HIV and AIDS: where is the epidemic going?*

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Routine surveillance of HIV (human immunodeficiency virus) infection and AIDS has been established over the past decade in many countries around the world. HIV estimates derived from empirical data are essential to the assessment of the HIV situation in different parts of the world and trends are used in tracking the development of regional epidemics, thereby keeping intervention activities focused on realities. As of the end of 1995, and following an extensive country-by-country review of HIV/AIDS data, a cumulative total of 6 million AIDS cases were estimated to have occurred in adults and children worldwide and currently 20.1 million adults are estimated to be alive and infected with HIV or have AIDS. Of the total prevalent HIV infections, the majority remain concentrated in eastern, central and southern Africa, but the epidemic is evolving with spread of infection from urban to rural areas, as well as to West and South Africa, India and South-east Asia, and to a lesser extent — with proportional shifts to heterosexual infections — in North America, western Europe and Latin America.

While the longer-term dimensions of the HIV epidemic at global level cannot be forecast with confidence, WHO currently projects a cumulative total of close to 40 million HIV infections in men, women and children by the year 2000. By that time, the male:female ratio of new infections will be close to 1:1. Recent trends indicate that HIV prevalence levels may be stabilizing or even decreasing among pregnant women in southern Zaire and parts of Uganda, among military recruits aged 21 in Thailand, and in some populations of northern Europe and the USA. While these changes may take place as part of the intrinsic dynamic of the epidemic, there is some evidence that declines in HIV prevalence are related to declines in HIV incidence which are, at least partly, due to prevention efforts. The challenge of surveillance and evaluation methods is now to identify the ingredients of success which may reveal a glimmer of hope.

Introduction

The HIV (human immunodeficiency virus) and AIDS epidemic, which emerged in the last quarter of the twentieth century, has within less than two decades spread to over 190 countries in all continents (1). The infection is caused by two main types of virus, HIV-1 and HIV-2. Globally, HIV-1 accounts for the great majority of HIV infections; HIV-2 appears largely confined to West Africa, with foci in Angola and Mozambique and some cases in Europe, the Americas and India (2). Furthermore, HIV infection is characterized by a wide genetic diversity of viral strains in different parts of the world (3). In vitro studies have shown important differences in the biological properties of HIV-1 subtypes (4), but very little is known about possible differences in the transmissibility of these subtypes. In this paper, the abbreviation HIV refers to HIV-1.

Over the last decade AIDS and HIV surveillance has been established by national AIDS programmes in collaboration with the World Health Organization (WHO) in most countries. HIV surveillance and estimates can be used routinely in assessing the magnitude of the problem, in keeping intervention activities focused when estimates are available by subpopulation, and in tracking the development of regional epidemics in the context of the global situation. This paper presents the methods and results of global HIV/AIDS estimates, describes subcontinental characteristics of the epidemic, and discusses important trends which emerge and their possible determinants.

Methods

WHO uses several methods for estimating and forecasting, based on empirical data which are drawn
from the global disease surveillance system for AIDS and HIV sentinel surveillance, as well as published studies and the WHO/GPA country files which are updated continuously through contact with professionals in the country (5). The process is based on a strong relationship between surveillance, estimation, forecasting and evaluation of trends, both in developing capability at the country level and ensuring that results can be interpreted comparatively and in a global context. A detailed account of the methods has been published elsewhere (1, 5). Briefly, WHO bases its estimates on a review of HIV seroprevalence studies, reported AIDS cases, estimates of underreporting, population size and structure (including the age/sex distribution and urban/rural differentials), and the predominant modes of transmission. Two important methods are combined, the HIV estimation process and the use of a fore-casting method for validation, with consistency between HIV incidence, prevalence and AIDS cases and their future projections.

The estimation procedure for country-specific prevalent infections may be described in five basic stages. First, subpopulations in which there is evidence of HIV infection are identified by reviewing all available data, regardless of their quality. Second, prevalence studies are reviewed for their methodological qualities according to criteria described previously (5), and studies with a predetermined threshold sample size are selected. Third, using all remaining seroprevalence data points to provide upper and lower bounds, a conservative estimate (i.e., usually lower than the median value of all prevalence levels) is selected for each subpopulation, taking into account seroprevalence trends over the past two years. Fourth, the best available information is used to estimate the size of the subpopulation. Finally, the estimated prevalence rates are applied to the estimated subpopulations' sizes and totalled to provide an estimate of prevalent infections for the country (5).

