	2002	54.4% (40.8-68%)	50% (37.2-62%)	50% (37.2-62%)	3% (2.1-3.8%)	50% (37.2-62%)	50% (37.2-62%)	50% (37.2-62%)	k14

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
partners	2009	41.4% (31.1-51.8%)	24.7% (18.9-30.9%)	66.1% (49.6-82.6%)	41.8% (31.4-52.3%)	46.5% (34.9-58.1%)	38.5% (28.9-48.1%)	22.1% (16.6-27.6%)	
Proportion of KSW who inject drugs	2000	5.0%* (3.7-6.2%)	5.0%* (3.7-6.2%)	5.0%* (3.7-6.2%)	5.0%* (3.7-6.2%)	5.0%* (3.7-6.2%)	5.6% (1-10%)	4.30% (3-6%)	k15
	2002	3.0% (2.3-3.8%)	3.0%† (2.3-3.8%)	3.0%† (2.3-3.8%)	3.0%† (2.3-3.8%)	3.0%† (2.3-3.8%)	3.0%† (2.3-3.8%)	3.0%† (2.3-3.8%)	
	2005	8.9% (6.6-11.1%)	1.0% (0.8-1.3%)	0.64% (0.5-0.8%)	4.7%‡ (3.5-5.8%)	4.7% (3.6-5.9%)	4.0% (3-5%)	5.3% (4-6.6%)	
Percentage tested for HIV per year	2005	5% (2.1-15.3%)	5% (2.1-14.3%)	5% (2.1-17.3%)	5% (2.1-25%)	5% (2.1-27.4%)	5% (2.1-33%)	5% (2.1-15.6%)	k16
Female street-based sex workers (SSWs)									s1
Population size (lower and upper estimates)	2004-2008	1,040 (520-1,560)	920 (460-1,381)	346 (173-519)	170 (85-255)	1,300 (650-1,950)	2,080 (1,040-3,120)	13,000 (6,500-19,500)	s2
Mean duration of selling sex in years	2002	3.0 (2.3-3.8)	2.8* (2.1-3.5)	2.8* (2.1-3.5)	2.5 (1.9-3.1)	2.8* (2.1-3.5)	2.8* (2.1-3.5)	2.8* (2.1-3.5)	s3

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2005	5.4 (4-6.7)	5.2 (3.9-6.4)	3.9 (2.9-4.9)	4.4† (3.3-5.5)	3.7 (2.8-4.6)	3.7 (2.7-4.6)	4.5 (3.4-5.6)	
	2009	5.9 (4.5-7.4)	5.9 (4.5-7.4)	5.8 (4.3-7.2)	4.9† (3.7-6.1)	4.6 (3.5-5.8)	4.6 (3.4-5.7)	5.5 (4.1-6.8)	
Average number of one-time clients per year	2000	346* (260-433)	516 (387-645)	268 (201-335)	346* (260-433)	604 (453-755)	308 (231-385)	380 (285-475)	s4
	2002	168 (126-210)	212 (159-266)	103 (77-128)	371† (278-464)	1,318 (989-1,648)	168 (126-210)	425 (319-531)	
	2005	149 (112-187)	151 (113-189)	83 (62-104)	124‡ (93-154)	(195) (147-244)	141 (106-176)	81 (61-102)	
	2009	150 (133-188)	117 (88-146)	152 (114-190)	162‡ (122-203)	237 (178-296)	176 (132-220)	232 (174-290)	
Average Number of regular clients per year	2000	92* (69-115)	88 (66-110)	64 (48-80)	92* (69-115)	84 (63-105)	84 (63-105)	232 (174-290)	s5
	2002	45† (34-56)	76 (57-95)	54 (41-68)	24 (18-30)	45 (34-56)	21 (16-27)	72 (54-90)	
	2005	93 (70-116)	66 (50-83)	39 (29-48)	48‡ (36-60)	41 (31-51)	46 (34-56)	45 (34-56)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
	2009	62 (47-78)	60 (45-75)	64 (48-80)	63‡ (47-79)	62 (47-78)	80 (60-100)	73 (55-91)	
Average number of non-commercial casual sexual partners per year	2002	2.7* (2.0-3.3)	4.2 (3.1-5.2)	5.5 (4.1-6.8)	2.7* (2.0-3.3)	2.7* (2.0-3.3)	4.1 (3.1-5.1)	4.9 (3.7-6.1)	S6
	2005	7.8 (5.9-9.8)	5.3 (3.9-6.6)	6.0 (4.5-7.5)	5.2† (3.9-6.5)	4.1 (3.0-5.1)	4.3 (3.3-5.4)	4.3 (3.3-5.4)	
Average number of non-commercial regular sexual partners per year	2000	0.12* 0.09-0.15	0.14 0.1-0.17	0.11 0.08-0.13	0.12* 0.09-0.15	0.13 0.1-0.16	0.05 0.04-0.07	0.17 0.13-0.21	S7
	2002	0.4 0.3-0.5	0.37† 0.28-0.46	0.37† 0.28-0.46	0.13 0.1-0.16	0.37† 0.28-0.46	0.37† 0.28-0.46	0.37† 0.28-0.46	
	2005	0.24 0.18-0.30	0.30 0.23-0.38	0.13 0.09-0.16	0.20‡ 0.15-0.25	0.15 0.12-0.19	0.21 0.16-0.26	0.14 0.11-0.18	
	2009	0.42 0.32-0.53	0.51 0.38-0.64	0.42 0.32-0.53	0.49 0.37-0.61	0.29 0.22-0.36	0.39 0.29-0.49	0.53 0.40-0.66	
Average number of sexual acts per regular client per year	2005	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	12 (6-24)	s8
Average number of sexual acts per non-commercial regular	2005	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	87 (65-109)	s9

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
sexual partner per year	2009	75 (56-94)	69 (52-86)	57 (43-72)	73 (54-91)	65 (48-81)	82 (61-102)	107 (80-134)	
Frequency of condom use with one-time clients	2000	94.1%* (70.6-100%)	94.8% (71.1-100%)	99.7% (67.9-100%)	94.1%* (70.6-100%)	90.5% (67.9-100%)	93.5% (70.1-100%)	91.9% (68.9-100%)	s10
	2002	52.5% (39.4-65.6%)	98.0% (73.5-100%)	99.1% (74.3-100%)	87.0% (65.3-100%)	91.5% (68.6-100%)	84.6 (63.5-100%)	97.9% (73.4-100%)	
	2005	96.8% (72.6-100%)	98.7% (74.0-100%)	99.2% (74.4-100%)	97.4%‡ (73.1-100%)	96.8% (72.6-100%)	99.0% (74.3-100%)	93.4% (70.1-100%)	
	2009	98.0% (73.5-100%)	85.1% (63.8-100%)	98.9% (74.2-100%)	91.4%‡ (68.5-100%)	99.3% (74.5-100%)	79.7% (59.8-99.6%)	73.8% (55.4-92.3%)	
Frequency of condom use with regular clients	2000	82.4%* (61.8-100%)	79.5% (59.6-99.4%)	95.3% (71.5-100%)	82.4%* (61.8-100%)	82.1% (61.6-100%)	75.9% (56.9-94.9%)	79.1% (59.3-98.9%)	s11
	2002	48.1% (36.1-60.1%)	92.8% (69.6-100%)	97.4% (73.1-100%)	55.6% (41.7-69.5%)	78.8% (59.1-98.5%)	73.2% (54.9-91.5%)	93.9% (70.4-100%)	
	2005	92.2% (69.1-100%)	96.3% (72.2-100%)	94.8% (71.1-100%)	92.0% (69.0-100%)	91.9% (68.9-100%)	93.4% (70.1-100%)	85.9% (64.4-100%)	
	2009	94.8% (71.1-100%)	93.8% (70.3-100%)	96.5% (72.4-100%)	86.3%‡ (64.7-100%)	96.9% (72.7-100%)	63.5% (47.6-79.3)	65.8% (49.3-82.2%)	

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Frequency of condom use with non-commercial casual partners	2000	31.6%* (23.7-39.5%)	23.6% (17.7-29.5%)	29.1% (21.8-36.4%)	31.6%* (23.7-39.5%)	34.3% (25.7-42.9%)	34.3% (25.7-42.9%)	36.6% (27.5-45.8%)	s12
	2002	36.1%† (27.1-45.2%)	34.5% (25.9-43.1%)	37.9% (28.4-47.4%)	36.1%† (27.1-45.2%)	52.6% (39.5-65.8%)	30.0% (22.5-37.5%)	25.6% (19.2-32.0%)	
	2005	61.0% (45.8-76.3%)	30.20% (27.7-37.8%)	42.5% (31.9-53.1%)	40.7%‡ (30.5-50.9%)	33.3% (25.0-41.7%)	32.8% (24.6-41.0%)	33.6% (25.2-42.0%)	
Frequency of condom use with non-commercial regular partners	2002	48.6% (36.5-60.8%)	47.0%* (34.9-58.2%)	47.0%* (34.9-58.2%)	25% (18.8-31.3%)	47.0%* (34.9-58.2%)	47.0%* (34.9-58.2%)	47.0%* (34.9-58.2%)	s13
	2009	33.3% (25.0-41.7%)	35.0% (26.3-43.8%)	75.0% (56.3-93.8%)	44.3% (33.2-55.4%)	57.7% (43.2-72.1%)	16.7% (12.5-20.8%)	30.1% (22.6-37.6%)	
Proportion of SSW who inject drugs	2000	18.6%* (13.9-23.2)	18.6%* (13.9-23.2)	18.6%* (13.9-23.2)	18.6%* (13.9-23.2%)	18.6%* (13.9-23.2%)	21.5% (16.1-26.9%)	15.6% (11.7-19.5%)	s14
	2002	8.3% (6.2-10.4%)	14.1%† (10.6-16.8%)	14.1%† (10.6-16.8%)	57.1% (42.8-71.4%) *	14.1%† (10.6-16.8%)	14.1%† (10.6-16.8%)	14.1%† (10.6-16.8%)	
	2005	2.9% (2.2-3.7%)	17.3% (13-21.6%)	0.58% (0.4-0.7%)	10.9%‡ (8.2-13.6%)	7.2% (5.4-9.0%)	16.7% (12.5-20.9%)	5.0% (3.8-6.3%)	
Percentage tested for HIV per year	2005	5% (2.1-23.1%)	5% (2.1-27.2%)	5% (2.1-19.4%)	5% (2.1-25%)	5% (2.1-17.4%)	5% (2.1-24%)	5% (2.1-11.4%)	s15

		An Giang	Can Tho	Da Nang	Dien Bien	Hai Phong	Hanoi	HCMC	Footnote
Parameters	**Year**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	**Estimated value (uncertainty bound)**	
Harm reduction programs									
Number of condoms distribution	2006	303,828	5,800	751,904	758,642	100,000	7,150	300,000	h1
	2007	356,813	369,385	379,465	44,746	487,108	405,736	2,102,683	
	2008	390,092	162,417	214,280	47,200	1,468,262	395,820	1,968,605	
	2009	2,346,789	287,899	235,927	158,225	1,043,614	2,104,066	3,113,937	
Needles and syringes distributed	2006	8,781	55,759			622,779	160,345	235,442	
	2007	146,729	297,427		48,475	1,983,473	1,164,375	320,511	
	2008	253,267	672,113		45,000	3,635,830	12,180,739	849,839	
	2009	319,700	635,156		85,160	2,861,278	3,020,996	1,395,520	

p1: The total size of the population in each province was estimated from the latest released data (in 2007) from the official website of the General Statistics Office of Vietnam (http://www.gso.gov.vn/) and we assume 57% of the population to be sexually active (those aged 15-49 years) based on http://www.nationmaster.com/country/vm-vietnam.

m1: There are very little data on the sexual behavior of men in the general community. Unless otherwise specified for each province we have

assumed that men in the general male population have the same sexual behavior on average. This behavior is based on data in the Vietnam Population and AIDS Indicator Survey conducted in 2005 [4].

m2: The percentage of the population that is classified as general male is given by 50.2% (as obtained from http://www.nationmaster.com/country/vm-vietnam [7] minus the percentage of males that are clients of sex workers, IDUs, and MSM. This is applied across all provinces. No uncertainty range is given as the overall population size is fixed in the model.

m3 & m4: The Vietnam Population and AIDS Indicator Survey (VPAIS) conducted in 2005 [4] provides evidence of very little pre-marital sex, with ~8% of men who have never been married having had sex (Table 6.1.2, page 54 from the VPAIS report [4]) and 0.7% of men not previously married reporting more than one sexual partner in the past (Table 6.2.2, page 57 from the VPAIS report [4]). The overall male population surveyed in the VPAIS was 6,707 (VPAIS 2005, Table 6.1.2. page 54 [4]). Of these, 4,128 were men who had sexual intercourse in the past 12 months (VPAIS 2005, Table 6.2.2. page 57 [4]). It is reported that 3.7% of the 4,128 surveyed men who had sexual intercourse in the past 12 months had higher risk sex (VPAIS 2005, Table 6.2.2. page 57 [4]). Thus, for the overall male population, 2.3% of men surveyed had higher risk sex (defined to be sex with a non-marital or non-cohabitating partner) calculated by 3.7% of 4128/6707.

The overall mean number of sexual partners men have had in their lifetime is 1.4 (Table 6.2.2, page 57 of the VPAIS report [4]). While ~60% of men (Table 3.1, page 24 of the VPAIS report [4]) are married, we assume that men in the general male population have 1 regular partner in a given year (their wife, cohabiting partner, or girlfriend). We assume there are very few casual partners per year, reflecting the small percentage of men who have multiple partners each year (0.7% according to the VPAIS report; Table 6.2.2, page 57 [4]). The value 0.025 is used such that males have 1 casual partner in total over a 40 year period of sexual activity. We assume 1-10 acts per casual partner. The range is an assumption, taken to be + 25% of the value, to account for the potential uncertainty in the data.

m5: The average number of sexual acts per regular partner per year is equal to 87 as reported in Global Sex Survey 2005 [26], with an assumed range of + 25% of this value.

m6: According to the Vietnam Population and AIDS Indicator Survey conducted in 2005 [4] 67.6% of 15-24 year old men reported using a condom at last higher-risk sex (Table 7.5, page 75 of the VPAIS report [4]). The range is an assumption, taken to be + 25% of the value, to account for the potential uncertainty in the data.

m7: From the Vietnam Population and AIDS Indicator Survey conducted in 2005 [4] 12.3% and 43.1% of urban females and males aged 15-24 years reported using a condom at first sex, respectively, and 3.5% and 19.2% of all males and females reported using a condom at first sex (Table 7.3, page 72 of the VPAIS report [4]). For those who have ever been married the percentage who reported using a condom at first sex was 2.9% for females and 6.1% for males. Given the low level of premarital sex in Vietnam and first sex is likely to be within a marriage, condom use per act within a regular partnership is therefore assumed to be low at 6.1% with an assumed uncertainty range of + 25% of this value.

m8: We assume the overall population percentage of 2.6% of males and 2.1% of females who tested for HIV and received their results in the previous year (Table 6.4, page 60 of the VPAIS report [4]) to be representative of yearly HIV testing rates. The uncertainty bound is base on the 95% confidence interval which is calculated from the sample size ever tested (n=355, 5.3% of 6,707 men surveyed) and the proportion tested and received results in the previous year (2.6%). However, in the VPAIS 2005 due to the President's Emergency Plan for AIDS Relief (Table 6.4, page 60 of the VPAIS report [4]) the percentage of men aged 15-49 who were tested for HIV and received their results in the previous year before the survey for Hai Phong is 6.3%, 15.3% for Ha Noi and 5.1% for HCMC. These higher percentages reflect the impact of this intervention so we use the overall population value (2.6% and 2.1%) for the baseline testing rates.

c1: Male respondents (aged 15-49 years) to the Vietnam Population and AIDS Indicator Survey (VPAIS) 2005 who reported that they had sex with a prostitute in the 12 months preceding the survey [4].

c2: The proportion of males who reported paying for sexual intercourse in the past 12 months was reported in the Vietnam Population and AIDS Indicator Survey (VPAIS) conducted in 2005 (Table 6.3, page 58 of the VPAIS report [4]). The proportion of males who had paid for sex was 1.1% (n=141) for Hai Phaong, 0.2% (n=218) for Ha Noi, and 0.3% (n=427) for HCMC (Table 6.3, page 58 of the VPAIS report [4]). There are no equivalent data for men in An Giang, Dien Bien, Da Nang, and Can Tho. We assume a proportion equal to the overall proportion of men aged 15-49 years in Vietnam reporting payment for sexual intercourse in the past 12 months, estimated to be 0.5% (n=6,707) (Table 6.3, page 58 of the VPAIS report [4]). However, based on expert opinion, anecdotal evidence and data from comparable settings outside Vietnam, it is thought that a greater proportion of men pay for sex. Other studies report that up to 33% of Vietnamese men have visited a FSW in their lifetime [27] and the estimates used in the Vietnam HIV/AIDS Estimates and Projections 2007-2012 are also higher than indicated in the VPAIS report. To incorporate this uncertainty a range of 0.1-10% is used for all provinces. This high estimate of 10% of adult males aged 15-49 years is consistent with that used in the Vietnam HIV/AIDS Estimates and Projections 2007-2012 for the 'high' scenario [8].

c3: There are no specific data on HIV testing in clients of commercial sex workers. We assume the same testing rate as general males aged 15-49 as reported in the Vietnam Population and AIDS Indicator Survey (VPAIS) conducted in 2005 (Table 6.4, page 60 of the VPAIS report [4]). See m8 for details.

i1: In the 2000 BSS report [1], an IDU was defined as an individual who has injected illegal drugs (e.g., heroin, opium) or injected various other drugs or combination of drugs for the purpose of getting high rather than for medical reasons. In the 2002 Baseline Survey Report [2] IDUs were defined to be men who used intravenous drugs (not drugs following a medical prescription) within the last six months. In the IBBS 2005-2006 report [3],

IDUs were defined as 18 years or older, currently injecting drugs (identified by reported drug injection in the month prior to the survey), being at selected locations (Hai Phong and An Giang only) at the time of the survey, and willing to participate.

i2: Size estimates of IDUs and their lower and upper bounds were provided by the Vietnam HIV/AIDS Estimates and Projections 2007-2012 [8].

i3: The estimated percentage of IDUs who are female was obtained through correspondence with Dr. Quang at the Pasteur Institute of Ho Chi Minh City, Vietnam. As there are very little data on this proportion we have assumed a larger range of ± 50% to reflect this uncertainty.

i4: The average size of the sharing group is estimated from the number of people an IDU shared a needle with the last time they shared in the 2005-2006 IBBS report (Figure 8 page 23 [3]). The figure in the report gives the proportion of IDUs who shared with one other person and those that shared with two or more people (size of sharing group (n)). To calculate the estimated value we assumed 2 or more can be estimated as 3 people on average. This gives an average size of a sharing group of 3. There are no specific data for Hai Phong, Ha Noi, and Dien Bien. We assume that the average size of the sharing group is same across all provinces, with an assumed uncertainty of ± 25%.

