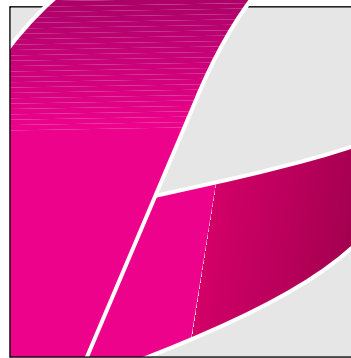
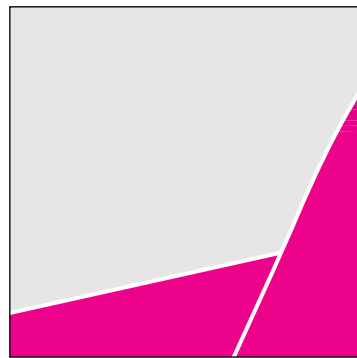


# Trends in HIV incidence and prevalence:

*natural course of the epidemic or results of behavioural change?*



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# Trends in HIV incidence and prevalence:

*natural course of the  
epidemic or results of  
behavioural change?*

UNAIDS *in collaboration with*  
Wellcome Trust Centre  
for the Epidemiology  
of Infectious Disease



Joint United Nations Programme on HIV/AIDS  
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# 1. Introduction

## The current state of the HIV epidemic

Both donor agencies funding HIV control programmes, and government agencies trying to bring about changes need to know whether their efforts are having an impact.

It is important to understand changes in the incidence and prevalence of HIV in order to plan for the scale of future problems and to evaluate the effectiveness of current national strategies to limit the spread of infection. To make confident statements about the course of HIV we require confidence in both the quality of data on the levels of infection and in our ability to interpret changes in prevalence and incidence.

Recently in detailed analysis of some of the most reliable HIV surveillance data in developing countries, declines in the prevalence of HIV in young people have been observed. The decline has been observed amongst young men and women in Uganda and in 21-year-old male conscripts in Thailand, suggesting some success in stemming the spread of HIV. However, this success is not mirrored in data from surrounding countries. The dynamics of an epidemic mean that a reduction in the prevalence or incidence of infection is not necessarily a consequence of reduced risk amongst a population. When reductions in the

prevalence/incidence of HIV are observed at the population level a number of questions arise:

- 1• Are the observed changes valid in a statistical sense?
- 2• Are the observed changes a reflection of the natural progression of the epidemic?
- 3• Are the observed changes a product of changes in behaviour?
- 4• Are the observed changes a product of interventions?

The prevalence of HIV in a particular population will not grow indefinitely, it will saturate at some level. Following the initial spread of HIV there is likely to be a fall in the incidence of infection followed in turn by a resultant reduction in prevalence. A fall in incidence is likely to precede the fall in prevalence as the time scale over which the epidemic saturates is likely to be more rapid than the time scale on which HIV associated mortality increases.

UNAIDS and the Wellcome Trust Centre for the Epidemiology of Infectious Disease organized a workshop to explore the validity and interpretation of observed trends in HIV prevalence and incidence; to develop a better understanding of observed epidemiological patterns; and to generate guidelines for evaluating changes in HIV.

## Objectives

- *To review current evidence for declining HIV prevalence and incidence in selected sites and to explore the reason for the decrease in particular the role of behavioural change.*
- *To agree on principles for surveillance methods for evaluating changes in HIV prevalence.*
- *To agree on a research agenda to develop methods and collect data required to interpret changes in HIV prevalence/incidence.*

# Background

## Monitoring the course of HIV epidemics

In developing HIV surveillance activity there is a trade-off between the need for a rapid, broad assessment of HIV's spread and a more detailed understanding of epidemiological pattern. A series of quick cross sectional studies stratified by age and sex would provide information on the scale of HIV spread. Many such studies have been collated in the US Bureau of the Census Database, and a few are longitudinal data sets, but very few are genuine cohort studies (US Bureau of the Census, 1997).

Falls in HIV prevalence have been observed in some of the best constructed studies of prevalence and incidence. The longitudinal community based studies in rural Uganda, which are intensive scientific studies, have observed a decline in prevalence (Mulder et al., 1995; Wawer et al., 1997). One problem with this is that the very studies themselves are likely to have altered the course of the epidemic. However, declines have also been observed in recruits to the Thai army, where conscription by lot at the age of 21 years means that the study of HIV prevalence in young men comes from a large more or less random sample (Nelson et al., 1996).

More generally, a number of practical problems inhibit understanding of the extent of HIV spread globally and changes in the incidence and prevalence of infection. The major problem is the lack of representativeness of samples used to monitor the epidemic, which can arise for a number of reasons:

**Sampling biases.** The majority of studies of HIV prevalence are based on convenience samples. Hospital patients, STD

clinic patients, drug users, prisoners, soldiers and sex workers all include many with unusually high risks of having acquired HIV infection. While they indicate whether the virus has entered a community and the level of infection in the specific group they are little use in determining the extent of the problem through-out national populations. They can though provide insights into the changing pattern of incidence within the groups they represent and indicate whether behaviour of those with "high risks" is altering.

Blood donors and pregnant women are also often used as sentinel surveillance groups as they are more likely to represent the "general" population. However, blood donors are often pre-screened for risks of HIV infection; this means that they tend to underestimate the prevalence of infection. The situation is complex in the case of pregnant women who are believed to represent most closely the general population. They are in the age classes where HIV is likely to be most common and must have recently been sexually active. However, it may be wrong to assume that they overestimate HIV prevalence. In Mwanza, Tanzania, a comparison of infection in a random sample of women with a sample of women attending antenatal clinics found the prevalence of infection to be higher in the random sample (Kigadye et al., 1993). A high risk of HIV infection is associated with a low risk of pregnancy for at least two reasons. First, other bacterial STDs, which are more common in those with high risks of HIV infection, cause tubal occlusion and hence infertility (Brunham et al., 1992). Second, the pathology asso-

ciated with HIV may include a reduction in fertility, either through spontaneous abortion or other less well-defined means. These factors cast some doubt on the validity of antenatal clinics as sentinel sites for HIV surveillance.

**Sample size and reliability of diagnostic tests.** Data from reviewed scientific publications are not available for many localities. In their absence, small studies, often with no diagnostic test details being reported, are relied upon to indicate the course of the HIV epidemic. Small sample size is an important problem for two main reasons. First, in a situation of low HIV prevalence larger samples are required to detect accurately the small fraction of the population infected. Secondly, in situations where HIV is more prevalent small changes in the prevalence of infection can only be detected with any confidence by larger samples.

**National representativeness.** For many countries, no data on the prevalence of HIV are published, for many others studies are patchily distributed. There is a tendency for prevalence to be monitored in large urban centres. Often such centres comprise a minority of a nation's population. The true extent of HIV could only be estimated with a diverse set of urban and rural samples. There is no reason to believe that the relationship between urban and rural prevalences will be in any way fixed between places and between times, so

extrapolation from urban prevalence to rural prevalence and thence to national prevalence should be handled with extreme care.

Despite the problems above global HIV surveillance has, because of ethical, financial and logistic constraints, had to concentrate on sentinel surveillance of convenience samples. As well as the cost involved in recruiting random representative samples, there is the problem of persuading study participants to undergo an invasive specimen collection procedure. The development of new technology for saliva based sampling of antibodies may have generated a more favourable climate for the use of more representative community based samples. However, the problems of cost in contacting a population-based sample and the ethical and practical problems associated with testing, counselling and care remain.

To understand changes in incidence and prevalence within a population many of the detailed stratifications, by age, sex, education, socio-economic status and geography can help identify particular patterns of change within population subgroups that may be masked by reliance upon a general sample of the population (Batter et al., 1994). The stratification into such groups makes studies more difficult as samples need to be large enough to permit accurate detection of changes in particular subgroups.

## Observed changes in HIV prevalence/incidence

Declines in the prevalence of HIV have been observed in young people in two of the best monitored populations—in Uganda and Thailand.

Changes in the observed prevalence of infection could simply be the product of changing sampling biases. For

example, increased levels of infertility in HIV-infected women as the epidemic ages could increase the bias towards HIV-negative women in antenatal samples. However, if declining prevalences are really occurring within the population there are alternative explanations.