Once a provisional country-specific estimate is obtained, the reported and estimated AIDS cases are compared with the numbers that could be expected from estimated past and present HIV levels, using a projection model (usually, but not always, epimodel (6)) with the appropriate inputs, and the estimate is adjusted accordingly (1). All estimates are discussed with the appropriate WHO Regional Office and with the country's national AIDS programme.

To estimate the future number of HIV infections and current and future AIDS cases in the short term, WHO uses a model based upon the natural history of HIV and a theoretical gamma-shaped epidemic curve (6). This requires three inputs: an estimate of current prevalent HIV infections, the year the epidemic began, and the current position along the epidemic curve. The shape and the position on the epidemic curve are changed according to evidence provided by surveillance data, particularly the trajectories of AIDS cases over time. The model then calculates the total number of infections from the start of the epidemic, which is necessary to produce the current level of HIV prevalence. The total number of infections is distributed along the gamma curve of HIV incidence to produce the number of new HIV infections each year. The incubation distribution is then applied to these annual infections to determine the annual number of AIDS cases.

Short-term projections of future HIV infections are produced by extrapolating along the epidemic curve past the current position to generate the number of new infections in future years. The incubation distribution is applied to these new infections to produce estimates of the future number of AIDS cases.

Results

Global estimates

By 15 December 1995, a total of 1,291,810 AIDS cases had been reported to WHO (7), but WHO estimates that as of the end of 1995, allowing for underdiagnosis, underreporting, and delays in reporting, and based on the estimated number of HIV infections, there have been 6 million cumulative AIDS cases worldwide. Of these, it is estimated that nearly 1.5 million are paediatric AIDS cases resulting from mother-to-child HIV transmission, the majority of them in sub-Saharan Africa.

As of the end of 1995, following a country-by-country review of HIV/AIDS data (7), WHO estimated that since HIV began its spread in North America, Europe and sub-Saharan Africa, around 24 million adults had been infected (7). Fig. 1 shows the global distribution of prevalent adult HIV infections, including persons living with AIDS. As people infected with HIV early in the epidemic die of AIDS, the gap between HIV prevalence and cumulative incidence is widening.

Globally, there are currently 3 men infected for every 2 women and by the year 2000 the number of new infections among women will be closer to that among men (7). Fig. 2 shows the trends in the proportion of AIDS cases in females in selected countries. In sub-Saharan Africa the male to female ratio is close to 1:1, whereas a steady increase in female AIDS cases is observed in the rest of the world. The rising infection rates in women are accompanied by a

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*a Low-Beer D et al. The global burden of HIV (unpublished data).*
corresponding rise in the number of children born with HIV infection. To date, it is estimated that over 1.5 million children have been infected with HIV through mother-to-child transmission (7). These children rapidly develop AIDS and die — usually before the age of 5, although in the USA and Europe the incubation period may be longer.

These figures are the testimony of the tragedy unfolding for the last 15 years and point to the fact that HIV is still spreading very fast across continents. However, there is now evidence to suggest that a stabilization and, perhaps, a decline in the prevalence of HIV infection may be taking place in certain areas and populations of the industrialized regions of Australasia, North America and Western Europe, as well as in the high prevalence areas of East and Central Africa and in some populations of Thailand (1, 5).

Mother-to-child transmission of HIV includes transmission during pregnancy or delivery and through breast-feeding. The wide variation of rates of transmission may be due to differences in the distribution of determinants of transmission, such as the degree of maternal immune deficiency, the presence of chorioamnionitis, maternal vitamin A deficiency, or exposure to infected breast milk (8). In an essentially nonbreast-feeding population the majority of mother-to-child transmission occurs during pregnancy and delivery, although data from various
countries up to 1992 suggest that up to 15% of babies breast-fed by HIV-infected mothers may become infected through breast-feeding (9). As for heterosexual transmission, the rates of mother-to-child transmission appear to be strongly influenced by the level of viraemia in mothers, with higher levels leading to higher infectiousness (8).