Number of other IDUs who shared used needle (n	**An Giang**		**Da Nang**		**HCMC**		**Can Tho**	
	Proportion shared (s)	**n x s**	**Proportion shared (s)**	**n x s**	**Proportion shared (s)**	**n x s**	**Proportion shared (s)**	**n x s**
1	0.67	0.67	0.75	0.75	0.69	0.69	0.52	0.52
≥2 (assume 3 on average)	0.33	0.99	0.25	0.75	0.31	0.93	0.48	1.44
Weighted average		2		2		2		2

i5: The frequency of injecting for 2000 is calculated from the 2000 BSS report (Table 14, page 28 [1]). For 2002, it is calculated from data provided by the Vietnamese Data Triangulation Team. For 2005, it is calculated from the 2005-2006 IBBS survey (Table 10, page 48 [3]). These surveys provide data on the percentage of surveyed IDUs who report injecting less than once per day, once per day, 2-3 times per day, and >=4 times per day. We assume those who inject less than once per day is equivalent to injecting once per week, those who inject 2-3 times inject on average 2.5 times per day and those who inject >= 4 times a day inject 5 times per day. The average frequency of injecting per year is then given by the weighted average where the corresponding proportion is . The2005 value is calculated from the 2005-2006 IBBS (Table 10, page 48 [3]) as above. The 2009 value is calculated from the 2009 IBBS, IDU Questionnaire, Q204. In the 2002 Baseline Survey Report (Table 24, page 58 [2]), the survey provides data on the percentage of surveyed IDUs who report injecting at least once a month, at least once a week, and at least once per day. We assume those who inject at least once a month inject on average once per month, those who inject at least once a week inject on average once per week, and those who inject at least once per day inject on average once per day. The frequency of injection per year is then given by the weighted average where the corresponding proportion is .

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

‡ For 2005, the values used for Dien Bien are taken from an average across all other provinces.

The range for this value is based on an assumed ± 25% of the given value to account for uncertainty in the data.

Frequency of injecting/day		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
f	days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days

2000	2000 BSS report Table 14, page 28 [1]										
0.15	365	0.063	3	0.684	37	0.399	22	0.314	17	0.033	2
1	365	0.354	129	0.246	90	0.34	124	0.278	101	0.167	61
2.5	365	0.565	516	0.071	65	0.252	230	0.408	372	0.676	617
5	365	0.018	33	0	0	0.09	164	0	0	0.124	226
Weighted average			681		192		540		491		906

Frequency of injecting/day		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
f	days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days
2002	Vietnam Data Triangulation Team										
0.15	365	0.023	1	0.014	1	0.424	23	0.056	3	0.039	2
1	365	0.433	158	0.142	52	0.325	119	0.164	60	0.267	97
2.5	365	0.539	492	0.741	676	0.247	225	0.68	621	0.669	610
5	365	0.006	11	0.103	188	0.004	7	0.098	179	0.025	46
Weighted average			662		917		375		862		756

Frequency of injecting/day		**An Giang**	**Dien Bien**

f	days	Proportion ( )	f* *days	Proportion ( )	f* *days
2002	Baseline Survey Report (Table 24, page 58 [2])				
0.04	365	0.008	0	0.157	2
0.15	365	0.117	6	0.239	13
1	365	0.875	319	0.604	220
Weighted average	365		326		236

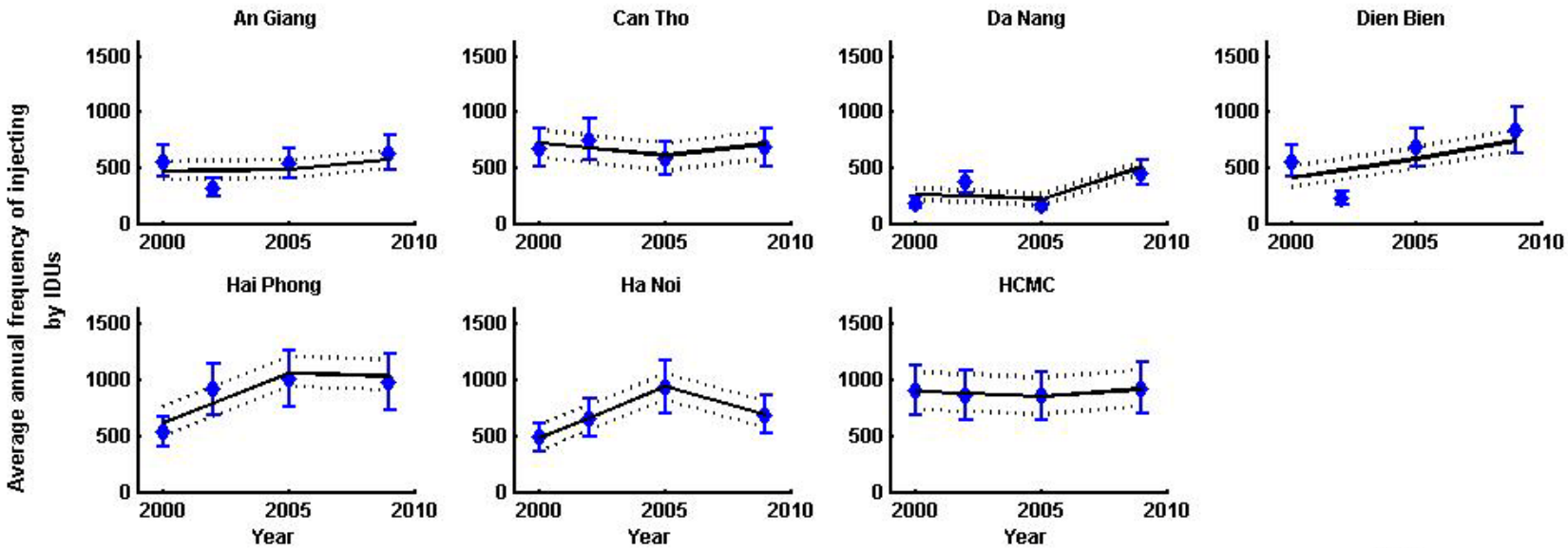
Frequency of injecting/day		**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**	
f	days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days
2005	As sourced from the Vietnam Data Triangulation Team										
0.15	365	0.175	10	0.215	12	0.774	42	0.007	0	0.018	1
1	365	0.406	148	0.279	102	0.142	52	0.04	15	0.115	42
2.5	365	0.413	377	0.494	451	0.082	75	0.824	752	0.746	681
5	365	0.007	13	0.012	22	0.002	4	0.13	237	0.118	215
Weighted average			547		586		173		1004		939

Frequency of injecting/day		HCMC	
f	days	Proportion ( )	f* *days
2005	Baseline Survey Report (Table 24, page 58 [2])		
0.15	365	0.015	1
1	365	0.126	46
2.5	365	0.825	753
5	365	0.033	60
Weighted average			860

Frequency of injecting/day		An Giang		Can Tho		Da Nang		Hai Phong		Ha Noi	
f	days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days	Proportion ( )	f* *days
2009	IBBS 2009, IDU Questionnaire Q204										
0.15	365	0.1639	9	.0830	5	0.2715	15	0.0033	0	0.1067	6
1	365	0.2575	94	0.3032	111	0.4364	159	0.0367	13	0.3100	113
2.5	365	0.5719	522	0.5993	547	0.2749	251	0.8600	785	0.5300	484

5	365	0.0067	12	0.0144	26	0.0172	31	0.1000	183	0.0467	85
Weighted average			637		688		456		981		688

Frequency of injecting/day		**HCMC**		**Dien Bien**	
f	days	Proportion ( )	f* *days	Proportion ( )	f* *days
2009	IBBS 2009, IDU Questionnaire Q204				
0.15	365	0.0097	1	0.0530	3
1	365	0.0935	34	0.1325	48
2.5	365	0.8161	745	0.7616	695
5	365	0.0806	147	0.0530	97
Weighted average			926		843

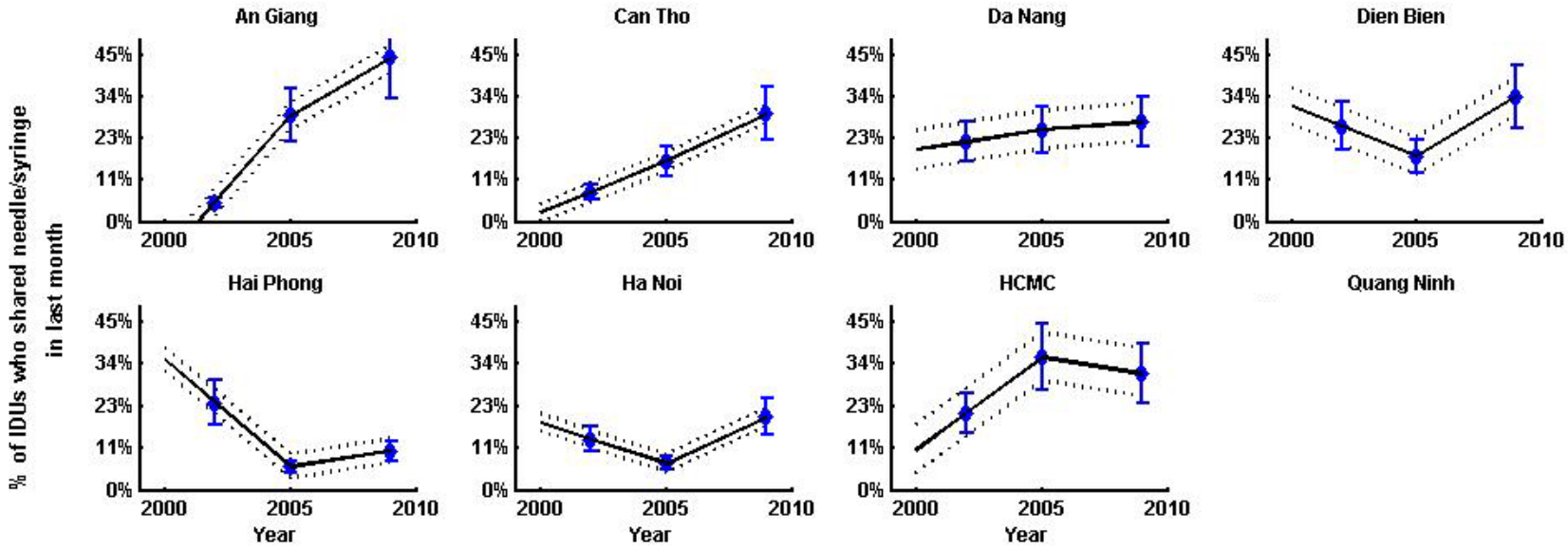


i6: There are no data available for 2000. For 2002, the data for An Giang and Dien Bien is obtained from the percentage that shared a needle/syringe in the last month in the 2002 Baseline Survey Report (Table 24, page 58 [2]) which is 5.3% and 25.7%, respectively. The 2002 data for Can Tho (8%), Da Nang (21.6%), Hai Phong (23.4%), Ha Noi (13.7%), HCMC (20.6%) is obtained from the percentage that reused someone else's needle/syringe in the last month in the data provided by the Vietnamese Data Triangulation Team. For 2005, the percentage of receptive sharing of needle/syringe among IDUs in the last month for An Giang (28.7%), Can Tho (16.3%), Da Nang (24.9%), Hai Phong (6.3%), Ha Noi (7.2%), HCMC (35.4%) is obtained from the 2005-2006 IBBS (Table 11, page 50 [3]). For 2009, we assume condom usage: always = 100%, most of time = 67%, occasionally = 33% and never = 0%. The weighted average is calculated for each province in the following table. The data is from IBBS 2009, IDU Questionnaire, Q303 [28].

†For 2005, values used for Dien Bien are taken from an average across all other provinces.

The range is based on ± 25% the given value to account for uncertainty in the estimated sharing of needle and syringe.

Needle/syringe Sharing	Assumed sharing rate percentage	An Giang	Can Tho	Da Nang	Hai Phong	Ha Noi	HCMC
Always	100%	0.1522	0.0417	0.0000	0.0000	0.0147	0.0263
Most of time	67%	0.2174	0.1458	0.1019	0.0000	0.0882	0.1184
Occasionally	33%	0.4348	0.4583	0.6019	0.3182	0.3676	0.6184
Never	0%	0.1957	0.3542	0.2963	0.6818	0.5294	0.2368
	Weighted Average	0.4421	0.2917	0.2686	0.1061	0.1960	0.3114



i7: There are no data available for rates of cleaning shared injecting equipment. We assume that the percentage of shared syringes that are cleaned is 1%, with a range of 0.1-10%.

i8: For 2000, the number of casual partners an IDU has per year is calculated from the 2000 BSS (Table 16, page 30 [1]), which gives the percentage of IDUs who have 0, 1, 2, and >=3 partners per year. We assume that >=3 partners per year is equivalent to 4 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. For 2002 and 2005, the number of regular, casual, and commercial (sex worker) partners an IDU has each year is calculated from the data obtained from the Vietnamese Data Triangulation Team (for 2002) and from the 2005-2006 IBBS survey (Table 12, page 50 [3]) which give the percentage of IDUs who have 0, 1 and >=2 partners per year. We assume that >=2 partners per year is equivalent to 3 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. For An Giang and Dien Bien provinces for 2002, the data is estimated based on the percentage of IDUs who have 0, 1, 2, 3 and >=4 partners per year reported in the 2002 Baseline Survey Report (Table 25, page 59 [2]). We assume that >=4 partners per year is equivalent to 5 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. For 2009, the number of casual sexual partners in the past 12 months is measured directly as one of the indicators in IBBS 2009, IDU Questionnaire, Q605c [28].

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

‡For 2005, the values used for Dien Bien are taken from an average across all other provinces.

The range is assumed to be ± 25% of the given value to account for uncertainty in the estimated number of partners per year.

2000 BSS (Table 16, page 30 [1])					
Number of casual sexual partners in the past 12 months	**Can Tho**	**Da Nang**	**Hai Phong**	**Ha Noi**	**HCMC**

N	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.961	0	0.797	0	0.936	0	0.918	0	0.952	0
1	0.031	0.031	0.139	0.139	0.046	0.046	0.073	0.073	0.019	0.019
2	0.00	0.006	0.047	0.094	0.012	0.024	0.006	0.012	0.007	0.014
4	0.006	0.024	0.017	0.068	0.006	0.024	0.003	0.012	0.022	0.088
Weighted average		0.06		0.30		0.09		0.10		0.12

2002 data from the Vietnam Data Triangulation Team

Number of casual sexual partners in the past 12 months	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
N	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.992	0	0.935	0	0.937	0	0.901	0	0.935	0
1	0.003	0.003	0.026	0.026	0.052	0.052	0.086	0.086	0.031	0.031
3	0.006	0.018	0.039	0.117	0.012	0.036	0.013	0.039	0.028	0.084
Weighted average		0.02		0.14		0.09		0.13		0.12

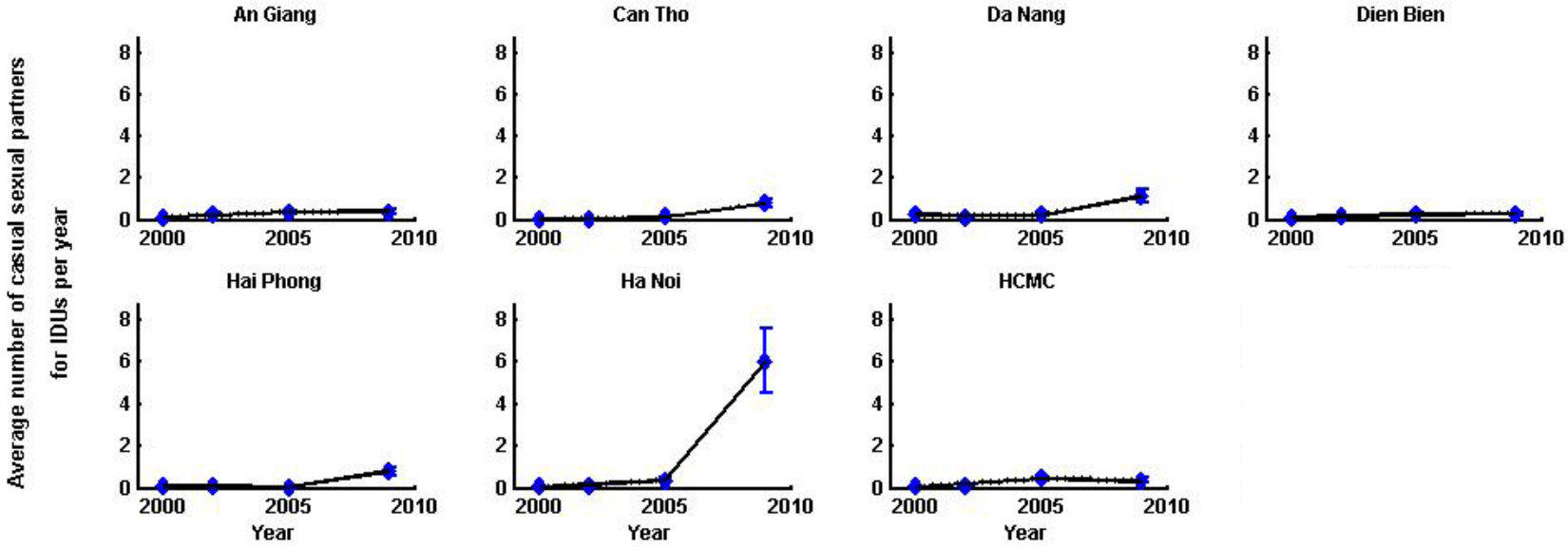
2002 Baseline Survey Report (Table 25, page 59 [2])

Number of casual sexual partners in the past 12 months	**An Giang**		**Dien Bien**	
n	Proportion ( )	n*	Proportion ( )	n*
0	0.812	0	0.888	0
1	0.119	0.119	0.064	0.064
2	0.051	0.102	0.032	0.064
3	0.014	0.042	0.008	0.024
5	0.003	0.015	0.008	0.04
Weighted average		0.28		0.19

2005-2006 IBBS survey (Table 12, page 50 [3])

Number of casual sexual partners in the past 12 months	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
n	Proportion	n*	Proportion	n*	Proportion	n*	Proportion	n*	Proportion	n*	Proportion	n*

	( )		( )		( )		( )		( )		( )	
0	0.807	0	0.894	0	0.881	0	0.964	0	0.811	0	0.775	0
1	0.118	0.118	0.078	0.078	0.043	0.043	0.027	0.027	0.087	0.087	0.089	0.089
3	0.074	0.222	0.028	0.084	0.076	0.228	0.01	0.03	0.101	0.303	0.136	0.408
Weighted average		0.34		0.16		0.27		0.06		0.39		0.50



i9: For 2000, the number of regular partners an IDU has per year is calculated from the 2000 BSS (Table 16, page 30 [1]), which gives the percentage of IDUs who have 0, 1, 2, and >=3 partners per year. We assume that >=3 partners per year is equivalent to 4 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. For 2002 and 2005, the

number of regular partners an IDU has each year is calculated from the data obtained from the Vietnamese Data Triangulation Team (for 2002) and from the 2005-2006 IBBS survey (Table 12, page 50 [3]) which give the percentage of IDUs who have 0, 1, 2, 3 and >=4 partners per year. We assume that >=4 partners per year is equivalent to 5 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. For An Giang and Dien Bien provinces for 2002, the data is estimated based on the percentage of IDUs currently married reported in the 2002 Baseline Survey Report (Table 23, page 57 [2]). For 2009, the number of regular sexual partners in the past 12 months is measured directly as one of the indicators in IBBS 2009, IDU Questionnaire, Q605a [28].

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

‡For 2005, the values used for Dien Bien is taken from an average across all other provinces.