Two general explanations could explain a fall in prevalence. The first is that interventions have reduced the level of risk factors in the population and thence the incidence of new infections. The second is that the expected endemic prevalence is lower than the peak prevalence and that the prevalence is merely falling to this new stable level. The distinction between these is important in evaluating the impact of national AIDS prevention programmes and could only be made with understanding and quantification of the factors controlling the magnitude of the fall in prevalence expected in the absence of successful interventions.

**There are two mechanisms acting on the expected fall:**

- ① Differential AIDS-associated mortality in those with the highest risk of HIV infection and transmission: if there is no compensatory increase in the rate of supply of susceptibles with a high risk, or increase in the risk behaviour of others in the population, then the average level of risk will fall, causing a reduced incidence of infection.
- ② The initial epidemic has a momentum, so that there is a high prevalence of infection before any substantial numbers progress to AIDS. This generates a high risk of infection per susceptible for a given level of risk behaviour. Then as the number of HIV-infected people falls, through mortality, even if the effective reproductive rate remains constant, the risk of infection per susceptible with a given behaviour also falls.

The scale of the expected decline in HIV prevalence in the absence of deliberate preventative action will be determined by:

- The distribution of risks in the population (i.e. where we expect the prevalence to saturate).
- The speed with which infection spreads, which will determine how concentrated the duration of high prevalence is.
- How concentrated the period of infectiousness is within an individual, i.e. if people are only infectious for a short duration, or they move rapidly from high- to low risk-behaviour (as a function of age or time), then the epidemic is likely to have a more accentuated short-term peak followed by a lower steady state prevalence.
- The pattern of spread through different risk groups—that is, how many geographically/socially distinct HIV epidemics there are in a population and how synchronized these epidemics are.
- How behaviour changes in response to those with higher risks dying. Is there an increase or decrease in the proportion of the population entering into higher risk behaviours (e.g. to match supply of drugs or demand for commercial sex)? Is there a change in the age distribution of entry into high risk behaviours?
- Does the mortality of those with high risk decrease the prevalence of other STDs and thereby decrease HIV transmission probabilities?

Further to the question of what changes are likely to occur in the natural course of the epidemic or in the risk behaviours in the population is the issue of whether changing behaviours can be attributed to intervention programmes. For example, if in response to the experience of deaths within the community the rate of susceptibles acquiring high risk behaviours decreases, or those with high risks take action to



change them, can this be seen as a product of intervention/ education?

Teasing apart the underlying epidemic pattern from the impact of control on the basis of changes in HIV incidence/prevalence requires supplementary information and careful analysis. What do we need to measure to understand the epidemiological processes and how might we approach this measurement?

This report is divided into sections reflecting the input and outcome of the

workshop. First data and opinions presented at the outset to inform deliberations are summarized. The workshop considered three main areas in reviewing the impact of interventions. First the monitoring of infection, second the monitoring of risk behaviour, and third the evaluation of interventions and national policy. This report considered each in turn. In the final section of the report the conclusions and recommendations of the workshop are presented.

## 2. The transmission dynamics of HIV-1: empirical and theoretical considerations

### The incidence and prevalence of infection

In an endemic steady state the prevalence of infection is simply the product of incidence and the mean duration of the infection. However, in an epidemic situation the relationship between prevalence and incidence varies as the epidemic ages. The relationship between, incidence, prevalence and mortality is illustrated in Figure 1 where the flows in and out of the HIV-infected population are shown schematically. The rate of spread of HIV depends upon the basic reproductive number ( $R_0$ ), the number of new infections caused by one infectious individual in an entirely susceptible population. The reproductive number at time  $t$  ( $R_t$ ) then alters as illustrated, as the epidemic progresses. Initially the incidence and prevalence of infection are likely to grow exponentially in the population at risk. As the epidemic

grows the proportion of contacts of those infectious who have already been infected will grow. This reduces the reproductive rate of the infection slowing the growth of incidence. Eventually incidence will decline, while prevalence continues to grow. It is only when recovery or, in the case of HIV, mortality of those infected increases that prevalence decreases or levels off. If the mortality rate of those infected is greater than the incidence of new infection then prevalence will decline until the two balance and prevalence remains constant. This pattern is excellently portrayed in data from a study of injecting drug users in Thailand (Fig. 2, Kitayaporn et al., 1994)

There are a number of methods for estimating incidence, each with advan-

tages and disadvantages. In considering incidence it is important to make clear whether it is measured per individual in the population or per susceptible individual in the population. Cohort studies are efficient and focus on a well defined population. However, there are problems related to loss to follow up, the impact of being in a cohort (Hawthorne effect) and probably most importantly the complication and cost of maintaining a cohort study. Cross-sectional seroprevalence studies can only provide an estimate of incidence through time if there is no change in incidence with age

(or vice versa). Serial cross-sectional seroprevalence studies are common but ignore mortality and migration as well as changing sampling biases, and require large overall sample sizes. A further method of estimating incidence is to measure prevalence and to use a marker of recent infection (Brookmeyer and Quinn, 1995). The presence of p24 is one such marker but is only valid for a short duration, so necessitating unreasonably large sample sizes. A longer duration marker of recent infection would greatly improve this method.

Figure 1

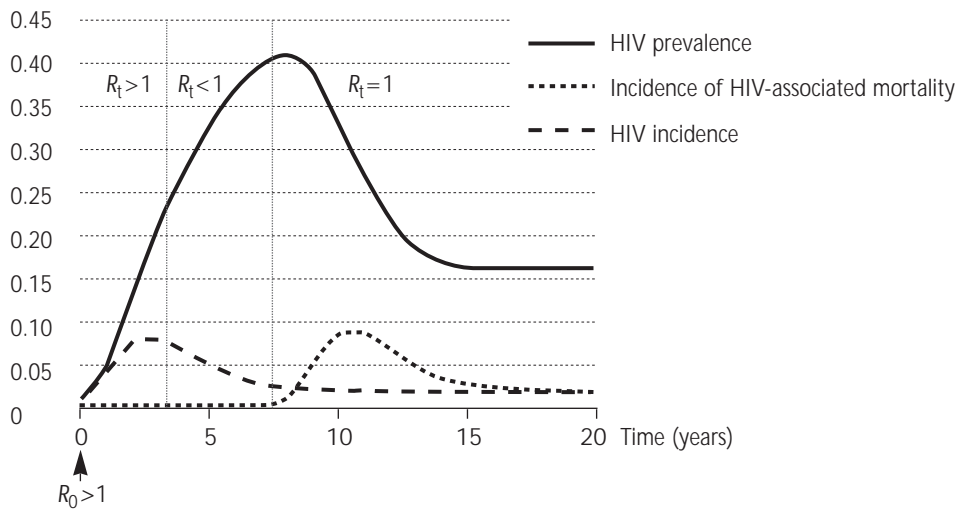
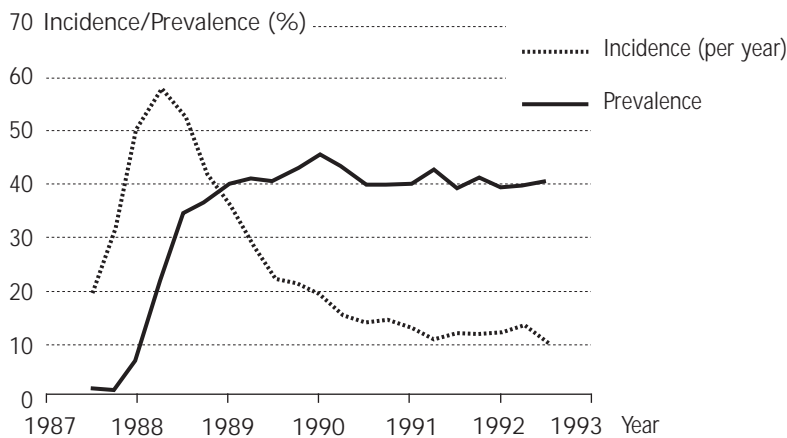


Figure 2



## Empirical studies of biases in antenatal clinic surveillance data

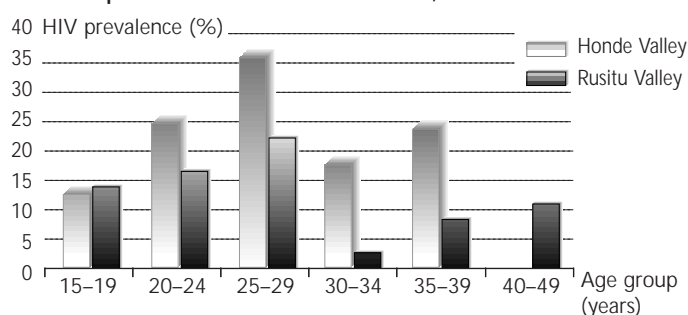
Antenatal clinics provide a context within which anonymous samples can be taken and assessed for HIV infection. The women attending antenatal clinics, may be considered a representative sample of the general population. However, there are a number of potential biases (Boisson et al., 1996), some of which have been explored empirically in several studies.

