
Chapter 14

UNSAFE SEX

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SUMMARY

The risk factor “unsafe sex” has been defined here as sex between a susceptible person and a partner who has a sexually transmitted infection (STI), without taking measures to prevent infection. Unsafe sex cannot therefore be defined *a priori* (because sex is only unsafe with respect to the context in which it occurs), or measured directly from reported behaviours. A set of behaviours was defined as “risky sex” and the prevalence of various behaviours was estimated for 57 countries. The prevalence of risky sex as defined here is given by the proportion of the population who have had sex in the last year with a non-co-resident partner, and who did not use a condom on the last occasion with that partner. For the comparative risk assessment (CRA) estimates, the prevalence of risky sex between men and women was the primary focus.

The main outcome considered was infection with HIV, which is responsible for the majority of the burden of mortality and morbidity associated with STIs. Infections with *Chlamydia trachomatis* (chlamydia), *Neisseria gonorrhoeae* (gonorrhoea), human papillomavirus (HPV) and *Treponema pallidum* (the causative agent of syphilis; hereafter referred to as “syphilis”) were considered in less detail because the information available for these infections is inadequate for detailed analysis.

Infection with HIV/AIDS is the fourth leading cause of mortality in the world. Currently, most (29.4 million) of the 42 million people globally who are infected with HIV are concentrated in Africa, but epidemics elsewhere in the world are growing rapidly. Prevalence is increasing most swiftly in eastern Europe and central Asia (UNAIDS/WHO 2002). Most of the infections prevalent in 2001 were acquired through heterosexual sexual intercourse. Most people infected with HIV do not know they are infected, making prevention and control difficult. The other STIs included in the burden estimates, *C. trachomatis*, *N. gonorrhoeae*, HPV

and *T. pallidum* (syphilis), cause morbidity in all regions of the world. Infection with some of these agents can lead to infertility (e.g. *C. trachomatis*) or cancer (HPV), and an acute STI may enhance the transmission of and susceptibility to HIV.

To estimate the prevalence of sexual risk behaviours, suitable studies were located and, where possible, the data produced by these studies were analysed to create a set of standard indicators for different aspects of sexual behaviour. The prevalence of different sexual behaviours and characteristics varies greatly between countries and between subregions.¹ The levels of risk behaviour did not vary in a predictable manner, and variations in reported behaviour at the aggregate level do not correspond to differences in HIV prevalences. A literature search was also carried out to identify reported risk factors for HIV infection and estimates of the risk associated with each factor. Since the outcomes are infections transmitted from person to person, the relative risk of infection changes with the prevalence of the infection, and changes in prevalence affect incidence.

Two different approaches were used to estimate the avoidable burden of HIV/AIDS attributable to unsafe sex. For countries in sub-Saharan Africa where the prevalence of HIV/AIDS in adults is high and the epidemic is largely driven by heterosexual sex, a mathematical projection model (the Epidemic Projection Package [EPP]) was used to estimate how many infections were attributable to unsafe sex, and how many were potentially avoidable. For countries where adult prevalence is lower and the spread of HIV/AIDS is confined to specific subgroups, a different approach was used whereby current estimates of HIV/AIDS and projections were based on estimates of sub-epidemics related to the mode of transmission (e.g. injecting drug use, men who have sex with men, heterosexual transmission). For these countries the risk associated with unsafe sex was the percentage of all infections that were sexually acquired. The other STIs were assumed to be entirely the result of unsafe sex and therefore 100% of the burden caused by these STIs is avoidable.

The modelling exercise suggests that there would not have been an HIV epidemic in Africa had there never been any sexual transmission since of the cases of HIV infection prevalent in 2001, >99% were associated with a sexually acquired infection at some point in the chain of transmission. In the rest of the world, the estimated percentage of the HIV infections prevalent in 2001 that were attributable to unsafe sex ranged from 25% in eastern Europe (EUR-C) to 95% in parts of Latin America (AMR-D). Using these estimates, the mortality attributable to unsafe sex ranged from 4000 deaths in EUR-C to 1 632 000 in AFR-E. Globally, 2 444 000 deaths and 75 783 000 disability-adjusted life years (DALYs) were attributable to this risk factor. If unsafe sex were to cease, most parts of the world would see a substantial drop in the number of new HIV infections.

1. INTRODUCTION

A variety of infectious agents can be transmitted through sexual contact, including HIV, chlamydia, gonorrhoea, HPV and syphilis). While having sex (which in this chapter refers to vaginal sexual intercourse, unless otherwise stated) may place a person at risk of being infected by one or more of these agents, it is difficult to assess the magnitude of this risk. Sex can only be defined as “safe” or “unsafe” if something is known about the context in which it takes place and with whom. Having sex does not place a person at risk of contracting a disease unless that person’s partner has an infection, which they can transmit. Therefore, unlike many other risk factors, which are independent of the situation in the broader population, or with respect to other individuals, unsafe sex cannot be uniquely defined by the set of actions of an at-risk individual. Rather, a definition must be based on an analysis of the individual’s actions in light of the background prevalence of disease. The principal health outcome considered in this chapter is the number of adults aged 15–49 years who become infected with HIV as a consequence of unsafe sex, and the number of these infections that is potentially avoidable. Infections in children resulting from vertical transmission were not included since these are not caused directly by unsafe sex, but by infection via the mother, together with a lack of pre- and postnatal treatment of mother and child. The other STIs (chlamydia, gonorrhoea, HPV and syphilis) were considered separately and in less detail because they contribute to a lesser degree to the burden of disease and mortality, and because of the limited amount of information available regarding the prevalence and current transmission dynamics of these infections in different subregions. A thorough review of the epidemiology and importance of these STIs was given in previous burden of disease work (Rowley and Berkley 1998).

The relationship between the risk factor unsafe sex and the disease outcomes, which contribute to the global burden of disease, cannot be described using the standard epidemiological tradition of constant, extrapolable hazards. This is owing to the fact that the outcomes considered in this chapter all relate to infections which are transmitted from person to person. The relative risk of being infected by any one of these diseases is therefore dependent on the prevalence of the disease.

1.1 DEFINITIONS OF UNSAFE SEX

In this chapter, STIs were the only negative outcomes of sexual contact considered. Other potentially deleterious outcomes, such as an unwanted pregnancy or the psychological consequences of sexual violence, are considered elsewhere in the CRA (see chapters 15 and 23). It is important to define the group of people who share a common risk factor for contracting an STI in order to be able to carry out a risk assessment. The risk factor has been called “unsafe sex”, but this term does not

immediately suggest a clearly defined characteristic of either an individual or a population that can be used to determine how many people are affected by the risk factor. “Safe” sex has previously been defined as follows:

Consensual sexual contact with a partner who is not infected with any sexually transmitted pathogens and involving the use of appropriate contraceptives to prevent pregnancy unless the couple is intentionally attempting to have a child. (Berkley 1998)

This definition is not useful for the purposes of this chapter, since many of the ways in which the above definition can be negated would not put an individual at risk of acquiring an STI. For example, sex with an uninfected partner without using contraception does not pose a risk of infection and nor would sex with an infected partner if a condom was used properly.

Therefore, before defining unsafe sex we must first consider what type of classification would be suitable to describe the degree of risk experienced by an individual or population. The risk of contracting an STI depends both on the individual and on the population. Individual behaviours determine whether or not it is possible for infection to occur. The prevalence of infection in the population determines whether or not the individual becomes exposed to an infectious agent. Therefore an ideal measurement of this risk would include both individual and population characteristics.

If it were possible to measure this risk at the individual level, a gradation across the population would be observed. Risk gradation suggests the possibility that a continuous index of risk could be constructed by combining several factors. However, many if not most behavioural factors do not retain a simple dose–response relationship when considered in combination with others. For example, consider a person who is not infected with HIV at a particular instant in time. The frequency of this person’s sexual relations with a regular partner could show a dose–response relationship relative to the risk of acquiring infection, but only if the partner were infected. Similarly, the rate at which this person acquired new partners could also show a dose–response relationship, but only if each partner were infected. Past partner history would not be relevant, unless the individual had contracted another STI which could enhance the dose–response relationships between risk of infection and both coital frequency and partner acquisition rate. The conditionality of these interactions makes it practically impossible to quantify and construct a continuous measure of risk.

Individuals must therefore be categorized into static groups based on average levels of risk. This can be done so as to allow for the important effect of STI prevalence if the definitions of risk are based on probability of contact with cases, rather than on reportable behaviours. These

definitions will be valid at an instant in time, or for a very short time period; it is important to realize that such distinctions may be very short-lived since sexual networks are dynamic. The following definitions provide a way of thinking about the true distinctions.

UNSAFE SEX

Unsafe sex occurs if a susceptible person has sex with at least one partner who has an STI, without taking measures to prevent infection. Susceptible people are not yet infected, either because the infectious agent has not been successfully transmitted, or because the agent has been transmitted but infection has not yet been established. Such susceptible people form the group which is truly exposed to infection and they are at a very high risk of becoming infected. For intervention and prevention purposes, this group is not as important as that defined below, because it is too late to prevent the members of this group from being exposed to infection. However, this group is the most relevant in terms of predicting the number of new cases of STIs.

HAZARDOUS SEX

The group of people engaging in hazardous sex are those susceptible persons who either engage in unprotected sex but who have not yet encountered a partner who has an STI, or who have had sex with at least one partner who has an STI, but have taken measures to prevent transmission. These people have the potential to be exposed to infection, either by encountering an infected partner, or if the measures taken to prevent transmission are ineffective (e.g. condom failure). This group of people is important for prevention efforts; a change in the size of this group has the most potential to change the number of new infections occurring in the future.

These two definitions (“unsafe” and “hazardous” sex) would provide a way to allocate people to risk groups if membership of the two groups could be measured. However, there is currently no way by which this can be measured and so it is necessary to use a definition based on reportable behaviours, i.e. “risky sex”, as a proxy.

RISKY SEX

The people who have risky sex share a certain set of behaviours; these can be different in different epidemic situations, but are likely to include having many sexual partners and not using condoms. This classification is based on individual reports and will include infected as well as susceptible people, because infection status is not known from such reports. Ideally, we seek to identify reportable behaviours so that the group identified as having risky sex would include those having unsafe sex and those having hazardous sex but exclude others (those having “safe” sex or no sex).

Figure 14.1(a) shows the relationship between groups of infected and susceptible people in terms of those who have unprotected sex, those who have sex with an infected partner, and those who report a “risk behaviour”. The reported risk behaviour is the measurable component of an individual’s sexual behaviour.

From this figure it is possible to see why classifying people into risk groups on the basis of reported behaviours is not necessarily a good measure of exposure to infection. Some people will be wrongly classified as at risk because they report risk behaviours, but actually they are already infected. Others will be wrongly classified because they report behaviours which have not exposed them to infection, as they did not behave in exactly the way they reported. Some people will be wrongly classified as not at risk because although they have had a sexual contact which could potentially have led to infection, they did not report this behaviour. This could be deliberate, because they do not wish to admit to “undesirable” behaviour, or unintentional, because the behaviour has been forgotten. People will also be misclassified if the risk behaviour they are asked to report is not the best predictor of the actual risk experienced. For example, in a population of married women this could happen if risk were classified on the basis of reporting sex with non-marital partners, but the main source of infection was in fact the women’s husbands.

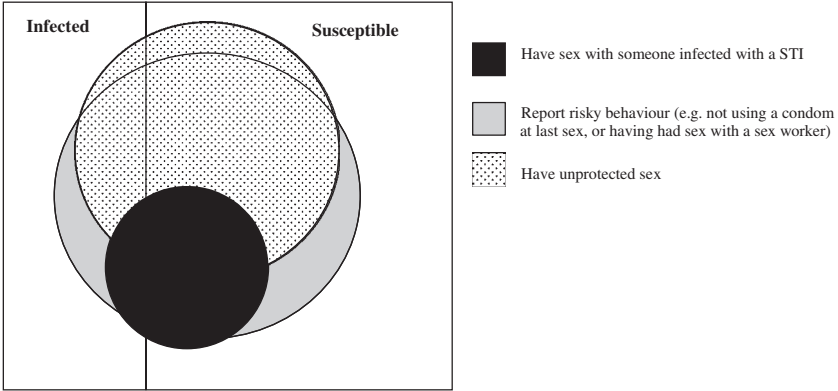
Figure 14.1(b) shows where the groups defined above (unsafe sex and hazardous sex) fall in this schematic. The black section shows the group having unsafe sex: the susceptible people who have unprotected sex with a partner who has an STI. By definition, this group falls wholly within the group of susceptibles and includes some of the people who report risk behaviours and some of the people who are classified as having hazardous sex. The group which has hazardous sex is shown in the light grey and dark grey sections and is composed of those who either have unprotected sex or who have protected sex with a partner who has an STI. This includes people who do report risk behaviours and some who do not. Again, by definition, this group includes only susceptible persons. Some members of the group who report risky behaviour, shown in white, are not included in either the group having hazardous sex or the group having unsafe sex.

1.2 ESTIMATING LEVELS OF RISKY SEX IN A POPULATION

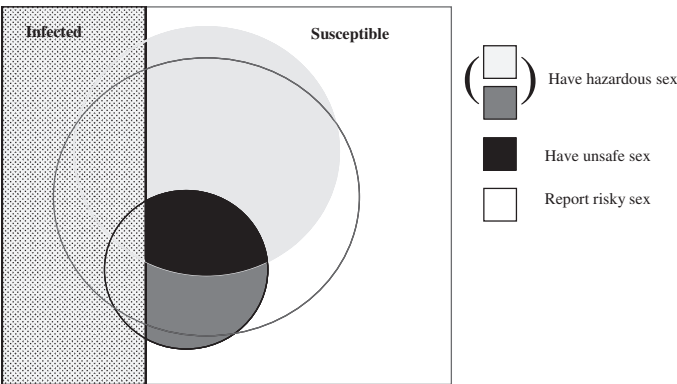
If there were no STIs, then there would be no unsafe and/or risky sex. In areas where there is a high prevalence of STIs, a larger number of sexual behaviour patterns will be dangerous than in places where very few people are infected with a sexually transmitted pathogen. A pragmatic definition of a specific behaviour, or group of behaviours, (e.g. sex without a condom) as “risky” can be useful, providing it is understood that the degree of risk associated with this behaviour will not be the same in different populations, or at different times in the same population.

Figure 14.1 Venn diagram illustrating the relationship between three ways of defining unsafe sexual behaviour

(a) Components of risk behaviour



(b) Correspondence between the components of risk behaviours and definitions of unsafe, risky and hazardous sex



With this caveat in mind, the question arises as to how best to describe populations with different levels of risk.

Aggregate measures of sexual behaviour will inevitably be less informative than more local measures. However, even country-level indicators cannot capture the more subtle variations in sexual mixing patterns, such as partnership concurrency. The level of risk attached to a particular behaviour changes with the prevalence of the infection; if prevalence is high, there are more infected people in the population and so a susceptible person has a greater chance of choosing an infected person as their next sexual partner. In each subregion, the prevalence of STIs and

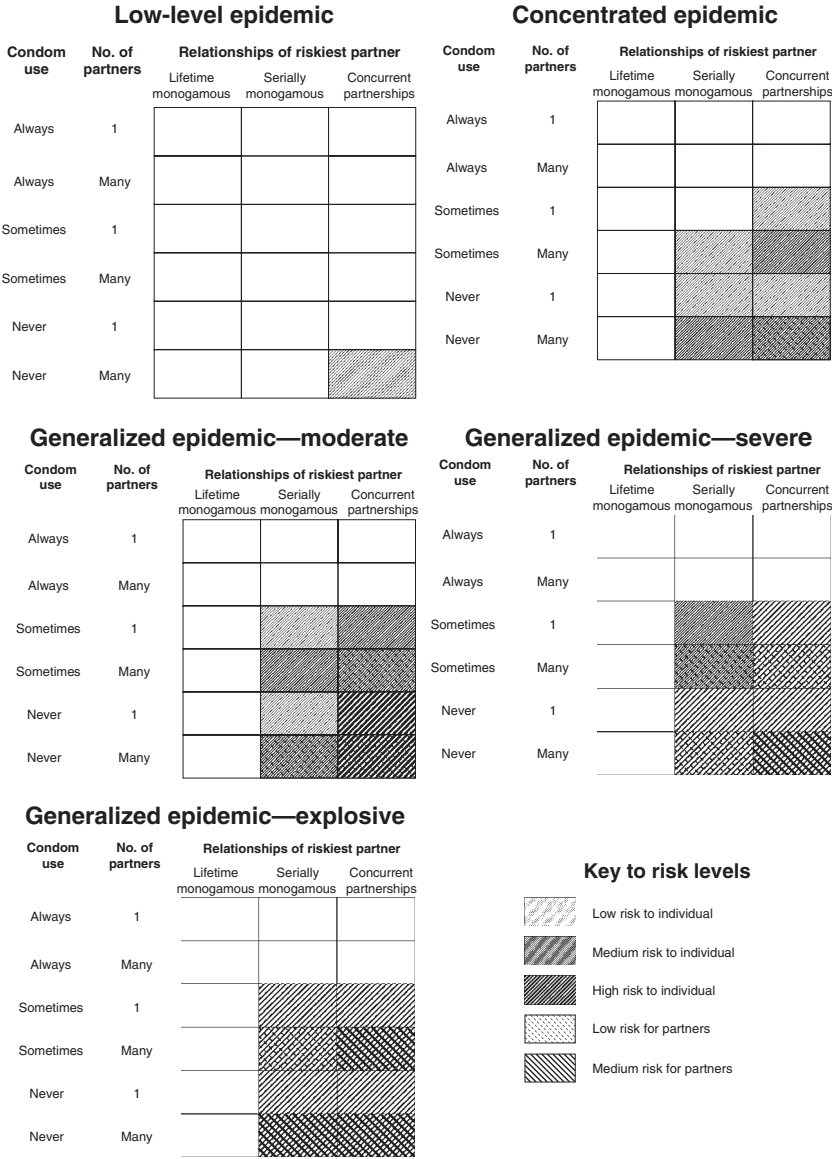
of certain behaviours varies between the countries. Within the different countries, STI prevalence and sexual behaviour can vary between urban and rural areas, age groups and sexes, socioeconomic classes, religious groups, between people of different sexual orientation and according to other factors such as proximity to transport links and health services. Personality and physiology play a significant role in determining a person's sexual behaviour and, in the case of the latter, susceptibility to infection. The impact of these determinants cannot be measured at the population level, but they are of great importance in determining how many people are exposed to STIs and how many people become infected.

The effect of heterogeneity in sexual behaviour on the ability to measure the level of dangerous exposure is more subtle. When sexual behaviour is measured in a survey, data are only collected regarding the respondents' behaviour. However, the behaviour of the sexual partner is as important a predictor of risk as the behaviour of the respondent. A respondent who has a large number of sexual partners is probably at a high risk of contracting an STI. However, if all of these partners have never had sex with anybody else, the respondent is perfectly safe. Therefore in a population where people vary greatly in the number and frequency of their sexual contacts, a one-sided measure of "sexual behaviour" is difficult to interpret. It is known that in most populations men and women have very different patterns of sexual behaviour. Most populations also have a subset of both men and women who are distinguished by high levels of sexual activity. Both of these imbalances make it difficult to quantify risk based on reported behavioural data from surveys.

The level of risk, to oneself and one's partner, is illustrated assuming different patterns of partnership and condom use in three different epidemic situations in Figure 14.2. The epidemic states correspond to those defined in WHO/UNAIDS (2000). A low-level epidemic is one in which, although HIV infection may have been present in the population for some time, it has not spread outside defined groups at a high risk of infection, and the prevalence among these groups has not exceeded 5%. A concentrated epidemic is one in which HIV infection has spread within defined groups and prevalence has exceeded 5% in at least one of these groups, but prevalence among pregnant women in urban areas remains below 1%. A generalized epidemic is one in which HIV infection has spread throughout the general population, as indicated by a prevalence of infection of greater than 1% among pregnant women.