The range is assumed to be ± 25% of the given value to account for uncertainty in the estimated number of partners per year.

2000 BSS (Table 16, page 30 [1])

Number of regular sexual partners in the past 12 months	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
n	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.659	0	0.572	0	0.592	0	0.63	0	0.854	0
1	0.318	0.318	0.418	0.418	0.396	0.396	0.35	0.35	0.127	0.127
2	0.01	0.02	0.01	0.02	0.012	0.024	0.017	0.034	0.01	0.02
4	0.013	0.052	0	0	0	0	0.003	0.012	0.01	0.04

Weighted average		0.4		0.4		0.4		0.4		0.2

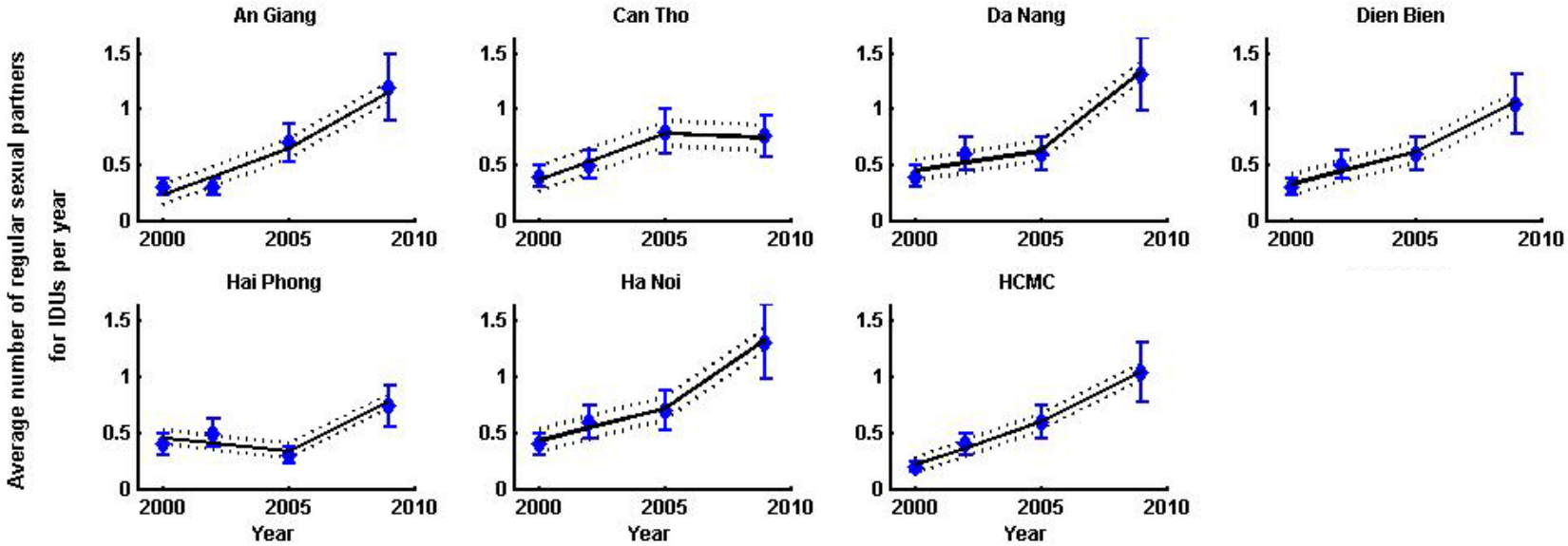
2002 data from the Vietnam Data Triangulation Team

Number of regular sexual partners in the past 12 months	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
N	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.572	0	0.474	0	0.571	0	0.401	0	0.661	0
1	0.392	0.392	0.487	0.487	0.384	0.384	0.583	0.583	0.303	0.303
2	0.022	0.044	0.039	0.078	0.041	0.082	0.016	0.032	0.022	0.044
3	0.006	0.018	0	0	0	0	0	0	0.011	0.033
5	0.008	0.04	0	0	0	0	0	0	0.003	0.015
Weighted average		0.5		0.6		0.5		0.6		0.4

2005-2006 IBBS survey (Table 12, page 50 [3])

Number of regular sexual partners in the past 12 months	**An Giang**	**Can Tho**	**Da Nang**	**Hai Phong**	**Ha Noi**	**HCMC**

n	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.467	0	0.606	0	0.467	0	0.724	0	0.403	0	0.549	0
1	0.4	0.4	0.134	0.134	0.447	0.447	0.249	0.249	0.547	0.547	0.376	0.376
2	0.087	0.174	0.159	0.318	0.062	0.124	0.023	0.046	0.039	0.078	0.031	0.062
3	0.03	0.09	0.064	0.192	0.018	0.054	0.003	0.009	0.004	0.012	0.015	0.045
5	0.017	0.085	0.037	0.185	0.003	0.015	0	0	0.004	0.02	0.027	0.135
Weighted average		0.7		0.8		0.6		0.3		0.7		0.6



i10: The number of commercial sex partners an IDU has each year is calculated from the 2000 BSS (Table 16, page 30 [1]), data obtained from the

Vietnamese Data Triangulation Team (for 2002) and from the 2005-2006 IBBS survey (Table 12, page 50 [3]), which gives the percentage of IDUs who have 0, 1, 2, 3 and >=4 partners per year. We assume that >=4 partners per year is equivalent to 5 partners per year and the overall number of partners is given by the weighted average where is the corresponding proportion. Data for An Giang and Dien Bien for 2002 is calculated from the 2002 Baseline Survey Report (Table 25, page 59 [2]). For 2009, the number of female commercial sexual workers an IDU has in the past 12 months is measured directly as one of the indicators in IBBS 2009, IDU Questionnaire, Q605b [28].

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

‡For 2005, the values used for Dien Bien are taken from an average across all other provinces.

The range is assumed to be ± 25% of the given value to account for uncertainty in the estimated number of partners per year.

2000 BSS (Table 16, page 30 [1])

Number of commercial partners in the past 12 months	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
n	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.943	0	0.797	0	0.849	0	0.769	0	0.919	0
1	0.026	0.026	0.051	0.051	0.059	0.059	0.028	0.028	0.029	0.029
2	0.023	0.046	0.058	0.116	0.025	0.05	0.017	0.034	0.025	0.05
3	0.003	0.009	0.015	0.045	0.025	0.075	0.037	0.111	0.012	0.036

5	0.005	0.025	0.08	0.4	0.044	0.22	0.149	0.745	0.014	0.07
Weighted average		0.11		0.61		0.40		0.92		0.19

2002 data from the Vietnam Data Triangulation Team

Number of commercial partners in the past 12 months	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
n	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.886	0	0.581	0	0.513	0	0.391	0	0.828	0
1	0.047	0.047	0.062	0.062	0.114	0.114	0.063	0.063	0.054	0.054
2	0.033	0.066	0.138	0.276	0.198	0.396	0.139	0.278	0.04	0.08
3	0.006	0.018	0.052	0.156	0.108	0.324	0.098	0.294	0.04	0.12
5	0.028	0.14	0.167	0.835	0.067	0.335	0.309	1.545	0.04	0.2
Weighted average		0.27		1.33		1.17		2.18		0.45

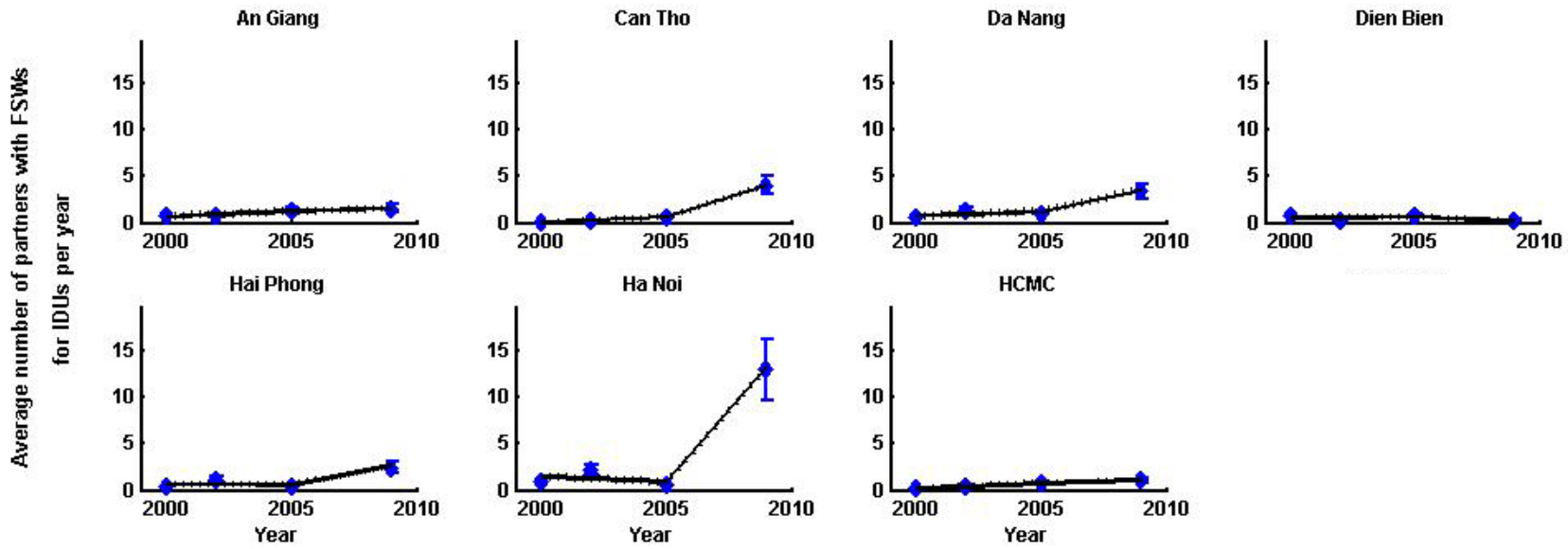
2002 Baseline Survey Report (Table 25, page 59 [2])

Number of commercial partners in the past 12 months	**An Giang**		**Dien Bien**	
n	Proportion ( )	n*	Proportion ( )	n*

0	0.654	0	0.867	0
1	0.118	0.118	0.044	0.044
2	0.093	0.186	0.029	0.058
3	0.066	0.198	0.036	0.108
5	0.065	0.325	0.024	0.12
Weighted average		0.83		0.33

2005-2006 IBBS survey (Table 12, page 50 [3])

Number of commercial partners in the past 12 months	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
n	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*	Proportion ( )	n*
0	0.57	0	0.713	0	0.651	0	0.86	0	0.795	0	0.725	0
1	0.094	0.094	0.121	0.121	0.091	0.091	0.053	0.053	0.044	0.044	0.081	0.081
2	0.104	0.208	0.075	0.15	0.072	0.144	0.017	0.034	0.082	0.164	0.049	0.098
3	0.074	0.222	0.023	0.069	0.038	0.114	0.017	0.051	0.029	0.087	0.054	0.162
5	0.155	0.775	0.068	0.34	0.144	0.72	0.053	0.265	0.048	0.24	0.088	0.44
Weighted average		1.30		0.68		1.07		0.40		0.54		0.78



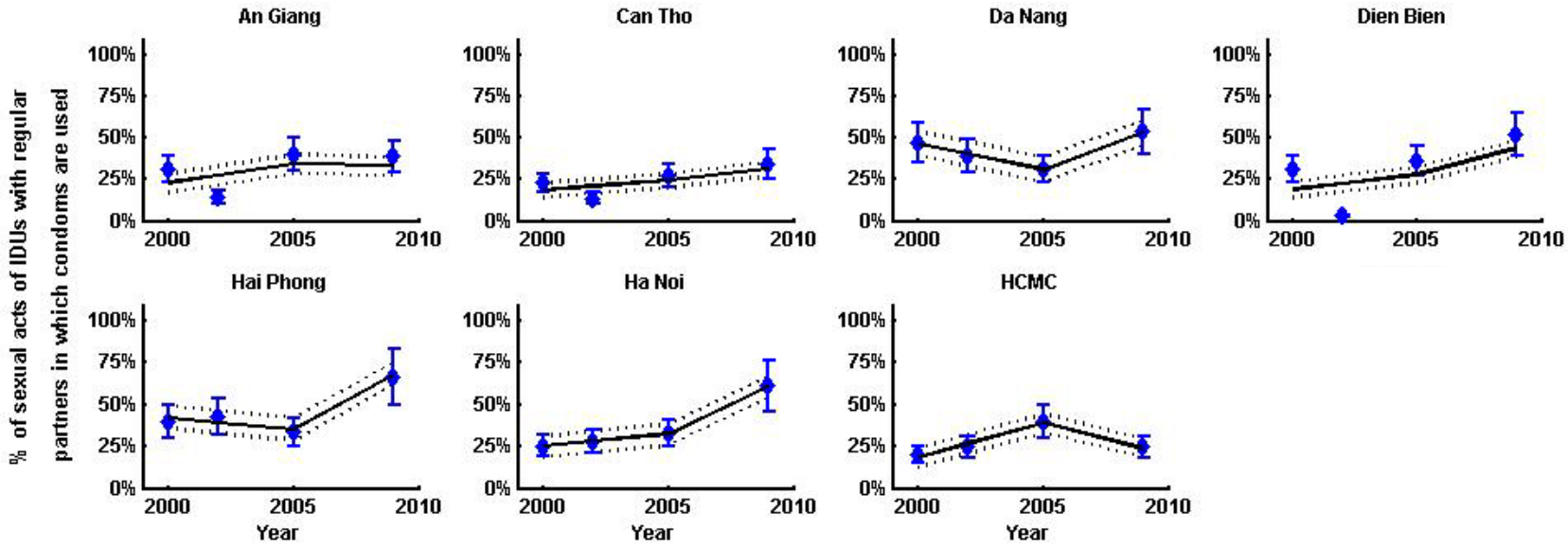
i11, i12, & i13: The proportion of sexual acts where a condom has been used for 2000, 2002 and 2005 is given by the percentage of people who used a condom the last time they had sex with a regular, casual, and commercial sex worker partners in the 2000 BSS (Figure 7, page 32 [1]), data provided by the Vietnam Data Triangulation Team and in the 2005-2006 IBBS (Table 13, page 51 [3]). For An Giang and Dien Bien in 2002, the percentage condom use with regular partners is given by the condom use with wife/girlfriend in the last 12 months for IDUs: An Giang (14.3%) and Dien Bien (3%)from the 2002 Baseline Survey Report (Table 27, page 60 [2]). The percentage condom use in 2002 with casual partners and CSWs for IDUs in An Giang and Dien Bien is from the 2002 Baseline Survey Report (Table 26, page 60 [2]). The 2009 data is obtained from IBBS 2009, IDU Questionnaire, Q702, 802 and 902 [28]. Condom usage in Dien Bien is estimated as the average of other provinces. The range (+ 25%) is an assumption to account for uncertainty in the data.

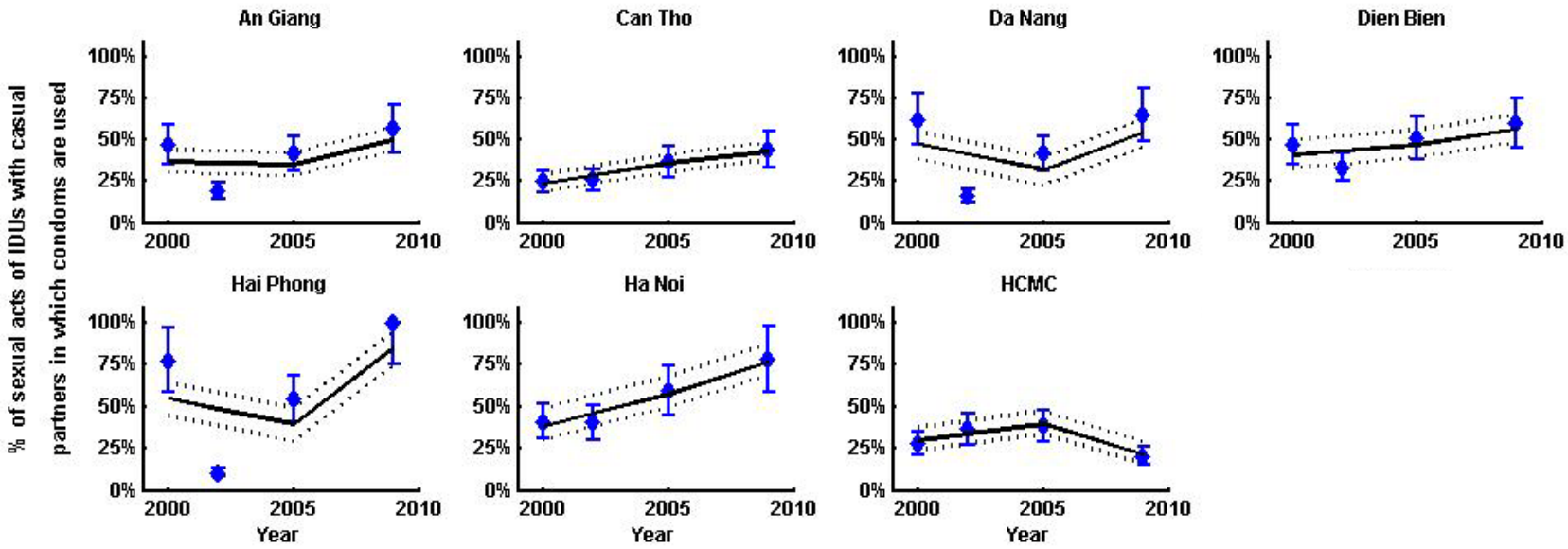
*For 2000, the values used for regular partnerships for An Giang and Dien Bien are taken from an average across all other provinces.

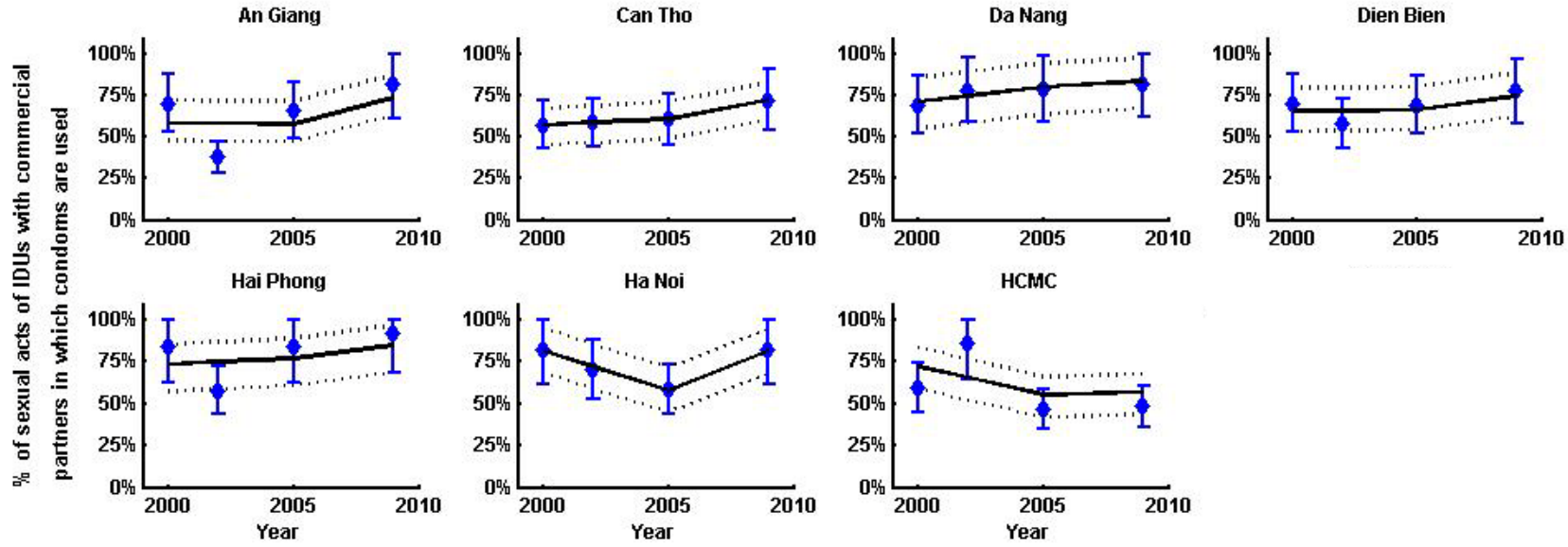
†For 2002, the values used for Can Tho are taken from an average across all other provinces.