One such bias is the age difference between women attending antenatal

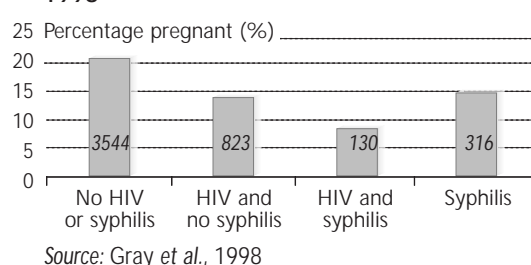
clinics and the rest of the population. It is possible to adjust for this bias if we know the age-specific distribution of HIV infection and the age distribution of the population. For example the prevalence of HIV-1 in women attending antenatal clinics in Zimbabwe was recorded (Gregson et al., 1995 Fig. 3a) and compared with the age distribution of the population derived from household surveys (Fig. 3b). The peak prevalence of HIV infection was in the 20 to 29 year age groups, which were over-represented

**Figure 3**

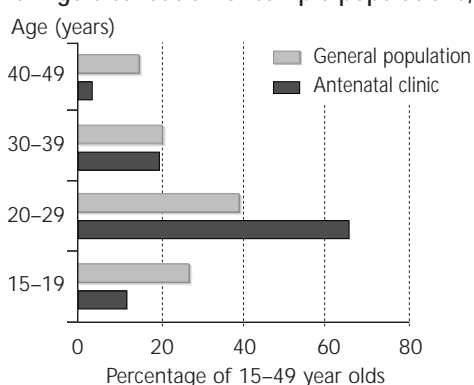
**a. HIV-1 prevalence in rural Zimbabwe, 1994**



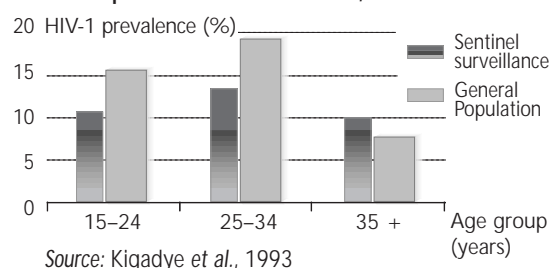
**d. Pregnancy prevalence in rural Rakai, Uganda, 1998**



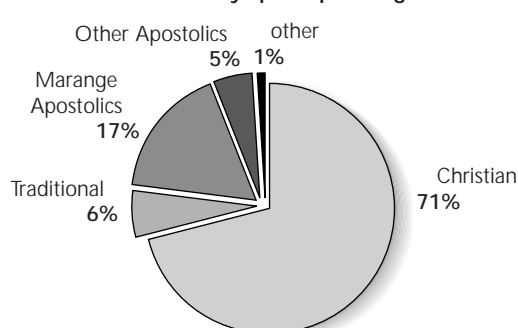
**b. Age distribution of sample populations, Zimbabwe**



**e. HIV-1 prevalence in Mwanza, 1990-1991**



**c. Honde Valley: principal religions**



in the antenatal clinic sample. An additional bias in the use of antenatal clinics was identified in this study. HIV prevalence was higher in the Honde than in the Rusitu valley. However, a substantial fraction (17%) of the population in the former were Marange apostolics (Fig. 3c), a religious group who do not use modern medical facilities (i.e. do not use the antenatal service) and are believed to have a lower risk of HIV infection (Gregson et al., 1995). Thus, there are biases in the uses of antenatal clinics which will be locally specific.

While the age distribution of pregnant women may bias unadjusted HIV prevalences to overestimate the prevalence of HIV infection, there are several reasons why those infected with HIV are less likely to be fertile. Data from a prospective study of pregnancy in women infected with HIV and syphilis and uninfected controls show that infection with either is a risk factor for lower fertility (Gray et al., 1998; Fig. 3d).

This may be a direct result of pathology associated with the infections. However, other bacterial sexually transmitted infections cause tubal occlusion leading to infertility, and have the same behavioural risk factors as HIV and syphilis. The study by Gray and colleagues controlled for the presence of other bacterial infections (gonorrhoea and chlamydia) in the population, but could not control for the history of bacterial infections, which is the variable which would be expected to influence the prevalence of sterility. The different etiologies of reduced fertility are not a mute point. Reduced fertility, whether associated with HIV or other STDs would cause the same bias towards underestimating the prevalence of HIV infection. However, in the former case the infertility caused by other bacterial STDs is likely to be most influential early in the epidemic and then to decline either as HIV

spreads to those with a lower risk of bacterial infection, or as successful HIV interventions reduce the prevalence of other sexually transmitted infections. In the case of HIV-associated infertility, the morbidity associated with infection increases with time from infection. This bias is likely to increase as the HIV epidemic ages. Thus the bias will increase or decrease with time depending upon the cause of infertility.

Studies have been carried out exploring the prevalence of HIV in antenatal clinic populations and random samples of the population. In Mwanza, Tanzania, the prevalence of HIV infection was found to be higher in a random sample of women than in those attending antenatal clinics, the sentinel population (Fig. 3e; Kigadye et al., 1993). Whereas, in Addis Ababa, Ethiopia, the prevalence among 15 to 24 year olds at antenatal clinics was 11.8%, it was 6.4% among a household-based sample of adults where blood was taken to screen for measles, mumps and hepatitis B antibodies (A. Fontanet, personal communication). It may be that the HIV epidemic was at an earlier stage in the Ethiopian population so that HIV-associated morbidity had not yet reduced fertility in those infected. However, the refusal rate was very high in the random sample (60%) which may have biased results. A better method for taking random samples is the use of saliva. In the first study using such samples K. Fylkesnes (personal communication) compared a random sample with antenatal clinic data in Zambia (Fig. 4).

Interestingly the antenatal sample underestimated HIV prevalence, but there was a relationship between age and the bias, with HIV prevalence being overestimated by antenatal data in the younger ages. This is in part because a fraction of younger women will not have reached sexual debut and are neither at

risk of HIV infection or pregnancy. It may also, in part, be due to those in older age groups having been infected for longer

with more chance of HIV associated morbidity having reduced fertility.

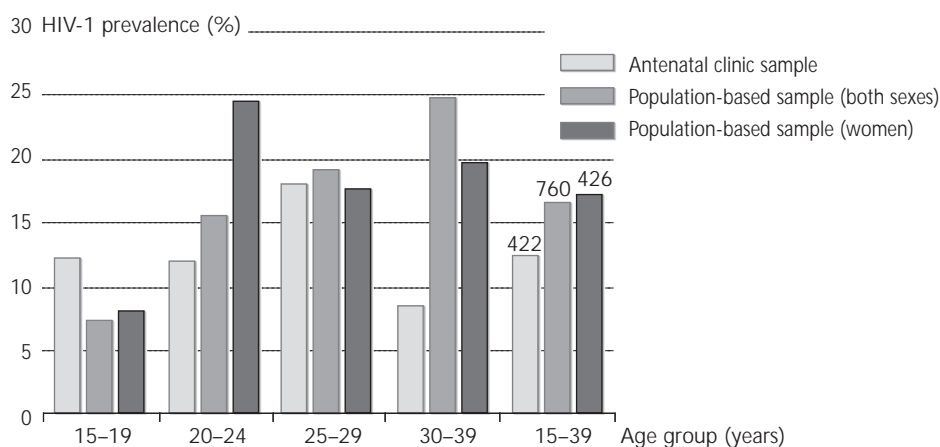
## The HIV epidemic in Uganda

In both rural and urban Uganda studies have detected a reduced prevalence of HIV-1 in men and women between the ages of 15 and 19 years. In roadside trading centres and rural villages of rural Rakai, Uganda prevalence fell from 23.4% to 20.9% between 1990 and 1992. However, detailed analysis of patterns of infection, mortality and migration in the study cohort revealed a steady HIV incidence of 2.1 cases per 100 person years of observation (PYO) in 1990 to 1991 and 2.0 per 100 PYO in 1991 to 1992 (Wawer et al., 1997). Thus changes in the prevalence of infection did not parallel current patterns of incidence.