A partnership is mutually monogamous if both partners only have sex with each other for the duration of the relationship. Lifetime mutual monogamy is always safe, regardless of the prevalence of STIs in the population. One-sided lifetime monogamy is safe for one of the partners in this type of relationship: individuals who have sex with a partner who has never had sex with anyone else do not place themselves at risk of infection from this partner, but may themselves present a risk to this partner if they have also had sex with other people. Serial monogamy is

Figure 14.2 Risk matrices: the level of risk to an individual and their partner is illustrated assuming different behavioural patterns in different epidemic situations



defined as a succession of monogamous relationships. These relationships are monogamous from the individual's standpoint, but no assumptions can be made about the behaviour of the partner. Partnerships of this sort may last for days or years. The frequency with which partnerships are dissolved and reformed will affect the risk of acquiring an STI and this will also be affected by the prevalence of STIs in the population. If an individual has sexual partnerships that overlap, such partnerships are said to be concurrent. STIs can be spread more easily if people have sex with several partners within a short space of time. Therefore although having concurrent partnerships is associated with the greatest risk of contracting an STI, serial monogamy with very short intervals between successive partners also places the partners at high risk.

2. DATA SOURCES

The data used to calculate levels of risky sexual behaviour came from general population surveys designed to be nationally representative. More than 300 surveys were identified that could potentially have been used in this analysis. Many of these had been carried out under the auspices of the Demographic and Health Surveys (DHS) programme conducted by Macro International. The focus of these surveys was family formation and fertility, and only more recently have questions on sexual behaviour been incorporated. Most DHS data are from African countries, but some surveys have been carried out in South America and Asia. South American countries are also covered by the Centers for Disease Control and Prevention (CDC) Reproductive Health Surveys (RHS) which asked questions about sexual behaviour. CDC has also carried out some surveys in Asian and eastern European countries. Other organizations, such as Population Services International (PSI), also carry out surveys which provide suitable information.

Most of the established market economy countries have carried out their own surveys of sexual behaviour, many of which date from the late 1980s and early 1990s, a time when policy-makers began to be concerned about the potential for the spread of HIV in these populations. For example, the data from the United Kingdom of Great Britain and Northern Ireland used in this analysis date from 1990; the survey was repeated in 2000 but the data were not yet available. The problem of standardization is greater for established market economy countries' surveys because they have been carried out by many different organizations, each of which sought different information to address different concerns.

2.1 SEARCH STRATEGY

The scientific literature was searched for information on the prevalence of different sexual behaviours and the relationship between risky sex and STIs. Information dating from after 1990 was used wherever possible.

Identifying survey data sets and or reports which incorporated information on sexual behaviour was not straightforward since these terms are not indexed in the major bibliographic databases. Therefore the use of a formal search strategy alone would not have been adequate. Suitable surveys were located in several ways:

STEP 1: WEB SITES OF SURVEYING ORGANIZATIONS

Organizations that carry out surveys that include information on sexual behaviours provide lists of these on their web sites; this was the first source of information for the majority of surveys. These organizations are:

- Demographic and Health Surveys (DHS), Macro International and Measure, USA (<http://www.measuredhs.com>) and (<http://www.measureprogram.org>)
- Reproductive Health Surveys (RHS) carried out by CDC, Atlanta, USA (http://www.cdc.gov/nccdphp/drh/gp_surveys.htm)
- Population Services International (PSI), USA (<http://www.psi.org/>)
- Family Health International (FHI), USA (<http://www.fhi.org/>)
- Global programme on AIDS (GPA) listed on http://www.unaids.org/publications/documents/epidemiology/determinants/Survey_Sexual_Behaviour.doc

STEP 2: SEARCH OF PUBLISHED MATERIALS

Medline, Popline and Web of Science databases were searched for appropriate publications. Other databases providing qualitative information (such as Psychinfo) were not used because quantitative information was considered more important for this work.

STEP 3: CONTACT WITH OTHER RESEARCHERS

This turned out to be the most efficient strategy because researchers involved with one survey frequently knew of other existing surveys.

STEP 4: INTERNET SEARCH USING GOOGLE

The Google Internet search engine was used, the principle search terms employed being the names of authors of surveys known to have been carried out and the names of institutes likely to have been involved in suitable surveys. It is not useful to carry out Internet searches using keywords related to sex.

Search terms

- Popline

Search terms used were “sex behaviour”, “condoms, male” “condoms, female” “population” “HIV infections”. This yielded 709 references, of which 75 were selected.

- Medline

Search terms employed were sexual behaviour, risk, ratio, odds, changes, sexual behaviour, incidence or prevalence, change*, reduction or lower or decline, HIV.

- Web of Science

Search terms used were sexu* and country name. If a search term returned a large number of hits, it was narrowed by adding “risk”.

All the databases were searched for information from countries where there was no DHS, CDC, PSI or national (state) survey available.

2.2 PREVALENCE STUDIES: HIV AND OTHER SEXUALLY TRANSMITTED INFECTIONS

Data on the prevalence of HIV are generally from national surveillance systems. In most countries, women who attend antenatal care clinics (ANC) are tested for HIV anonymously and these data are taken to be representative of the general population in these countries. Other sources of surveillance data include blood donors, STI clinic patients and military recruits. Only ANC clinic prevalence data were used in this work. These data are collected by the United States Bureau of the Census and at the Joint United Nations Programme on HIV/AIDS (UNAIDS) in Geneva, from which the information is disseminated. The quality, coverage, history and competence of national surveillance schemes vary enormously (Walker et al. 2001). Consequently, prevalence data from some areas are more reliable than from others and more recent estimates are generally more reliable than older ones.

WHO collects the available STI prevalence data on a regular basis. However there is a lack of time-series data, which means that mathematical projection models cannot be used to make projections of future prevalence.

2.3 PREVALENCE STUDIES: SEXUAL BEHAVIOUR

As described above, it is not clear which types of behaviours best define the group of people who are at risk of contracting an STI. Therefore information was collected on all behaviours which might be important in defining this group.

MEASURING SEXUAL BEHAVIOUR

Target population

Many surveys of sexual behaviour have focused on high-risk groups within a population. In countries with concentrated epidemics, most STIs occur within these groups, which are often composed of people such as commercial sex workers or men who have sex with men. Unfortunately, the size of these groups relative to the total population is rarely known.

Information from surveys of groups at a high risk of infection cannot be extrapolated to the general population without an accurate estimate of the overall size of the group. General population surveys are unlikely to find a representative sample of members of groups at a high risk of infection and therefore underestimate the prevalence of risk-associated behaviour in a population. Data from groups at a high risk of infection have not been used directly in this work because sufficient information is rarely available to be able to use these data in the context of aggregate national estimates of risk behaviour. Therefore the estimates of the level of exposure could be too low in countries where STIs occur mainly within groups at a high risk of infection.

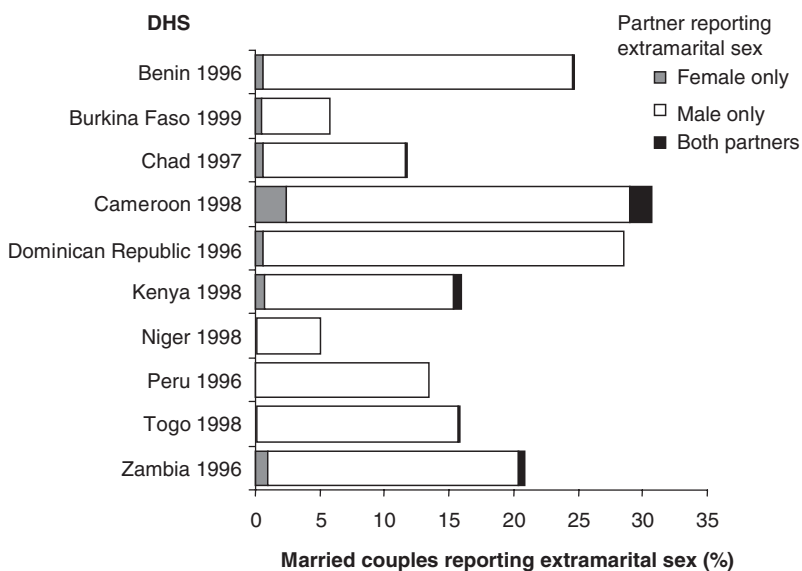
Methods of data collection

Sexual behaviour surveys are a fairly recent activity and the best methods for obtaining the required information have not been established. The most appropriate reference period for information on the number and characteristics of sexual partners is not known. There is no reliable method for comparing data collected for different periods of time. For example, somebody who reports having had one partner in the last month has not necessarily had twelve in the last year, but may well have had more than one partner in this time. Asking people for information from a longer time period will introduce a recall bias. This bias could be a problem because people might be more likely to recall partners of longer duration than those with whom contact is more short-term. This could lead to underestimates of the number of more risky sexual contacts.

If sexual behaviour patterns are changing over time, a cross-sectional survey will not give a good estimate of the cumulative lifetime exposure to risk, because the risk exposure of the youngest age groups at the time of the survey will not reflect the risk that the older age groups experienced when they were young. Ideally, current state measurements should therefore be supported by life course measures, even if we have to rely on recall data for the latter.

Surveys which only collect information on the respondent's own behaviour will misclassify some individuals with respect to their risk of acquiring an STI. They will systematically underestimate risk because people who are at a low risk because of their own behaviour could be put at risk by the behaviour of their partner. If people who are at a low risk always chose low-risk partners, then surveys could accurately estimate the proportion of those who are at risk. There is evidence from selected DHS with a couple subsamples that this is not the case, and that there is substantial misclassification of women as at a low risk based on their own behaviour, but who are in fact at risk through their husbands. This is illustrated in Figure 14.3 and supported by the results of other studies (e.g. Rwanda and Kenya, Chao et al. 1994; Hunter et al. 1994).

Figure 14.3 The proportion of married couples in which at least one partner reports having had extramarital sex during the last year, by country



Source: Data from selected DHS.

The accuracy of survey instruments in correctly evaluating people's behaviour is unknown. In studies where cross-sectional household surveys have been validated with in-depth interviews, it has been found that people tend to under-report "undesirable" behaviours (Konings et al. 1995). The age, sex and personal characteristics of the interviewer may also influence the reporting of sensitive information (Malamba et al. 1994), which is likely to include the behaviours of interest. Many surveys find that the number of partners reported by men greatly exceeds the number reported by women. Two factors contribute to this: general population surveys may fail to include the few women who have a large number of partners, and women may consistently under-report how many partners they have had (Glynn et al. 2001).

In choosing which data to use for the risk assessment, the first criterion was that the survey sample should be representative of the general population. Some surveys, mainly those with a demographic focus, only interviewed women, and some were concerned only with ever-married women (women who are currently married or who have been married at some stage in their lives). The latter samples were generally carried out in countries where it is not possible to discuss sexual behaviour

openly and consequently they provide only a limited amount of information. The age range of persons included in the surveys also varied. If a survey was limited to a narrow population in terms of sex, age or marital status, it was only analysed in the absence of a suitable alternative. This was the case for several countries. The surveys used, the populations covered and the data sources for each are listed in Appendix A. The type of information available and the number of countries and subregions covered are listed in Table 14.1.

The surveys referred to in Table 14.1 were carried out between 1989 and 2001. In general, the most recent survey available was used for each country. Individual-level data were required to calculate values for most of the sexual behaviour indicators because these were not usually given in a suitable format in published reports. In some cases, the data used to calculate the estimates presented in this chapter did not come from the most recent survey because such data were not available at the time of writing.

There were very few countries for which more than one survey was suitable for calculating sexual behaviour indicators. If more than one eligible survey for a country existed, the survey providing the most information was used first. Data from different surveys were not combined when calculating any one indicator for a particular country, but the full set of indicators for a country were not always derived from the same survey. The estimates for each indicator were rated according to how directly each indicator could be calculated from the information elicited by the survey questions and the number of assumptions which had to be made in the calculation. In cases where two estimates were available for one indicator, the estimate that was considered better was used.

The responses received in a survey may have been influenced by the manner in which the questions were phrased. The data presented here were derived from responses to several differently-phrased questions and this may have distorted the results. Within subregions this should not be of concern, beyond increasing the uncertainty of the measurement, as it seems unlikely that this error should vary with respect to exposure to STIs. However, a bias may well be introduced when making comparisons between subregions with different styles of questions because questionnaire styles are generally more similar within subregions.

Most general population data only cover heterosexual behaviour. Those surveys which discuss sex between men are generally carried out only among men who have sex with men and the number of these individuals in a population is rarely known. Therefore the behavioural measures collected for this analysis focussed entirely on heterosexual sex. For some subregions where sex between men plays a key role in the epidemic, this is an important omission. However, data are rarely available on behaviour in homosexual men in the subregions with the greatest burden of STIs, and the focus of this chapter has been largely dictated by the epidemic in these countries. As will be explained in more detail below,

Table 14.1 Indicators of sexual behaviour and the number of countries and subregions for which relevant data are available, by sex

| Indicator of sexual behaviour | Denominator | Numerator ^a | Information available (n) | | | |
|--|---|--|---------------------------|------|-------------------------|------|
| | | | Countries | | Subregions ^c | |
| | | | Female | Male | Female | Male |
| Ever had sex | Everyone | Number who say they have ever had sex | 63 | 42 | 13 | 9 |
| Sexually active in the last year | Everyone who has ever had sex | Number who had sex in the last year | 59 | 40 | 12 | 6 |
| Higher-risk sex in the last year | All who have had sex in the last year | Sex with non-co-resident partner in the last year | 47 | 34 | 10 | 8 |
| Condom use last time had higher-risk sex | All who have had higher-risk sex in the last year | People who used a condom last time had higher-risk sex | 34 | 30 | 7 | 8 |
| Men who had sex with a CSW in the last year | All men | Men who had sex with a CSW in the last year | NA | 41 | NA | 10 |
| Condom use last time had commercial sex | Men who report having had commercial sex in the last year | Men who used a condom last time they had commercial sex | NA | 23 | NA | 6 |
| Young people ^b having premarital sex in last year | All young people who have never had a co-resident partner (i.e. currently single) | Never had a co-resident partner and had sex in the last year | 53 | 37 | 9 | 7 |
| Condom use last time had premarital sex | All young, single and sexually active people | Young, single, sexually active and used a condom last time had sex | 33 | 29 | 7 | 7 |

| | | | | | | |
|--|--|---|----|----|----|----|
| Young people having multiple partnerships in the last year | All young people | Young people who report more than one partner in the last year | 31 | 31 | 7 | 7 |
| Young people's condom use last time had higher-risk sex | All young people who had sex within the last year | Young people who used a condom the last higher-risk sex in the last year | 45 | 28 | 12 | 7 |
| Condom use first time had sex | All young people who have ever had sex | Young people who used a condom the first time they had sex | 9 | 10 | 3 | 4 |
| Had sex by age 15 years | Everyone | First had sex before the age of 15 years | 57 | 39 | 11 | 8 |
| Median age at first sex | Everyone | Lifetable median | 65 | 51 | 12 | 11 |
| Condom use last time had marital sex | Married people (including co-resident partnerships that are not legal marriages) | Married people who used a condom the last time they had sex with their spouse | 20 | 22 | 6 | 6 |
| Extramarital sex in the last year | All married people | Married people who had sex with a non-co-resident partner during the last year | 25 | 25 | 7 | 7 |
| ≥ 2 non-marital partners in last year | All people who have had sex in the last year | Number who report ≥ 2 partners, with whom they do not live, during the last year | 18 | 18 | 5 | 6 |
| Number of partners | Everyone | Mean and median number | 27 | 30 | 7 | 7 |
| CSW | Commercial sex worker. | | | | | |
| NA | Not applicable. | | | | | |
| ^a | Only people who can contribute to the denominator are included in the numerator. | | | | | |
| ^b | Young people are defined as people aged 15–24 years inclusive. | | | | | |
| ^c | Subregions for which at least one country-level estimate was available. | | | | | |

whilst homosexual men are not included in the exposure estimates, they are included in the estimates of attributable and avoidable infections as a result of the modelling approach taken.

Flow of data

Having identified a suitable survey, the questionnaire (if available) was assessed to ensure that the data would be suitable for inclusion in this analysis. If suitable, the data were obtained and converted (if necessary) for analysis using Stata version 7.0. Variables were created for as many of the standard indicators (those listed in Table 14.1) as was possible for each survey. These were then used to calculate the weighted numbers of people in each category, and the results were exported to a Microsoft Access database.

Survey design issues

There is no standard survey questionnaire. Even those carried out by the same organization, such as DHS, differ slightly from country to country and from year to year. DHS use a standard questionnaire for each survey round, but countries do not necessarily use all of, or only, the standard questions in their surveys. The standard questionnaire for the round four DHS has departed from the previous standard in the AIDS module and now asks about the previous three partners, in contrast to the prior rounds which asked about marital and non-marital partners. Other surveys have differently-worded questions and a different structure and order of questions. Therefore the data had to be standardized in some way.

Two major problems emerged while trying to compile the responses to different questionnaires to allow comparison. First, the reference period for questions on sexual behaviour varied. The majority of surveys asked about behaviour in the year prior to the survey but a few used different timescales. It is difficult to relate the responses to questions with one reference period to those with another reference period and therefore some of the data could not be used to calculate the standard indicators. Second, questions relating to condom use followed two styles. One style asked about condom use on the last occasion (with a particular partner). The other asks whether condoms were always, sometimes, or never used (with a particular partner). The latter question is impossible to compare between different surveys since it would be necessary either to quantify “sometimes” or to get an estimate of consistency of condom use with different partners. A significant amount of data on condom use could not be included here for this reason. Work has been done on methods for comparing responses to different types of questionnaire design; however, to do this effectively for this analysis would have required many assumptions to be made, and would thus have introduced another possible source of error.

Standardization of questionnaires

Given the differences in question wording and questionnaire structure, it was not possible to define a set of rules for this process. Table 14.2 shows some of the questions used in constructing the same indicator for different countries.

2.4 OUTCOME STUDIES: SEXUAL BEHAVIOUR AND HIV/AIDS

ESTIMATING THE RELATIVE RISK OF HIV INFECTION IN EXPOSED VS NON-EXPOSED PEOPLE

The relative risk or odds ratio for various indicators of sexual behaviour has been assessed in a number of general population studies listed in Table 14.3. The accuracy of these estimates is influenced by the following factors.

Methodological issues

The time at which a person became infected is an important piece of information because it is their behaviour at around that time which is the most relevant when estimating relative risk. People do not usually know that they are infected, let alone when this occurred, so behaviour is seldom measured for the relevant period of time. This could reduce the chances of detecting a real association. Studies which attempt to find risk factors for STIs, in particular HIV, face problems because of cultural unease about discussing STIs. Other problems include a lack of laboratory resources and expertise in geographical areas with high prevalence, as well as the ethical issues involved in serological testing.

The studies which estimate the risk associated with particular behaviours are mostly cross-sectional. If sexual behaviour patterns are changing over time then these surveys, which look for patterns of association between estimates of exposure and prevalence, could produce misleading results. The behaviour reported by HIV-positive people who have been infected for some time, and whose behaviour has changed between the time of infection and the time of the survey, will not reflect their behaviour at the time of infection. The degree to which people are misclassified in this way will depend on the stage of the epidemic (because in the early stages more infections are recently acquired) and on the reference period used in the survey.