‡For 2005, the values used for Dien Bien are taken from an average across all other provinces.

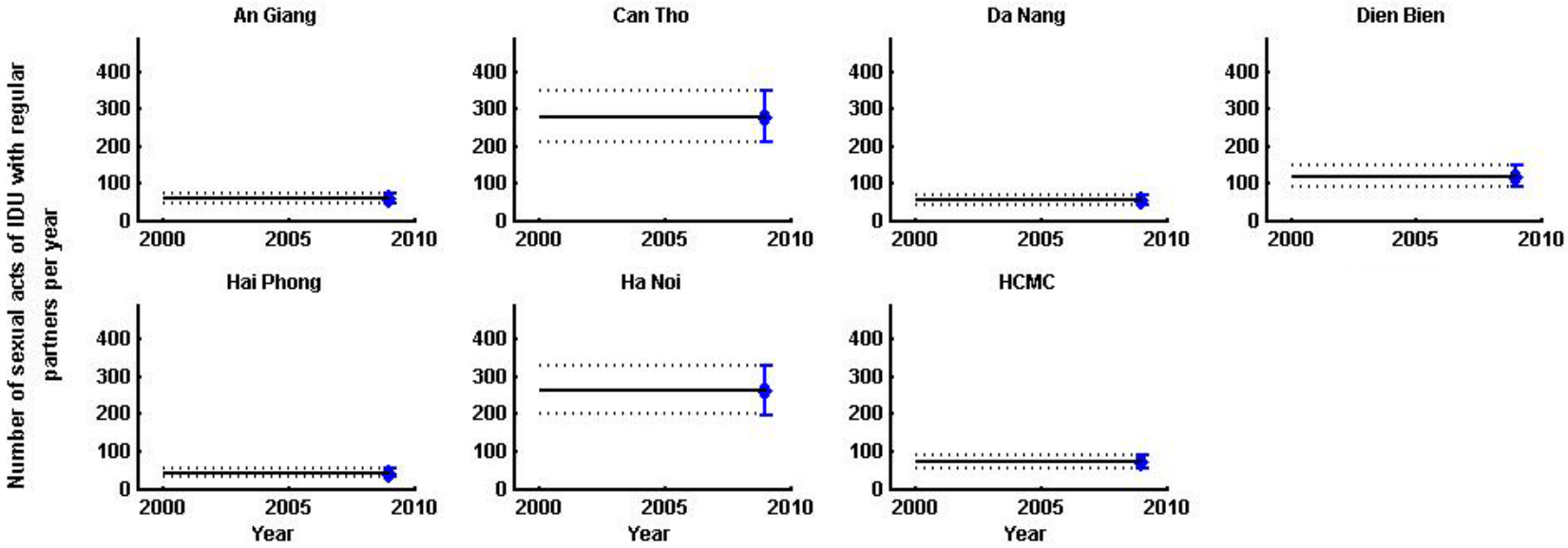
§Unadjusted data.

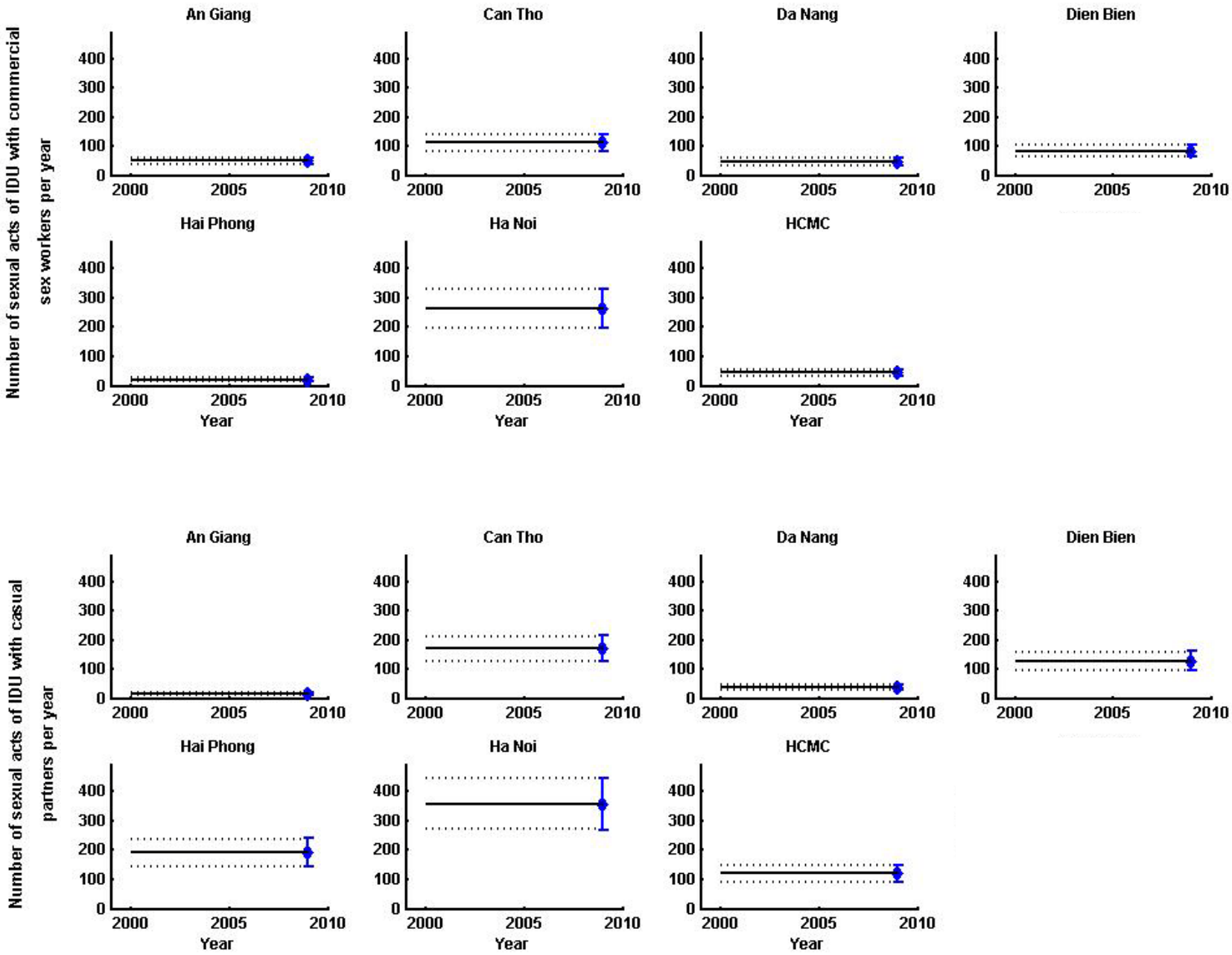



An Giang
Can Tho
Da Nang
Dien Bien
Hai Phong
Ha Noi
HCMC
% of sexual acts of IDUs with casual partners in which condoms are used
100%
75%
50%
25%
0%
2000
2005
2010
Year


An Giang
Can Tho
Da Nang
Dien Bien
Hai Phong
Ha Noi
HCMC
% of sexual acts of IDUs with commercial partners in which condoms are used
100%
75%
50%
25%
0%
2000
2005
2010
Year

i14, i15, i16: These are numbers of sexual acts between IDUs and regular partners, commercial sex workers and casual partners per year. The solely available 2009 data is obtained from IBBS 2009, IDU Questionnaire, Q701, 801 and 901 [28]. We assume the parameters stay constant during the studied years. The values used for Dien Bien are taken from an average across all other provinces.




An Giang
Can Tho
Da Nang
Dien Bien
Hai Phong
Ha Noi
HCMC
Number of sexual acts of IDU with commercial sex workers per year
Year
0
100
200
300
400
2000
2005
2010

An Giang
Can Tho
Da Nang
Dien Bien
Hai Phong
Ha Noi
HCMC
Number of sexual acts of IDU with casual partners per year
Year
0
100
200
300
400
2000
2005
2010

i17: There are no data available on the percentage of IDUs who receive a test for HIV every year. However, data are available in the 2005-2006 IBBS report (Table 15, page 52 [3]) on the percentage of IDUs who have ever voluntarily tested for HIV. We use this value as an upper bound on the proportion tested each year. It is assumed that IDUs are more likely to be tested than the general population due to their relative level of risk. Thus, the testing rate for the general population is used as a lower bound.

h1: MSM who participated in the 2005-2006 IBBS included men 15 years or older, who had engaged in sex with men at least once in the previous 12 months and who would consent to the survey. There are no data available for MSM in An Giang, Can Tho, Da Nang, Dien Bien and Hai Phong. The 2005-2006 IBBS only surveyed MSM in Hanoi and HCMC. There was essentially the same number of MSM surveyed in Hanoi and HCMC during the 2005-2006 IBBS (397 and 393 respectively) (Table 2, page 8 [3]), so for the other provinces an average of the Hanoi and HCMC values is used.

h2: There is no direct estimate on the size of the MSM population in Viet Nam. Studies in Asia suggest that 1% to 3% of the male population 15 years or older has practiced same-sex behavior in the last year [8, 29]. Because Ha Noi and Ho Chi Minh City are the principal economic, social, and cultural centers in Viet Nam, the number of MSM in these provinces are thought to be much higher than in other provinces. For the low scenario, it was assumed that 1% of males that are 15 years or older in Ha Noi and Ho Chi Minh City are MSM. In other provinces, the corresponding assumed value is 0.5% [8, 29]. It has been suggested that the national prevalence of MSM will remain at 2% until 2012 [8].

* For the other provinces an average of the Hanoi and HCMC values is used.

The uncertainty range is assumed to be ± 25% of these values.

h3: The value for male sexual partners (regular) per year is based on the proportion of MSM who reported they live with male partners from the 2005-2006 IBBS report (Table 34, page 66 [3]) with an assumed range of ± 25% the given value to account for uncertainty in the estimated number of partners per year.

* For the other provinces an average of the Hanoi and HCMC values is used.

h4: The average number of casual male sexual partners that men who have sex with men have each year is calculated from the 2005-2006 IBBS report (Table 36 page 68 [3]) which gives the percentage of MSM who have 0, 1, 2, 3 and >=4 partners in the past month. It is assumed that >=4 partners per month is equivalent to 5 partners per month and the overall number of partners is given by the weighted average

where is the corresponding proportion. The range is an assumption, ± 25% the given value to account for uncertainty in the estimated number of partners per year.

* For the other provinces an average of the Hanoi and HCMC values is used.

The uncertainty range is assumed to be ± 25% of these values.

2005-2006 IBBS report (Table 36, page 68 [3])

Number of male partners (casual) in the past month		**Ha Noi**		**HCMC**	
n	months (m)	Proportion ( )	n* *m	Proportion ( )	n* *m
0	12	0.359	0	0.5	0.00
1	12	0.202	2.424	0.291	3.49
2	12	0.207	4.968	0.246	5.90
3	12	0.091	3.276	0.132	4.75
5	12	0.139	8.34	0.324	19.44

Weighted average			19.0		33.6

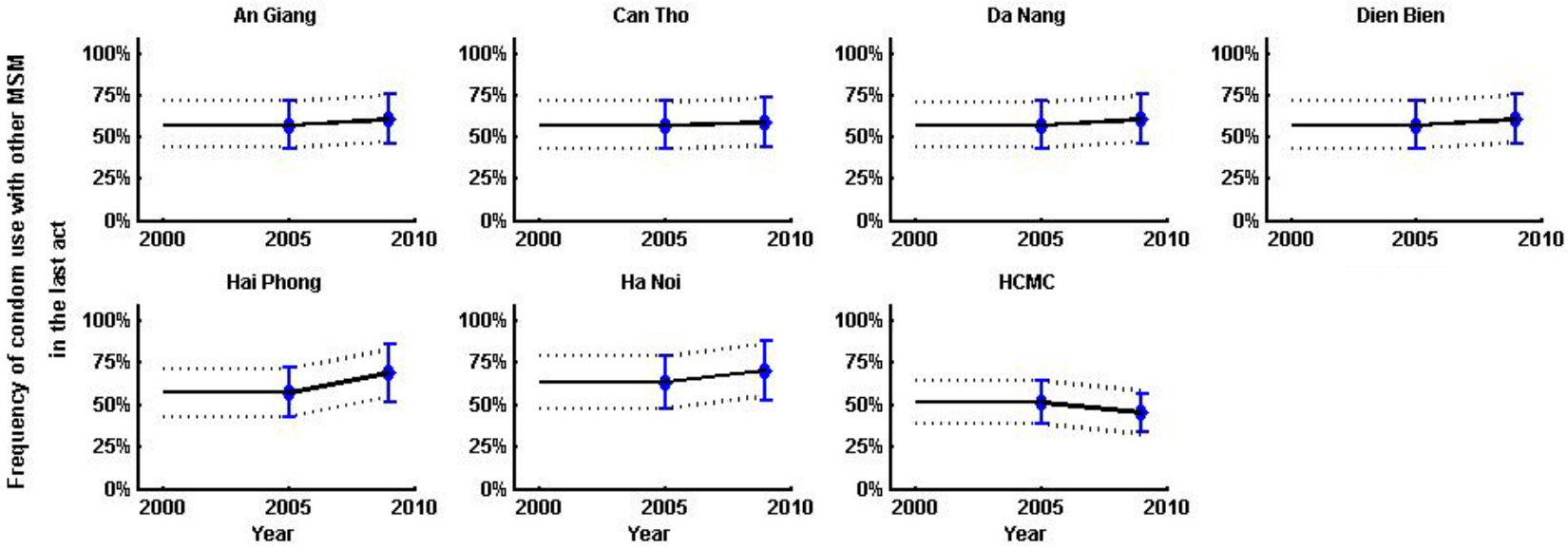
h5: The average number of female sexual partners per year is based on the percentage of MSM who had sex with female partners in the previous year in Hanoi and HCMC as presented in the 2005-2006 IBBS report (Table 37, page 69 [3]), with an assumed range of ± 25% the given value to account for uncertainty in the estimated number of partners per year.

* For the other provinces an average of the Hanoi and HCMC values is used. The uncertainty range is assumed to be ± 25% of these values.

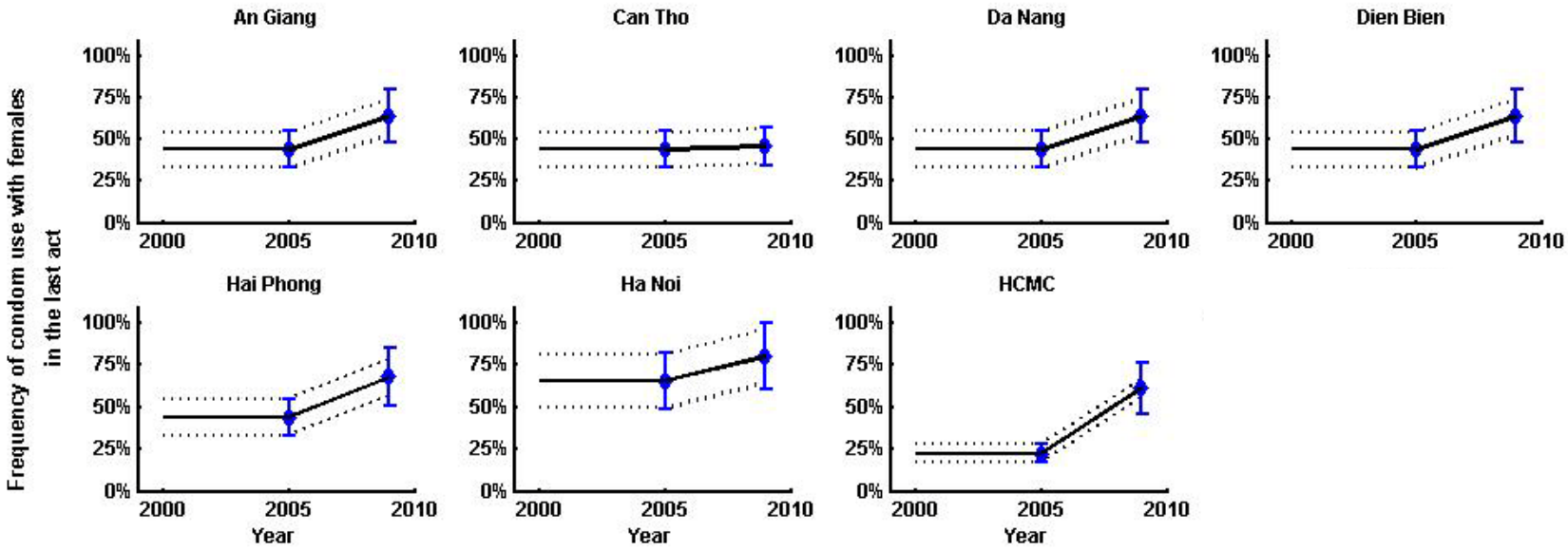
h6: The value for condom use last act with other MSM is based on the proportion of MSM who reported using condom during last sex with male sex workers and consensual partners in the 2005-2006 IBBS report (Table 38, page 69 [3]). There is a large difference between these values: for Ha Noi (51.2% and 75.5%, respectively); for HCMC (48.5% (unadjusted) and 54.4%, respectively) so we have taken an intermediate value. For the other provinces an average of the Hanoi and HCMC values is used. For 2009, condom usage frequencies from Can Tho, HCMC, Ha Noi and Hai Phong are used to estimate the weighted frequency of condom usage among MSM in these four provinces, as in the following table. Condom usage in other provinces is estimated as an average of the data from these four provinces. The available data are obtained from IBBS 2009, MSM Questionnaire, Q302 [28]. The uncertainty range is assumed to be ± 25% of these values.