The global estimates of HIV infections only partially represent the impact of the epidemic in terms of other disease. For example, an alarming increase in cases of tuberculosis has been reported in parallel with the AIDS epidemic in many countries, particularly in Africa (10). Tuberculosis is already one of the leading causes of adult death in many developing countries, killing around 3 million people a year. HIV infection is now one of the strongest known risk factors for the development of active tuberculosis in developing countries with a high prevalence of HIV essentially because of immune deficiency induced by HIV infection. The advent and continuing spread of HIV infection significantly complicates tuberculosis control programmes in countries or areas that are heavily affected by the AIDS epidemic.

The subcontinental epidemics

From restricted pockets of detected AIDS cases 15 years ago, a distinctive feature of the epidemic has been its ability to assume global proportions. However, the spread of HIV presents distinct characteristics in different societies, and one of the goals of global surveillance is to provide a framework in which regional patterns of spread can be identified and compared.

Western Europe, North America, Australasia

In this region taken as a whole, there have been over 1.8 million estimated adult cumulative HIV infections as of the end of 1995, with 1.2 million of these occurring in the USA. In total, over 700,000 cumulative AIDS cases are estimated by WHO to have occurred in adults alone as of end-1995.

HIV has predominantly affected homosexual men and injecting drug users (IDUs) (I), together with their sex partners. The proportion of heterosexually acquired infections has slowly been increasing over the past decade, with especially noticeable increases in urban populations with high rates of injecting drug use (I), crack (cocaine base) use in the USA, or sexually transmitted diseases (STDs) (10). Marked differences exist between and even within countries in the distribution of AIDS cases among homosexual men and IDUs, reflecting the variability in HIV transmission patterns. In Europe, for example, the majority of AIDS cases in Scandinavia and England have occurred in homosexual men, whereas IDUs constitute two-thirds or more of the AIDS cases reported from Italy and Spain. 

Latin American and the Caribbean

As of the end of 1995, WHO estimated that over 1.7 million cumulative adult HIV infections had occurred and that the prevalence was around 1.5 million (Fig. 1) (I). As of end-1995, more than 140,000 adult and paediatric AIDS cases had actually been reported (9). Both the number and the rate of AIDS cases per population are highest in Brazil, which had over 70,000 reported cases as of end-1995.

In Latin America, most infections were initially among homosexual or bisexual men. Since the late 1980s though, there has been increasing heterosexual transmission, principally among bisexual men and their female sex partners, and among female sex workers and their clients. For example, in Brazil data in selected male STD clinic attenders indicate that the geographical distribution of HIV is extensive throughout the country (I). HIV infections among IDUs are also a growing problem across the subcontinent: for example, the prevalence of HIV infection among IDUs ranges from 30% to 50% in Argentina and from 20% to 60% in Brazil (I).

In most of the Caribbean, heterosexual transmission has been the predominant mode of transmission for at least a decade (I). Studies from national programmes among pregnant women attending antenatal clinics in 1990–91 found HIV prevalence rates close to 3% in the Bahamas, and over 1% in Santo Domingo (Dominican Republic). In Haiti, HIV prevalence among antenatal clinic attenders was 7.5% in urban areas and 5.5% in rural areas in 1993, with highest seropositivity rate in the young age groups (I).

The epidemic in this region is very heterogeneous. Surveillance is particularly important to monitor and give warning of trends in the evolving heterosexual proportion of the epidemic in order to respond with the appropriate prevention strategies.

Sub-Saharan Africa

As of the end of 1995, WHO estimated 4.5 million adult and paediatric AIDS cases and 16 million cumulative adult HIV infections; with 12.9 million of these currently alive (including people with AIDS) (Fig. 1). Epidemiological evidence indicates that heterosexual intercourse is by far the predominant mode of transmission in this region.