In the same study site a comparison of fertility in prospective cohorts of HIV-1 infected and uninfected women, described above, demonstrated a significantly lower fertility risk (adjusted relative risk 0.7) in HIV-infected women across all ages. Although no correlation was found with current gonococcal and chlamydial infection their influence on sterility would

come from earlier infections. A more direct influence of HIV, reducing fecundity and increasing spontaneous abortion, could also explain the findings; later stages of infection and more severe disease would be found in older women, while younger women who are sexually active are both more likely to acquire infection and more likely to become pregnant. This latter explanation has serious repercussions for HIV surveillance. HIV prevalence among women attending antenatal clinics will be a biased measure of prevalence amongst all reproductively aged women. Initially this bias would lead to an overestimate of HIV infection because of the associated risks of pregnancy and infection, but as the epidemic aged and HIV-associated disease became more widespread the bias would be towards an underestimate of prevalence. This shifting bias could in part explain observed reductions in HIV prevalence. However, it will be least evident in 15 to 19 year olds who on the whole will not have had time to develop late stage HIV infection.

**Figure 4 – Antenatal versus population-based HIV prevalence rates, Lusaka, Zambia**



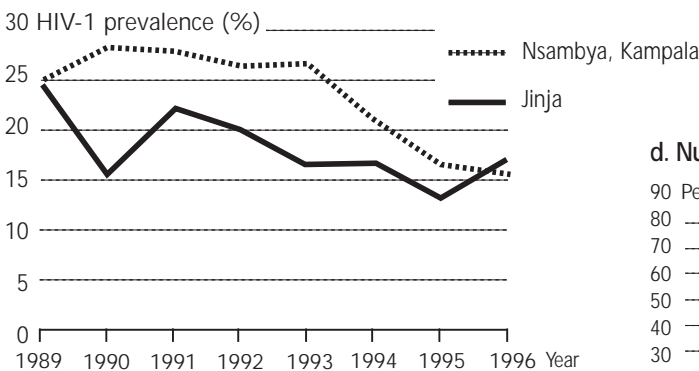
Source: Fylkesnes et al.

In addition to the 15 to 19 year olds suffering a lower level of HIV-related sub-fertility they are also less likely to be influenced by HIV-associated mortality for the same reason, that they are not likely to have been infected for long. Declines in prevalence in this age group are perhaps the best indicator of a decline in HIV incidence. In two studies of sexual behaviour in urban Ugandan populations in 1989 and 1995 an increase averaging 2 years in the age of first sexual intercourse was reported (Asimwe-Okiror et al.,

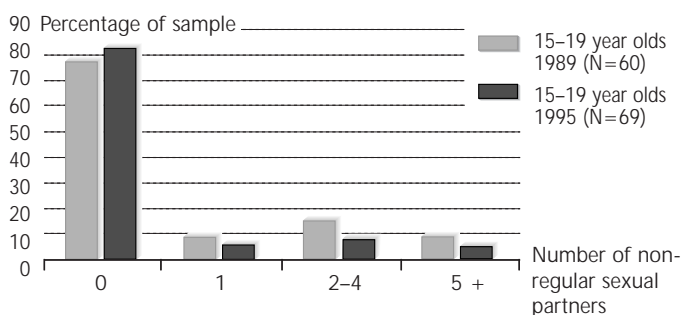
1997). This will have reduced the fertility of this age group as well as reducing HIV risk in the younger women. Thus, the prevalence of HIV infection observed in antenatal clinic attenders should have become more of an overestimate in recent years. The observed declines in HIV-1 prevalence in the 15 to 19 year old women in sentinel surveillance sites are more likely to reflect reduced incidence. These were recorded in urban Uganda in Kampala and Jinja, where the successive behavioural surveys were carried out

**Figure 5**

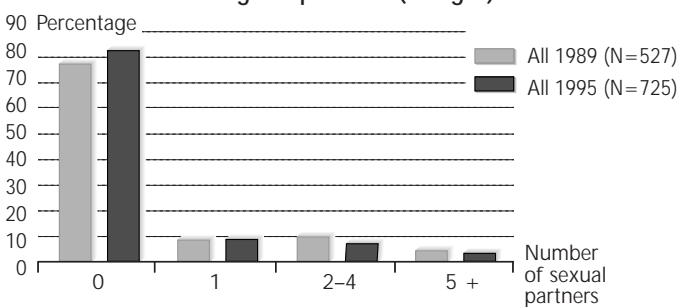
**a. HIV-1 prevalence in Uganda antenatal clinic attendees**



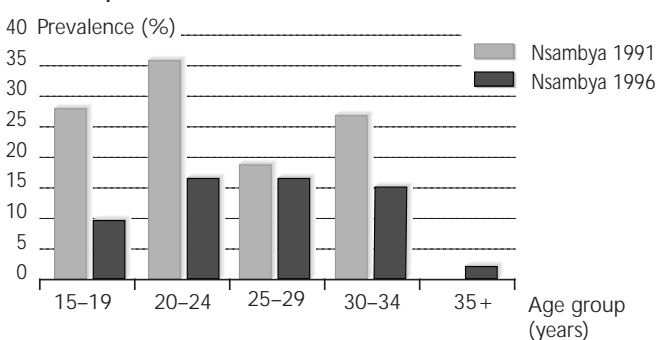
**d. Number of 15 to 19 year olds with non-regular sexual partners**



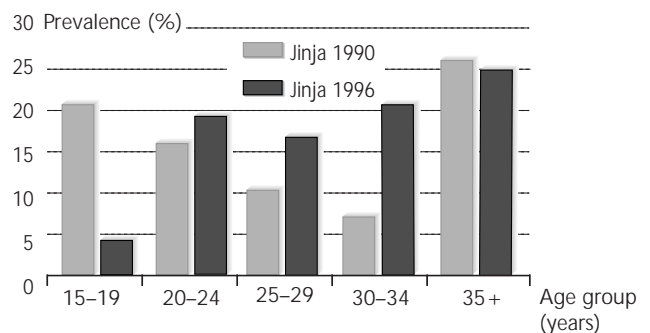
**b. Number of non-regular partners (all ages)**



**c. HIV-1 prevalence in antenatal clinic attenders**



**e. HIV-1 prevalence amongst antenatal clinic attenders**



(Asiimwe-Okiror et al., 1997). The change in the age of first intercourse clearly alters the distribution of risk of HIV infection by age. However, the difference between the two studies in the proportion of the population who have ever had sex is only maintained until 23 years of age (Asiimwe-Okiror et al., 1997). The question remains whether lifetime risk of infection is being reduced or the risk of infection is just being delayed. Small changes in the number of reported non-regular sexual partnerships (defined as partnerships of less than one year duration) were recorded (Fig. 5) along with a large increase in the proportion

of the population “sometimes” using condoms. In the 1995 study of sexual behaviour the proportion of participants who reported the use of a condom on their last risky sexual act far exceeded the proportion reporting ever using a condom in the earlier study.

It appears that HIV incidence has declined since the start of the epidemic, and that it is lower in those who have just become sexual active in recent years than it was. However, how much of the decline is due to the efforts of intervention programmes is open to question.