	Percentage	Can Tho	Hai Phong	Ha Noi	HCMC
Always	1.0000	0.3958	0.3185	0.5190	0.4497
Most of time	0.6667	0.2153	0.0514	0.1962	0.2275
Occasionally	0.3333	0.1458	0.3014	0.1709	0.2646

Never	0.0000	0.2431	0.3288	0.1139	0.0582
Weighted Average		0.5879	0.4532	0.7068	0.6896



h7: The value for condom use last act with general females is based on the proportion of MSM who reported using a condom during last sex with consensual female partners in the last 12 months in the 2005-2006 IBBS report (Table 39, page 70 [3]) with an assumed range of ± 25% the given value to account for uncertainty. For 2005, only data of Hanoi and HCMC is available, and an average of the Hanoi and HCMC values is used for other provinces. For 2009, data from Can Tho, HCMC, Ha Noi and Hai Phong are available; values for other provinces are estimated as averages of these four provinces. The available data are obtained from IBBS 2009, MSM Questionnaire, Q231 [28]. The uncertainty range is assumed to be ± 25% of these values.



h8: Bisexual behavioral of MSM is important for understanding HIV transmission routes. This set of data indicates the percentage of MSM who have had sexual relationships with females in the past 12 months. The data are obtained from IBBS 2009, MSM Questionnaire, Q229 [28].

h9: There are no data available on the percentage of MSM who receive a test for HIV every year. However, there are data on the percentage of MSM who have ever voluntarily tested for HIV in the 2005-2006 IBBS report (Table 42, page 71 [3]). We use this value as an upper bound on the proportion tested each year. It is assumed that MSM are more likely to be tested than the general population due to their at risk behavior. Thus the testing rate for the male general population is used as a lower bound. We have chosen a value of 5% slightly above this lower bound for our initial testing rate, this value may change during the modeling calibration process.

f1: As with general males there are little data on the sexual behavior of females in the general population (numbers of partners and condom use). Unless otherwise specified we have assumed that females in the general population have the same sexual behavior in each province on average. This behavior is based on data in the Vietnam Population and AIDS Indicator Survey conducted in 2005 [4].

f2: The proportion of the population that is a general female is given by 49.8% (as obtained from http://www.nationmaster.com/country/vm-vietnam) minus the percentage of females that are IDUs, SSWs, and KSWs.

f3 & f4: From the Vietnam Population and AIDS Indicator Survey (VPAIS) conducted in 2005 [4] there appears to be very little pre-marital sex, with 1.4% of women who have never been married having had sex (Table 6.1.1, page 53 from the VPAIS report [4]) and 0% of women not previously married reporting more than one sexual partner in the past (Table 6.2.1, page 56 from the VPAIS report [4]). The overall female population surveyed in the VPAIS was 7,289 (VPAIS 2005, Table 6.1.1. page 53 [4]). Of these, 4,721 were women who had sexual intercourse in the past 12 months (VPAIS 2005, Table 6.2.1. page 56 [4]). It is reported that 0.4% of 4,721 women who had sexual intercourse in the past 12 months had higher risk sex (VPAIS 2005, Table 6.2.1. page 56 [4]). Thus, for the overall female population, 0.3% of women surveyed had higher risk sex (defined to be sex with a non-marital or non-cohabitating partner) which equals 0.4% of 4721/7289 where 7289 is the total number of women surveyed.

The overall mean number of sexual partners women have in their lifetime is 1.0 (Table 6.2.1, page 56 of the VPAIS report [4]). While ~65% of women (Table 3.1, page 24 of the VPAIS report [4]) are married, we assume that women in the general female population have 1 regular partner per year (their husband, cohabiting partner, or boyfriend). We assume there are very few casual partners per year, reflecting the small percentage of women who have multiple partners each year (0% according to the VPAIS report; Table 6.2.1, page 56 [4]). The value 0.025 is used such that females have an average of 1 casual partner in total over a 40 year period of sexual activity. The uncertainty range is an assumed to be + 25%.

f5: The average number of sexual acts per regular partner per year is equal to 87 as reported in Global Sex Survey 2005 [26], with an assumed

uncertainty range of + 25%.

f6: See m8 above.

k1: In the 2000 BSS [1], karaoke-based sex workers (KSWs) were defined as women who work in a variety of establishments such as karaoke-bars, restaurants, hotels, massage parlors, truck stops who also sell sex to customers, considered to be indirect sex workers.

In the 2002 Baseline Survey Report [2] KSWs were defined to be commercial sex workers who meet male clients at entertainment places such as karaoke bars or cafes. Their income comes primarily from working as waitresses or drink and food sellers; sex work is their second source of income. Before participating in this study, karaoke commercial sex workers were carefully selected: only hospitality workers who are commercial sex workers on the side were invited to participate in this survey.

The 2005-2006 IBBS [3] recruited commercial sex workers based on the following criteria: women who were 18 years or older, who reported having sex for money at least once in the month prior to the survey, and were working on the street (as SSWs) or in establishments such as karaoke bars or massage venues (as KSWs). In some provinces, even though sex workers were identified at some establishments, based on the characteristics and nature of their workplaces, they were considered street-based sex workers. For example, in Hai Phong some sex workers who were working at in-house places were considered street-based since they moved in from the streets to avoid 'social evils' campaigns.

k2: In Vietnam, it is generally perceived that the number of SSWs is much greater than the number of KSWs. This is consistent throughout all provinces although the exact ratio may vary. Currently there is no sufficient data enabling a reasonable estimate of the ratio, but communication with Dr. Huang, from Pasteur Institute of Ho Chi Minh City, indicates that an approximation of the KSW:SSW ratio is 0.35:0.65. This means the proportion of sex workers that are KSWs is 35%. To account for any uncertainty we assume a range of approximately + 25% of this value.

k3: Estimates of the total number of female sex workers (and lower and upper bounds) were provided by the Vietnam HIV/AIDS Estimates and Projections 2007-2012 [8]. The number of KSWs is estimated by multiplying 35% to the number of FSWs (see k2).

k4: There are no available data for 2000. In the 2002 Baseline Survey Report (Table 14, page 47 [9]) the duration that KSWs sell sex is stratified into <1, 1-2, 3-4, and >= 5 year spans. To calculate the average duration we assume >= 5 years corresponds to 6 years and take a weighted average given by where the corresponding proportion is . The values for the proportions are taken from the 2002 Baseline Survey Report (Table 14, page 47 [2]). For 2005 the average duration of selling sex in KSWs is as reported in the 2005-2006 IBBS (Table 26, page 60 [3]). For 2009, the average number of years of selling sex is directly measured by the IBBS 2009 KSW Questionnaire, Q203 [28].

*For 2002, the average between An Giang and Dien Bien is taken for all other provinces.

†The 2005 and 2009 values used for Dien Bien are the averages across all other provinces. The uncertainty range for both 2002 and 2005 data given is an assumed ± 25% of the given value.

2002 Baseline Survey Report (Table 14, page 47 [2])				
Duration of selling sex (years)	**An Giang**		**Dien Bien**	
d	Proportion (p_x)	$d*p_x$	Proportion (p_x)	$d*p_x$
<1 = 0.5	0.139	0.1	0.224	0.1
1-2 = 1.5	0.609	0.9	0.51	0.8
3-4 = 3.5	0.192	0.7	0.204	0.7
≥5 = 6	0.06	0.4	0.061	0.4

Weighted average		2.0		2.0

k5: The number of one-time clients per year for KSWs is calculated from the 2000 BSS (Table 9, page 22 [1]), 2002 Baseline Survey report (Table 16, page 50 [2]) and from the 2005-2006 IBBS (Table 27, page 61 [3]). It is assumed that KSWs and SSWs engaged in sex work about 40 weeks each year and inactive during the remaining 12 weeks. This assumption is based on a discussion between the NCHECR/UNSW modeling team and the Vietnam team during their first meeting in Vietnam in October 2009. Casual clients are assumed to be one-time clients. For 2009, monthly number of one-time clients of KSW is given by IBBS 2009, KSW Questionnaire Q403.1 [28], this number is multiplied by 12 to give the estimated number of one-time clients of KSW per year.

For 2000 and 2002 data, there is no report for the 'number of clients in the past month' which has been used for the calculation of annual estimate in other provinces. Thus the number of partners per week (n) was multiplied by the assumed weeks engaged in sex (w) 40 to get the yearly estimate.

For 2005, the number of one-time clients per year and regular clients per year for KSWs is calculated from the 2005-2006 IBBS (Table 27, page 61 [3]). The number of partners per month (n) was multiplied by assumed months engaged in sex work (m) 9.23 to obtain the annual estimate.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

†For 2002, a weighted average between An Giang and Dien Bien is taken from across all other provinces.

‡For 2005 and 2009, the values used for Dien Bien are taken from an average across all other provinces.

An uncertainty range of ± 25% of the given value is assumed.

2000 BSS (Table 9, page 22 [1])– one-time clients

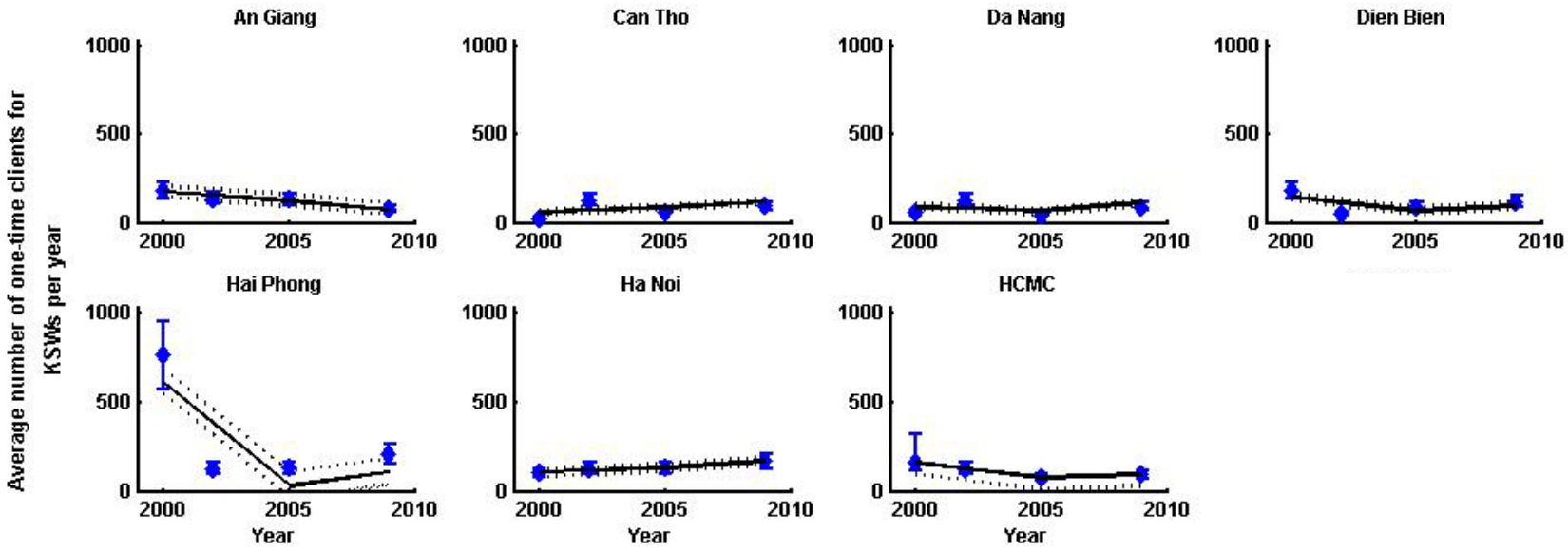
Assumed weeks engaged in sex work	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
w	n	n*w	n	n*w	n	n*w	n	n*w	n	n*w
40	0.6	24	1.5	60	19.2	768	2.6	104	4	160

2002 Baseline Survey report (Table 16, page 50 [2]) – one-time clients

Assumed weeks engaged in sex work	**An Giang**		**Dien Bien**	
w	n	n*w	n	n*w
40	3.5	140	1.3	52

2005-2006 IBBS (Table 27, page 61 [3]) – one-time clients

Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23	14.41	133	7.06	65	5.07	47	14.57	134	14.14	131	8.29	77



k6: The number of regular clients per year for KSWs is calculated from the 2000 BSS (Table 9, page 22 [1]), 2002 Baseline Survey report (Table 16, page 50 [2]) and from the 2005-2006 IBBS (Table 27, page 61 [3]). It is assumed that KSWs and SSWs engaged in sex work about 40 weeks each year and inactive during the remaining 12 weeks. This assumption is based on a stakeholder discussions/expert opinion. Casual clients are assumed to be one-time clients.

For 2000 and 2002 data, there is no report for the "number of clients in the past month" which has been used for the calculation of annual estimate in other provinces. Thus the number of partners per week (n) was multiplied by the assumed weeks engaged in sex (w) 40 to get the yearly estimate.

For 2005, the number of one-time clients per year and regular clients per year for KSWs is calculated from the 2005-2006 IBBS (Table 27 page 61 [3]). The number of partners per month (n) was multiplied by assumed months engaged in sex work (m) 9.23 to obtain the annual estimate. For 2009, monthly number of regular clients of KSW is given by IBBS 2009, KSW Questionnaire Q403.2 [28], this number is multiplied by 12 to give the

estimated number of regular clients of KSW per year.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

†For 2002, a weighted average between An Giang and Dien Bien is taken across all other provinces.

‡For 2005 and 2009, the values used for Dien Bien are taken from an average across all other provinces.

An uncertainty range of ± 25% of the given value is assumed.

2000 BSS (Table 9, page 22 [1]) – average number of regular clients per year

Assumed weeks engage in sex work	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
w	n	n*w	N	n*w	n	n*w	n	n*w	n	n*w
40	0.7	28	0.4	16	3.2	128	2.4	96	3.5	140

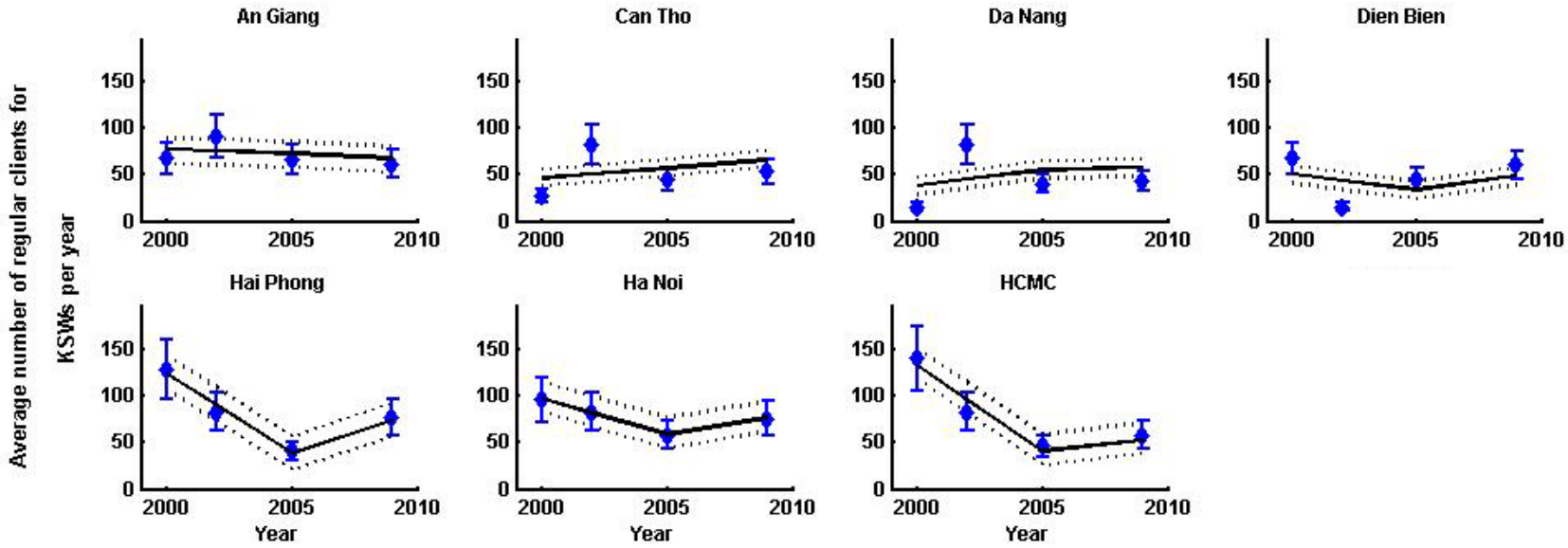
2002 Baseline Survey report (Table 16, page 50 [2]) – average number of regular clients per year

Assumed weeks engage in sex work	**An Giang**		**Dien Bien**	
w	n	n*w	n	n*w
40	2.3	92	0.4	16

2005-2006 IBBS (Table 27, page 61 [3]) – average number of regular clients per year

Assumed months engage in sex work	**An Giang**	**Can Tho**	**Da Nang**	**Hai Phong**	**Ha Noi**	**HCMC**

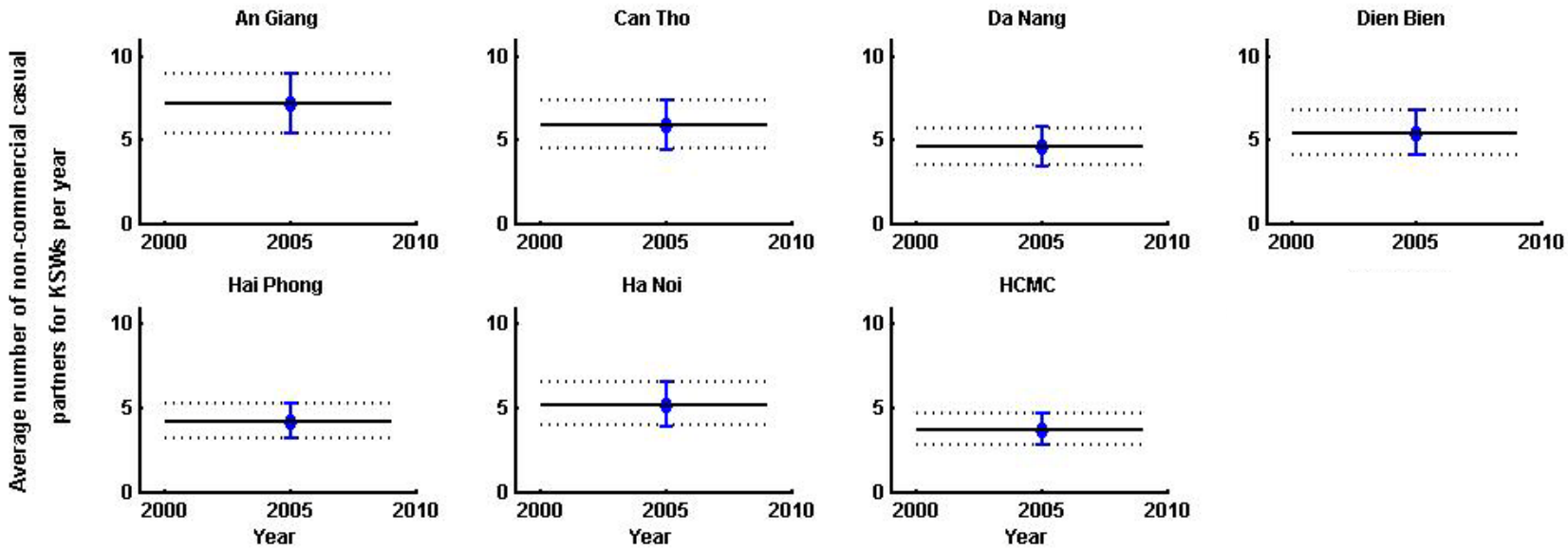
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23	7.3	67	4.87	45	4.44	41	4.47	41	6.26	58	5.03	46



k7: The average number of non-commercial casual sexual partners per year for 2005 is based on the average number of non-commercial sex partners in the past month reported in the 2005-2006 IBBS (Table 27, page 61 [3]). It is assumed that KSWs engage in sex work about 40 weeks (~9 months) each year and inactive during the remaining 12 weeks. Thus, the number of non-commercial casual sexual partners per month (n) is multiplied by assumed months engaged in sex work (m) 9.23 to obtain the annual estimate as below.