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East and Central Africa account for 50–60% of the HIV infections that have occurred in Sub-Saharan Africa, but only about 15% of the total population of the region (1). Data on HIV incidence have been collected in the last few years and are important because this incidence directly determines the trends of infection and the future course of the epidemic. Seroprevalence rates in some rural areas of southern Uganda have been estimated at above 10% among the general population (unpublished data, WHO), but a recent study indicates that in the rural district of Massaka, south-west Uganda, the annual incidence rates declined from 7.5% in 1989-90 to 4.6% in 1993 among adults (above 12 years of age).c

In western and southern Africa the epidemic continues to evolve. Among antenatal clinic (ANC) attenders in one state of Nigeria, HIV prevalence was estimated to be 6% by 1992 (1). Similar HIV levels are also emerging in southern Africa. Two serial cross-sectional surveys conducted in March 1992 and December 1993 in a rural district in the north-east of South Africa among ANC attenders showed an increase in seroprevalence from 4.2% to 7.9% (1). Fig. 3 shows trends in HIV prevalence among antenatal clinic attendees and STD patients in South Africa between 1991 and 1994.

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Despite the grim picture in large parts of sub-Saharan Africa, there are indications that HIV prevalence may still be relatively low among the general population in selected countries (10). For example, in Cameroon and Benin, prevalence rates among antenatal clinic attenders appears to have been <5% between 1989 and 1993 (WHO, unpublished data). The reasons for the disparities in the spread of the epidemic across the subcontinent need to be explored by examining in a standardized way the sexual mixing patterns in various parts of the world. Further research is also needed to assess any contribution of HIV genetic variability to infectiousness and transmission.

South and South-east Asia

The progression of the epidemic in this region has been rapid in several populations since the late 1980s. As of the end of 1995, WHO estimated that over 4.25 million HIV infections had cumulatively occurred in adults (Fig. 1). An estimated 300000 cumulative AIDS cases are believed to have occurred by the end of 1995, but only 25090 cases had been reported up to the end of 1995.

In Thailand, HIV spread first among IDUs, then among commercial sex workers and their clients, and through the regular partners of clients into the general population. Rapidly rising seroconversion rates towards the end of the 1980s, followed by a relative decline and stabilization around 1991–92, have recently been described among IDUs in Bangkok (11). Data from the national AIDS programme indicate that HIV prevalence among ANC attenders is now around 8% in the northern part of the country, while the median prevalence nationwide was 1.7% by mid-1994 (1). Among female sex workers in northern Thailand the prevalence is well above 30% whereas prevalence among army conscripts was above 7% in 1993 (unpublished data, WHO). However, a decline in incidence appears to have recently occurred among selected female sex workers (1) and among Royal Thai Army conscripts in northern Thailand where an incidence of 0.87 per 100 person-years was observed as compared to previous incidence rates of around 3.4% per year. This is reflected partly by a more recent decline in HIV prevalence (Fig. 4).

In India, which accounts for 16% of the world’s population, there is evidence of HIV infection among IDUs, female or male sex workers, and the general population in selected urban centres (1). Gaining an accurate picture of HIV spread across different parts of India is difficult because of the variability of the epidemiological environments, the multitude of urban and semi-urban areas, and the lack of consistency in serological surveys regarding the period and population tested. Despite these problems, a concerted surveillance effort has resulted in increasing evidence becoming available of the levels and the trends of HIV infection in subpopulations to guide both interventions and forecasts. In Madras, in the south, seroprevalence among STD patients increased from around 1% during the period 1986–89, to 8.5% in 1991–92 (1). In the State of Maharashtra in the west, with close to 100 million inhabitants and an urban population of over 23 million, the epidemic is now well established; the results of the first round of sentinel surveillance in 1994 among ANC attenders in Bombay indicated a prevalence of 2.5% (1). Fig. 3 shows HIV trends in selected populations of different cities in India. In north, central and east India, the available data suggest that the epidemic has not yet started to rise although the scarcity of rigorously conducted serosurveys preclude any conclusion (1).

Rapid spread of HIV into the general population has also been seen in some parts of urban and rural Myanmar, contiguous to Thailand. In Cambodia, the epidemic is spreading through heterosexual contact, with prevalence rates of 3.5% among blood donors in Phnom Penh in mid-1994 (1). In Viet Nam, increases in seroprevalence from 2% to 30% were observed among IDUs in 1992–93 (5). The extent of the epidemic is less clear in Bangladesh, Pakistan and Indonesia.