## The HIV epidemic in Thailand

The first evidence of HIV spread in Thailand came with the rise in prevalence in injecting drug users. An extensive system of surveillance was rapidly established, with 14 provinces included by 1989 and all 73 provinces surveying HIV prevalence in a number of high risk groups and among pregnant women by 1990. A group that provides a useful measure of HIV spread in a representative sample of men is conscripts. These are chosen by lot (i.e. randomly) from all 21-year-old men (except those going on to higher education) and all are tested for HIV infection. Surveillance revealed the spread among heterosexuals of type E HIV (a different serotype from the type B which initially infected the IDU population). Subsequently type E has also spread in IDU's suggesting that the virus among heterosexuals is a source infection for IDUs rather than vice versa (Mastro et al., 1997).

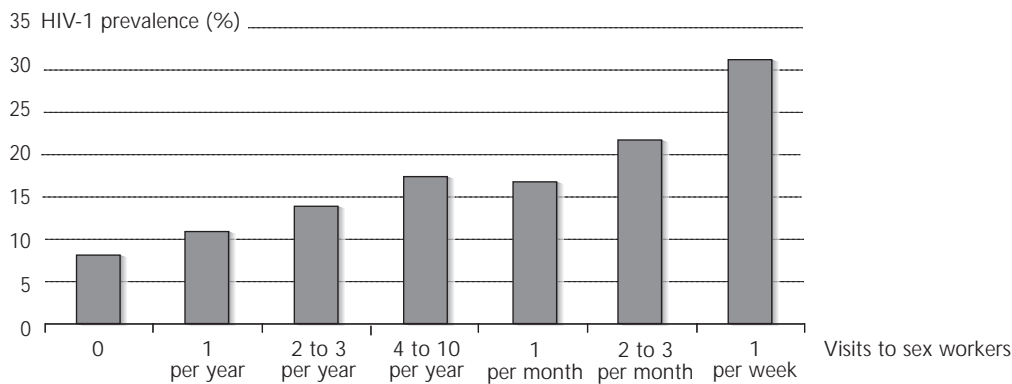
Studies of the sexual behaviour of the population in Thailand demonstrated a significant sex industry (Sittitjai et al., 1994; Sittitjai and Brown, 1994). The HIV prevalence was highest in the poorer

Northern part of the country from which a great many sex workers came to the South and Bangkok. Studies showed a clear link between visits to commercial sex workers and HIV infection in men (Fig. 6; Nelson et al., 1993; Nopkesorn et al., 1993), and a high incidence of HIV infection, particularly in direct (i.e. brothel based) sex workers (Nelson et al., 1994; Sawanpunyalert et al., 1994). In response to the HIV epidemic the government introduced a number of measures including raising awareness, promoting reductions in risky behaviour, providing AIDS care, ensuring a safe blood supply, treating bacterial STDs and encouraging the use of condoms amongst commercial sex workers. The latter was called the “100% condom programme” and involved establishing a roster of venues providing sex, where condoms were then actively promoted. The commercial sex workers were also treated for STDs and establishments from which sexually transmitted diseases were regularly acquired by STD patients were targeted by the Ministry of Public Health and the police.

The initial indication of change came from falling rates of sexually transmitted infections (Rojanapithayakorn and Hanenberg, 1996). This preceded changes in HIV prevalence as might be expected since treatment immediately resolves bacterial sexually transmitted infections rapidly changing the observed incidence of infections. While changes in the incidence and prevalence of other infections indicate a change in the environment for HIV spread, the differences in their biology make them unreliable as a direct measure of HIV incidence. However in Thailand a second random sample of the general population

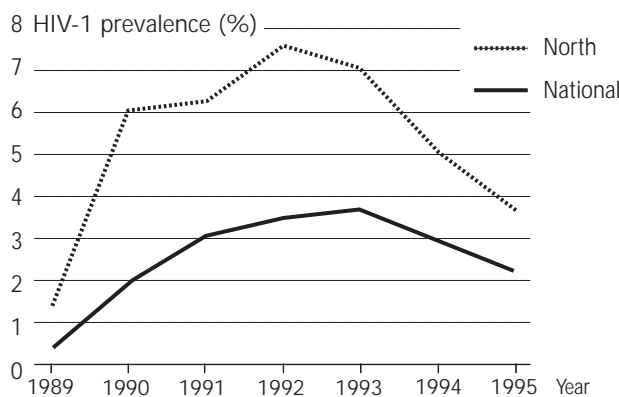
carried out in 1993 (Thongthai and Guest, 1995) found very different risk behaviours from the earlier study (Sittitrai et al., 1994) carried out in 1990. The proportion of men reporting unprotected commercial sex fell from 15% to 2%. Although, direct and indirect sex continue to report the same number of clients (Rehle et al., 1992; OPTA, 1996) there has been a shift away from direct to indirect sex work where around one rather than four clients per night are reported. Condom use reported by commercial sex workers rose from 14% to 90% by 1992 (Rojanapithayakorn and Hanenberg, 1996). These findings have been con-

**Figure 6** – HIV risk prevalence according to frequency of visits to sex workers



Source: After Nelson et al., 1993

**Figure 7** – HIV-1 prevalence in Thai military conscripts



Source: Jugsudee et al., 1996

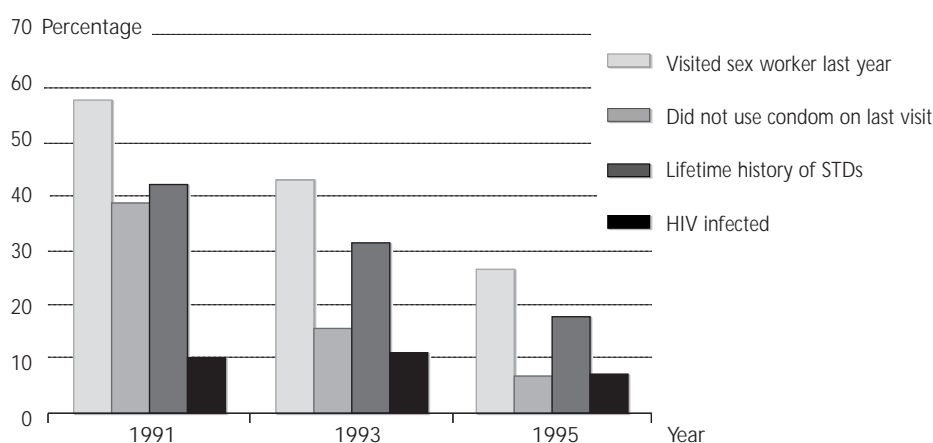


firmed in many studies (Rehle et al., 1992; Sawanpanyalert et al., 1994; Rugsao et al., 1997). Researchers posing as clients have found that the reported rates of condom use are only slight overestimates (Visrutaratna et al., 1995). In behavioural surveillance of sex workers reported consistent condom use in 1993 was greater in direct (87%) than indirect sex worker (56%) but this difference was the focus of subsequent intervention activity and condom use is now similar for direct (97%) and indirect (89%) sex workers (Mills et al., 1997). Worryingly, in the same study the commercial sex workers report low rates of consistent condom use with non-client partners from 1993 to 1996 (Mills et al., 1997).

A body of evidence consistently points towards a reduction in unprotected commercial sex in Thailand. This has been translated into a rapid decline in HIV prevalence in military conscripts in the North where the scope for change was greater and a more modest reduction in the prevalence of HIV amongst 21-year-old military conscripts throughout the

country (Fig. 7, Jugsudee et al., 1996). Studies in military conscripts have been able to show that the fall in prevalence is due to reduced reported risk behaviour in the conscripts (Fig. 8, Nelson et al., 1995). A fall in prevalence amongst those seeking antenatal care was observed in 1996 and 1997. In the North this decline started a year earlier (Surasiengsunk et al., 1997). While there are biases in antenatal prevalence data this fall is consistent with the results from the less biased conscripts, and was consistent with an 80% reduction in transmission probabilities in a model of HIV spread in Thailand (Surasiengsunk et al., 1997). The observed fall in HIV prevalence can be explained in terms of changes in sexual behaviour promoted by the government in Thailand. There are still problems, for example the prevalence in injecting drug users has been maintained at around 40%, but Thailand can be viewed as a success story, both in terms of reducing the incidence of HIV and monitoring the changes in risk and incidence in the population.