This effect could be mitigated if life course measures were also considered. Comparison between life course and the more recent measures could show if behaviours have changed. Some indicators of behaviour are known to correlate with others. For example, age at which the individual first has sex has been shown to correlate with number of extra-marital partners later in life (White et al. 2000) and so inconsistencies in this relationship, where this has been previously documented, could point to changing patterns of behaviour.

Table 14.2 Examples of questions whose responses were used to construct various indicators of sexual behaviour

| Name of survey | Question asked | Mode |
|--|--|------|
| Number of people who have ever had sex NEM European Group | Have you ever had sexual intercourse? | FTF |
| NATSAL 1990 (United Kingdom) | How old were you when you first had sexual intercourse with someone of the opposite sex, or hasn't this happened?" | FTF |
| DHS Zambia 1996 | Married: When was the last time you had sexual intercourse with (your husband/the man you are living with)? Not married: When was the last time you had sexual intercourse (if ever)? | FTF |
| DHS Kazakhstan 1999 | How old were you when you first had sexual intercourse (if ever)? | FTF |
| PSI Rwanda 2000 | Avez-vous jamais fait l'amour avec une personne de sexe opposé? | FTF |
| Number of people who had sex in the year before the survey NEM European Group | With how many persons of the opposite sex have you had sex over the last 12 months, even only once? | FTF |
| NATSAL 1990 (United Kingdom) | When, if ever, was the last occasion you had vaginal sexual intercourse with a (man/woman)? | SAQ |
| DHS Zambia 1996 | Married: When was the last time you had sexual intercourse with (your husband/the man you are living with)? Not married: When was the last time you had sexual intercourse (if ever)? | FTF |
| DHS Kazakhstan 1999 | When was the last time you had sexual intercourse? | FTF |
| PSI Rwanda 2000 | Quand avez-vous fait l'amour la dernière fois? | FTF |
| Number of men who had sex with a commercial sex worker in the year before the survey NEM European Group | Have you ever had sex with a person you paid to have sex? If yes: When was it for the last time? | FTF |
| NATSAL 1990 (United Kingdom) | Have you ever paid money for sex with a woman? If yes: When was the last time you paid money for sex with a woman? | SAQ |
| DHS Zambia 1996 | Have you given or received money, gifts or favours in return for sex at any time in the last 12 months? | FTF |
| DHS Kazakhstan 1999 | Have you ever paid for sex? If yes: How long ago was the last time you paid for sex? | FTF |
| PSI Rwanda 2000 | Au cours des douze derniers mois, avez-vous reçu de l'argent ou des cadeaux en échange des rapports sexuels ou bien avez-vous payé quelqu'un pour faire l'amour avec vous? | FTF |

Key: FTF, face-to-face; SAQ, self-administered questionnaire.

3. ESTIMATING LEVELS OF SEXUAL RISK BEHAVIOUR

3.1 FACTORS WHICH DETERMINE THE INCIDENCE OF A SEXUALLY TRANSMITTED INFECTION

Worldwide, there is great variation in the prevalence of STIs and in patterns of sexual behaviour, but there is little concordance in the variation between the two. Figure 14.4 shows schematically some of the factors which theoretically determine the incidence of an STI, using the example of HIV. The first box shows societal factors which determine general patterns of sexual behaviour and sexual mixing. The second shows the characteristics which influence whether the sexual contact is potentially infectious, i.e. whether a person is exposed to infection. The third shows the mediating factors, which affect the potential for transmission of infection from the infected partner. The fourth box shows those factors which determine whether or not the contact results in a new infection.

Table 14.3 shows some of the factors which have been found to be associated with HIV infection in the general population in a variety of studies.² The Ugandan samples are from cohort studies, which were designed to elucidate some of these relationships. Table 14.4 shows some of the behavioural changes which have been reported at the same time as observed HIV prevalence has decreased, as has happened in some countries, most noticeably Uganda and Thailand. Changes in HIV prevalence can be attributed to changes in behaviour if incidence has also decreased, but it is difficult to establish if this is the case because prevalence can decline due to excess mortality among people already infected with HIV.

DISTAL DETERMINANTS OF BEHAVIOUR

Age

Age is correlated with whether or not someone is sexually active and the likelihood that their sexual partner is their spouse. In countries where the HIV epidemic is of recent origin, older age groups may have a lower cumulative exposure to infection because most of their past sexual

Figure 14.4 Factors which can influence the incidence of HIV infection

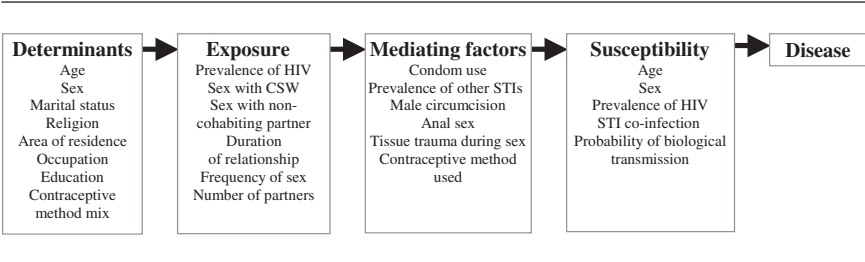


Table 14.4 Changes in behaviour which have been observed concomitantly with a decline in HIV prevalence or incidence

| | Age first had sex | Age at first marriage | Age at birth of first child | Number of partners | Higher risk sex in the last year | Commercial sex | Ever used condom | Condom used last high risk sex | Condom used last commercial sex | Ever had STI | Sex with a girlfriend |
|-------------------------------------|-------------------|-----------------------|-----------------------------|--------------------|----------------------------------|----------------|------------------|--------------------------------|---------------------------------|--------------|-----------------------|
| <i>Males</i> | | | | | | | | | | | |
| Uganda (Asiimwe Okiror et al. 1997) | ↑ | | | → | ↓ | | ↑ | ↑ | | | |
| Uganda (Kamali et al. 2000) | ↑ | | | ↑ | | | ↑ | ↑ | | | |
| Thailand (Kilmarx et al. 2000) | | | | | | ↓ | | | ↑ | | |
| Thailand (Nelson et al. 1996) | | | | | | ↓ | | | | ↓ | ↑ |
| Zambia (Fylkesnes et al. 2001) | | | | ↓ | | | ↑ | ↑ | | | |
| <i>Females</i> | | | | | | | | | | | |
| Uganda (Asiimwe Okiror et al. 1997) | ↑ | | | → | | | ↑ | ↑ | | | |
| Uganda (Kamali et al. 2000) | | ↑ | | ↑ | | | ↑ | ↑ | | | |
| Thailand (Kilmarx et al. 2000) | | | | | | | | | ↑ | | |
| Zambia (Fylkesnes et al. 2001) | | | ↑ | ↓ | | | ↑ | ↑ | | | |

Key: ↑, increase in prevalence of this factor observed at the same time as decline in HIV prevalence or incidence; ↓, decrease in this factor observed at the same time as decline in HIV prevalence or incidence; ↑, inconsistent or non-significant increase; ↓, inconsistent or non-significant decrease; →, factor did not change significantly.

Note: In two of the countries in this table (Uganda and Thailand), the declines in prevalence are evidence of convincing long-term downward trends in incidence, but in the remainder the decrease in prevalence has not been observed over such an extended period, and may in fact be the result of rapidly increasing number of AIDS deaths masking a steady incidence of new infections, a phenomenon that was observed in the early stages of the prevalence decline in Uganda (Wawer et al. 1997).

exposure occurred at a time of low prevalence. The association of HIV infection with young age was not seen in all the studies listed in Table 14.3, and where an association was found it was not always in the same direction and was sometimes different for men and women.

Sex

In most cultures, men and women initiate sexual activity at different ages. The typical age difference between partners may be different for men and women. Societies may condone some sexual behaviours for men and not for women. In countries with generalized epidemics, prevalence is usually higher in women than men, especially in younger age groups.

Travel, place of residence, workplace

Factors such as travel, area of residence and occupation or place of work have been measured differently by the various studies. In those studies where these factors were associated with HIV infection (Auvert et al. 2001a; Nunn et al. 1994; Quigley et al. 1997; Seed et al. 1995) they could be acting as proxy measures for potential contact with infected sexual partners. These factors will all influence the number of sexual partners and proportion of available partners who are infected.

Religion

In the studies which found religion to be associated with HIV infection, the comparison was between Muslims and non-Muslims (Malamba et al. 1994; Nunn et al. 1994; Quigley et al. 1997). There are two characteristics of Muslims which may be relevant to HIV infection: the customary practice of male circumcision and the requirement to abstain from alcohol. The use of alcohol and other mood-altering substances is an independent risk factor in other studies (Auvert et al. 2001b, 2001c; de Gourville et al. 1998; Gregson et al. 2001). The social values incorporated in the Muslim faith may also cause people to have risky sex less frequently.

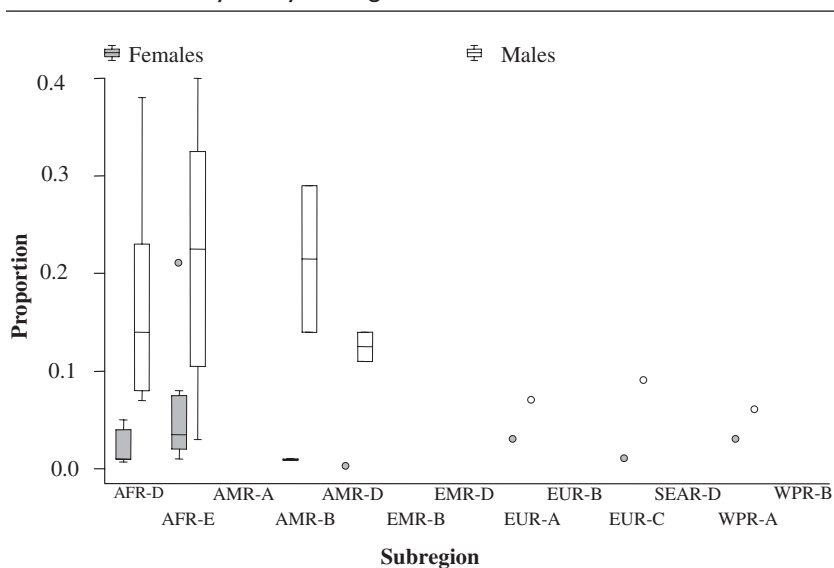
Marital status

Married people usually have sex more frequently than unmarried people. In most countries, being sexually active outside of a co-resident (cohabiting) relationship is associated with an increased incidence of HIV infection. Sex between co-resident partners usually carries a lower risk of infection than sex with other types of partner, so prevalence may be lower among married people. This may depend on how much extra-marital sex is taking place: the proportion of people who have sex outside marriage varies between countries (see Figure 14.5). In countries where HIV prevalence is high, the surviving partners of people who died of AIDS will tend to have a higher prevalence of HIV infection than the group of people who are still married. However, in some places being currently married has been shown to increase the risk of HIV infection. This may be because married people gain an additional sexual partner at the time of marriage (Auvert et al. 2001b) compared to their never-married peers. The increased frequency of (unprotected) sex within marriage may also increase the risk of HIV transmission.

Contraceptive method mix

Condoms may be used to prevent unwanted pregnancies but many couples choose to use non-barrier methods. In many cultures, condoms are not seen as appropriate for use within marriage or in a long-standing relationship. A pattern commonly seen in developed countries is that initial condom use with a new partner is followed by a switch to oral contraceptives after a few months, e.g. France (Commissariat Général du

Figure 14.5 The proportion of married men and women who report having had sex with someone other than their spouse in the last year, by subregion



Note: The figure shows the range of values, within a subregion, for the national estimates of the proportion of married people who report extramarital sex. The line across the middle of the box represents the median value, the box itself spans the interquartile range and the lines extend to the adjacent values at either end of the interquartile range (only shown where the adjacent values fall outside of this range). Data points which fall outside this range are plotted separately. There are no suitable data for AMR-A, EMR-B and EMR-D, EUR-B and SEAR-D.

Plan: Observatoire régional de santé d'Ile-de-France and Agence Nationale de Recherches sur le SIDA 2001). In some populations, negative attitudes towards condoms may lead to lower levels of use.

EXPOSURE

Prevalence of HIV

The proportion of people infected with HIV in the population is the main factor influencing the probability of having sex with somebody who is infectious for HIV.

Sexual mixing patterns

Partner selection would be described as completely assortative if people always chose partners who were similar to themselves in all the measured respects. However, the way in which people select their sexual partners is usually incompletely assortative, that is, people tend to choose partners who are similar to themselves in most, but not all respects. The

differences may be predictable and some mixing patterns can have significant influence over the spread of STIs. For example, age-mixing in sexual relationships (older men with young women) is thought to be an important factor in accelerating the spread of HIV (Anderson and May 1991).

Traditional STI epidemiology defines “core” and “non-core” groups. The incidence of infection is high in the core groups, and most transmission occurs within these groups. The core group is composed of people who have a large number of sexual contacts compared to the rest of the population. Core groups tend to be small, and as long as infection remains confined to these groups, the population prevalence will remain fairly low. Since mixing patterns are incompletely assortative with respect to frequency of partner change, there will be occasional contacts between members of the core group and the rest of the population. The people involved in these sorts of partnerships are known as “bridge” groups and provide the route by which an infection moves from the core group to the general population. An example of this would be married men who visit commercial sex workers: married men are mostly members of the non-core group, commercial sex workers are members of a core group and the subset of married men who visit the sex workers is the bridge group. Simple measures of partner change and proportions exposed in either group fail to capture variation in density of exposure which arises from non-random mixing (Anderson and Garnett 2000).

Number of partners

If condom use is not widespread in the population, then having a greater number of sexual partners means being exposed to a greater risk of infection. This is probably not a linear relationship because in many countries a disproportionate number of STIs occurs among the small group of people who have numerous partners. Most of the surveys listed in Table 14.3 found an increasing risk of infection (Auvert et al. 2001b; Chao et al. 1994; Hunter et al. 1994; Quigley et al. 1997; ter Meulen et al. 1992) and seroconversion (the detection of antibodies to HIV in a person who has not previously produced such antibodies, indicating recent infection with HIV) (Gray et al. 2000) associated with increasing numbers of partners. The reference periods were not the same in these surveys so it is not possible to compare the magnitude of the increased risk; this pattern was not clear in all studies. In the Masaka cohort in Uganda, the effect of the number of partners seemed to be modified by age. There was a greatly increased risk associated with having more partners for those aged <25 years, but no clear pattern among older people (Malamba et al. 1994). In the Four Cities study, women reporting a greater number of lifetime partners had a significantly increased risk of being infected with HIV in Kisumu (Kenya), Ndola (Zambia) and Yaoundé (Cameroon) but not in Cotonou (Benin) (Auvert et al. 2001b). Only in Ndola (Auvert et al. 2001b) was an increased chance of being HIV-positive observed among men reporting a higher number of lifetime partners.

In Uganda, a reduction in the number of partners does not appear to have been necessary for a decline in prevalence to occur (Asiimwe Okiror et al. 1997; Kamali et al. 2000). In Zambia, localized decreases in the prevalence of HIV among young women attending antenatal care clinics were observed between 1994 and 1998, and the proportion of people reporting large numbers of sexual partners in the same area in coincident general population behavioural surveys was also seen to decline (Fylkesnes et al. 2001).

Commercial sex

Contact with sex workers, a group that often has a high prevalence of HIV infection, seems mainly to be important outside of Africa. Commercial sex is difficult to define in a meaningful way across cultures because the exchange of money or gifts may generally accompany sex in some cultures, but this may not mean that the woman has a great many partners, or that she is demanding the payment in return for sex.

Duration of relationships

Sex within a relationship that has been established for a long time is thought to carry a lower risk of HIV infection than sex with a more recently acquired partner. Logically, this would only be the case if both the partners were mutually monogamous throughout the duration of the relationship. It may be that mutually monogamous partnerships last longer than others and that the observed association is a selection effect.

MEDIATING FACTORS

Male circumcision

In Africa, male circumcision is associated with a lower probability of male HIV infection (Auvert et al. 2001c; Gray et al. 2000; Hunter et al. 1994; Seed et al. 1995; Weiss et al. 2000). There is a plausible biological mechanism for this (Glynn et al. 2001; Royce et al. 1997), although its importance outside of Africa remains to be measured. It is also unclear whether a circumcised, infected man is less likely to transmit the infectious agent to a female partner than an uncircumcised man.

Sexually transmitted infections

HIV infection is likely to be associated with a history of infection with another STI because these agents share the same mode of transmission. Being infected with an STI indicates that a person has had a sexual contact which could also have led to HIV infection, if their partner was infectious for HIV. However, it has been found that, in addition to providing a marker for this type of contact (Obasi et al. 1999), the presence of another active disease increases the risk of both HIV transmission and infection (Mbopi Keou et al. 2000). In the studies summarized in Table 14.3, relevant information was collected for different diseases in differ-

ent ways. This is because the locally important STIs vary and the setting of the studies imposes restrictions on the information collected. However, in all the studies, having ever had another STI clearly increased the chance of being infected with HIV.

Condom use

The efficacy of condoms in preventing the transmission of HIV and other STIs has been established (Weller and Davis 2002). However, only one of the studies listed in Table 14.3 (a study carried out among men attending an STI clinic in India (Rodrigues et al. 1995) found a protective association between reported condom use and HIV infection. The reason for this may be that in African countries condom use is actually a marker for risky sex. That is, condoms are only used by those who (rightly) perceive themselves to be at risk of infection. In this case, condom use would only be protective if condoms were properly used at every risky encounter. Condom use would only be revealed as protective in a statistical analysis if this could be confined to those who indulge in risky sex, or if the propensity to have risky sex could be controlled for. If members of groups at a high risk of HIV infection were initially more likely to use condoms, a protective effect would only become apparent as condom use became more widespread in the general population. The availability and acceptability of other methods of contraception might affect the chances of a couple using a condom.

Sexual practices

Anal sex, both in homosexual male and in heterosexual couples, carries a higher risk of transmission than other practices. It has been suggested that drying the vagina before sex, and having sex during menses also increase the risk of HIV infection in women. However, this has not been clearly demonstrated (Auvert et al. 2001b; Buve et al. 2001a; Malamba et al. 1994).

SUSCEPTIBILITY

There is a high incidence of HIV infection among young women who have become sexually active at an early age. A partial explanation for this observation may be that young women are particularly vulnerable to HIV infection because the immaturity of the genital tract renders them physiologically susceptible. This is a complex issue, as demonstrated by the results of the Four Cities study, which showed that the high prevalence of HIV infection among young women was not fully explained by behavioural factors (Glynn et al. 2001).

In Europe, transmission from males to females has been observed to be more efficient than vice versa (Anonymous 1992) but this was not confirmed in Rakai (Uganda) (Quinn et al. 2000). This pattern of differential transmission probabilities between the sexes is inconsistent in the rest of the world (Mastro and Kitayaporn 1998).

3.2 CHOICE OF INDICATORS OF POTENTIALLY HAZARDOUS SEXUAL BEHAVIOURS

Sexual behaviour can be summarized by a variety of different measures and, as described above, many of these measures have been found to be associated with HIV infection. However, it is also clear that these associations are not found in all populations, nor are they consistent in direction and magnitude across those populations in which an association has been observed. The most appropriate indicators of potentially hazardous behaviour were judged to be those which have been associated with HIV infection in different settings, and which:

- are available and relevant for all age groups, both sexes and all subregions;
- describe an important aspect of behaviour in all subregions; and
- are associated with the risk of acquiring HIV infection, or with being already infected with HIV.