Western Pacific Region, Eastern Europe and Central Asia

WHO estimated that there were 32000 current adult HIV infections in the Western Pacific Region by
the end of 1995. Here, also, there is diversity in transmission modes across the region. A large proportion of the reported AIDS cases in Japan have been among people with haemophilia who were transfused with HIV-infected blood products in the early to mid-1980s. Should the epidemic gain a foothold in China, the potential for a large increase in the numbers of HIV infections in the world's most populous country, even with low incidence rates, is of serious concern (1).

The magnitude of the HIV/AIDS problem in Eastern Europe and Central Asia also remains poorly defined. In St Petersburg, in Russia, most recent infections are attributed to heterosexual transmission (1). In some Eastern European countries injecting drug use is associated with very high rates of HIV infection; a cross-sectional study conducted in Warsaw, Poland, in 1993 found a seroprevalence of 46% among IDUs attending treatment centres (1). Social and structural changes that are likely to increase the risk of HIV transmission are taking place throughout much of the region.

North Africa and the Middle East

As of the end of 1995, WHO estimated that there were around 210000 prevalent adult HIV infections in the region, which includes Sudan, contiguous to eastern sub-Saharan Africa, but the extent of spread is uncertain and only 3474 AIDS cases had been reported by the end of 1995. This uncertainty is partly due to considerable gaps in HIV surveillance, and most available data come from North Africa. In Morocco, HIV prevalence among blood donors was 0.01% in 1993 (1). In Nouakchott, Mauritania, the period prevalence between 1988 and 1992 among blood donors was 0.4% (1). In Eritrea, data from national sero-surveillance from 1994 indicated a prevalence rate of 25% among sex workers, 2.7% among blood donors, and 3% among antenatal clinic attenders (1).

Global projections of HIV and AIDS

As a result of HIV infection rates, the number of new AIDS cases is expected to stabilize in large parts of the industrialized world during the mid-1990s, while continuing to increase in most parts of the developing world where the health care infrastructure is already overwhelmed by other diseases. By the year 2000, in Africa and Asia, around 700000 and close to 500000 new AIDS cases are projected to occur every year, respectively.

The longer-term dimensions of the HIV/AIDS pandemic cannot be forecast with confidence. However, on the basis of available data on the current global status of the pandemic and recent trends in its spread, WHO has generated a plausible range of projections. For the year 2000, WHO currently projects a cumulative total of close to 40 million HIV infections in men, women and children, of which more than 90% will be in the developing countries. The projected cumulative total of adult AIDS cases for the year 2000 is well over 10 million. Cumulatively, by the year 2000 as many as 5 million children under age 5 will be HIV-infected through their mothers, the majority of them in sub-Saharan Africa.

Projections of the number of AIDS cases in infants and children are based on perinatal transmission rates of about 30% and specific fertility rates. However, because the infected mothers are likely to die of AIDS within 5 to 10 years of their giving birth, the uninfected infants will constitute a growing population of orphans. WHO estimates that close to 5 million children under 10 years of age will be orphaned by the end of the 1990s as a result of the HIV-related deaths of their mothers. The number of maternal — and paternal — orphans will increase further in the early years of the next century as a result of the death of those mothers and fathers who were infected with HIV in the 1990s.

Discussion

Of the total prevalent HIV infections, the majority remain concentrated in eastern, central and southern Africa, but the epidemic continues to evolve with diffusion of infection from urban to rural areas, to West and South Africa, to India and south-east Asia, and to a lesser extent — with proportional shifts to heterosexual infections — in North America, western Europe and Latin America.

The past concentration of infections has led to a relentless rise in AIDS cases and subsequent mortality. Recent data suggested that AIDS is emerging as a leading cause of death in adults aged 25–44 years in substantial areas of the developed and developing worlds. Despite identification of only 55–85% of HIV-related deaths, AIDS is the leading cause of death in males aged 25–44 years in 66 U.S. cities (12). In some countries that are furthest into the epidemic in Africa, more than half of adult mortality is now attributable to HIV infection (13). In Zambia, crude mortality among employees of 33 factories and other businesses soared from 2.5 per 1000 in 1987 to 183 in 1993 — an increase virtually wholly attributable to HIV-related disease (14).