**Figure 8** – Behavioural change and HIV/STD decline in 21-year-old men in North Thailand



Source: After Nelson et al., 1996

# 3. Group report

## Assessing HIV levels and trends

Every country needs to have in place an effective and efficient system of HIV surveillance. The overall aim of such a system is to provide data to guide and target intervention activities. The specific objectives are:

- *To establish the presence or absence of infection, particularly in countries or regions where the epidemic has not yet commenced.*
- *To measure the current level of infection in the population, and to identify variations by age, sex and risk factors.*
- *To monitor the progress of the epidemic, and to measure trends in prevalence or incidence by age and sex.*
- *To make projections of future numbers of infections and AIDS cases.*
- *To measure the health burden of the epidemic, in terms of morbidity and mortality.*
- *To assess the impact of HIV control measures on the epidemic.*

### Methods of HIV surveillance

Here we focus chiefly on methods to assess levels and trends of HIV infection (Objectives 1–3). The main approaches for this purpose are:

1. Sentinel surveillance
2. Cross-sectional surveys in the general population or in specific population subgroups
3. Cohort studies
4. Methods based on AIDS case reports (e.g. based on back-calculation).

The use of these methods to monitor levels and trends is reviewed below.

### Establishing presence of infection in areas not previously affected

At the early stages of an epidemic, it is most important to monitor for infection among subgroups of the population most at risk. This might include sex workers, STD patients, or injecting drug users.

Monitoring can be carried out by sentinel surveillance for groups who are seen routinely at clinic-based sites. This includes STD patients, and sometimes sex workers (attending special health facilities) or drug users (attending drug treatment centres). For other groups, special ad hoc surveys may need to be conducted at periodic intervals.

#### Action points:

- National programmes need to:
  - identify high risk behaviours (for example, the existence and location of populations engaging in sex work or injecting drug use);
  - ensure the inclusion of such groups in periodic HIV surveillance, either through sentinel surveillance or ad hoc surveys.
- Research:
  - Tools for identifying risk behaviours (such as rapid assessment methods) require further refinement and evaluation.

### Measuring current levels of prevalence

In areas where the epidemic is well-established, sentinel surveillance of groups more representative of the general population have been promoted as the main tool for HIV surveillance. Antenatal clinic (ANC) attenders have been used as

the primary sentinel group for this purpose. (In some industrialized countries, dried blood spots from neonates are used as an alternative convenient method of measuring prevalence among women giving birth.)

The usefulness of ANC data for HIV screening depends on the degree of representativeness of pregnant women attending ANC relative to the general population. Selection biases may vary over time, complicating analysis of trends. Usage of ANC services shows substantial geographical variation, with 80–90% coverage in many African countries, compared with 30% or less in some parts of Asia.

The factors leading to selection biases in this group are illustrated in Figure 9.

There are insufficient data on the relative importance of these factors in different populations, or on how these vary over time. Studies are needed to measure these factors, and to evaluate the performance of ANC sentinel surveillance

in identifying HIV trends in the general population (see below).

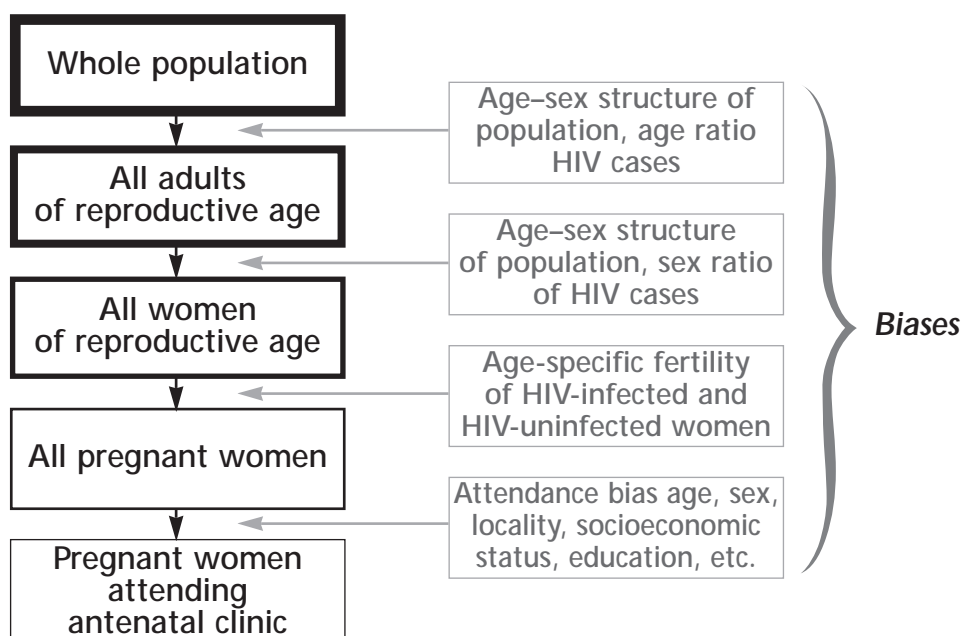
Despite these possible sources of bias, ANC sentinel surveillance continues to represent the most important component of HIV surveillance in areas where the epidemic is established. It is essential that such programmes are established and sustained.

Continuing surveys of other groups (for example, sex workers or drug users) are also likely to be necessary depending on the local context.

### Measuring trends in prevalence and incidence

Examination of serial data from HIV sentinel surveillance is likely to be the most common method of monitoring changes in prevalence in the general population. The main concern is that the selection biases referred to above may change over time, in which case misleading conclusions may be drawn about trends. This issue could be

**Figure 9** – Biases in HIV sentinel surveillance



addressed in studies to evaluate these biases over time in specific populations (see previous page).

Prevalence data are of relatively limited value in evaluating changes in the course of the epidemic, since prevalence reflects infections acquired over many years. Incidence data would be of more value for tracking the progress of the epidemic.

Incidence can be estimated from serial prevalence data, for example from ongoing data collected through ANC sentinel surveillance. However, to estimate incidence from ANC data in older age-groups is problematic, since this depends heavily on assumptions regarding the differential mortality, fertility and mobility of HIV-positive compared with HIV-negative women. By contrast, incidence can be estimated more readily from prevalence data in younger women, since prevalence in this age-range reflects infections that have occurred recently. For the same reason, concerns over differential mortality and fertility will be of less concern in these age-groups. Moreover, in mature epidemics, the majority of new HIV infections are now occurring in young people.

It has therefore been suggested that, to enhance information on prevalence trends and incidence, more effort should be put into obtaining data from young women. In countries with mature epidemics, and in which effective ANC surveillance systems are in place, it is recommended that consideration should be given to over-sampling ANC attenders in the age-range 15–24 years.

#### **Further recommendations are that:**

1. Older ANC attenders should continue to be covered, to give continuing

data on overall prevalence, and trends in prevalence, by age.

2. Data are collected by single years of age for women aged 15–24 years. This is so that more accurate incidence calculations can be carried out, and so that data for the youngest women (aged 15, 16...) can be excluded if it is found that this group is particularly subject to bias (see below).

3. If high HIV prevalence is already found in 15–16 year olds, special studies may be needed among younger girls.

4. Consideration should be given to the required sample size among younger women needed to obtain estimates of prevalence and incidence of adequate precision.

5. If possible, data on socioeconomic variables and educational level should also be recorded for ANC attenders, to provide more information on the representativeness of this group.

Despite the advantages of data from the youngest age-groups, it is possible that at the lower end of this age-range (eg. 15–17 years) those who are pregnant form a much more selected sample of all women, so that bias is likely to be greater. This is of particular concern for comparisons over time, since interventions may lead to behaviour changes which prevent pregnancy, so that particularly in this youngest age-group pregnant women may over-represent those who have maintained high risk behaviours. Research is therefore required on the most appropriate age-range to use (eg. 20–24, 18–24, etc.) for estimation of incidence and trends, and this may differ between populations. This can partly be addressed by collecting data on changes over time in the age-distribution of women attending ANC.