*There are no available data for Dien Bien in 2005. Thus, an average (5.4) of the other 7 provinces is used for Dien Bien. There are also no available data for 2000 and 2002. The uncertainty range is assumed to be ± 25% of the given value.

2005-2006 IBBS (Table 27, page 61 [3]) – average number of non-commercial casual sexual partners per year												
Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23	0.78	7.2	0.64	5.9	0.5	4.6	0.5	4.2	0.6	5.2	0.4	3.7



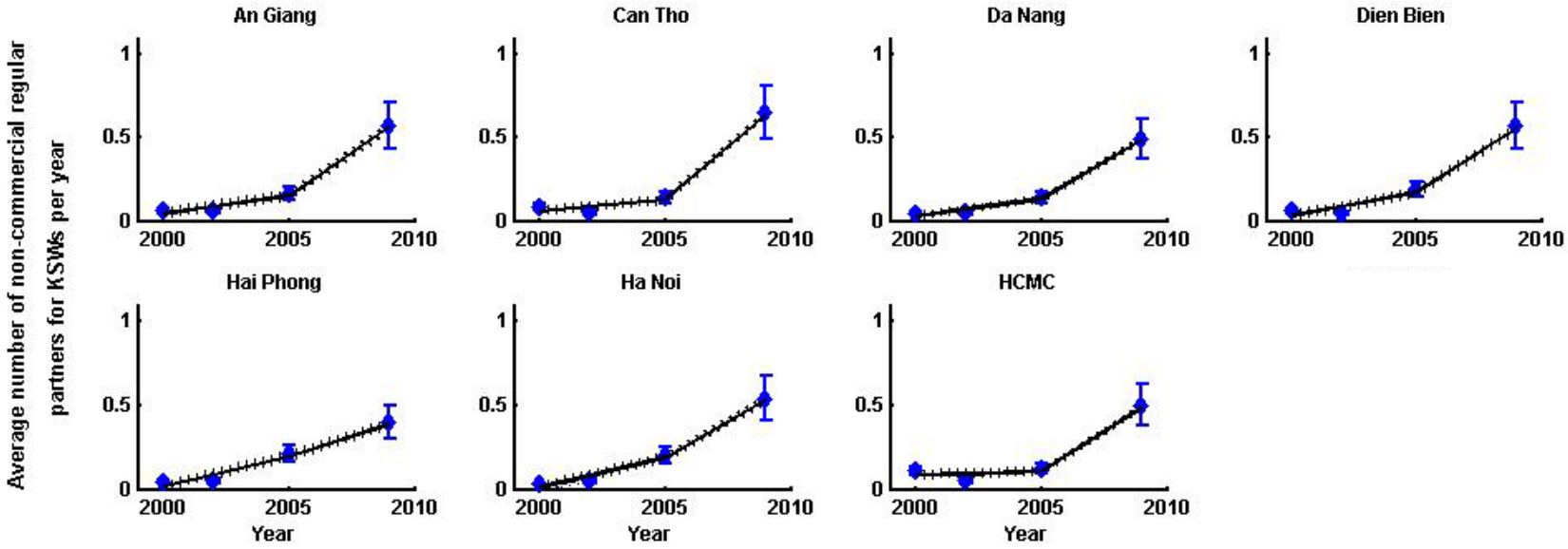
k8: The average number of non-commercial regular sexual partners per year for all provinces is based on the proportion of KSWs who reported they were currently married in the 2000 BSS report (Table 3, page 14 [1]), 2002 Baseline Survey Report (Table 14, page 47 [2]) and 2005-2006 IBBS

(Table 26, page 60 [3]), with an assumed range of ± 25% the given value to account for uncertainty in the data. For 2009, monthly number of regular male partners (boyfriends/husband) of KSW is given by IBBS 2009, KSW Questionnaire Q403.3 [28], this number is assumed to be identical to the number of regular male partners of KSW per year.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

†For 2002, an average between An Giang and Dien Bien is taken from across all other provinces.

‡For 2005 and 2009, the values used for Dien Bien are taken from an average across all other provinces. The uncertainty ranges are assumed to be ± 25% of the given value.



k9: The average number of sexual acts per regular client per year is equal to 12 corresponding to one visit per month. The number of times a regular client visits a sex worker is highly uncertain as there is no available data. To take this high uncertainty into account we assume a range from 6-24 representing a visit frequency of 2 months to once every two weeks.

k10: The average number of sexual acts per regular partner per year for the general male and female populations is taken to be 87, as reported in the Global Sex Survey 2005 [26]. For 2009, the monthly number of sexual acts a KSW has with regular male partners (boyfriends/husband) is taken to be the data obtained from the IBBS 2009, KSW Questionnaire Q701 [28]; this number is multiplied by 12 to give the number of regular sexual acts per year. The Dien Bien data is estimated as the average of other provinces in 2009.

This value has an assumed uncertainty range of + 25%.

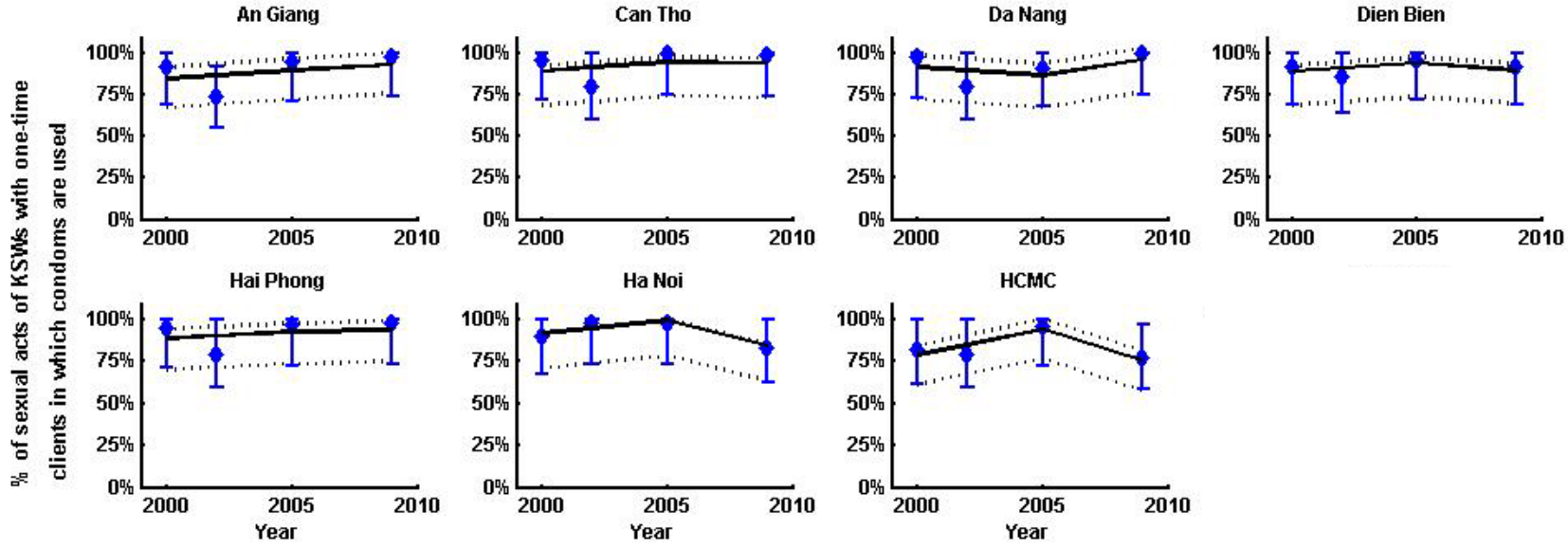
k11 & k12: The proportions of condom use per act with one-time/casual clients and regular clients during last sex (or most recent sex) among KSWs are taken from the 2000 BSS report (Figure 2, page 25 [1]), 2002 Baseline Survey Report(Table 7, page 23 and Table 17, page 50 [2]) and 2005-2006 IBBS (Table 28, page 62 [3]). The reported condom use with both one-time/casual clients and regular clients during last sex was high, which may have affected due to social desirability bias. For 2009, the percentage of condom usage of a KSW with a one-time client/regular client in the last sexual act is measured by IBBS 2009, KSW Questionnaire Q504 [28]. The ranges for these parameters are assumed to be ± 25% of the given value to account for uncertainty in the data.

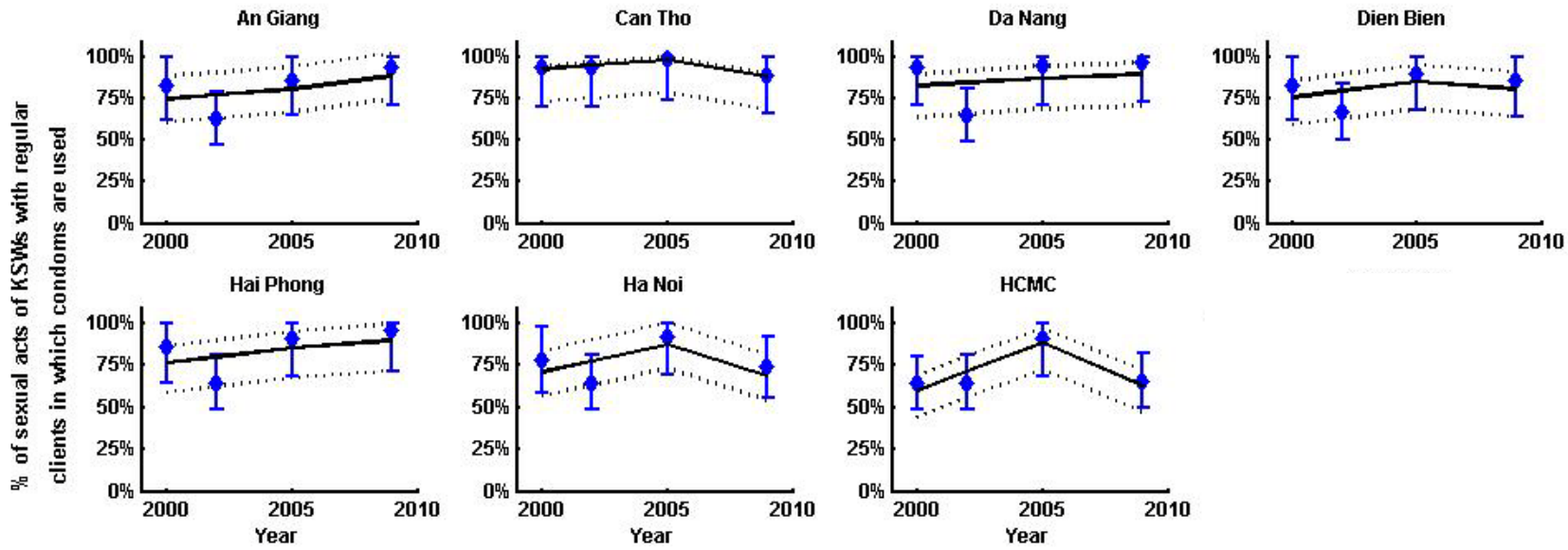
*The original 2005 percentage condom use per act among KSWs with one-time/casual clients during last sex for Da Nang reported is 100%. Because this appears to be unrealistically high, we have used the data for “consistent condom use with one-time clients in the past month”, which is 90.63%.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

†For 2002, an average between An Giang and Dien Bien is taken for data from across all other provinces.

‡For 2005 and 2009, the values used for Dien Bien are taken from an average across all other provinces.

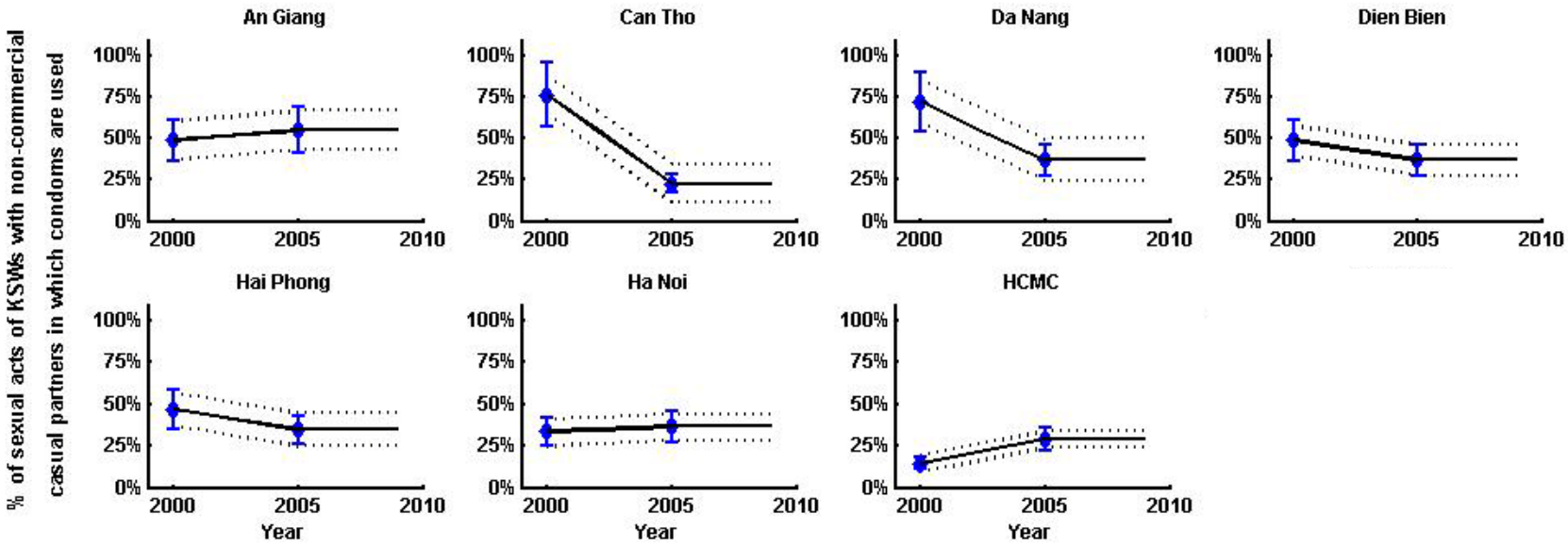




k13: For 2000, the proportion of condom use per act with non-commercial casual partners during last sex among KSWs is based on condom use at last sex with non-paying partner reported in 2000 BSS (Figure 2, page 25 [1]). There is no available data for 2002. For 2005, this data is based on condom use with non-commercial sex partner during last sex among KSWs reported in the 2005-2006 IBBS (Table 28, page 62 [3]). The uncertainty range for this value is assumed to be ± 25% of the given value.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

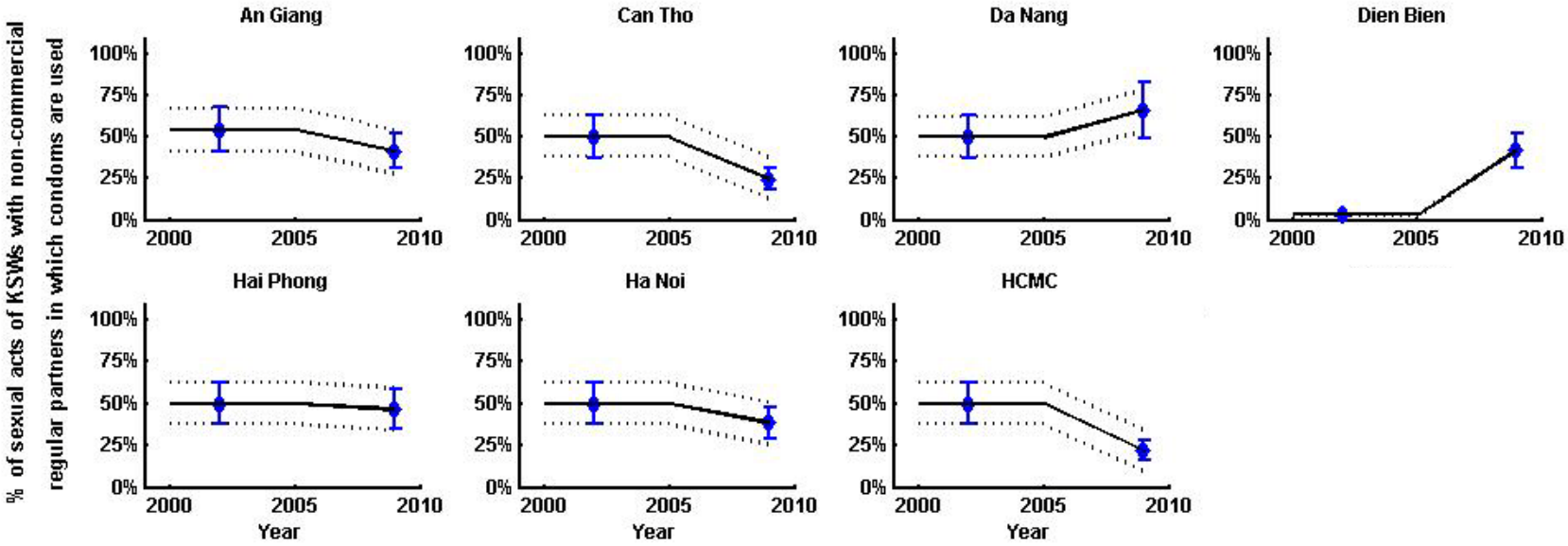
‡For 2005, the value used for Dien Bien is taken from an average across all other provinces.



k14: The percentage of acts in which condoms are used with non-commercial regular partners is based on reported data of condom use in the most recent sex with husband/boyfriends among KSWs in An Giang and Dien Bien (Lai Chau); reported in the 2002 Baseline Survey Report (Table 7, page 23 and Table 17, page 50 [2]). There was 0% reported for Dien Bien. However, we assume that per-act condom use with non-commercial regular partners is 3% in Dien Bien. There is no available data for 2000 and 2005 and in other provinces. A weighted average (50%) between An Giang and Dien Bien has been used for all other provinces for 2002, where n= sample size and p=proportion condom use in most recent sex with husband/boyfriends among KSWs. For 2009, the percentage of acts in which condoms are used between KSW and a regular male partner (boyfriend/husband) is taken to be the reported measure of condom use at the last sexual act by IBBS 2009, KSW Questionnaire Q702 [28]. Dien Bien data in 2009 is estimated as the average of other provinces. The uncertainty range for this value is assumed to be ± 25% of the given value.

2002 Baseline Survey Report (Table 7, page 23 and Table 17, page 50 [2])			
Condom use in most recent sex with	n	Proportion (p)	n*p

husband/boyfriends			
An Giang	331	0.544	180.1
Dien Bien	34	0.03	1.0
Total	365		181.1
Weighted average - total n*p / total n			0.496



k15: The percentage of KSWs who inject drugs in 2000 is based on data reporting injection of drugs in the past six months reported in the 2000 BSS (Table 8, page 21 [1]), and is available for only Ha Noi and HCMC.

*An average (5%) between these two provinces has been used for other provinces.

For 2002, these data are based on ever injected drugs reported in the 2002 Baseline Survey Report (Table 15, page 48 [2]); 0% for Dien Bien.

†It is assumed that the percentage of KSWs who inject drugs for 2002 in other provinces is the same as for An Giang, which is 3%.

For 2005, the data are based on KSWs who reported ever injected drugs in the 2005-2006 IBBS (Table 30, page 63 [3]).