HIV prevalence levels in epidemics of at least ten years have begun to stabilize, and in homosexual populations in Europe and the United States have already declined. In the United States there was a downward trend with time among homosexuals, cor-
related with declines in other sexually transmitted diseases, behaviour change and public health interventions. There is also a strong suggestion of stable or declining HIV prevalence among pregnant women in southern Zaire since 1989, in the general population in some rural districts of Uganda, in some urban areas of Uganda (WHO, unpublished data), and from analyses of AIDS case surveillance data at the national level for Uganda (WHO unpublished data). Important qualitative shifts in the epidemic, for example towards increased heterosexual transmission and increased proportion of HIV infections in younger groups, have been observed and need to be understood in the context of differential patterns of underlying HIV incidence across age and population groups (1).

Both data and modelling suggest a more rapid and time-limited growth stage of the epidemic than was described earlier (1, 10, 15), and in some subpopulations the initial epidemic burst may take between 1 and 4 years. For example, HIV prevalence among IDUs in Thailand increased from 1% in 1986 to stabilize at 43% by 1988, and HIV incidence subsequently declined to stabilize at a much lower level than the peak incidence (11). Continuous and systematic global HIV surveillance will show whether such indications of the course of the epidemic are replicated more generally in different populations of Africa, Asia and Latin America.

The diversity of surveillance trends emerging from global surveillance leads to two difficult questions. First, what are the underlying trends in HIV incidence which govern the patterns of HIV prevalence and AIDS? Describing and explaining the HIV incidence curve is fundamental to estimation, forecasting and effective interventions. For example, decreases of incidence combined with increase of mortality lead to declining trends in HIV prevalence. At population level, changes in HIV incidence rates over time, which, in addition to changes in AIDS-related mortality, undergo changes in HIV prevalence rates, may be explained by a variety of factors. These factors include saturation, possible behavioural changes, potential changes in the virulence of HIV-1 or in the natural immunity, or change in infectiousness of people infected with HIV over time. The level of viraemia is high immediately after HIV infection for a period of several weeks, then decreases and levels off for many years before rising again with the development of HIV-related diseases. This time course of viraemia is described as the "bathtub" and appears to be correlated with HIV transmission efficacy, with higher levels leading to higher infectiousness (1, 5, 10, 15). The latter has potentially broad implications for the dynamics of the epidemic in different countries. Given a population with the same sexual behaviours and mixing patterns over a period of time, variable infectiousness may be the driving force behind the rapid expansion phase, and may also contribute to the decrease in overall HIV incidence later in the course of a given epidemic as overall transmission efficacy decreases. Early in a given epidemic, relatively larger numbers of individuals are highly infectious as compared to later in the epidemic (1). However, it is likely that a combination of several of the above four factors determines the changes in HIV incidence.

Notwithstanding the fact that stabilization or decline in HIV prevalence can occur independently of prevention efforts, as a result of the intrinsic dynamic of the epidemic, the decreases in incidence observed among sex workers and Royal Thai Army conscripts in northern Thailand, or those observed in parts of East Africa, may genuinely be due to prevention efforts. These declines possibly reflect either a reduction in the number of commercial sex contacts, or the success of the Thai government's "100% condom" policy in brothels, the impact of improved STD control on HIV incidence (16) or behavioural changes resulting from attending the death of many relatives.

The second question is how to evaluate the impact of interventions and other determinants of diverse infection patterns emerging from global surveillance? Declining rates of STD cases have been observed in communities where interventions have been successfully applied, and in the last year at the national level in Thailand (1). Whether public health interventions can be shown to influence the overall course of the epidemic depends greatly on the replication of surveillance data from more general populations in Africa, Asia and Latin America combined with in-depth evaluation. WHO has developed an evaluation package (17) and implemented evaluation activities tied closely to the progress achieved in HIV and AIDS surveillance over the last ten years. It is essential that continuity in the global surveillance framework be sustained over time, in order to interpret trends resulting from intervention efforts which are beginning to influence the epidemic and provide a glimmer of hope.

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4See footnote c on page 125.
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References