To evaluate the above sources of bias, we recommend that in certain countries and settings, ongoing ANC sentinel surveillance over a period of several years should be accompanied by periodic cross-sectional studies, carried out in the catchment population of ANC clinics used for surveillance. Such studies could be used for a number of purposes:

1. To measure the various factors influencing the selection bias among ANC attenders, as set out in Figure 9.

2. To compare data on prevalence and trends in the general population with those obtained from ANC sentinel surveillance.

This approach could be used to “calibrate” the use of sentinel surveillance data. Such studies are not easy to conduct, and should only be conducted where high quality of data can be assured. However, it would be valuable if UNAIDS could document the findings from a range of such studies in different areas. Such information could assist in the interpretation of data from other countries. Careful consideration needs to be given to the logistical and ethical difficulties involved in HIV surveys in the general population, but past experience has shown that these are usually surmountable, and that high quality data can be obtained from well-conducted surveys. Behavioural data could usefully be collected in the same studies.

### **The role of cohort studies**

Cohort studies, involving the prospective follow-up over several years of defined populations, involve considerable expense, and are logistically complex. Nevertheless, such studies can provide extremely valuable data on a range of variables that are of great importance, both for our general under-

standing of the HIV epidemic, and for the effective analysis and interpretation of surveillance data. Such variables include the natural history of the infection (incubation period, survival, mortality), and associations of HIV infection with rates of fertility and migration. Knowledge of these parameters is essential to validly estimate incidence from prevalence data.

While it is unlikely that many such large-scale cohort studies can be established, full advantage should be taken of them whenever possible, and every effort should be made to achieve continuing follow-up over a long time period to adequately measure natural history.

### **Other approaches**

Methods based on reported AIDS cases, e.g. using back-calculation techniques, are commonly used in industrialized countries where reporting coverage is high. However, such methods provide limited information on recent changes in HIV incidence, are reliant on information on age-specific variations in the incubation period, and are particularly problematic in mature epidemics, when incidence is stable or declining. In many of the developing countries, their use for HIV surveillance is further limited by the low coverage of AIDS case reporting. However they may continue to be useful in establishing lower bounds on HIV infections, and providing some information on the relative importance of different modes of transmission.

# 4. Group report

## Monitoring risk behaviour and behavioural change

In considering the relationship between interventions and changes in epidemiological patterns it is useful to think in terms of a “results chain”:

### Chain of effect



Behavioural change is an essential part of this results chain or casual pathway, flowing from one level to the next. Because of its centrality we can only know when programme input has had an influence on infection if we are aware of the patterns of risk behaviour and how they change. Here we concentrate on the behaviours surrounding the heterosexual spread of infection because this is the dominant route where infection has spread more widely. For other risk behaviours the focus has to shift, but the basic principles remain.

To study the pattern of risk behaviour and how it alters with time and place it is proposed that studies are designed to include three different forms of data collection:

1. Periodical cross-sectional surveys on a large scale e.g. regional or national surveys.
2. Intervention-linked behavioural surveillance surveys, in which simple surveys are added to interventions.
3. Epidemiology-linked behavioural surveys, in which detailed surveys are included in epidemiological surveys. However, experience of sentinel behav-

our surveys from Thailand suggests that the context within which antenatal sentinel surveillance occurs would not be appropriate for reliable behavioural responses (Mills et al., 1997). It is therefore suggested that behavioural surveillance operates within the same areas as epidemiological surveillance but does not use the same sampling methods.

Because there is considerable evidence that in many populations adult women under-report their number of sexual partners it is possible that adult behavioural surveys may best be confined to men. However, because HIV surveillance is conducted mostly amongst women, and because of the particular vulnerability of women, knowledge of their behavioural risks can add substantially to our understanding. It is also likely that in many contexts reports of young women may be more reliable than for older women, so that surveys of youth, in particular, should be conducted among both men and women.

There are four key questions in the design of any study:

1. What behaviours should be measured?
2. How can they best be measured?
3. How can behaviour change best be evaluated?
4. How can reliability and validity be assured?

### Key indicators

It is important that, while methods and questions are designed with the

particular locality and culture in mind, there are a set of measured behaviours that are comparable between locations. These should be the key behaviours dominating the spread of infection and while they can be explored in different ways they should be recorded with standard definitions and units. This standardization is necessary for comparison between studies and a sensible interpretation of the relationship between risk behaviour and HIV transmission dynamics.

It is possible to divided indicators (i.e. measures that define the risk of HIV) into those commonly used and those that are “additional” indicators. The commonly used “classical trio” of indicators included:

1. Number of sexual partners
2. Condom use, especially in casual or commercial sex
3. Age of sexual inception

This last is partly important because it determines when people start to be exposed to the risk of sexual transmission of HIV. However, its main significance and the reason that it is part of the “classical trio” is its importance in understanding the selection biases that exist if child-bearing women are used to monitor trends in HIV prevalence.

The number of sexual partners and use of condoms determine potential exposure to the virus. It is important to acknowledge what we mean when we measure the number of partners and the use of condoms. Do we mean new partners or all partners? To what time period do we refer? A consensus is required on such issues.

The following additional indicators might well be added to many studies as they have particular relevance:

**1. Sexual coercion.** It is becoming increasingly clear that in many communities sexual coercion has an important role in exposing (mainly) women to risk of HIV infection and is extremely important in determining the ability of women to control whether precautions are take to avoid infection. Levels of sexual coercion should be considered in the design of interventions as well as as a marker of how sexual behaviour is changing.

**2. Age disparity between partners.** There is often an age difference in sexual partnerships, generally with older men and younger women. This influences the pattern of infection with age and hence an individual's risk of infection is partly determined by the age of their sexual partner(s).

**3. STD symptoms and care.** STD symptoms have two-fold importance—they may be a marker of risk behaviour, or they may be an influence on the transmission of virus. Their control may be an aim of an intervention. A principal cause of different STD prevalences is different access to and use of care and treatment, so it is useful to monitor the uptake of care in evaluating success in improving the control of STDs.

**4. Alcohol consumption.** Many studies report that alcohol or drug use is a precursor to risk behaviour. However, whether risk behaviour would change if alcohol or drug use changed is probably dependent on the context of its influence.

**5. Number of sex acts.** The transmission of HIV is a binomial event (for each exposure someone is either infected or they are not). The sex act is the exposure event and to understand the risk of infection we need information on the number of sex acts within partnerships, their timing, type and whether condoms

are used. This is extremely difficult to measure as it is subject to significant recall biases. Even if the number of sex acts is measured, interpretation requires an improvement in our understanding of the relationship between the number of sexual acts within a sexual partnership and the likelihood of transmission of infection within the partnership.

**6. Mobility.** In many countries the movement of people, particularly migrant labour, has an important influence on risk behaviour. In addition, the movement of people between areas can influence who appears in HIV surveillance samples. The immigration or emigration of people with a high risk of HIV infection could alter biases in estimates of HIV prevalence.

**7. Sexual partnership networks.** To understand fully the spread of HIV the pattern and timing of sexual contacts throughout the community needs to be measured. To understand HIV transmission fully we need to measure networks of sexual partnerships. However, these present novel challenges for both methods of sampling and interpreting data.

### **Reliability and validity**

To be taken seriously the reliability and validity of sexual behaviour data have to be rigorously assessed. There are several strategies to improve reliability and validity. Quality assurance is extremely important, with careful sampling frames, questionnaire construction and piloting and interviewer training and supervision.

An important method is triangulation, that is, corroborating information by using multiple methods. For example, survey reports of increasing age of sexual onset may be corroborated by evidence of declining youth pregnancy or fertility. Similarly, data on increasing condom use may be corroborated by evidence of

increasing condom sales or distribution and confirmatory partner reports, especially among sex workers and clients. In addition, biological markers, including STD rates, may also be used to confirm self-report data.

### **The following are research priorities:**

1. How to link specific programme inputs to behaviour changes.
2. How to link behaviour changes to changes in STD/HIV incidence.
3. How best to measure partner change.
4. How to identify who changes their behaviour, not simply aggregate changes. For example, condom use in the most sexually active sub-set contributes far more to HIV reduction than condom use in the general population.