First, an empirical approach was used to identify this subset. Population-level estimates are available for many of these behavioural indicators and estimates of HIV prevalence are also available for many countries. However, it is well known that there is no simple relationship between observed HIV prevalence and reported sexual behaviours at the population level. In many African countries with generalized epidemics, the national prevalence estimates are based on fitting a mathematical model of the HIV epidemic to observed HIV prevalence data acquired from among women attending antenatal care clinics. An estimate of the model parameter representing the fraction of the population that is at risk of contracting HIV infection was extracted from the model and a regression analysis was conducted to examine the association between this estimate and various indicators of sexual behaviour. The model, known as the Epidemic Projection Package (EPP), is described in detail in section 4.

Estimates for the behavioural indicators were calculated for all countries with data, as described in Table 14.1. Suitable model fits were available for 16 countries, and a complete set of indicators and model fits were available for nine countries. Each country contributed an urban and a rural estimate, bringing the sample size for the regression analysis to 18.

All analyses were carried out in Stata version 7.0. Correlation coefficients were calculated for each combination of model parameter and behavioural indicator. The results of these correlations governed which behavioural indicators were included in a linear regression model. This model also included another parameter, which describes the force of infection, as an instrumental variable. It was not possible to quantify a relationship between the behavioural data and the model parameter using this method. The analysis was hampered by the small sample size

and the associations that did emerge as statistically significant were not easy to interpret. Some indicators whose effects would be expected to be similar (such as age at first sex and the proportion of the population who had ever had sex), when included in the same regression model produced opposing coefficients. A robust analysis would require a much larger sample size than was available, given the large number of behavioural indicators and the high degree of correlation between these indicators.

The failure of our work, and that of other groups, to find a suitable quantification suggests that there may be no single relationship between any one measure of sexual behaviour at the aggregate level and the incidence of HIV infection in the general population. Rather, data at the level of individuals and their partners before infection may be required. The choice of which indicators to present was therefore governed by which indicators were commonly found to be associated with HIV infection in observational studies and the measures recommended by UNAIDS (2000), even if the nature of the association with HIV infection was not clear.

3.3 PREVALENCE OF POTENTIALLY HAZARDOUS SEXUAL BEHAVIOURS

Different sexual behaviour patterns are summarized here by three measures: lifetable median age at first sex; mean number of sexual partners in the last year; and the proportion of adults in the subregion who have had sex with a non-co-resident partner within the year preceding the survey, and who did not use a condom the last time they had sex with this partner. All the indicators were calculated for individual countries and the subregional estimates were created by weighting these estimates by the total population size of the country relative to the subregion. The number of countries and sample size used for each estimate are given in Table 14.5.

No subregions were completely described and there were no data at all for some subregions. Values had to be estimated for the missing categories by extrapolation of the results from other subregions; this was based primarily on the values of the available estimates. If no estimates were available for a subregion, the values were extrapolated from the subregion with the most similar proportion of people currently married (Figure 14.6). Throughout the results, extrapolated estimates are shown in the shaded cells as explained in the footnotes of the tables.

MEDIAN AGE AT FIRST SEX

The median age at which people first had sex is presented in Table 14.6. This was calculated from the reported age at first sexual intercourse, or current age for people who have not yet had sex. Lifetable techniques were used to calculate this measure to allow for the inclusion of those people who had not yet had sex. The age of sexual debut is important because it affects the duration of exposure to STIs. There is evidence that

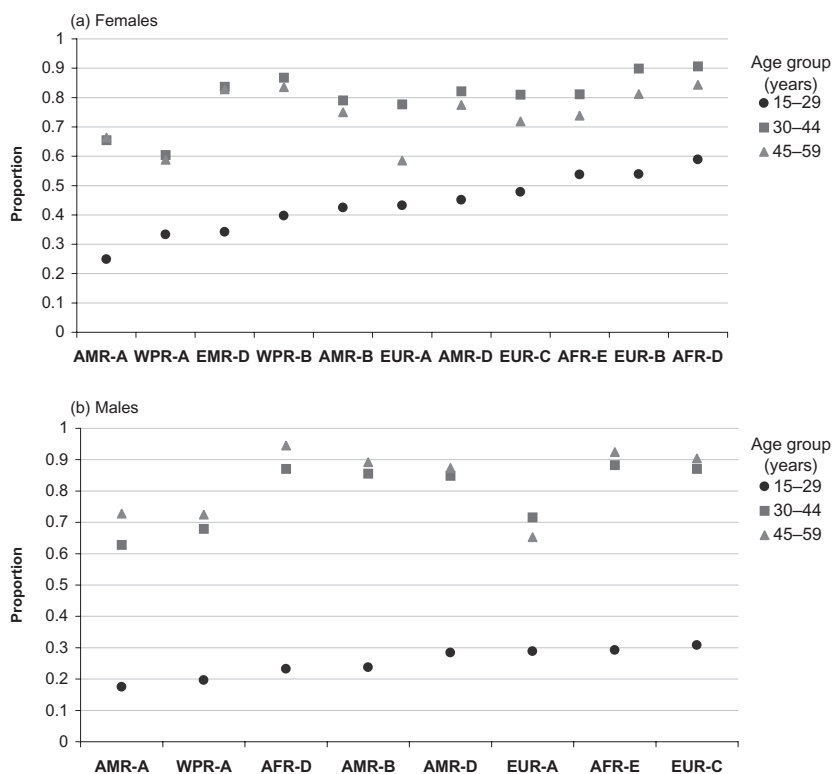
| Subregion ^a | Condom use last higher-risk sex | | | | | | Number of partners | | | | | | Age at first sex | | | | | | |
|------------------------|---------------------------------|-------|-------|-------|-------|-------|--------------------|--------|-------|--------|-------|-------|------------------|--------|-------|--------|--------|-------|--------------------------|
| | Females | | | Males | | | Females | | | Males | | | Females | | | Males | | | |
| | 15-29 | 30-44 | 45-59 | 15-29 | 30-44 | 45-59 | 15-29 | 30-44 | 45-59 | 15-29 | 30-44 | 45-59 | 15-29 | 30-44 | 45-59 | 15-29 | 30-44 | 45-59 | N countries ^b |
| AFR-D | 3 942 | 999 | 102 | 4 308 | 1 568 | 365 | 23 842 | 14 041 | 3 037 | 11 758 | 7 151 | 3 911 | 43 507 | 26 158 | 5 465 | 16 377 | 10 519 | 6 057 | 26 |
| | 7 | 7 | 5 | 8 | 8 | 8 | 6 | 6 | 6 | 9 | 9 | 9 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| AFR-E | 4 317 | 1 414 | 220 | 4 178 | 1 205 | 315 | 29 204 | 15 020 | 3 239 | 11 140 | 6 101 | 2 948 | 50 776 | 27 047 | 5 581 | 13 371 | 7 502 | 3 516 | 20 |
| | 7 | 7 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 10 | 10 | 10 | 10 | 7 | 7 | 7 |
| AMR-B | 1 762 | 863 | 120 | 2 571 | 786 | 312 | 11 354 | 8 766 | 2 183 | 2 661 | 1 856 | 950 | 20 490 | 14 588 | 3 309 | 6 582 | 4 216 | 2 347 | 26 |
| | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 4 | 4 | 4 | 4 | 2 | 2 | 2 |
| AMR-D | 680 | 282 | 32 | 600 | 221 | 91 | 14 619 | 10 665 | 2 513 | 1 149 | 814 | 429 | 35 317 | 23 360 | 5 192 | 3 770 | 2 546 | 1 427 | 6 |
| | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 5 | 5 | 5 | 2 | 2 | 2 | 2 |
| EUR-A | 806 | 363 | — | 1 200 | 419 | — | 5 047 | 5 601 | 689 | 5 305 | 5 659 | 731 | 5 903 | 6 796 | 683 | 4 642 | 5 487 | 668 | 26 |
| | 1 | 1 | — | 1 | 1 | — | 10 | 10 | 8 | 10 | 10 | 8 | 6 | 6 | 5 | 6 | 6 | 5 | 5 |
| EUR-B | — | — | — | — | — | — | — | — | — | — | — | — | 4 389 | 3 226 | 643 | 836 | 2 108 | 868 | 16 |
| | — | — | — | — | — | — | — | — | — | — | — | — | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| EUR-C | 240 | 196 | 30 | 237 | 108 | 21 | 2 151 | 2 130 | 522 | 573 | 555 | 291 | 2 097 | 2 043 | 515 | 578 | 570 | 290 | 9 |
| | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| SEAR-B | — | — | — | — | — | — | 789 | 739 | 147 | 546 | 498 | 82 | 11 558 | 15 300 | 3 603 | 546 | 498 | 82 | 3 |
| | — | — | — | — | — | — | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| SEAR-D | — | — | — | — | — | — | — | — | — | — | — | — | 4 091 | 3 177 | 700 | — | — | — | 7 |
| | — | — | — | — | — | — | — | — | — | — | — | — | 1 | 1 | 1 | — | — | — | — |
| WPR-A | 26 | 11 | 10 | 35 | 23 | 9 | 144 | 297 | 231 | 120 | 262 | 206 | 171 | 309 | 249 | 675 | 640 | 321 | 5 |
| | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| WPR-B | — | — | — | — | — | — | — | — | — | — | — | — | 7 333 | 5 380 | 1 199 | — | — | — | 22 |
| | — | — | — | — | — | — | — | — | — | — | — | — | 1 | 1 | 1 | — | — | — | — |

— No data.

^a Upper number for each subregion refers to number of people, lower number refers to number of countries from which data were available.

^b Total number of countries in the subregion.

Figure 14.6 The proportion of people who are currently married, by age and subregion



Note: The lowest proportion of older women who are currently married is found in EUR-A, despite the fact that EUR-A falls in the middle of the range for the two younger age groups. This could be due to a larger proportion of women who never marry, or a higher incidence of marital dissolution in this subregion compared to the others.

young women are more susceptible to HIV infection and that people who start to have sex at a younger age may have more risky behaviour over a lifetime than those who delay the first time they have sex. Values for AMR-A were extrapolated from Australia and New Zealand. These values were used instead of those for the WPR-A subregion as a whole because the latter subregion is very heterogeneous and AMR-A is very similar to Australia and New Zealand for the other indicators, where there are data. The values for the EMR-B and EMR-D were extrapolated from EUR-C.

Table 14.6 The median age at first sex: lifetable estimates

| Subregion | Females | | | Males | | |
|-----------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| | 15–29 | 30–44 | 45–59 | 15–29 | 30–44 | 45–59 |
| AFR-D | 17.3 | 16.5 | 17.1 | 19.7 | 19.4 | 20.3 |
| AFR-E | 17.5 | 16.2 | 15.9 | 18.9 | 18.2 | 19.3 |
| AMR-A | 17.5 | 17.5 | 19.5 | 17.5 | 17.5 | 18.5 |
| AMR-B | 18.6 | 19.5 | 20.2 | 16.5 | 16.5 | 16.5 |
| AMR-D | 19.4 | 18.4 | 18.4 | 17.5 | 18.0 | 18.5 |
| EMR-B | 20.5 | 20.5 | 20.5 | 18.5 | 19.5 | 19.5 |
| EMR-D | 20.5 | 20.5 | 20.5 | 18.5 | 19.5 | 19.5 |
| EUR-A | 18.5 | 18.6 | 20.5 | 17.8 | 17.8 | 18.3 |
| EUR-B | 19.5 | 19.7 | 20.3 | 20.3 ^c | 20.8 ^c | 21.3 ^c |
| EUR-C | 20.5 | 20.5 | 20.5 | 18.5 | 19.5 | 19.5 |
| SEAR-B | 19.16 ^a | 19.0 ^a | 18.2 ^a | 18.5 | 18.5 | 20.5 |
| SEAR-D | 16.5 ^b | 16.5 ^b | 15.5 ^b | 18.5 | 18.5 | 20.5 |
| WPR-A | 18.8 | 18.8 | 20.1 | 19.0 | 19.0 | 19.6 |
| WPR-B | 23.5 | 21.5 | 21.5 | 20.9 | 20.13 | 19.1 |

^a Estimate includes the results of an Indonesian survey of ever-married women.

^b Estimate based on DHS of ever-married Nepalese women.

^c Estimate calculated from published medians reported for Polish men in different age groups, only that for men aged 30–44 years is complete.

Note: Extrapolated estimates are given in the shaded cells.

SEX WITH NON-CO-RESIDENT PARTNERS

The proportion of all people who report having had sex within the last year, with a partner with whom they do not live, and who did not use a condom the last time they had sex with that partner is perhaps the closest measure of unsafe sex that it is feasible to calculate and is our working definition of risky sex. Sex outside of a cohabiting (co-resident) partnership (within the last year) without using a condom is thought to carry a greater risk of HIV infection than marital sex. As shown in Table 14.7, there are striking variations in the levels of this indicator across the subregions, but they do not follow the pattern of HIV prevalence.

MEAN NUMBER OF PARTNERS DURING THE LAST YEAR

Table 14.8 shows the mean number of sexual partners in the preceding year in the adult population (aged 15–59 years), regardless of the relationship to any of the partners. Again, there are clear differences between the subregions.

Table 14.7 The proportion of the adult population (aged 15–59 years) who report having had sex with a non-co-resident partner in the last year, without using a condom on the last occasion

| Subregion | Females | | | Males | | |
|-----------|---------|-------|--------------------|-------|-------|-------|
| | 15–29 | 30–44 | 45–59 ^a | 15–29 | 30–44 | 45–59 |
| AFR-D | 0.116 | 0.061 | 0.049 | 0.239 | 0.161 | 0.090 |
| AFR-E | 0.108 | 0.075 | 0.067 | 0.230 | 0.111 | 0.094 |
| AMR-A | 0.070 | 0.040 | 0.030 | 0.090 | 0.090 | 0.070 |
| AMR-B | 0.110 | 0.057 | 0.055 | 0.218 | 0.120 | 0.122 |
| AMR-D | 0.016 | 0.013 | 0.005 | 0.289 | 0.140 | 0.117 |
| EMR-B | 0.073 | 0.078 | 0.055 | 0.216 | 0.099 | 0.099 |
| EMR-D | 0.073 | 0.078 | 0.055 | 0.216 | 0.099 | 0.099 |
| EUR-A | 0.212 | 0.074 | 0.074 | 0.267 | 0.119 | 0.119 |
| EUR-B | 0.073 | 0.078 | 0.055 | 0.216 | 0.099 | 0.099 |
| EUR-C | 0.073 | 0.078 | 0.055 | 0.140 | 0.087 | 0.048 |
| SEAR-B | 0.116 | 0.061 | 0.049 | 0.239 | 0.161 | 0.090 |
| SEAR-D | 0.116 | 0.061 | 0.049 | 0.239 | 0.161 | 0.090 |
| WPR-A | 0.068 | 0.043 | 0.025 | 0.091 | 0.087 | 0.066 |
| WPR-B | 0.068 | 0.043 | 0.025 | 0.091 | 0.087 | 0.066 |

^a It was assumed that survey data for women aged 15–49 years applied to women aged 15–59 years.

Note: Extrapolated estimates are given in the shaded cells.

4. RISK FACTOR–DISEASE RELATIONSHIP

4.1 HIV

HIV infection is known to be sexually transmitted. Some sexual practices with an HIV-positive partner carry a greater risk of infection than others. In some populations, there are groups of people who can be identified as having a greater likelihood of being infected with HIV. The factors that govern whether a susceptible person chooses one of these people at a higher risk of being infected as a sexual partner will influence their own risk of infection. Sexual behaviour and its determinants are not easy to measure, and can vary in several dimensions, all of which may be pertinent for HIV transmission.

It is hard to model the impact of changes in exposure for an infectious disease with person-to-person transmission because the risk associated with exposure will change with changes in the prevalence of the infection. A sexual contact is only an exposure if one partner is infected with HIV and the other is not, and the likelihood of this occurring will change as the prevalence of infection changes. The social perception of risk may feedback to behaviour and further contribute to change. There-

Table 14.8 The mean number of sexual partners in the last year reported by the adult population (aged 15–59 years)

| Subregion | Females | | | Males | | |
|-----------|---------|-------|--------------------|-------|-------|-------|
| | 15–29 | 30–44 | 45–59 ^a | 15–29 | 30–44 | 45–59 |
| AFR-D | 0.679 | 0.764 | 0.738 | 1.106 | 1.336 | 1.097 |
| AFR-E | 0.729 | 0.928 | 0.809 | 0.923 | 1.132 | 1.040 |
| AMR-A | 1.433 | 1.104 | 0.834 | 1.797 | 1.421 | 1.116 |
| AMR-B | 0.643 | 0.915 | 0.826 | 1.276 | 1.316 | 1.154 |
| AMR-D | 0.492 | 0.849 | 0.742 | 1.413 | 1.629 | 1.235 |
| EMR-B | 0.576 | 0.915 | 0.774 | 1.125 | 1.153 | 1.010 |
| EMR-D | 0.576 | 0.915 | 0.774 | 1.125 | 1.153 | 1.010 |
| EUR-A | 1.248 | 0.987 | 0.912 | 1.378 | 1.134 | 1.130 |
| EUR-B | 0.576 | 0.915 | 0.774 | 1.125 | 1.153 | 1.010 |
| EUR-C | 0.576 | 0.915 | 0.774 | 1.125 | 1.153 | 1.010 |
| SEAR-B | 0.649 | 0.842 | 0.755 | 4.007 | 1.941 | 1.469 |
| SEAR-D | 0.649 | 0.842 | 0.755 | 4.007 | 1.941 | 1.469 |
| WPR-A | 1.236 | 1.077 | 0.900 | 1.792 | 1.229 | 1.039 |
| WPR-B | 1.236 | 1.077 | 0.900 | 1.792 | 1.229 | 1.039 |

^a It was assumed that survey data for women aged 15–49 years applied to women aged 15–59 years.

Base: All respondents.

Note: Extrapolated estimates are given in the shaded cells.

fore a relative risk measured for a particular population at a particular point in time is meaningless for another place or point in time, unless the overall prevalence, the epidemic maturity and the degree to which infected and susceptible people mix are almost identical.

An alternative way to predict the future prevalence of an infection which is transmitted from person to person is to use a recursive mathematical projection model to account for the increase in incidence caused by the increase in the number of prevalent cases. Simpler approaches, based on a static risk of infection, will not adequately capture the dynamics of infection over a period of time if prevalence is high, because the risk of infection will change as the prevalence of infection changes.

If prevalence is low, a simpler approach can be justified because the error introduced in the estimates of the number of new infections by ignoring changes in prevalence is much smaller. The size of the error that results from using an approach based on a static level of risk in a high-prevalence situation will depend on the prevalence of the infection, the speed at which prevalence changes and the period of time considered. To illustrate the scale of errors introduced by ignoring the nonlinearities of epidemic dynamics, we note that in a population with an

HIV prevalence of 20%, with a concurrent infection rate among HIV-negative people of approximately 3.5% per year, over a five-year period the prevalence could increase by 2% or fall by 3% without any changes occurring in risk behaviour, but depending on the maturity of the epidemic at the time when the HIV prevalence of 20% was reached. Currently, UNAIDS estimates that the prevalence of HIV in nine African countries is in the order of $\geq 20\%$ among women attending antenatal clinics in urban areas (and in four countries the prevalence of HIV is $> 20\%$ among women attending clinics in rural areas) (UNAIDS/WHO 2002). The estimates of avoidable infections presented here are for a five-year period. To determine the range of probable outcomes, it is essential that a suitable mathematical model be used to derive estimates of new infections for these subregions, both for the “business-as-usual” scenario, and to estimate what may happen under the different counterfactual scenarios.