‡The 2005 value used for Dien Bien is an average of all other provinces, which is 4.7%. The range for this value is assumed to be ± 25% the given value to account for uncertainty in the data.

k16: There are no data available on the percentage of KSWs who get tested every year. However, there are data on the percentage of KSWs who have ever voluntarily tested for HIV in the 2005-2006 IBBS report (Table 31, page 64 [3]). We use this value as an upper bound on the proportion tested each year. It is assumed that KSWs are more likely to be tested than the general population due to their at risk behavior. Thus, the testing rate for the general population is used as a lower bound.

* For Dien Bien, the upper bound for the uncertainty range is assumed to be 25%.

s1: In the 2000 BSS report [1], street-based sex workers (SSWs) are defined as women who sell directly on the streets actively soliciting clients outside or with the help of a pimp. Sex work is their primary source of income. According to the 2002 Baseline Survey Report [2] SSWs are classified as those who do not work at entertainment establishments but meet male clients in alleys, football stadiums, bus stations, in low-price guesthouses, or outside of bars. Sex work is their primary source of income. See k1 above for the definition of SSWs in the 2005-2006 IBBS [3].

s2: Estimates of the total number of female sex workers (and lower and upper bounds) were provided by the Vietnam HIV/AIDS Estimates and Projections 2007-2012 [8]. The number of SSWs is estimated by multiplying 65% to the number of FSWs (see k2).

s3: There are no available data for 2000. In the 2002 Baseline Survey Report (Table 14, page 47 [2]) the duration that SSWs sell sex is stratified into <1, 1-2, 3-4, and >= 5 year spans. To calculate the average duration we assume >= 5 years corresponds to six years and take a weighted average given by where the corresponding proportion is . The values for the proportions are taken from the 2002 Baseline Survey Report (Table 14, page 47 [2]). For 2009, the average number of years of selling sex is directly measured by the IBBS 2009 SSW Questionnaire, Q203 [28].

*For 2002, the average between An Giang and Dien Bien is taken for all other provinces.

For 2005, the average duration of selling sex in SSWs is as reported in the 2005-2006 IBBS (Table 18, page 54 [3]).

†The 2005 and 2009 values used for Dien Bien are taken to be the average across all other provinces.

The uncertainty range for both 2002 and 2005 data given is assumed to be ± 25% of the given value.

2002 Baseline Survey Report (Table 14, page 47 [2])				
Duration of selling sex (years)	**An Giang**		**Dien Bien**	
d	Proportion (p_x)	$d*p_x$	Proportion (p_x)	$d*p_x$
<1 = 0.5	0.09	0.05	0.019	0.0
1-2 = 1.5	0.433	0.6	0.611	0.9
3-4 = 3.5	0.206	0.7	0.259	0.9
≥5 = 6	0.271	1.6	0.111	0.7
Weighted average		3.0		2.5

s4: The average number of one-time clients per year for SSWs is calculated from the 2000 BSS (Table 11, page 24 [1]), 2002 Baseline Survey report

(Table 16, page 50 [2]), data obtained from the Vietnam Data Triangulation Team, and from the 2005-2006 IBBS (Table 19, page 55 [3]). It is assumed that SSWs engaged in sex work about 40 weeks each year and inactive during the remaining 12 weeks. This assumption is based on a discussion between the NCHECR/UNSW modeling team and the Vietnam team during their first meeting in Vietnam in October 2009. Casual clients are assumed to be one-time clients.

In the 2000 BSS [1] and 2002 Baseline Survey Report [2], there is no report for the "number of clients in the past month" which has been used for the calculation of annual estimate in other provinces. Thus the number of partners per week (n) was multiplied by the assumed weeks engaged in sex work (w) (equal to 40) to get the yearly estimate. For 2009, the monthly number of one-time clients of SSW is given by IBBS 2009, SSW Questionnaire Q403.1 [28], this number is multiplied by 12 to give the estimated number of one-time clients of SSW per year.

*2000 data for An Giang and Dien Bien is not available. Thus, the average across other provinces is taken.

For 2002 and 2005, the number of partners per month (n) is multiplied by an assumed number of months engaged in sex work per year (m) (equal to 9.23) to obtain the annual estimate.

†2002 data for Dien Bien is not available. Thus, the average across other provinces is taken.

‡Similarly, 2005 and 2009 values used for Dien Bien are obtained from the average of all other provinces.

An uncertainty range of ± 25% of the given value is assumed.

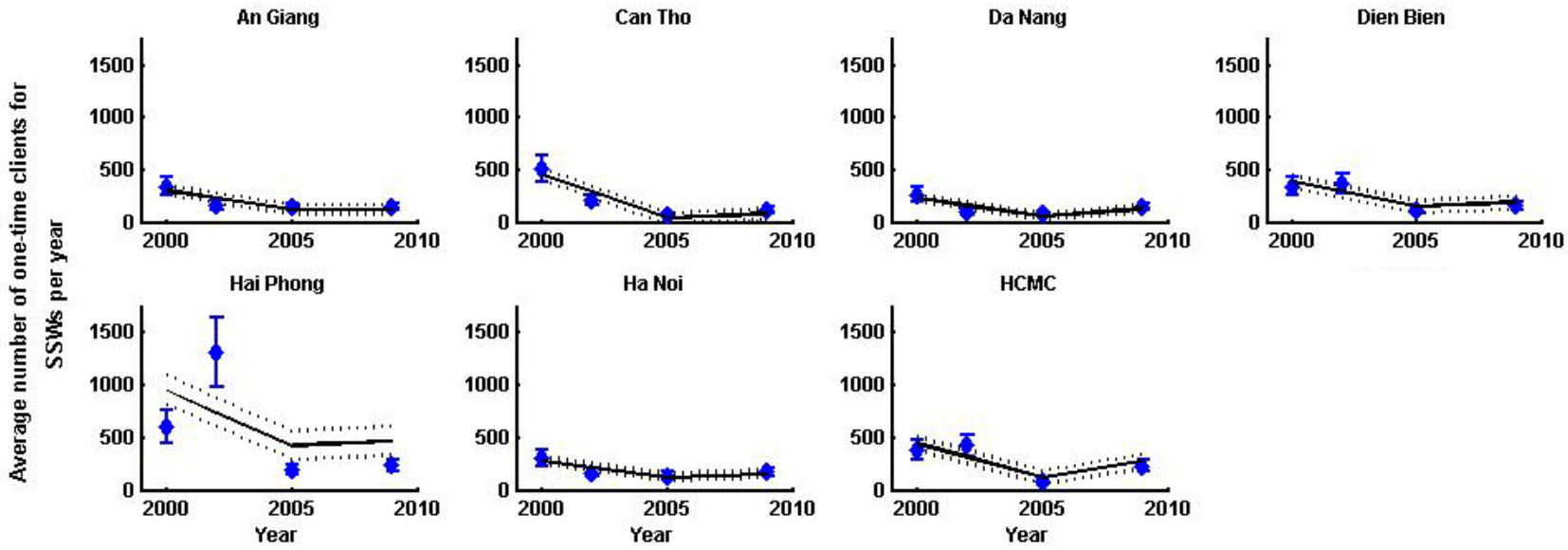
2000 BSS (Table 11, page 24 [1]) – average number of one-time clients per year

Assumed weeks engaged in sex work	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
w	n	n*w	n	n*w	n	n*w	n	n*w	n	n*w
40	12.9	516	6.7	268	15.1	604	7.7	308	9.5	380

2002 Baseline Survey report (Table 16, page 50 [2]) – average number of one-time clients per year				
Assumed weeks engaged in sex work	**An Giang**		**Dien Bien**	
w	n	n*w	n	n*w
40	4.2	168	3.1	124

2002 Vietnam Data Triangulation Team – average number of one-time clients per year										
Assumed weeks engaged in sex work	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*w	n	n*w	n	n*w	n	n*w	n	n*w
40	23.02	921	11.13	445	142.8	5712	18.2	728	46.02	1841

2005-2006 IBBS (Table 19, page 55 [3]) – average number of one-time clients per year												
Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23	16.17	149	16.39	151	9.01	83	21.17	195	15.26	141	8.82	81



s5: The number of regular clients per year for SSWs is calculated from the 2000 BSS (Table 11, page 24 [1]), 2002 Baseline Survey report (Table 16, page 50 [2]), data obtained from the Vietnam Data Triangulation Team and from the 2005-2006 IBBS (Table 19, page 55 [3]). It is assumed that SSWs engaged in sex work about 40 weeks each year and inactive during the remaining 12 weeks. This assumption is based on a discussion between the NCHECR/UNSW modeling team and the Vietnam team during their first meeting in Vietnam in October 2009. Casual clients are assumed to be one-time clients.

In the 2000 BSS [1] and 2002 Baseline Survey Report [2], there is no report for the "number of clients in the past month" which has been used for the calculation of annual estimate in other provinces. Thus the number of partners per week (n) was multiplied by the assumed weeks engaged in sex work (w) (equal to 40) to get the yearly estimate. For 2009, the monthly number of regular clients of SSW is measured by IBBS 2009, SSW Questionnaire Q403.2 [28], this number is multiplied by 12 to provide an estimated number of regular clients of SSW per year and to be consistent with the estimates in previous years.

*2000 data for An Giang and Dien Bien is not available. Thus, the average across other provinces is taken.

For 2002 and 2005, the number of partners per month (n) is multiplied by assumed months engaged in sex work (m) (equal to 9.23) to obtain the annual estimate.

†2002 data for Dien Bien is not available. Thus, the average across other provinces is taken.

‡Similarly, 2005 values used for Dien Bien are obtained from the average of all other provinces.

An uncertainty range of ± 25% of the given value is assumed.

2000 BSS (Table 11, page 24 [1]) – average number of regular clients per year

Assumed weeks engaged in sex work	**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
w	n	n*w	n	n*w	n	n*w	n	n*w	n	n*w
40	2.2	88	1.6	64	2.1	84	2.1	84	5.8	232

2002 Baseline Survey report (Table 16, page 50 [2]) – average number of regular clients per year

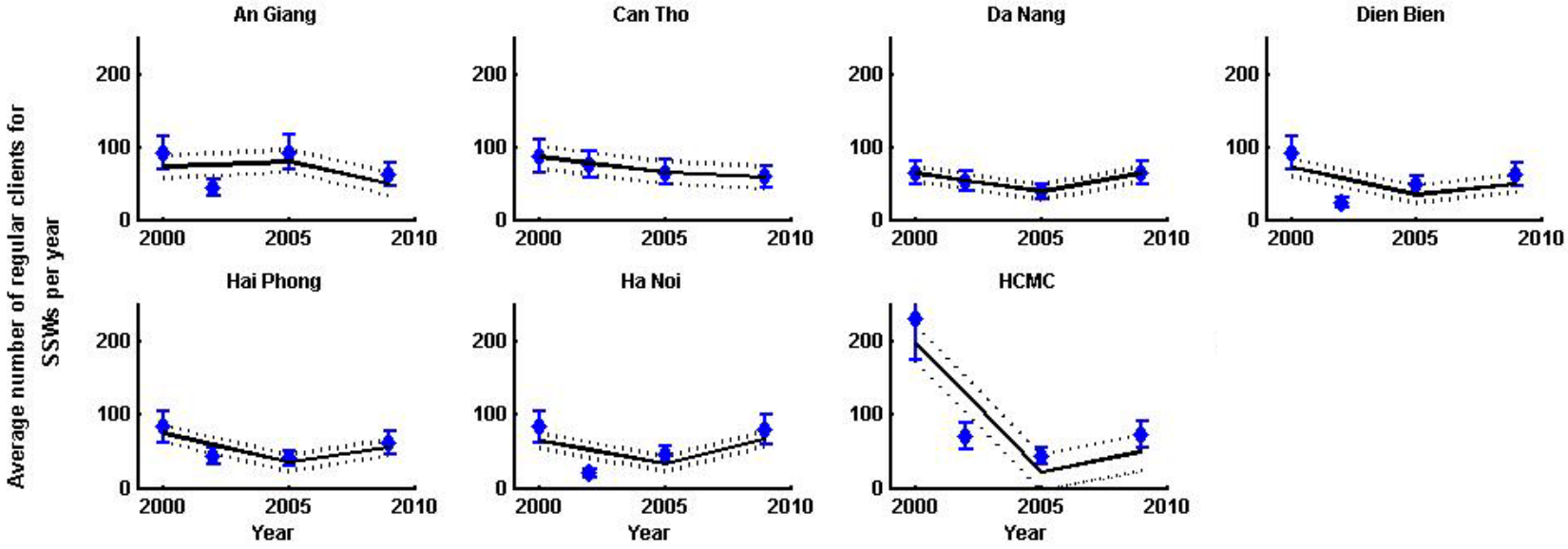
Assumed weeks engaged in sex work	**An Giang**		**Dien Bien**	
w	n	n*w	n	n*w
40	1.8	72	0.6	24

2002 Vietnam Data Triangulation Team – average number of regular clients per year

Assumed weeks engaged in sex work	**Can Tho**	**Da Nang**	**Hai Phong**	**Ha Noi**	**HCMC**

m	n	n*w	n	n*w	n	n*w	n	n*w	n	n*w
40	8.24	76	5.86	54	4.89	45	2.3	21	7.82	72

2005-2006 IBBS (Table 19, page 55 [3]) – average number of regular clients per year												
Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23	10.04	93	7.17	66	4.19	39	4.45	41	4.94	46	4.89	45



s6: The average number of non-commercial casual sexual partners per year for 2002 and 2005 is based on the average number of non-commercial sex partners in the past month reported in the Vietnam Data Triangulation Team and in the 2005-2006 IBBS (Table 19, page 55 [3]). As in s4 & s5 it is assumed that SSWs engaged in sex work about 40 weeks (~9 months) each year and are inactive during the remaining 12 weeks. Thus the number of non-commercial casual sexual partners per month (n) is multiplied by assumed months they are engaged in sex work (m) (equal to 9.23) to obtain the annual estimates below. There is no available data for An Giang and Dien Bien in 2002. Thus, an average (2.7) across other provinces is taken for these provinces. The 2000 data for Hai Phong gives the mean number of non-commercial sex partners in the past month as 4.89 which seems too high and is exactly the same as the mean number of regular clients in the past month. We assume that this could be an input error and have used the average value across other provinces of 2.7 instead. For 2005, the average across the other 7 provinces (equal to 5.2) is used for Dien Bien. There are no available data for 2000 for any province. The uncertainty range is assumed to be ± 25% of the given value.

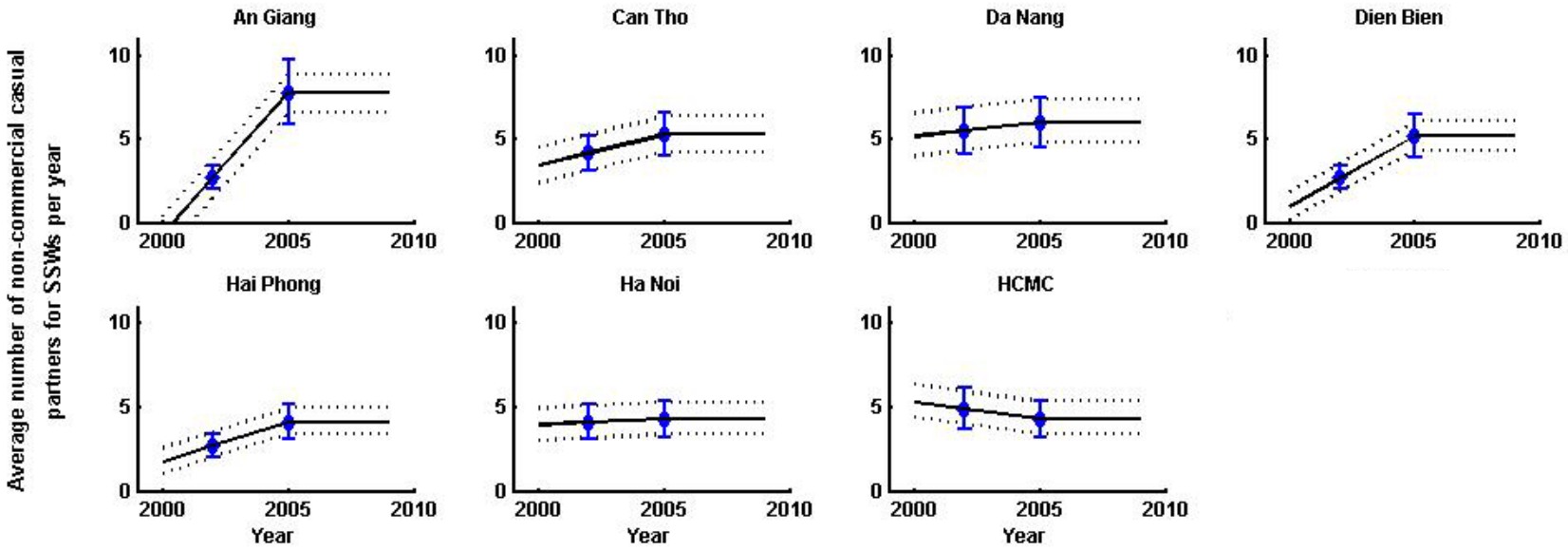
2002 Vietnam Data Triangulation Team – average number of non-commercial casual sexual partners per year

Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m
9.23			0.45	4.2	0.59	5.5			0.44	4.1	0.53	4.9

2005-2006 IBBS (Table 19, page 55 [3]) – average number of non-commercial casual sexual partners per year

Assumed months engaged in sex work	**An Giang**		**Can Tho**		**Da Nang**		**Hai Phong**		**Ha Noi**		**HCMC**	
m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m	n	n*m

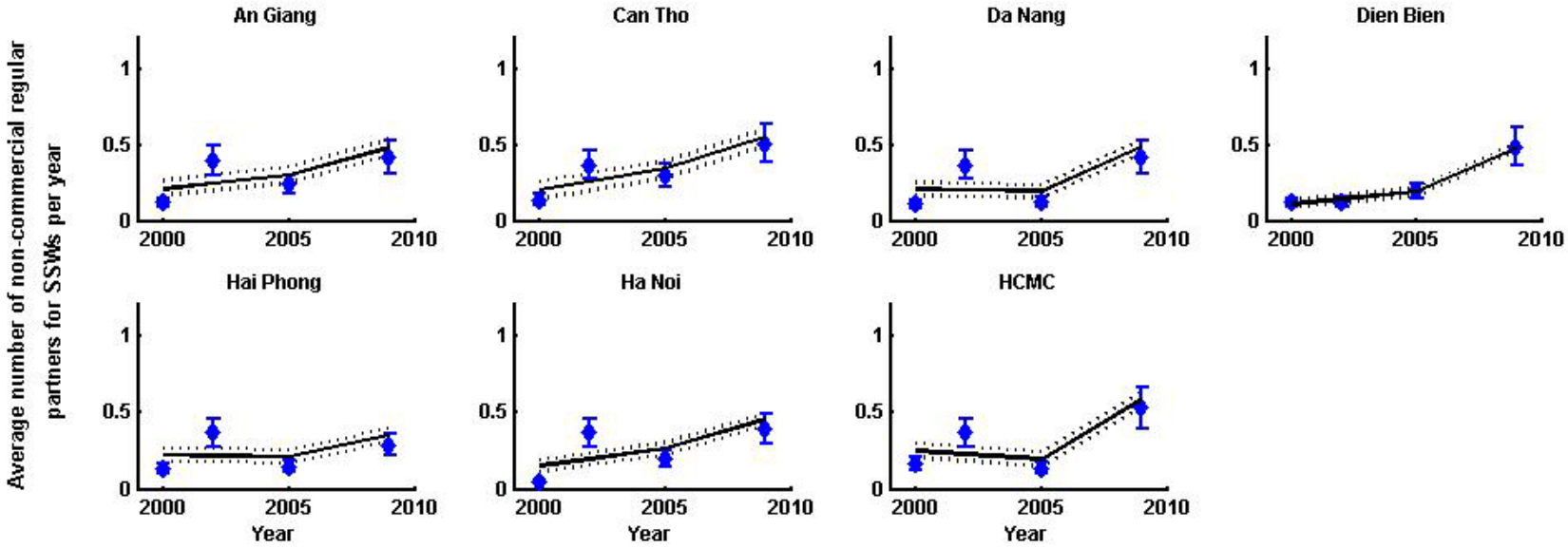
9.23	0.85	7.85	0.57	5.26	0.65	6.5	0.4	3.69	0.47	4.34	0.47	4.34



s7: The average number of non-commercial regular sexual partners per year for all provinces is based on the proportion of SSWs who reported they were currently married in the 2000 BSS report (Table 4, page 15 [1]), 2002 Baseline Survey Report (Table 14, page 47 [2]) and 2005-2006 IBBS (Table 18, page 54 [3]),with an assumed range of ± 25% of the given value to account for uncertainty in the data. For 2009, monthly number of regular male partners (boyfriends/husband) of SSW is given by IBBS 2009, SSW Questionnaire Q403.3 [28], this number is assumed to be identical to the number of regular male partners of SSW per year.