# 5. Group report

## Assessing programmes and interventions

### Introduction

In the assessment of interventions, whether at a local, a national, or a research programme level, a balance must be struck between the obvious need in all countries and communities to act without delay to try and reduce the spread of the HIV and its impact on morbidity and mortality, and the need to scientifically evaluate the relative effectiveness of different types of interventions in various societies or communities. A delicate balance must be struck between the need for action and the need to continually and constructively evaluate intervention activities. In view of limited resources and competing health priorities, it is also important to assess cost effectiveness of HIV/AIDS interventions. Resources must obviously be used as effectively as possible in the area of HIV and AIDS control. What follows is an attempt to evaluate current successes and failures at both the research and national levels and to identify needs and priorities, both in the implementation of interventions and the evaluation of their relative effectiveness in terms of reducing HIV incidence and prevalence. In our deliberations, it was fully recognized that there is no single solution or single best practice given the great heterogeneity in societal organization in different countries and the observed variability in the pattern of development of the epidemic.

### Successes

In the developing world, to date, there have been relatively few successful HIV interventions that have been clearly demonstrated through effective scientific evaluations. Perhaps the best documented example is in Thailand where recent declines in HIV prevalence and incidence among young Thai men have resulted from a

combination of increased condom use and a reduction in sex worker patronage, and were accompanied by a sharp decline in reported STDs. These changes are largely attributed to the national "100% Condom Campaign" and are evident from the results of an ongoing HIV surveillance programme and focused research studies. In Uganda, declines in HIV prevalence among women attending antenatal clinics are attributed to broad-based behavior changes. A large randomized trial of STD control in Mwanza, Tanzania, resulted in a 42% decline in HIV incidence (Grosskurth et al., 1995).

In developed countries, successful interventions have been demonstrated in San Francisco among men who have sex with men and in Amsterdam among IDUs (Ameijden et al., 1996). Also, sharp reductions in perinatal HIV transmission have resulted from the use of zidovudine.

### Outcome/impact indicators

In assessing programmes, it is important to have data on HIV prevalence and incidence as well as intermediate determinants, such as behavioural change (as in KAP surveys), condom use, and STDs. Information on determinants is necessary to allow linkage between specific outcomes and specific interventions.

### Efficacy of intervention strategies

In view of the balance between efforts placed on interventions and evaluations, there remains a pressing need for a limited number of definitive efficacy evaluations of existing interventions (e.g., HIV counselling and testing). These studies must be of sufficient size to yield clear results and should be designed to allow an understanding of mechanisms/causality.

**Need for situation assessment (national and local)**

In assessing programmes, it is important that interventions evaluated be adapted to the local and temporal situation. Factors to be considered include the phase of the epidemic, dominant transmission modes. Ongoing surveillance and monitoring of the epidemic are required to guide intervention evaluations.

**Bringing it together**

Interventions must be balanced with local needs. In planning interventions, it will be useful to assess the impact fraction the intervention can be expected to achieve. Impact fraction is defined as such:

$$\text{Impact fraction} = \text{Attributable fraction} \times \text{Relative efficacy} \times \text{Coverage}$$

Additionally, cost-benefit assessments should be conducted.

**Conclusions**

In conclusion, HIV transmission (as measured by HIV prevalence and incidence) should remain the central issue in the assessment of programmes and interventions. HIV surveillance is an essential component to this assessment and should be used as a tool in planning and guiding programme design. Priorities should be set on a local or national level and there should be ongoing feedback of assessment results to further guide programme design. There remains a need for a number of definitive efficacy trials of existing interventions.

## 6. Conclusions

**1•** Quality national surveillance is vital, and not a luxury—it is essential in order to assess the continued evolution of the HIV epidemic. HIV seroprevalence is the key variable, with appropriate stratification and incidence estimates where possible.

**2•** The objectives of surveillance have evolved since the start of the epidemic with a growing emphasis on its use as a tool in targeting and designing interventions and assessing them.

**3•** Antenatal clinic attendees should remain the major focus but there should be continued research on biases.

**4•** Long-term cohort studies serve a variety of purposes (natural history, viral evolution, incubation periods, mortality) including the measurement of incidence and intervention impact.

**5•** Cohort studies are difficult to manage, expensive and need (usually) to be large scale (statistical issues related to the detection of changes in incidence while accounting for loss to follow up and mortality).

**6•** The desirability of cohort studies will depend upon local capabilities and resources—but a few large multipurpose, multidisciplinary studies should be encouraged. (Over the past decade there have been too many small studies that fail to answer questions with precision.)

**7•** Cross-sectional studies are still vital in sentinel and population-based surveys but more emphasis should be placed on younger age groups and finer age stratification.

**8•** In cross-sectional and cohort studies behavioural data are essential, along with socioeconomic data. It is particularly important in the assessment of interventions that epidemiology and behaviour are studied concomitantly.

**9•** Periodic cross-sectional behavioural surveys are needed, with questions founded on a core 'trio' of measures—the number of sexual partners, age of sexual inception and condom use.

**10•** There have been a few well designed studies of behaviour, but many others have been of poor quality in terms of size, methods and validation of responses. The methods of studies need to be improved using the examples of the best studies as models.

**11•** Where possible data should be cross-associated with other information to check reliability (e.g. age at first sexual experience and age-related pregnancy rates).

**12•** Measures of average behaviour are not sufficient—variability is important—as is who changes behaviour and who has contact with whom.

**13•** There is need for further thought on what behavioural measures best reflect impact of a given intervention or set of interventions.

**14•** In the introduction and assessment of interventions care must be taken to balance the need for action and the need for research. Ideally we should try to meld both objectives. A research element is useful in intervention designs, but may not be practical throughout programmes, where

simple monitoring of the intervention could be more practical.

**15•**Evaluation is intrinsically complex owing to the temporal evolution of epidemics and imprecise understanding of how different behaviours and epidemiological factors influence epidemic pattern as it moves via a growth phase to an endemic state.

**16•**A decline in prevalence or incidence does not necessarily reflect changes in behaviour or intervention effects, a point poorly understood by many policy makers and researchers.

**17•**Despite the complexity in interpretation there are success stories, most visibly in Thailand at a national scale and in selected groups, such as those with certain risk behaviours or in certain age groups or regions. Examples include: young adults in Uganda, gay men in Amsterdam, IDUs in New York, and in Mwanza, Tanzania. These success stories need more detailed evaluation in order to define more clearly best practice.

**18•**In all interventions, political will, well motivated individuals and advocacy linked to quality information matter greatly.

**19•**Most intervention programmes place too little emphasis on scientific evaluation. Scientific evaluation need not be universal but should be more common and with improved methodologies.

**20•**Further thought is needed on when and where to use randomized controlled trials to assess interventions. Some believe them to be vital in certain contexts to evaluate specific or combinations of interventions.

**21•**Mathematical models can sharpen understanding of what to measure and how to interpret trends in prevalence and

incidence. Sensibly used they can provide a basis for trial design and evaluation.

**22•**Biological markers of intervention impact are desirable in most circumstances. More thought is needed on what STDs are useful epidemiological markers in different circumstances and settings. The expansion of available clinical diagnostic tools would be useful.

**23•**In the light of limited resources cost effectiveness analysis is highly desirable but difficult. Costs are relatively straightforward to assess, whereas how actions will translate into changing incidence is more difficult to estimate.

**24•**More well evaluated interventions are needed.

### Research needs

**1•**The bias in sentinel surveys needs continued research to improve surveillance methods.

**2•**Which behaviours to measure?

**3•**Methods of incidence measurement.

**4•**Linking STD and HIV incidence—what STDs are the best markers?

**5•**Randomized controlled trials—under what circumstances should they be encouraged?

**6•**How to measure partner acquisition rates and who mixes with whom (contact tracing if and where?).

**7•**How to target interventions without stigmatization.

**8•**Mathematical model development to aid design and to assess what to measure.

**9•**The importance of structural and environmental factors including the role of governments and NGOs.

**10•**Natural history of infections including the incubation period and infectiousness and how this related to viral genotype.

# Annex

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