METHODS FOR ESTIMATING HIV PREVALENCE OVER A PERIOD OF TIME

UNAIDS/WHO make country-specific estimates and projections of HIV infection worldwide and the UNAIDS Epidemiology Reference Group has developed a model to make projections of HIV prevalence. The model has been implemented in a program known as the Epidemic Projection Package (EPP) (The UNAIDS Reference Group on Estimates Modelling and Projections 2002). EPP is designed to represent the evolution of generalized epidemics and so its use for prediction is confined to countries in which generalized epidemics have developed. In this chapter, EPP was used to calculate estimates for the two African subregions (AFR-D and AFR-E) (Table 14.9).

Reasons for using the EPP model

There are a number of models which could have been used for the CRA, but the EPP model, currently used by UNAIDS, was deemed to be the most appropriate. The other available models include deterministic models, such as AVERT (Rehle et al. 1998), but most of these make no allowance for behaviour change. The GOALS model (<http://www.futuresgroup.com>), developed by WHO and the Futures Group models the impact of interventions concerning behavioural change, primarily from a programme manager’s or policy-maker’s perspective, with the focus on the cost-effectiveness of different interventions. This model requires a much larger amount of input data than EPP and is not appropriate for longer-term projections. Most of the models designed to explore the effects of different interventions are more complex than EPP. Additional assumptions (such as profiles of commercial sex work) would have been needed for such models to be used, as sufficient data are not always available.

Table 14.9 Countries for which an EPP model fit is available

| <i>Country</i> | <i>EPP fit available</i> | <i>Country</i> | <i>EPP fit available</i> |
|-----------------------|--------------------------|----------------------------------|--------------------------|
| <i>AFR-D</i> | | <i>AFR-E</i> | |
| Algeria | — | Botswana | ✓ |
| Angola | ✓ | Burundi | ✓ |
| Benin | ✓ | Central African Republic | ✓ |
| Burkina Faso | ✓ | Congo | ✓ |
| Cameroon | ✓ | Côte d'Ivoire | ✓ |
| Cape Verde | — | Democratic Republic of the Congo | ✓ |
| Chad | ✓ | Eritrea | — |
| Comoros | — | Ethiopia | ✓ |
| Equatorial Guinea | ✓ | Kenya | ✓ |
| Gabon | ✓ | Lesotho | ✓ |
| Gambia | ✓ | Malawi | ✓ |
| Ghana | — | Mozambique | ✓ |
| Guinea | ✓ | Namibia | ✓ |
| Guinea-Bissau | ✓ | Rwanda | ✓ |
| Liberia | — | South Africa | ✓ |
| Madagascar | — | Swaziland | ✓ |
| Mali | ✓ | Uganda | ✓ |
| Mauritania | — | United Republic of Tanzania | ✓ |
| Mauritius | — | Zambia | ✓ |
| Niger | ✓ | Zimbabwe | ✓ |
| Nigeria | ✓ | | |
| Sao Tome and Principe | — | | |
| Senegal | ✓ | | |
| Seychelles | — | | |
| Sierra Leone | ✓ | | |
| Togo | ✓ | | |

✓ Available.

— Not available (insufficient data points to fit the model; no generalized epidemic in the smaller countries).

Stochastic models are also available, the prime example being STDSIM (Korenromp et al. 2000; van der Ploeg et al. 1998), which is a complex model requiring detailed specification of a range of demographic, biological and behavioural inputs. STDSIM is designed to closely model the HIV epidemic in small communities and would not have been suitable for use at the international level, despite the fact that it does explicitly model changes in behaviour. A limitation of all sto-

chastic models is the need for repeated runs to ensure reasonably stable results. To run a stochastic model for the countries with sufficient data in all regions of the world would have taken a prohibitive amount of time.

Structure of the EPP model

The mathematical model used is fully described elsewhere (The UNAIDS Reference Group on Estimates Modelling and Projections 2002; UNAIDS Epidemiology Reference Group 2001), but is summarized below using a slightly simplified notation. EPP models both epidemiology, with a feedback loop from prevalence to incidence, and demography, with competing mortality risks and population renewal. This is important because AIDS mortality is a significant factor in the course of the epidemic. The model was deliberately kept simple to allow projections to be based on real data. The model is not subdivided by either age or sex.

Figure 14.7 shows how the model divides a population into three groups (infected, susceptible and at-risk, and susceptible and not-at-risk), and how people can move between these groups over time.

People enter either the at-risk or not-at-risk group on their 15th birthday. Exit from the not-at-risk group is by death from a non-AIDS-related cause. Exit from the at-risk group is either through a non-AIDS-related death or by becoming infected with HIV and moving to the infected group.

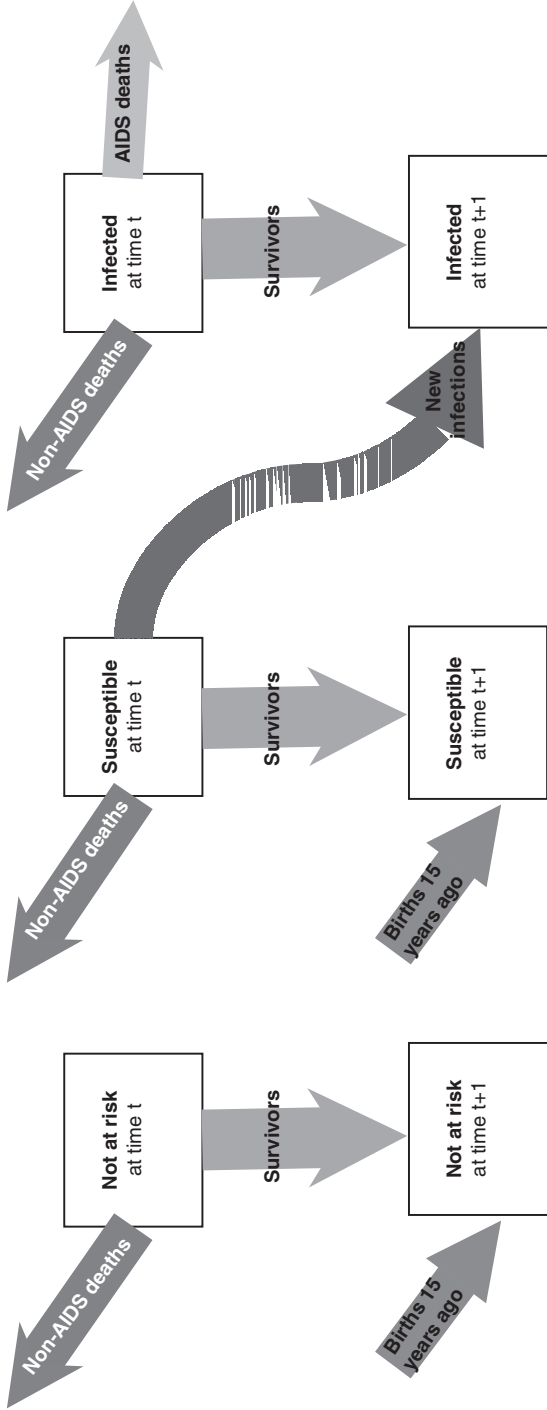
Entry to the population at age 15 years occurs at a constant rate, based on birth rates and rates of survival to age 15 years observed in the population being modelled. Adjustment is made for the impaired fertility of women infected by HIV and for the vertical transmission of HIV. HIV-infected children are assumed not to survive to age 15 years. Death rates from causes unrelated to HIV infection are assumed to be constant. Deaths resulting from AIDS are governed by a mortality function based on a Weibull distribution, which gives survival times after HIV infection. The Weibull survival function is based on data from observational studies in Uganda and the median survival time is compatible with data from Haiti, Thailand and Uganda.

The EPP model is controlled by four main epidemiological parameters:

| | |
|--------------|---|
| t_0 | The start year for the epidemic |
| s_0 | The initial proportion susceptible |
| r | Proportionality constant of the force of infection |
| ϕ (phi) | The relative recruitment rate into the susceptible category |

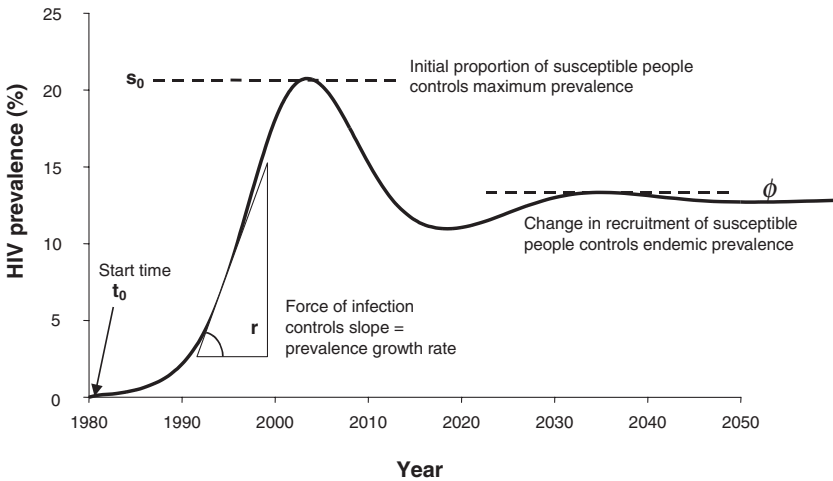
These parameters interact, but their main influence is exercised on the shape and location of different parts of the epidemic curve. These effects are shown in Figure 14.8.

Figure 14.7 Flow of people through the EPP model



Note: Birth and death rates are constant, determined by demographic and epidemiological measurement.
New infection rate varies; it = constant transmissibility factor x probability that partner is HIV+.
Probability that partner is HIV+ = infected / (not-at-risk + susceptible + infected) = prevalence.

Figure 14.8 The effects on HIV prevalence of changes in the main epidemiological parameters in the EPP model



The main demographic parameters governing the model are:

| | | |
|-----------|---------|--|
| m | | Modal survival age after HIV infection (Weibull level parameter) |
| k | | Shape parameter for Weibull survival function |
| μ | (mu) | Adult mortality rate from non-HIV related causes |
| λ | (lamda) | Proportion of non-infected children surviving to age 15 years |
| ν | (nu) | Vertical transmission proportion |
| β | (beta) | Birth rate for the adult population |
| δ | (delta) | Low fertility adjustment for HIV-positive adults |

In the mathematical exposition below, the following variables are also used, but as they are either derived from the formal parameters listed above, or treated as constants in the normal use of the model, they are not regarded as formal parameters. These are defined below.

Auxiliary constants:

| | | |
|------------|-----------|---|
| Δ | (Delta) | Time increment for differential equations |
| ϵ | (epsilon) | Initial exogenous force of infection |

Endogenous variables, dependent on formal parameters:

| | | |
|-------------|---------|--|
| $\theta(t)$ | (theta) | Force of infection between susceptible and infected, at contact time t |
| $\sigma(x)$ | (sigma) | Proportion of infecteds surviving x years after infection |

Finally, the numbers and proportions of not-at-risk, susceptible and infected persons at time t are denoted as shown below:

| Number | | Proportion | |
|--------|----------------------------------|------------|------------------------------------|
| $N(t)$ | Not-at-risk population | n_t | Not-at-risk proportion |
| $S(t)$ | Susceptible population | s_t | Susceptible proportion |
| $I(t)$ | Infected population | i_t | Infected proportion = prevalence |
| $P(t)$ | Total population | | |
| $F(t)$ | 15-year olds entering population | f_t | 15-year-old proportion susceptible |
| | | $1 - f_t$ | 15-year-old proportion not-at-risk |

The dynamics of the system are given by the following equations. The number of people aged 15 years entering the adult population at time t is the number of uninfected children born 15 years ago multiplied by the probability of surviving to age 15.

$$F(t) = \lambda\beta[N(t-15) + S(t-15) + (1-\nu)\delta I(t-15)]$$

The proportion of susceptible people entering the population at time t is a function of the overall current proportion of the adult population that is not at risk, governed by the formal parameters f and s_0 , the initial proportion of susceptible people.

$$f_t = f(n_t) = \frac{\exp(\phi[n_t - 1 + s_0])}{\exp(\phi[n_t - 1 + s_0]) - 1 + 1/s_0}$$

Note that since at time zero there are no infected persons, $1 - n_0 = s_0$, so for any value of ϕ , $f_0 = s_0$. Similarly, if $\phi = 0$, then the proportion of susceptible 15-year olds is the same as the initial proportion of those who are susceptible at all times, $f_t = s_0$. If $\phi < 0$, recruitment to the susceptible group declines over time; if $\phi > 0$, recruitment increases.

The Weibull function gives the proportion of those infected surviving x years after infection.

$$\sigma(x) = \exp(-\mu x - [x/m]^k)$$

The force of infection at the t is given by:

$$\begin{aligned} \theta(t) &= \varepsilon & \text{for } t = 0 \\ \theta(t) &= r \cdot i_t & \text{for } t > 0 \end{aligned}$$

Having defined these variable components, it is now possible to formulate the change-of-state equations governing transitions between the population classes.

$$\begin{aligned}\frac{\Delta N(t)}{\Delta t} &= (1 - f_i)F(t) - \mu N(t) \\ \frac{\Delta S(t)}{\Delta t} &= f_i F(t) - [\theta(t) + \mu]S(t) \\ I(t) &= \int_{x=0}^t \theta(x)S(x)\sigma(t-x)dx\end{aligned}$$

The last of these equations is presented as an integral equation rather than a differential, because this is the easiest way to express the fact that the infected population consists of survivors who were infected at a range of times in the past.

Fitting the EPP model to surveillance data

The four epidemiological parameters (t_0 , s_0 , r and ϕ) were fitted to prevalence data from antenatal clinic surveillance using maximum likelihood fitting. The model was fitted twice for each country, once for the clinics in urban areas and once for those in rural areas.

Alternative implementation of EPP model

The EPP package is designed for use by national AIDS programme managers, to help validate the UNAIDS estimates and projections. Not all the underlying calculations and parameter estimates that are needed for this chapter are the outputs of the standard EPP package, which makes the epidemic scenarios defined by the counterfactual assumptions difficult to create. Therefore, an alternative implementation of the same mathematical model was created as a spreadsheet using the Microsoft Excel program.

CURRENT LEVELS AND PROJECTIONS OF HIV PREVALENCE

Subregions with a high prevalence of HIV

Estimates of the current levels of HIV infection and projections of future levels are necessary to be able to calculate the proportion of these infections that is attributable to unsafe sex and thus the proportion that is potentially avoidable.

The current estimates and projections of HIV prevalence in the African subregions (under the baseline scenario of no behaviour change) were based on fits of the EPP model to antenatal clinic surveillance data. These projections were prepared by UNAIDS/WHO. The parameter estimates from these model fits were used in the spreadsheet version of the model to calculate the future prevalence, incidence and number of infections for each of the countries concerned. Subregional estimates were created by combining these estimates, weighted by the total population of each country. Weighted estimates were used because the EPP model could not be fitted for those countries with insufficient data on prevalence (11

countries). It is important to note the time scales used in making the model-based estimates. The last available prevalence estimate generally exerts more leverage on the fitted curve than do other points, and a more robust fit is generally obtained when more data points are used. Therefore prevalence estimates for 2001 were included where available and 2001 was taken as the base year for all projections. The projections of avoidable infections extend until 2006 because the model is designed to give reasonably accurate short-term predictions over a five-year period.

Other subregions

For the 146 countries in which the prevalence of HIV/AIDS is low, a different approach was used to model the epidemic. For countries with epidemics that are concentrated in groups with higher-risk behaviour (e.g. men who have sex with men; injecting drug users, sex workers and their clients), a three-step process was followed to produce the current estimates (for the end of 2001) of HIV/AIDS prevalence. First, for each country, groups at the highest risk of acquiring HIV/AIDS were identified and estimates of the size of these groups were made. Next, estimates of point prevalence were made by applying the most recent prevalence rates for these groups to the populations. Finally, prevalence in populations at a lower risk of infection was estimated by allowing for transmission from high to low groups via sexual mixing. This estimate was made in one of the following ways. For countries with data from pregnant women, an adjusted prevalence rate from this group was applied to the number of women of reproductive age (aged 15–49 years) to produce an estimate of the number of women infected via sex with a partner from a group at an increased risk of being infected with HIV. Alternatively, for some countries where the epidemic was more recent and there were no data for populations at a lower risk, assumptions were about the number of infected people at a higher risk who had sexual partners with no other risk of infection. A transmission probability was then applied to produce an estimate of the number of women infected via sex with a partner from a group at a higher risk of being infected with HIV.

Projections of the extent of these epidemics up until 2006 were based on assumptions about saturation levels for each of the groups at a higher risk of infection, the time to saturation, and the spread over time from populations with a high risk to populations with a low risk of being infected with HIV.

For these same 146 countries (excluding countries with a generalized epidemic where EPP was used), trends in prevalence of HIV among groups at a high risk of infection were compiled and compared. Saturation levels for each risk group and time to reach saturation were determined by reviewing available data from countries in the subregion. The particular level of, and time to, saturation were applied to the risk groups

in each country based on current level of prevalence and rate of increase in the groups, and by comparison with saturation levels and rates in neighbouring countries.

Using this approach, we projected low growth for countries with long-running and relatively stable epidemics (e.g. Brazil, Myanmar, the United Kingdom). For countries with recent epidemics, but rapid rates of growth, the projections show much higher rates of increase (e.g. China, Estonia). For all of these countries, we assumed that there was no general heterosexual transmission except from individuals in groups at a higher risk of infection to their lower-risk sexual partners. These procedures, which have been previously described, gave us projections of adult HIV prevalence over time (Stover et al. 2002).

Estimates of incidence were made by using assumptions about survival (median adult survival for those without highly active antiretroviral therapy—HAART—was nine years), growth of populations and levels of accessibility to treatment with HAART. The specific assumptions and procedures used to translate prevalence into estimates of incidence and mortality have been described in detail elsewhere (Stover et al. 2002; The UNAIDS Reference Group on Estimates Modelling and Projections 2002; Walker et al. 2003).

ATTRIBUTABLE INFECTIONS AND DISEASE BURDEN

In most subregions, some data were available on the probable mode of transmission for at least a sample of prevalent infections. These data have been used to estimate how many infections were sexually acquired in each subregion. The estimated burden due to unsafe medical injections and blood transfusions was taken from chapter 22 and from a WHO/UNAIDS review of blood safety. To calculate the proportion of infections that results from unsafe sex, the numbers of all people who, according to the model, were infected via unsafe blood transfusions, unsafe medical injections (based on the subregional level estimates) or due to injected drug use (based on country-level estimates) were combined to form the group infected via non-sexual transmission. The number of infections remaining, i.e. those acquired via sexual contact (either heterosexual or homosexual), was divided by the total number of infections to give the percentage of infections due to unsafe sex.

However, to estimate how many of the HIV infections prevalent in 2001 were truly attributable to unsafe sex, it is not enough to simply calculate how many infections arose from unsafe sex at a particular point in time. The burden of infections which result from unsafe sex is determined by the total number of cases of sexually transmitted HIV infection that have arisen since the beginning of the epidemic. In countries with low-level epidemics, estimates of attributable infections based on the mode of transmission of prevalent cases and estimates which account for the effects of past sexual transmission will be broadly similar. In

countries where prevalence is high, there will be a greater discrepancy between the two estimates. We calculated additional estimates for countries with a high prevalence by re-running the EPP model using the fitted value of the s_0 parameter (the initial proportion at risk) reduced to 5% of its original value. This value was used because it is estimated that 5% of HIV transmission is due to unsafe injections and blood transfusion in these countries (all in the WHO African Region). This estimate is based on the probable mode of transmission for existing infections. Estimates of HIV prevalence based on this reduced value of s_0 demonstrate what might have happened had there never been any sexual transmission in these populations. The difference in the number of infected persons estimated in 2001 and the number predicted by the model for 2001, under the altered circumstances, was taken to be the number of infections which were attributable to sexual transmission (see Table 14.12). The results shown for the two African subregions correspond to attributable burden, as defined by the CRA methodology. The results presented in Table 14.12 for the other subregions are an approximation of attributable burden, based only on the exposure of prevalent cases. To obtain better estimates of attributable burden in these subregions, we would need information on the patterns of sexual mixing between the groups at a high risk of infection and the general population for the duration of the epidemic.