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

†For 2002, a weighted average between An Giang and Dien Bien is taken for all other provinces. For 2005 and 2009 the data for Dien Bien is taken from an average across all other provinces.



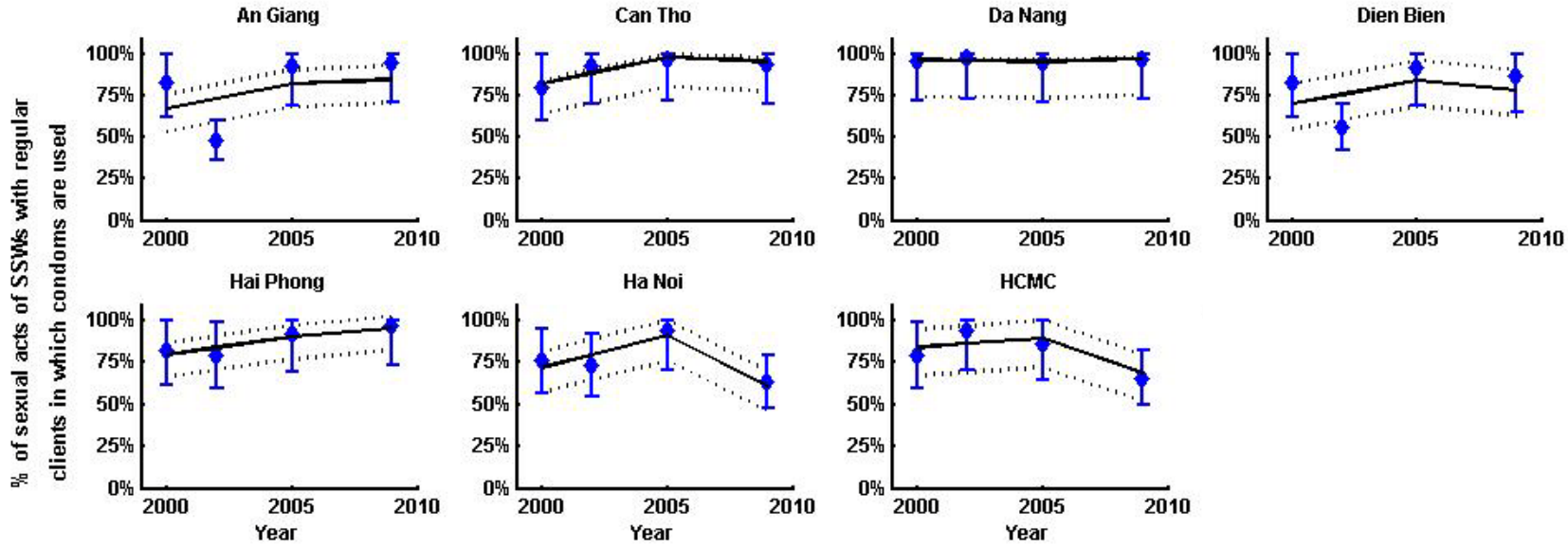
s8: As with KSWs, the assumed average number of sexual acts per regular client per year is 12 corresponding to one visit per month. The number of times a regular client visits a sex worker is highly uncertain as there are no available data. To take this high uncertainty into account we assume a range from 6-24 representing a visit frequency of 2 months to once every two weeks on average.

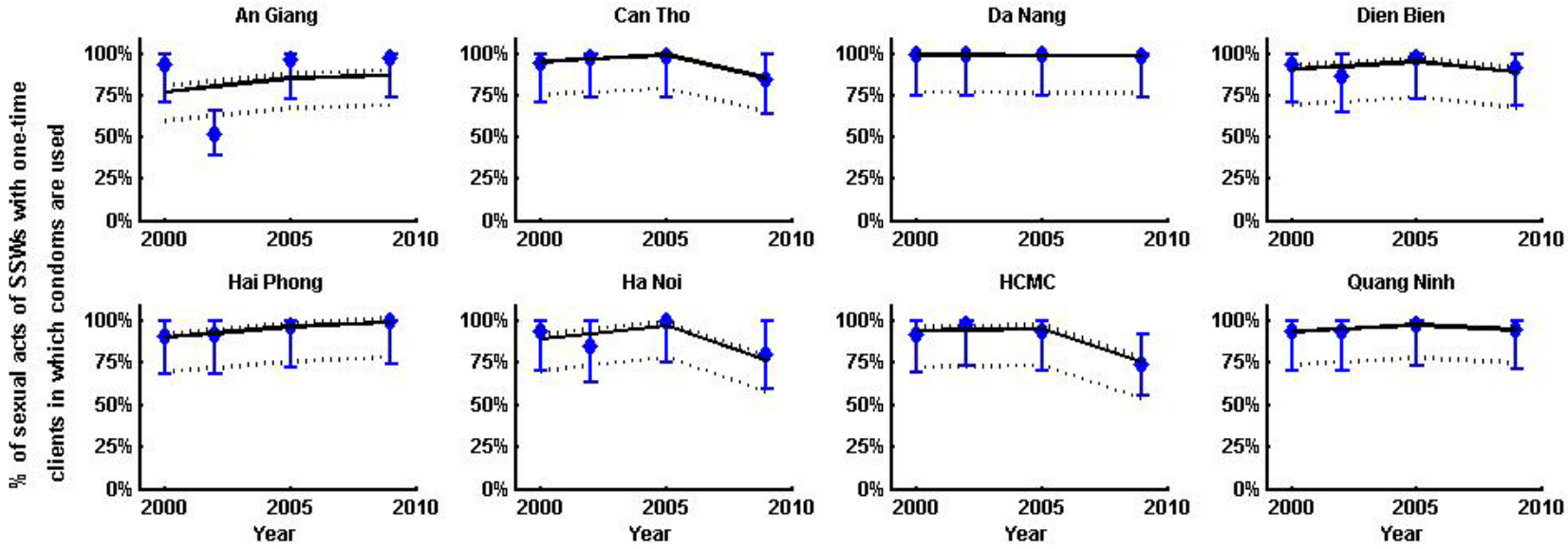
s9: The average number of sexual acts per regular partner per year for the general male and female populations is taken to be 87, as reported in the Global Sex Survey 2005 [26]. This value has an assumed uncertainty range of + 25%. For 2009, the monthly number of regular male partners (boyfriends/husband) of SSW is taken from data collected by IBBS 2009, SSW Questionnaire Q403.3 [28]; this number is assumed to be identical to the number of regular male partners of SSW per year.

s10 & s11: The proportions of condom use per act with one-time/casual clients and regular clients during last sex (or most recent sex) among SSWs are taken from the 2000 BSS report (Figure 4, page 27 [1]), 2002 Baseline Survey Report (Table 6, page 22 and Table 17, page 50 [2]), a table of behavioral surveillance data provided by the Vietnamese Data Triangulation Team, and 2005-2006 IBBS (Table 20, page 56 [3]). The reported condom use with both one-time/casual clients and regular clients during last sex was high, which may have affected due to social desirability bias. For 2009, the percentage of acts in which condoms are used between SSWs and one-time clients or regular clients is based on data of condom use at the last sexual act (IBBS 2009, SSW Questionnaire Q504 [28]).

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

† For 2005 and 2009, the values used for Dien Bien are taken from an average across all other provinces. The uncertainty ranges for these parameters are assumed to be ± 25% of the given value.

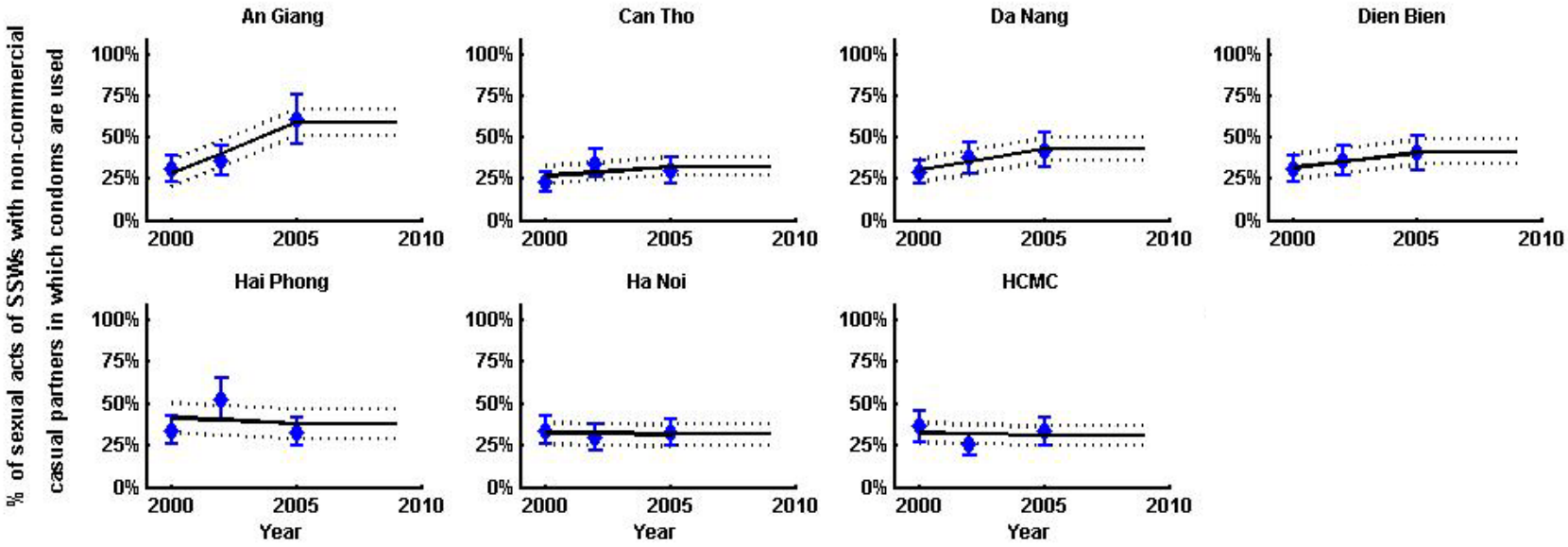




s12: For 2000, the probability of condom use per act with non-commercial casual partners during last sex among SSWs is based on condom use at last sex with non-paying partner reported in 2000 BSS (Figure 4, page 27 [1]). The data for 2002 is derived from a table of behavioral surveillance data provided by the Vietnamese Data Triangulation Team. For 2005, this data is based on condom use with non-commercial sex partner during last sex among SSWs reported in the 2005-2006 IBBS (Table 20, page 56 [3]).

*For 2000, the values used for An Giang and Dien Bien are taken from an average across all other provinces.

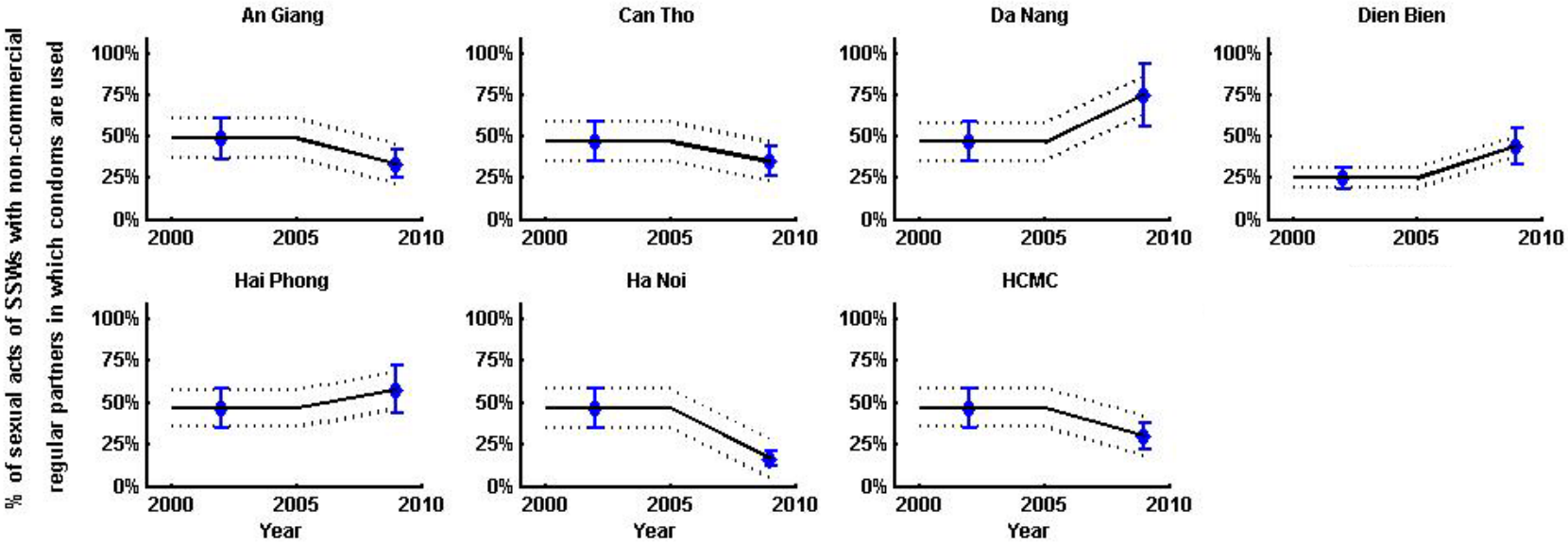
†For 2002, the values used for An Giang are taken from an average across all other provinces. For 2005, the values used for Dien Bien are taken from an average across all other provinces. The uncertainty range for these values is assumed to be ± 25% of the given value.



s13: The percentage of acts in which condoms are used between SSWs and non-commercial regular partners is based on condom use at most recent sex with husband/boyfriends; this is reported for An Giang and Dien Bien (Lai Chau) in the 2002 Baseline Survey Report (Table 6, page 22 and Table 17, page 50 [2]). There are no available data for 2000 and 2005 and in other provinces. A weighted average (47%) between An Giang and Dien Bien has been taken for all other provinces for 2002, where n= sample size and p=proportion condom use in most recent sex with husband/boyfriends among SSWs. For 2009, the percentage of acts in which condoms are used between SSWs and regular male partners (boyfriend/husband) is taken as the values reported on condom use at the last sexual act (IBBS 2009, SSW Questionnaire Q702 [28]). Dien Bien values used in 2009 are estimated as the average across other provinces. The uncertainty range for these values is assumed to be ± 25% of the given value.

2002 Baseline Survey Report (Table 6, page 22 and Table 17, page 50 [2])

Condom use in most recent sex with husband/boyfriends	n	Proportion (p)	n*p
An Giang	383	0.486	186.1
Dien Bien	37	0.25	9.3
Total	420		195.4
Weighted average - total n*p / total n			0.47



s14: For 2005, the reported value is based on ever injected drugs in the 2005-2006 IBBS (Table 22 page 57 [3]). The number for 2002 is based on the percentage of commercial sex workers who have ever injected drugs in the 2002 Baseline Survey Report (Table 15, page 48 [2]). The percentage of SSWs who injects drugs for 2000 is based on injecting drugs in the past six months reported in the 2000 BSS (Table 10, page 23 [1]),

and is available for only Ha Noi and HCMC.

*An average (18.6%) between these two provinces has been used for other provinces.

For 2002, this data is based on ever injected drugs reported in the 2002 Baseline Survey Report (Table 15, page 48 [2]).

For 2005, the data is based on SSWs who reported ever injected drugs in the 2005-2006 IBBS (Table 30, page 63 [3]).

‡The 2005 data for Dien Bien is an average of all other provinces, which is 10.9%.

The uncertainty ranges for these values are assumed to be ± 25% of the given value.

s15: There are no data available on the percentage of SSWs who receive a test for HIV every year. However, there are data on the percentage of SSWs who have ever voluntarily tested for HIV in the 2005-2006 IBBS report (Table 23, page 58 [3]). We use this value as an upper bound on the proportion tested each year. It is assumed that SSWs are more likely to be tested than the general population due to their at risk behavior. Thus the testing rate for the general population is used as a lower bound.

* For Dien Bien the upper bound for the uncertainty range is assumed to be 25%.

hr1: Intervention data for the total number of condoms distributed and total number of syringes distributed in each province were collated as the sum over multiple sites hosted by the World Bank, US CDC and Family Health International. Available data cover the years 2006-2009.

Table of province-independent parameters used in the VHM

References	Values	Parameter description
Biological transmission parameters		
[30-34]	0.0002-0.015	Transmission probability per unprotected act of receptive penile-vaginal sex (male-to-female)
[30-34]	Min: 0.0002 Max: M-to-F level	Transmission probability per unprotected act of insertive penile-vaginal sex (female-to-male)
[35]	0.001-0.015	Average transmission probability per unprotected act of penile-anal sex (male-to-male)
[36-43]	0.004 - 0.009	Transmission probability per injection with a contaminated syringe
[44-48]	85-95%	Efficacy of condoms in preventing HIV transmission
[49-50]	70-80%	Efficacy of syringe cleaning in preventing HIV transmission
HIV disease progression and clinical parameters		
[51]	8-14 years	Average time for disease to progress through chronic stage to late/AIDS stage disease in the absence of antiretroviral therapy
[52]	3-6% per year	Rate of treatment failure for those on antiretroviral therapy
Experimental variable	2-2.8% per year	Background rate of leaving sexually mixing population
[53-57]	1-2% per year	Death rate for untreated people in chronic stage of HIV infection
[58-60]	30-75% per year	Death rate for untreated people in late/AIDS stage of HIV infection
[60]	1-10% per year	Death rate for people on antiretroviral therapy
Other parameters		
[61-62]	2	Average number of people who share injecting equipment per sharing event
Experimental variable	0.5-2.5%	Average proportion of distributed units of injecting equipment that are not used (i.e. wasted)

The Global HIV/AIDS Program

The World Bank

THE UNIVERSITY OF NEW SOUTH WALES