The fraction of infections attributable to unsafe sex was applied to the mortality and disease burden (Table 14.13). Prevalent HIV infections are the result of episodes of HIV transmission which occurred over the 15 or so years before measurement. Prevalent AIDS cases and recent deaths will be, on average, the product of transmission patterns from approximately 10 years before measurement (in populations where there is no treatment for AIDS). The estimates for the non-African subregions are based on the assumption that the ratio of sexual to non-sexual transmission has not changed significantly over that time. The model-based estimate for Africa accounts for this possibility. If the ratio of sexual to non-sexual transmission has changed significantly over time, the estimates of attributable disease burden based on the current ratio may be inaccurate.

AVOIDABLE INFECTIONS

The counterfactual exposure scenarios

As described earlier, it was not possible to measure relationships between specific behaviours and the risk of acquiring HIV infection in a way that could be generalized to all populations. It may be that consistent relationships of this sort do not exist. Therefore counterfactual exposure scenarios cannot be defined in terms relating to measurable changes in behaviour. Predicting changes based on hypothetical scenarios, which are

not linked to a particular group of behaviours but to corresponding model parameters, is the best possible method for estimating how many future infections are potentially avoidable.

The counterfactuals were defined in a way that could be applied in subregions with both low and high prevalence. The counterfactual scenarios selected relate to decreases in the number of people having unsafe sex as represented by model parameters. The scenarios were chosen to provide a range of estimates based on proportional changes in the size of the at-risk group. The counterfactuals were operationalized differently for countries with low and high prevalence because the methods used to project future HIV prevalence in the two situations require different inputs. Three levels of reduction in unsafe sex were used in the calculation of the avoidable proportion of future infections: 100%, 50% and 10%. These levels were achieved by estimating what would happen if all, 50% or 10% of the people who were having unsafe sex immediately ceased doing so. In theory, the intermediate counterfactual scenarios (50% and 10% reductions) could have been engineered to describe a situation in which those who were having unsafe sex reduced the amount of unsafe sex that they were having. The net effect would be the same because the approach is based on person-time at risk, and assumes that length of exposure is proportional to risk of infection.

Reversibility

Infection with any of these STIs need only occur once to produce disease. Therefore removing exposure to the STI will automatically reduce the risk of infection with immediate effect and this is demonstrated by the results of the HIV prevalence projections under the different counterfactual scenarios. However, in reality it is unlikely that all exposure could be removed and the spread of infection reversed at a particular point in time. Infectious people will remain in the population even if all risky behaviour ceases. Unless every person with an infection (married and unmarried alike) stopped having sex without a condom (i.e. if there was no unsafe sex) they would continue to infect new people. This is the reason for considering counterfactual scenarios that include partial reduction in unsafe sex, as described above.

Countries with a high prevalence of HIV infection

It is possible to define counterfactuals in terms of changes in the size of the EPP model's at-risk group for the countries in the two African subregions. Reductions were made to the size of this group at the start of 2001, first by moving a specified fraction of the at-risk group to the not-at-risk group, and second, by slowing recruitment to the at-risk group by the same amount. Three reductions in the original size of the at-risk group were made: 10%, 50% and 95%. The greatest reduction (resulting from total cessation of unsafe sex) thus resulted in only 5% of the

original at-risk group remaining at risk after 2001 and recruitment to this group was cut to 5% of its former level. The size of this group was not reduced to zero because a certain fraction of HIV-infected people will continue to contract their infection through a non-sexual mode of transmission in a non-generalized epidemic. This proportion is estimated to be 5% of infections in sub-Saharan Africa. While some people will contract their infection in one way, and transmit it in another, the degree to which this happens cannot be estimated for this work.

The ratio of sexual vs non-sexual transmission among those already infected is known, but the ratio of sexual vs non-sexual exposure among the uninfected is not. Implicit in the use of a 95% reduction in the at-risk group as the theoretical minimum level of unsafe sex is the assumption that these ratios are the same. This may be incorrect because if a mode of transmission is very efficient (e.g. infected blood transfusion) then the incidence of infection among susceptible people who are exposed in this way may be higher than that among people who are otherwise exposed to HIV infection. If different modes of transmission have different rates of infection, the modes most likely to produce an infection will be over-represented among cases of infected people in comparison with the distribution of the different exposures among uninfected people. If the non-sexual modes of transmission in Africa are significantly more efficient than sexual transmission, then the fraction of the at-risk group which is exposed to HIV infection via sexual transmission may be >95%. However, the opposite could also be true if unsafe medical injections were the most common form of non-sexual transmission; such injections may be associated with a lower infection rate because the re-used syringe does not always come into contact with the body fluids that could potentially transmit the infection. There is no means to assess the relative exposure to the different modes of infection and we must instead rely on the data from HIV-infected people, therefore 95% is an uncertain assumption.

The changes to the model were made through the s_0 parameter, and not the r parameter because the latter represents the transmission of infection, and the former describes the fraction of the population that is at risk of infection. Conceptually, transmission can be affected by changes in the level of unsafe sex (e.g. the proportion of sexual acts protected by condoms) but this could not be used satisfactorily to describe a counterfactual scenario. To model a total cessation of unsafe sex, we could not reduce r to zero because this would correspond to a total cessation of all HIV transmission. It is not possible to calculate a value of r which is related to the cessation of sexual transmission only. Two implicit assumptions in this approach are worthy of comment:

- a proportionate relationship between hazardous and unsafe sex: we have assumed that, when we reduce the size of the group of people

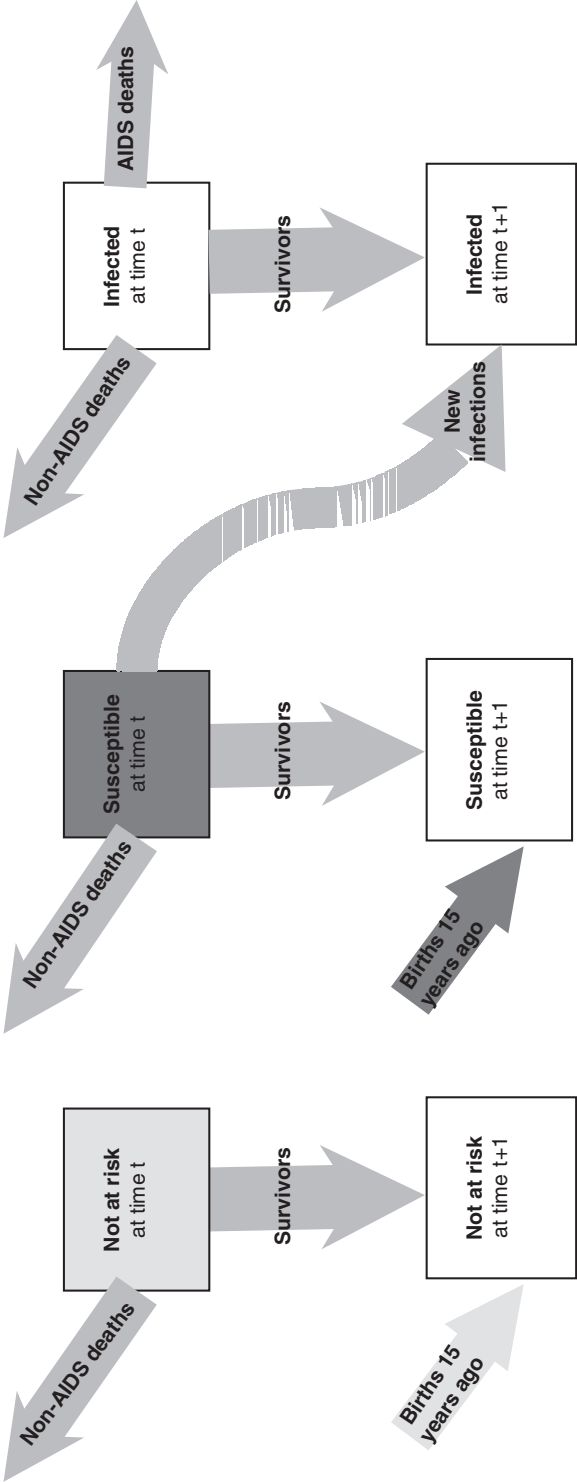
who have hazardous sex, the size of the group having unsafe sex will decrease by the same amount.

- random mixing in the at-risk population: the EPP model assumes random mixing, i.e. each person in the population has an equal chance of contacting another member. This assumption gives a good representation of the natural dynamics of a generalized epidemic of an STI. The question arises, in relation to the counterfactual scenarios, of whether random mixing is still a reasonable assumption in relation to the “hard core” of those remaining at risk after the sudden decrease in hazardous sexual behaviour. We would argue that in the case of sub-Saharan Africa, where the alternative modes of transmission are predominantly unsafe medical injections and unsafe blood transfusions, random mixing is still a close approximation. In the case of injecting drug users, one might want to model far more intensive contacts within the group of people at risk than outside of it, but use of injected drugs is not as important in these subregions as it is elsewhere in the world.

The spreadsheet (Excel) implementation of the EPP model was used, after the modifications described below were made in order to include the changes described by the different counterfactual scenarios. Recruitment of new members into the at-risk group was slowed by a specified amount, as defined in the counterfactual, starting in 2001 and continuing until the end of the projection in 2006. The slowing of the recruitment to the at-risk group was achieved by reducing the value of the s_0 parameter by the specified fraction, with effect from 2001. All the other model parameters remained unchanged. At the start of 2001, the size of the at-risk group was reduced to the fraction of its former size defined in the counterfactual, and the people removed from this group were added to the not-at-risk group. These modifications had the effect of reducing the pool of people who could potentially become infected with HIV, and therefore lowered the number of new cases occurring. Figure 14.9 shows how these modifications affected the projected infections. The dynamic relationship between the at-risk and infected groups remains the same, but the relative sizes of the two groups of susceptible people (at-risk and not-at-risk) are drastically altered and the rates of recruitment to both groups are changed.

Although the number of future infections would be small in the absence of unsafe sex, it was necessary to use a model to estimate the avoidable infections for the African subregions for two reasons. First, one of the counterfactual scenarios involves a reduction of only 10% in unsafe sex, which means that prevalence and the number of new infections remain high. Second, the relationship between current prevalence and the number of new infections in the future is not linear, even over a five-year period.

Figure 14.9 Effect of the modifications made to the EPP model which were used to calculate the number of new HIV infections occurring under different counterfactual scenarios



Note: Birth and death rates are constant, determined by demographic and epidemiological measurement.
New infection rate varies; it = constant transmissibility factor x probability that partner is HIV+.
Probability that partner is HIV+ = infected / (not-at-risk + susceptible + infected) = prevalence.
The model components affected are shaded; those components which are reduced in size by the modifications are shaded dark grey, those which are increased in size are shaded light grey.

Countries with a low prevalence of HIV infection

The counterfactuals for other subregions were again engineered to correspond to situations in which unsafe sex was reduced by 10%, 50% and 100% (no unsafe sex). Existing data on the distribution of prevalent HIV infections by mode of transmission was applied to the projections for the countries with a low prevalence of HIV infection. Reductions in unsafe sex were assumed to result in a decreased number of new STIs that were equal in proportion to the reduction in unsafe sex.

4.2 OTHER SEXUALLY TRANSMITTED INFECTIONS

Estimation of the relationship between unsafe sex and other STIs (chlamydia, gonorrhoea, syphilis and HPV) is subject to the same constraints as that between unsafe sex and HIV infection. Relative risks of infection with chlamydia, gonorrhoea and syphilis following certain behaviours have been estimated. However, like HIV infection, these relative risks will change as the prevalence of infection changes. This problem is compounded by an even greater lack of information for any of these STIs than for HIV. As a result, we have not attempted to quantify this relationship, and assume that for all these STIs, by definition, all current prevalent infections are attributable to unsafe sex. Therefore, the total burden of disease attributed to these STIs can be considered to arise from unsafe sex. This includes cervical cancer attributable to infection with HPV; recent work suggests that all cases of cervical cancer are attributable to infection with sexually transmitted HPV (Walboomers et al. 1999).

In order to make a reasonable estimate of the future prevalence of these STIs, it is necessary to use a mathematical projection model. In common with that for HIV, such a model would need to be fitted to existing time-series prevalence data to create a projection of the future levels of infection. Since there is no appreciable mortality as a consequence of most of these other STIs, a suitable model would be much simpler than those used for HIV. Cervical cancer due to HPV infection would necessitate a model which accounts for mortality. However, the necessary time-series prevalence data are not available for a sufficient number of countries to make this a viable approach. The methods used to calculate the number of new HIV infections that are potentially avoidable cannot therefore be used for these STIs.

STIs have been virtually eliminated from some populations in the recent past. In the early 1950s, the Chinese government initiated a programme to eradicate sexually transmitted diseases that was successful in the short term. The campaign relied on mass screening to identify and treat people with an STI and also involved the abolition of commercial sex work. The methods used might not be transferable to other cultures, but demonstrate that the problem of STIs can be confronted. It has been

suggested that the incidence of STIs only began to increase after China resumed more open relations with the rest of the world in the early 1980s (Cohen et al. 1996).

With this in mind it seems reasonable to assume that all STIs are avoidable, given appropriate changes in sexual and treatment-seeking behaviour, if these changes are accompanied by the provision of suitable services.

5. RESULTS

5.1 PREVALENCE OF DISEASE OUTCOMES IN 2001

Estimates of the current prevalence of HIV and other STIs were based on reported estimates from HIV surveillance and published studies. These were compiled and used to create subregional prevalence estimates (Tables 14.10 and 14.11). The estimates for the two African subregions were based on EPP model fits to antenatal clinic surveillance data. The prevalence in the other subregions was directly based on reported prevalence according to a variety of empirical sources (U.S. Census Bureau 2001).

Table 14.10 The prevalence of HIV infection in the adult population (aged 15–49 years) by subregion, in 2001

| <i>Subregion</i> | <i>HIV prevalence (%)</i> |
|------------------|---------------------------|
| AFR-D | 5.05 |
| AFR-E | 11.97 |
| AMR-A | 0.60 |
| AMR-B | 0.55 |
| AMR-D | 1.93 |
| EMR-B | 0.04 |
| EMR-D | 0.35 |
| EUR-A | 0.28 |
| EUR-B | 0.03 |
| EUR-C | 0.73 |
| SEAR-B | 0.45 |
| SEAR-D | 0.63 |
| WPR-A | 0.04 |
| WPR-B | 0.15 |
| World | 1.20 |

Table 14.11 The prevalence of chlamydia, gonorrhoea and syphilis in the adult population (all age groups) by subregion, in 2000

| Subregion | Females | | | Males | | |
|-----------|---------------|----------------|--------------|---------------|----------------|--------------|
| | Chlamydia (%) | Gonorrhoea (%) | Syphilis (%) | Chlamydia (%) | Gonorrhoea (%) | Syphilis (%) |
| AFR-D | 0.50 | 0.50 | 0.09 | 0.47 | 0.47 | 0.07 |
| AFR-E | 0.27 | 0.29 | 0.07 | 0.25 | 0.27 | 0.06 |
| AMR-A | 1.05 | 0.41 | 0.03 | 0.89 | 0.36 | 0.03 |
| AMR-B | 0.44 | 0.36 | 0.14 | 0.37 | 0.30 | 0.11 |
| AMR-D | 0.42 | 0.32 | 0.14 | 0.34 | 0.26 | 0.11 |
| EMR-B | 0.67 | 0.22 | 0.02 | 0.48 | 0.16 | 0.02 |
| EMR-D | 0.45 | 0.15 | 0.02 | 0.37 | 0.13 | 0.01 |
| EUR-A | 0.16 | 0.03 | 0.00 | 0.14 | 0.03 | 0.00 |
| EUR-B | 0.20 | 0.10 | 0.01 | 0.20 | 0.10 | 0.01 |
| EUR-C | 0.64 | 0.36 | 0.01 | 0.60 | 0.33 | 0.01 |
| SEAR-B | 1.53 | 0.55 | 0.10 | 1.15 | 0.42 | 0.08 |
| SEAR-D | 1.98 | 1.49 | 0.17 | 1.51 | 1.16 | 0.14 |
| WPR-A | 0.48 | 0.37 | 0.02 | 0.61 | 0.49 | 0.02 |
| WPR-B | 0.24 | 0.14 | 0.01 | 0.20 | 0.11 | 0.01 |
| World | 0.62 | 0.41 | 0.06 | 0.76 | 0.50 | 0.07 |

5.2 ATTRIBUTABLE INFECTIONS AND DISEASE BURDEN

The subregional estimates of the fractions of all HIV infections that are attributable to unsafe sex are given in Table 14.12. These comprise the percentage of infections prevalent in 2001 that were reportedly acquired through sexual contact. Therefore this fraction is directly attributable to unsafe sex. The feedback between prevalence and incidence has not been taken into account in the estimates for subregions outside Africa: in many of these subregions, the attributable fraction could be considerably higher if it included all infections for which sexual transmission had occurred at any point along the chain of transmission. As described above, the fractions were by definition 100% for other STIs.

5.3 AVOIDABLE INFECTIONS

The estimates of the fraction of infections which is potentially avoidable are given in the following tables and figures. Figure 14.10 shows the proportion of new infections that may be prevented by different reductions (100%, 50%, 10%) in the level of unsafe sex relative to the number of infections which would be expected to occur if there were no change in sexual behaviour. The height of the bar shows the total proportion that could be avoided if there was no unsafe sex. The proportions within the bar show the reductions that would be seen if unsafe sex was reduced

Table 14.12 The proportion of prevalent HIV infections in adults (aged 15–49 years) that is attributable to unsafe sex, by subregion, in 2001

| Subregion | % of HIV prevalence attributable to unsafe sex |
|-----------|--|
| AFR-D | >99 |
| AFR-E | >99 |
| AMR-A | 72 |
| AMR-B | 85 |
| AMR-D | 95 |
| EMR-B | 42 |
| EMR-D | 85 |
| EUR-A | 59 |
| EUR-B | 64 |
| EUR-C | 25 |
| SEAR-B | 73 |
| SEAR-D | 78 |
| WPR-A | 94 |
| WPR-B | 52 |
| World | 90 |

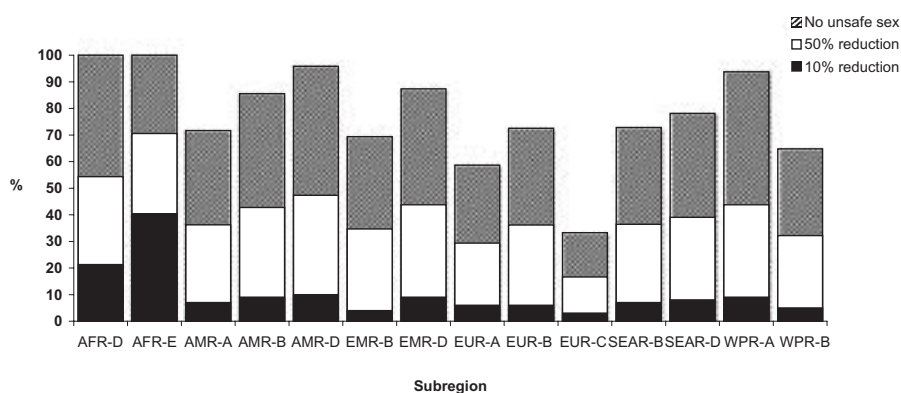
Figure 14.10 The proportion of new HIV infections currently predicted to occur during 2002–2006 that could be prevented by different reductions in the practice of unsafe sex, by subregion

Table 14.13 The mortality and burden of disease attributable to sexually transmitted infections, cervical cancer and HIV, by subregion, in 2001

| Subregion | STIs | | Cervical cancer | | HIV | |
|-----------|---------------------|-----------------|---------------------|-----------------|---------------------|-----------------|
| | Mortality (000s) | DALYs (000s) | Mortality (000s) | DALYs (000s) | Mortality (000s) | DALYs (000s) |
| AFR-D | 43 | 2224 | 21 | 283 | 367 | 11451 |
| AFR-E | 58 | 2828 | 37 | 508 | 1632 | 50386 |
| AMR-A | 0 | 73 | 6 | 93 | 11 | 350 |
| AMR-B | 1 | 484 | 19 | 293 | 29 | 978 |
| AMR-D | 1 | 73 | 5 | 74 | 23 | 684 |
| EMR-B | 0 | 135 | 3 | 53 | 0 | 4 |
| EMR-D | 19 | 1146 | 8 | 121 | 45 | 1366 |
| EUR-A | 0 | 80 | 8 | 107 | 4 | 128 |
| EUR-B | 1 | 150 | 7 | 112 | 1 | 28 |
| EUR-C | 0 | 130 | 12 | 163 | 4 | 136 |
| SEAR-B | 2 | 465 | 14 | 248 | 39 | 1222 |
| SEAR-D | 57 | 3891 | 82 | 1323 | 268 | 8204 |
| WPR-A | 0 | 34 | 3 | 35 | 0 | 7 |
| WPR-B | 5 | 582 | 29 | 377 | 21 | 839 |
| World | 188 | 12296 | 254 | 3790 | 2444 | 75783 |

by just 10% and if it was lowered by a half. These results are also given in Table 14.14.

Figure 14.11 shows how many new infections are predicted to occur in 2002–2006 in each subregion under the different counterfactual scenarios. These results are given in Table 14.15. The greatest changes would be seen in the African subregions, where sexual transmission dominates the epidemic. However in subregions such as WPR-B, which includes China, where a large number of new cases is predicted to occur, the proportion of infections that could be avoided is smaller, because use of injected drugs is a more important mode of transmission in this subregion.

It is important to consider the plausibility of the finding that almost all new HIV infections in Africa could be avoided if unsafe sex were to cease immediately despite the continuation of non-sexual transmissions. Intuitively, it seems unlikely that there would be almost no new HIV infections in the five years following the onset of behaviour change: transmission of the virus via other routes would continue, and it has been estimated that 5% of the newly-diagnosed infections in Africa in 2000 were acquired through a non-sexual mode of transmission. As discussed above, sexual and non-sexual transmission dynamics

Table 14.14 The predicted cumulative proportion of new HIV infections in adults during 2002–2006 that could be prevented by different reductions in unsafe sex, by subregion

| Subregion | Reduction in unsafe sex | | |
|-----------|-------------------------|-----|-------------------------|
| | 10% | 50% | 100% (No unsafe sex) |
| AFR-D | 21 | 54 | >99 |
| AFR-E | 40 | 71 | >99 |
| AMR-A | 7 | 36 | 72 |
| AMR-B | 9 | 43 | 86 |
| AMR-D | 10 | 47 | 96 |
| EMR-B | 4 | 35 | 69 |
| EMR-D | 9 | 44 | 87 |
| EUR-A | 6 | 29 | 59 |
| EUR-B | 6 | 36 | 73 |
| EUR-C | 3 | 17 | 33 |
| SEAR-B | 7 | 36 | 73 |
| SEAR-D | 8 | 39 | 78 |
| WPR-A | 9 | 44 | 94 |
| WPR-B | 5 | 32 | 65 |

cannot be considered in isolation. Even without considering the extent to which these transmission networks are interlinked, the sheer scale of the change to the susceptible population serves to illustrate why it is not implausible that HIV transmission would cease if unsafe sex stopped altogether in the African subregions. Consider, for example, the urban areas of an east African country with a population of eight million where the estimated prevalence of HIV infection among women attending antenatal clinics in 2001 is 11%. This gives a total of 898 000 prevalent cases, of which 45 000 are thought to be non-sexually acquired. The EPP model fit to the observed prevalence data produces an estimate for the susceptible fraction of the total population of 20%. Therefore, there are 1 633 000 people who could acquire HIV infection at the start of 2001.

Using the same example, to simulate the immediate and total cessation of unsafe sex, the at-risk group was reduced by 95%, such that only 1% of the total population would be able to acquire HIV infections (5% of the original 20%), or 16 000 people. The 898 000 cases are still prevalent but not all prevalent cases are potential sources of a new infection. Some HIV-infected people will not exhibit risky behaviours and so will not have the opportunity to transmit infection. For a new case to arise, the HIV-infected people must have an effective contact (i.e. give a blood

Figure 14.11 The total number of new HIV infections in adults predicted to occur during 2002–2006 assuming different reductions in unsafe sex, by subregion

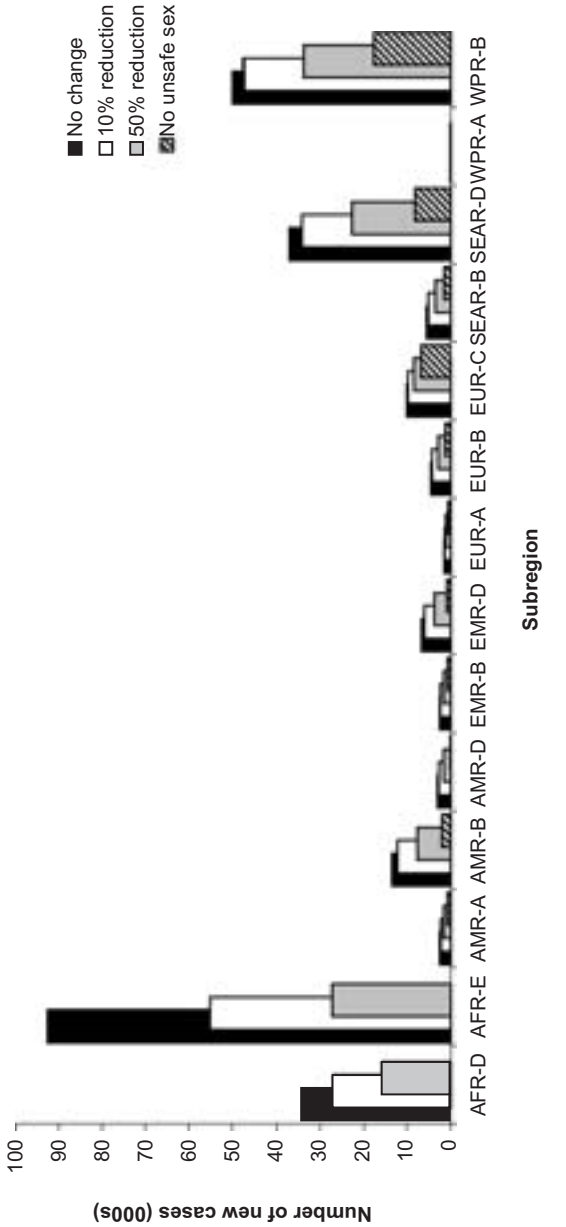


Table 14.15 The total number of new HIV infections in adults predicted to occur during 2002–2006 assuming different reductions in unsafe sex, by subregion

| Subregion | Reduction in unsafe sex | | | |
|-----------|-------------------------|------------|------------|-------------------------|
| | No change | 10% | 50% | 100% (No unsafe sex) |
| AFR-D | 3 420 598 | 2 691 787 | 1 562 368 | Approx.0 |
| AFR-E | 9 250 954 | 5 512 072 | 2 724 441 | Approx.0 |
| AMR-A | 240 000 | 223 200 | 153 000 | 68 000 |
| AMR-B | 1 350 000 | 1 228 500 | 773 000 | 195 750 |
| AMR-D | 300 000 | 270 000 | 158 000 | 12 500 |
| EMR-B | 245 000 | 235 200 | 160 000 | 75 000 |
| EMR-D | 665 000 | 605 150 | 374 000 | 84 000 |
| EUR-A | 150 000 | 141 000 | 106 000 | 62 000 |
| EUR-B | 451 000 | 423 940 | 288 000 | 124 000 |
| EUR-C | 1 008 000 | 977 760 | 840 000 | 673 000 |
| SEAR-B | 552 000 | 513 360 | 351 000 | 150 000 |
| SEAR-D | 3 720 000 | 3 422 400 | 2 268 000 | 815 000 |
| WPR-A | 8 000 | 7 280 | 4 500 | 500 |
| WPR-B | 5 000 000 | 4 750 000 | 3 390 000 | 1 760 000 |
| World | 26 360 552 | 21 001 649 | 13 152 309 | 4 019 750 |

transfusion or unsafe injection) with one of the 16 000 members of the at-risk group. In a population of eight million people, the probability of this happening is now much reduced, thus the number of new infections resulting is very small. The non-linearity in the relationship between changes in unsafe sex and the number of infections avoided results in a large fraction of infections averted by a 10% reduction in unsafe sex in the African subregions.

6. UNCERTAINTY

6.1 EXPOSURE

DATA QUALITY

Most of the behavioural surveys included in this analysis were large probability samples, which were weighted to be representative of the general population by age and sex. There may have been a selection or participation bias in these surveys. Reporting bias is probably inevitable in at least some surveys; people may have under-reported behaviours that are seen as undesirable, especially in the light of education and information campaigns aimed at promoting behavioural change. We have

limited means to assess the existence of such biases, and the assumption implicit in this work is that such biases can be ignored.

It is unclear how well quantitative household surveys measure sensitive information such as sexual behaviour and some surveys will have been designed and implemented better than others. There is little to indicate how good a survey is, apart from the quality of the data and an assessment of the questionnaire. One survey (Sri Lanka 1991 GPA survey) was excluded from the analysis because of poor quality data.

METHODOLOGICAL ISSUES

In creating the set of standard behavioural indicators, different questions were used as though they were synonymous. If these questions or their translations are not in fact equivalent, the calculated indicators will not measure the same thing in all places. This is quite likely, at least with respect to the questions and indicators which depend on a classification of partner type in different countries.

The aggregation of the country-level data to subregional level is perhaps a cause for concern. For some indicators, the values estimated for countries within a subregion varied by as wide a range as was observed between the countries in different subregions. Once combined at a subregional level, this variation was no longer apparent. In addition, countries for which no data were available did not contribute to the subregional estimate; it is unlikely that the subregional estimate would not change if we did have data for the missing countries. It is plausible that, within a subregion, the countries for which no data are available are systematically different from those countries in which sexual behaviour surveys have been carried out. These differences could be related to behaviour.

Extrapolation of the estimates of the prevalence of sexual risk behaviour to subregions where there were no data was based on comparison of the proportions of the population who were currently married in each subregion. Values from the most similar subregion were substituted for the missing data. In subregions where some data were available, the missing values were taken from the subregion which was most similar according to the available estimates. However, it was clear that the subregions did not vary in a predictable manner and this method of extrapolation introduced some unquantifiable error.

ERROR

Confidence intervals can be calculated around the point estimates of behavioural indicators for individual countries. Almost all of these intervals are very narrow, mainly because most of the exposure data come from very large DHS. The error that was introduced by aggregating these estimates to the subregional level cannot readily be quantified: error is introduced because countries with no data are assumed to have average values for the subregion.

OMISSIONS

Having concentrated solely on heterosexual sex, the behavioural review has clearly underestimated the amount of risk in populations where the main mode of HIV transmission is sex between men. The data on the prevalence of sex between men are too scanty to be used in an analysis of this type, and to include only the available data would introduce more uncertainty into these estimates. Infections that result from sex between men are included in the burden estimates, and in the estimates of attributable and avoidable infection, for both low- and high-prevalence subregions.

6.2 OUTCOMES

MODEL-BASED APPROACH

The accuracy of the estimates of the avoidable burden of HIV infection due to unsafe sex depends initially on the precision of the five-year projections of the HIV/AIDS epidemics. These projections represent only one possible future course of the epidemic. The projections for both countries with a high prevalence of HIV infection (using the EPP model) and countries with a low prevalence (using the saturation approach) must be considered as representing a likely course, not the certain future course, of the epidemic.

Beyond the accuracy of the projections of HIV prevalence under the business-as-usual scenario, there are other sources of potential inaccuracy in the estimates of avoidable infections. The estimated proportion of all infections that are not sexually acquired is central to the calculation of the proportion of avoidable infections in all subregions. The figure of 5% employed for Africa, though widely used, should be viewed as very uncertain. Information on mode of transmission is derived from reports on the way in which people who have been diagnosed with HIV infection are thought to have acquired the infection. There are limitations to this data. In many places, a diagnosis of HIV infection will not be made before the onset of symptoms. If diagnosis is delayed it may be more difficult to identify the source of infection, especially for those people who have had more than one type of exposure. Late diagnoses or failure to diagnose may introduce another bias because the people who receive a timely diagnosis may have acquired their infection in a different manner from those whose infections are not promptly diagnosed. Subregional data are based on national data that have been aggregated to the subregional level. The different national data may be subject to different biases. Countries for which no data are available have been assumed to have the average proportion of HIV infections for the subregion. This may have distorted the picture still further. The direction of this error may be influenced by the scale and stage of the epidemic, the health care system and the equity of access to health care.

Africa

The EPP model is based on the assumption that sexual mixing patterns are homogeneous in a population. Therefore, the assumption implicit in the estimates of the numbers of avoidable HIV infections is that the reduction in prevalence of hazardous sexual behaviour is evenly distributed among the population. If declines in the prevalence of hazardous sexual behaviour are concentrated in certain groups, and the remaining risk behaviours (unsafe medical injections, unsafe blood transfusions and injected drug use) are also clustered, then the number of avoidable infections might be lower. If the remaining risk behaviours are evenly distributed throughout the population, the reductions in unsafe sex will have an effect on non-sexual modes of transmission. Infections acquired in one way are not necessarily transmitted in the same way (if they are passed on at all). Therefore sexually acquired cases of HIV infection may act as the source of infection for non-sexually-acquired cases. A reduction in unsafe sex that leads to fewer prevalent cases of HIV infection will therefore also lower the number of new non-sexually-acquired cases.

The assumption of random mixing must be tenable for the EPP model to perform well. This model is intended to give accurate projections of future HIV prevalence in a population with a generalized epidemic. If the modes of transmission that remain after unsafe sex is reduced were to be concentrated among certain groups, the subsequent number of new infections would be higher than that forecast using EPP. Therefore the estimate of the proportion of infections which is avoidable may be too high. However, given the current epidemic situation in the two African subregions, the assumption of random mixing, even in the absence of unsafe sex, may hold true because use of injected drugs is uncommon and unsafe medical injections and blood transfusions are less likely to be concentrated among specific groups.

6.3 LIMITATIONS

The departures from the standard relative risk methodology and the reasons for this have, for the most part, been fully discussed in the text. However, two further differences remain to be explained. The CRA framework requires that all estimates be presented separately for all age groups and for each sex. The estimates of avoidable infections under the different counterfactual scenarios should be made from 2000 until 2030. Neither has been done for unsafe sex because these extensions would greatly add to the uncertainty of the estimates.

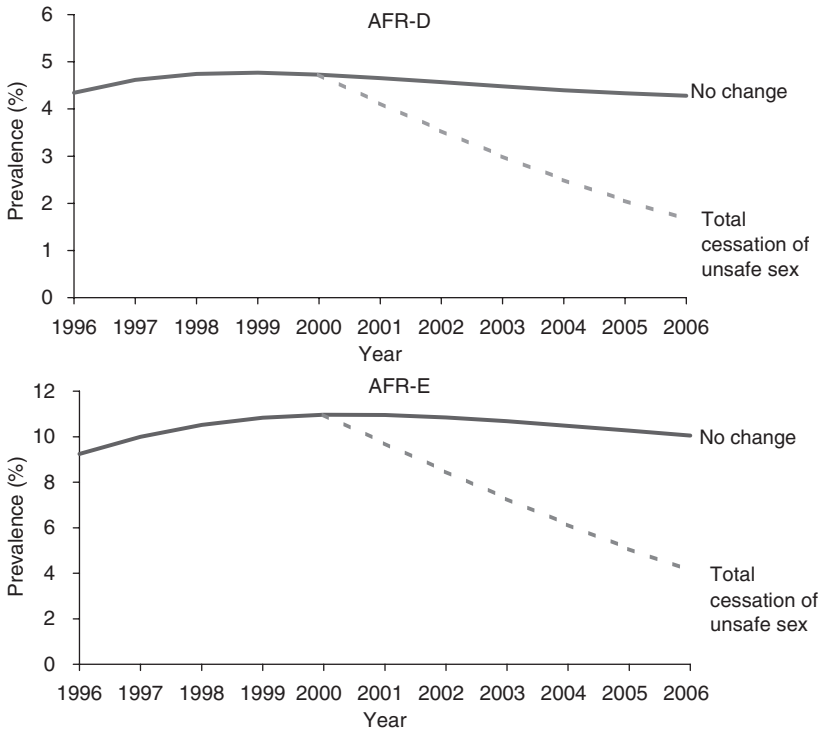
The models used for the prevalence projections are only valid in the short term. To extend them beyond 2006 would require additional assumptions about changes in the availability of treatment and prevention efforts. The effects of treatment on transmission are particularly

hard to predict since treatment will tend to increase the prevalence of infection (by prolonging the survival of infected people), but may also reduce the contagiousness of infected persons. Some of the counterfactuals considered include that there will be a massive reduction in the amount of unprotected sex after 2001. This would inevitably have an impact on fertility, which should in turn lower recruitment to the sexually active population. The methods used to predict HIV prevalence do not account for such changes. In the EPP model, as described in section 4, the recruitment of sexually active adults into the two groups of susceptible people is based on the number of births 15 years earlier and on survival rates to the age of 15 years. Therefore changes in fertility initiated in 2001 would not affect the projections until 2016. The EPP model assumes a constant birth rate that does not change over time and that is the same in the two groups of susceptible people. Although it would be possible to alter the process for implementing the counterfactual scenarios to allow for large future changes in fertility, and the emergence of a dramatic fertility differential, there is no information on which to base these estimates.

Because there is no way to estimate the size of the decline in fertility under the counterfactual scenarios in any subregion, there is no way to accurately model these scenarios beyond the short term. Similar issues are encountered in estimating HIV prevalence by age group and sex. In all subregions, prevalence is different for men and women and varies by age group. The distribution of infections by age and sex varies by epidemic duration and is not necessarily the same in all countries in a subregion, which makes it complicated to establish a subregional breakdown. Estimates of the prevalence of HIV infection among men are not available in most countries but must be inferred from prevalence in pregnant women. Changes in the number of people who are at risk of infection can be expected to change the distribution of new infections by age and sex, but the direction of these changes cannot be anticipated. Therefore, to make estimates of avoidable infections by age group and sex would be to add more uncertainty to the existing estimates.

Finally, the most extreme counterfactual scenario presented above produces some dramatic results for the African subregions. Modelling the complete cessation of unsafe sex implies that, even within marriage, discordant couples would no longer have procreative sex. Such a scenario is artificial and unprecedented: there are no historical examples of a total and sudden cessation of exposure to an infectious disease at the macro level. The reason for including this scenario is that if STIs are eliminated from a population there would be no unsafe sex: in this chapter the counterfactual has been defined in terms of the level of unsafe sex. Under the counterfactual scenario of no unsafe sex, the extraordinarily rapid decline in new infections also produces a discontinuity in prevalence, as the average duration of infection rapidly rises among those

Figure 14.12 HIV prevalence projections for subregions in Africa under two scenarios: no change in current levels of unsafe sex and the total cessation of unsafe sex

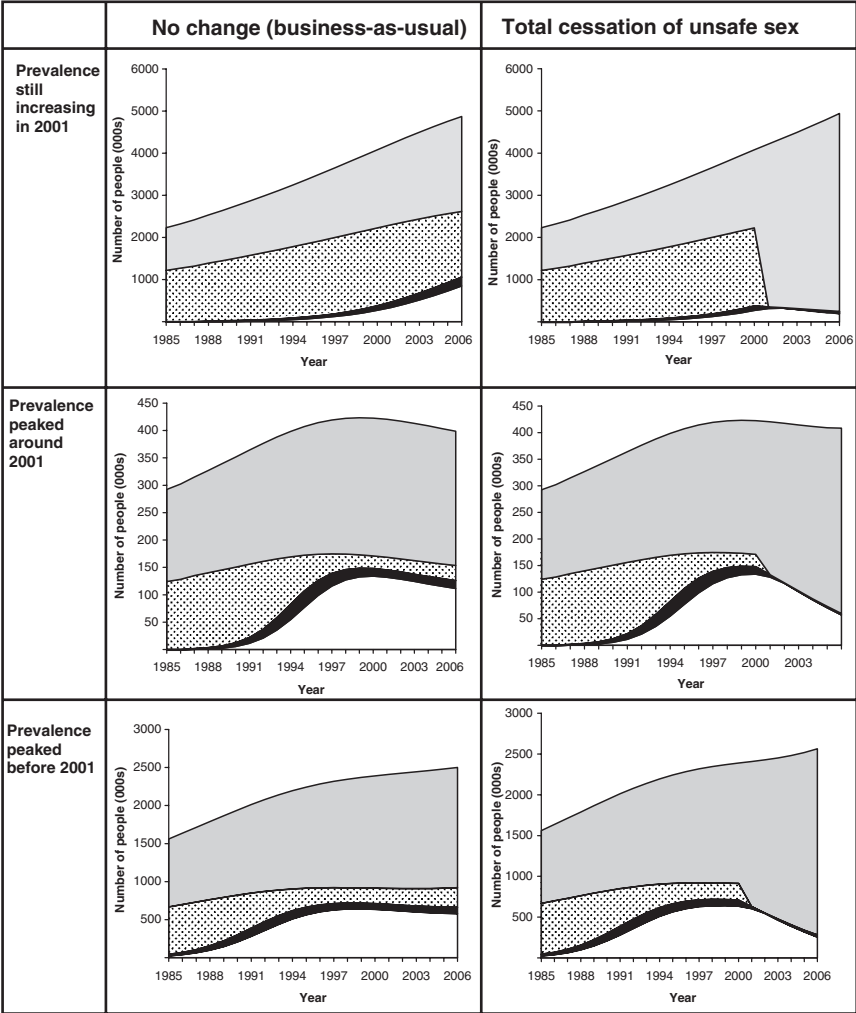


Note: The line representing the HIV prevalence following the total cessation of unsafe sex has been interpolated between 2000 and 2001 for the prevalence under the counterfactual scenario.

who are already infected, which in turn implies a rapid increase in mortality, since mortality of the people who are HIV-positive increases with the time since infection. This mortality increase exacerbates the decline in prevalence, with the results shown in Figure 14.12.

In any single EPP counterfactual scenario for a subnational population, the apparent effect of the rapid transfer of a large fraction of the susceptible population from the at-risk group to the not-at-risk group would depend on the timing of the decline in risk relative to the “natural” epidemic peak and the level of saturation (the proportion of infected people among infected and susceptible persons). Three different situations are shown in Figure 14.13, which illustrates the model fits for a population in which HIV prevalence is still rising rapidly in 2001, a second population in which growth in prevalence has stabilized in 2001;

Figure 14.13 EPP projections of the size of the infected, at-risk and not-at-risk groups for three subnational populations under two scenarios: no change in current levels of unsafe sex and total cessation of unsafe sex



Key: , not at risk; , at risk of infection; , newly infected; , already infected.

and a third population in which HIV prevalence has begun to decline by 2001. The figure shows the relative contributions of the infected, at-risk and not-at-risk groups for two scenarios: no behaviour change (business-as-usual) and total cessation of unsafe sex.

When the data from populations at these three different epidemic stages are amalgamated at the subregional level, the business-as-usual scenario gives the impression of an epidemic with a much broader prevalence peak than that seen in any one national population. However, for the no-more-unsafe-sex scenario, because the decrease in unsafe sex is assumed to occur in the same calendar year in all places, it produces the artificial-looking declines in the number of new infections, shown in Figure 14.13.

7. DISCUSSION AND CONCLUSIONS

Unsafe sex is a difficult exposure to address within the standard epidemiological framework of simple exposure measures and constant relative risks. The problem of relating behaviour patterns to risk of HIV infection is hardly a new one. Other researchers have tried to tackle this in many different ways. The Four Cities study (Buve et al. 2001b; Carael and Holmes 2001; Ferry et al. 2001) compared sexual behaviour in two African cities with a high prevalence of HIV infection and two cities with a relatively low prevalence in order to look for determinants of this heterogeneity. Individual and ecological analyses were carried out. Some behavioural factors were found to be more common in the cities with a high prevalence compared to the cities with a low prevalence of HIV infection. These were: young age at having sex for the first time (for women), young age at first marriage and the existence of a large age difference between spouses. Factors which affect transmission and which were more common in the cities with a high prevalence were herpes simplex virus (HSV-2, genital herpes) infection, trichomoniasis (for women) and lack of male circumcision. Factors that were not more common in the high-prevalence cities were: a high rate of partner change, sex with sex workers, concurrent partnerships, a large age difference between non-spousal partners, gonorrhoea, chlamydial infection, syphilis, dry sex and lack of condom use. The factors found more commonly in the cities with a high prevalence of HIV infection do not seem sufficient to explain the differences in prevalence (Buve et al. 2001a). A comparison of rural populations in Zimbabwe and the United Republic of Tanzania has also failed to find differences in sexual behaviour which could explain the higher HIV prevalence observed in the Zimbabwean population (Boerma et al. 2002). In this light, it is perhaps unsurprising that we have not been able to elucidate a relationship.

Using alternative methods for estimating the attributable disease burden, we found that most of the current burden of disease due to HIV infection is attributable to unsafe sex. If all sexual transmission were to cease, there would be just over 4 million new HIV infections between 2001 and 2006, compared to more than 26 million which are forecast to occur if there is no change in the pattern of transmission. Most of the avoidable infections are concentrated in the African subregions, which

is as expected given the current prevalence of HIV infection in these subregions. The other subregions where sexual transmission is expected to be important in the future are SEAR-D and WPR-B. These two subregions contain some countries which already report broad sexual spread of HIV infection, primarily through sex work (Cambodia, Myanmar) and even in countries where the current epidemic is now driven by injected drug use (Indonesia, China), HIV will spread more broadly from the injecting drug users to their sexual partners. In these countries, the fraction of future infections which would be averted by reductions in unsafe sex is higher than the fraction of current infections which is attributable to unsafe sex.

These findings do not come as a surprise. More important for intervention design and programme evaluation would be to identify which aspects of sexual behaviour contribute most to the spread of HIV in different settings. If this were known, the design and implementation of measures to prevent the spread of HIV infection could be improved. However, even in the absence of this information some measures are known to be effective in preventing HIV infection at the individual level. For example, increasing the levels of condom use can only help to slow the spread of infection.

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Europe: Data for eight countries (England, France, Germany, Greece, Italy, Norway, Portugal and Switzerland) from the European New Encounter Module (NEM) project were provided by Michel Hubert, on behalf of the NEM group.

France: Data from the 2001 Knowledge, Attitudes, Beliefs and Practices (KABP) survey (Grémy et al. 2001) were made available by Ruth Ferry and provided by Julien Chauveau.

Honduras: Data from the Centers for Disease Control and Prevention Encuesta Nacional de Salud Masculina 1996 survey were provided by Leo Morris.

Rwanda and Madagascar: Data were provided by Population Services International (PSI), courtesy of Dominique Meekers.

Models

We made use of the Epidemic Projection Package (EPP) and Spectrum. These are both available courtesy of the Futures Group.

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We are grateful to the UNAIDS/WHO Working Group on Global Surveillance of HIV/AIDS and STIs for making their country-specific models of HIV/AIDS available for use in this exercise.

NOTES

- 1 See preface for an explanation of this term.
- 2 The exception is the Indian study which was among people attending a clinic for sexually transmitted infections. The study was included to provide some information on Asia.

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APPENDIX A

SURVEYS USED TO ESTIMATE EXPOSURE

| Country | Year of survey | Age (years) | | Marital status | | Sample size | | Type of survey | Survey organization | Source of information |
|--------------------------|----------------|-------------|-------|----------------|-----------|-------------|-------|----------------|---------------------|-----------------------|
| | | Female | Male | Female | Male | Female | Male | | | |
| <i>AFR-D</i> | | | | | | | | | | |
| Benin | 1996 | 15-49 | 20-64 | All females | All males | 5 491 | 1 535 | DHS | DHS | Macro International |
| Burkina Faso | 1999 | 15-49 | 15-59 | All females | All males | 6 445 | 2 641 | DHS | DHS | Macro International |
| Cameroon | 1998 | 15-49 | 15-59 | All females | All males | 5 501 | 2 562 | DHS | DHS | Macro International |
| Chad | 1997 | 15-49 | 15-59 | All females | All males | 7 454 | 2 320 | DHS | DHS | Macro International |
| Comoros | 1996 | 15-49 | 15-64 | All females | All males | 3 050 | 795 | DHS | DHS | Macro International |
| Ghana | 1998 | 15-49 | 15-59 | All females | All males | 4 843 | 1 546 | DHS | DHS | Macro International |
| Guinea | 1999 | 15-49 | 15-59 | All females | All males | 6 753 | 1 980 | DHS | DHS | Macro International |
| Liberia | 1986 | 15-49 | — | All females | — | 5 239 | — | DHS | DHS | Macro International |
| Mali | 1996 | 15-49 | 15-59 | All females | All males | 9 704 | 2 474 | DHS | DHS | Macro International |
| Niger | 1998 | 15-49 | 15-59 | All females | All males | 7 577 | 3 542 | DHS | DHS | Macro International |
| Nigeria | 1999 | 10-49 | 15-64 | All females | All males | 7 647 | 680 | DHS | DHS | Macro International |
| Senegal | 1997 | 15-49 | ≥20 | All females | All males | 8 593 | 4 306 | DHS | DHS | Macro International |
| Togo | 1998 | 15-49 | 12-59 | All females | All males | 8 569 | 3 819 | DHS | DHS | Macro International |
| <i>AFR-E</i> | | | | | | | | | | |
| Burundi | 1987 | 15-49 | ≥20 | All females | Husbands | 3 970 | 542 | DHS | DHS | Macro International |
| Central African Republic | 1994 | 15-49 | 15-59 | All females | All males | 5 884 | 1 729 | DHS | DHS | Macro International |
| Congo | 1999 | 15-50 | 15-50 | All females | All males | 1 181 | 930 | STIs | | Supplied by PSI |

continued

SURVEYS USED TO ESTIMATE EXPOSURE (*continued*)

| Country | Year of survey | Age (years) | | Marital status | | Sample size | | Type of survey | Survey organization | Source of information |
|-----------------------------|----------------|-------------|-------|----------------|-----------|-------------|-------|---------------------------|---------------------|--------------------------|
| | | Female | Male | Female | Male | Female | Male | | | |
| Côte d'Ivoire | 1994 | 15-49 | 15-59 | All females | All males | 8 099 | 2 552 | DHS | DHS | Macro International |
| Ethiopia | 2000 | 15-49 | 15-59 | All females | All males | 15 367 | 2 607 | DHS | DHS | Macro International |
| Kenya | 1998 | 15-49 | 15-54 | All females | All males | 7 881 | 3 407 | DHS | DHS | Macro International |
| Lesotho | 1989 | 15-55 | 15-56 | All | All | 1 033 | 549 | KABP/PR | GPA | Supplied by ICP |
| Mozambique | 1997 | 15-49 | 15-59 | All females | All males | 8 779 | 2 335 | DHS | DHS | Macro International |
| Namibia | 1992 | 15-49 | — | All females | — | 5 421 | — | DHS | DHS | Macro International |
| Uganda | 1995 | 20-44 | 15-59 | All females | All males | 1 750 | 1 356 | In depth | DHS | Macro International |
| United Republic of Tanzania | 1999 | 15-49 | 15-59 | All females | All Men | 4 029 | 3 542 | Interim | DHS | Macro International |
| Zambia | 1996 | 15-49 | 15-59 | All females | All males | 8 021 | 1 849 | DHS | DHS | Macro International |
| Zimbabwe | 1999 | 15-49 | 15-54 | All females | All males | 5 907 | 2 609 | DHS | DHS | Macro International |
| AMR-A USA | 1997 | 14-20 | 14-20 | All females | All males | 4 039 | 4 170 | NLSY | NLS | NLS |
| USA | 2000 | ≥15 | ≥15 | All females | All males | — | — | Current population survey | — | Fields and Casper (2001) |
| USA | 1988 | 18-59 | 18-59 | All females | All males | — | — | Sexual behaviour | — | Laumann et al. (1995) |
| AMR-B Brazil | 1996 | 15-49 | 15-59 | All females | All males | 12 612 | 2 949 | DHS | DHS | Macro International |

| | | | | | | | | | | |
|---------------------|------|-------|-------|-------------|-----------|--------|-------|----------------------------------|--|---------------------------|
| Chile | 1998 | 18-69 | 18-39 | All | All | 3 163 | 2 244 | National Sexual Behaviour Survey | La Comision Nacional del SIDA (CONASIDA) | Published report |
| Colombia | 2000 | 15-49 | — | All females | — | 1 1585 | — | DHS | DHS | Macro International |
| Dominican Republic | 1996 | 15-49 | 15-64 | All females | All males | 8 422 | 2 279 | DHS | DHS | Macro International |
| El Salvador | 1985 | 15-49 | — | All females | — | 5 207 | — | DHS | DHS | Macro International |
| Honduras | 1996 | 15-59 | 15-59 | All | All | — | 2 925 | RHS | CDC | Leo Morris at CDC Atlanta |
| Mexico | 1987 | 15-49 | — | All females | — | 9 310 | — | DHS | DHS | Macro International |
| Paraguay | 1990 | 15-49 | — | All females | — | 5 827 | — | DHS | DHS | Macro International |
| Trinidad and Tobago | 1987 | 15-49 | — | All females | — | 3 806 | — | DHS | DHS | Macro International |
| AMR-D | | | | | | | | | | |
| Bolivia | 1998 | 15-49 | 15-64 | All females | All males | 1 187 | 3 780 | DHS | DHS | Macro International |
| Ecuador | 1987 | 15-49 | — | All females | — | 4 713 | — | DHS | DHS | Macro International |
| Guatemala | 1999 | 15-49 | — | All females | — | 6 021 | — | Interim | DHS | Macro International |
| Haiti | 1994 | 15-49 | 15-59 | All females | All males | 5 356 | 1 610 | DHS | DHS | Macro International |
| Nicaragua | 1997 | 15-49 | — | All females | — | 13 634 | — | DHS | DHS | Macro International |
| Peru | 2000 | 15-49 | — | All females | — | 32 000 | — | DHS | DHS | Macro International |
| Peru | 1996 | 15-49 | 15-59 | All females | All males | 28 951 | 2 487 | DHS | DHS | Macro International |
| EUR-A | | | | | | | | | | |
| France | 1998 | 18-49 | 18-49 | All | All | 819 | 795 | New Encounter Module | NEM European Group | NEM European Group |
| France | 2001 | 18-59 | 18-59 | All | All | 1 892 | 1 429 | KABP | ORS | ORS |
| Germany | 1998 | 15-49 | 15-49 | All | All | 1 422 | 1 161 | New Encounter Module | NEM European Group | NEM European Group |
| Greece | 1998 | 15-49 | 15-49 | All | All | 1 038 | 962 | New Encounter Module | NEM European Group | NEM European Group |
| Italy | 1998 | 15-49 | 15-49 | All | All | 1 384 | 1 219 | New Encounter Module | NEM European Group | NEM European Group |

continued

SURVEYS USED TO ESTIMATE EXPOSURE (continued)

| Country | Year of survey | Age (years) | | Marital status | | Sample size | | Type of survey | Survey organization | Source of information |
|----------------|----------------|-------------|-------|----------------|-----------|-------------|--------|---|---|------------------------|
| | | Female | Male | Female | Male | Female | Male | | | |
| Norway | 1997 | 15-49 | 15-49 | All | All | 2 122 | 1 582 | New Encounter Module | | NEM European Group |
| Portugal | 1999 | 15-49 | 15-49 | All | All | 360 | 320 | New Encounter Module | | NEM European Group |
| Spain | 1996 | ≥15 | ≥15 | All females | All males | 4 258 | 35 730 | National Household Survey, sexual behaviour and condom use re HIV | Aids care—psychological and socio-medical aspects of AIDS/HIV | Castilla et al. (1998) |
| Switzerland | 1997 | | | All | All | 1 418 | 1 359 | New Encounter Module | | NEM European Group |
| United Kingdom | 1990 | 16-59 | 16-59 | All females | All males | 10 758 | 8 115 | Sexual attitudes and lifestyles | NATSAL survey | Johnson et al. (1994) |
| EUR-B | | | | | | | | | | |
| Kyrgyzstan | 1997 | 15-49 | — | All females | — | 3 848 | — | DHS | DHS | Macro International |
| Poland | 1991 | 20-49 | 20-49 | All females | All males | 3 902 | 3 783 | FFS | PAU | United Nations |
| Uzbekistan | 1996 | 15-49 | — | All females | — | 4 415 | — | DHS | DHS | Macro International |
| EUR-C | | | | | | | | | | |
| Kazakhstan | 1999 | 15-49 | 15-59 | All females | All males | 4 800 | 1 440 | DHS | DHS | Macro International |
| Ukraine | 1999 | 15-44 | — | All females | — | 7 128 | — | RHS | CDC | Leo Morris at CDC |
| SEAR-B | | | | | | | | | | |
| Thailand | 1990 | 15-49 | 15-49 | All | All | 1 675 | 1 126 | PR | GPA | |

SURVEYS USED TO ESTIMATE EXPOSURE (*continued*)

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| Key: | |
| — | No data. |
| BSS | Behavioural surveillance study. |
| CDC | Centers for Disease Control and Prevention. |
| DHS | Demographic and Health Surveys. |
| FFS | Fertility and Family Surveys in countries of the United Nations Economic Commission for Europe (UNECE) region. |
| FHI | Family Health International. |
| GPA | Surveys carried out under the auspices of the WHO Global Programme on AIDS. |
| ICP | Mr Jean-Claude Dehenneff, Information Communication Partners, Brussels. |
| IIPS | Survey data from the International Institute for Population Studies, India. |
| KABP | Knowledge, attitudes, behaviours and practices (a sexual behaviour survey format). |
| NATSAL | National survey of Sexual Attitudes and Lifestyles, United Kingdom. |
| NEM group | Michel Hubert, Centre d'études sociologiques, Facultés universitaires Saint-Louis, Bruxelles, on behalf of the NEM group. |
| NLS | National Longitudinal Surveys (NLS) Program, Office of Employment and Unemployment Statistics, Bureau of Labor Statistics. |
| NLSY | National Longitudinal Survey of Youth 1997, USA. |
| ORS | Observatoire Régional de Sanitaire d'Île de France. |
| PAU | Population Activities Unit, UNECE. |
| PR | Partner relations (a sexual behaviour survey format). |
| PSI | Population Services International. |
| RHS | Reproductive Health Surveys. |
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