The present and future course of the AIDS epidemic in Côte d’Ivoire

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An assessment of the current and future mortality and morbidity from acquired immunodeficiency syndrome (AIDS) in Côte d’Ivoire was made using the results of the 1989 national survey of the prevalence of human immunodeficiency (HIV) infection in the country and the AIDS projection model developed by WHO. For 1989 it was estimated that about 25 000 AIDS cases in adults and children had occurred, although the total number of cases reported for 1989 (up to 1 July 1991) was about 13% (1:6.9) of this estimated total. It is projected that by 1994 in Côte d’Ivoire the cumulative number of cases of AIDS in adults will be 89 000, and that for infants and children the corresponding number will be 41 000. It was also projected that about 371 000 uninfected children will have been born to HIV-infected mothers in Côte d’Ivoire by 1994 and that many of these children will have been orphaned by the deaths of their mothers from AIDS.

Introduction

The prevention and control of acquired immunodeficiency syndrome (AIDS) and human immunodeficiency virus (HIV) infection has presented an important public health challenge in Côte d’Ivoire, where both HIV-1 and HIV-2 are epidemic. Information on the current and future dimensions of HIV-1- and HIV-2-related (HIV when referring to both) AIDS morbidity and mortality was required for planning purposes and justification of the allocation of resources to the prevention and control of AIDS and HIV infection. An AIDS projection model has been developed by WHO (1), and we report on its first application, using the results of the 1989 national seroepidemiological survey of HIV prevalence (2), to obtain an estimate of current and near-future projections of AIDS cases in Côte d’Ivoire.

Materials and methods

Study population

In 1989 the estimated total population of Côte d’Ivoire was 12 429 000 (3), of which an estimated 5 276 000 were of reproductive age, i.e., 15–49 years. The crude birth rates for 1980 and 1985 were 51.0 per 1000 population and 50.9 per 1000, respectively, while the projected rate for 1990 was 50.2 per 1000. Approximately 47% of the population live in urban areas (the 60 cities with 10 000 or more inhabitants), and the remaining 53% in rural areas. About a third of the total urban population lives in Abidjan, the capital. Côte d’Ivoire has a good all-weather road network, and Abidjan is one of the three major ports for the landlocked countries of the West African interior. The principal mode of HIV transmission is heterosexual.

Estimated number of HIV-infected adults in mid-1989

A nationwide seroepidemiological survey of HIV prevalence among adults aged 15–49 years was conducted in Côte d’Ivoire during February 1989 using a cluster sampling approach, with the sampling probability proportional to population size (1). Abidjan was not included in the sampling frame of the survey. The HIV-1 prevalences for persons aged 15–49 years were approximately 4.2% in urban and 3.2% in rural areas; the HIV-2 prevalences for this age group were approximately 2.4% in urban, and 1.6% in rural areas. Approximately 1.1% of the samples from urban and 0.6% from rural areas were positive for both HIV-1 and HIV-2 infections in serological tests. Since seropositivity to both HIV-1 and HIV-2 does not necessarily establish infection with both viruses (4), for AIDS projection purposes dual HIV-1/HIV-2 seropositivity was assumed to be equivalent to infection with HIV-2 alone.

The 95% confidence limits were calculated for each HIV prevalence, making the assumption that the variance of a cluster sample can be approximated.
by standard statistical methods for the variance of a simple random sample. This assumption was made in the absence of any data on the interclass correlation coefficient to be used in instances when cluster sampling was employed to estimate the HIV prevalences in a population.

The HIV prevalences obtained in the 1989 national seroepidemiological survey were assumed to be good approximations for those in mid-1989 of the population aged 15–49 years. Though Abidjan was not surveyed, this assumption was considered reasonable, because the limited HIV seroepidemiological data obtained from selected population groups through the national HIV sentinel surveillance network indicated that Abidjan had an HIV prevalence similar to or greater than the values for other urban areas (B. N. Soro & G. M. Gershy-Damet, unpublished data, 1990).

Estimates of the mid-1989 prevalence among individuals aged 15–49 years in Côte d’Ivoire were obtained for HIV-1 infection and HIV-2 infection by multiplying the prevalences obtained in the 1989 survey of HIV prevalence by published population estimates.

**Estimation of annual cohorts of infants born to HIV-infected mothers**

Using published estimates of the proportion of the total population aged 15–49 years, we adjusted the crude birth rates to a 15–49-year-age group denominator to obtain the adjusted crude birth rate. The number of infants born annually to HIV-infected mothers in Côte d’Ivoire was estimated by multiplying the adjusted crude birth rate by annual estimates of the prevalence of HIV among 15–49-year-olds obtained using the WHO AIDS projection model (2). A gradually declining future incidence of HIV infection was assumed in the projection model.

**AIDS modelling**

Although data on the natural history of HIV infections are limited, they are sufficient to construct a simple model to estimate the dimensions of the AIDS epidemic up to 3–5 years into the future. Such short-term projections are largely independent of the HIV incidence over the projection period (2). A natural history model for short-term AIDS projections has been developed by WHO for use at the global, regional, or national level (5). This model, which uses estimates of HIV prevalence, appears to be particularly useful in instances where AIDS case surveillance data cannot reliably be used for projection purposes because of extensive underdiagnosis, underreporting, and reporting delays. The model was used to estimate the current and future dimensions of the AIDS epidemic in Côte d’Ivoire. The model has been described in detail elsewhere (2) and only those aspects that are specific to Côte d’Ivoire are discussed here.

The results obtained using the model were compared with the number of AIDS cases reported to WHO by the Côte d’Ivoire National AIDS Programme up to 1 July 1991 (WHO Global Programme on AIDS, unpublished data).

**Modelling AIDS cases in adults.** In the absence of any reliable estimates of the future incidence of HIV infection in Côte d’Ivoire, it was assumed that the incidence peaked in 1989, the year for which an estimate of the HIV prevalence in the country was made. A simple gamma function was used to model the incidence (2), using $P = 5$ in the expression, to obtain a gradually declining future incidence.

Extensive epidemic spread of HIV infection in Côte d’Ivoire was assumed to have started in 1980. For the model, the cumulative progression rates from HIV-1 infection to AIDS were assumed to be 2% after 2 years of infection, 20% after 5 years, 50% after 10 years, and 75% after 15 years. This assumption was based on data available on the natural history of HIV-1 infection (6). For HIV-2 infections it was assumed, in the absence of other data, that the cumulative progression rates to AIDS were halve those for HIV-1, i.e., 1% after 2 years, 10% after 5 years, 25% after 10 years, and 37.5% after 15 years of infection. The survival rates after the development of AIDS were assumed to be 50% after 1 year, 20% after 2 years, 5% after 3 years, and zero after 4 years (7).

**Modelling AIDS cases in infancy and childhood.** HIV infection in infancy or childhood was assumed to be entirely the result of transmission from an HIV-infected mother to her fetus or infant. A perinatal transmission rate of 30% (range, 20–40%) was used for HIV-1 infection; a the perinatal transmission rate for HIV-2 is less well established. We therefore assumed that it was half that for HIV-1-infected mothers, i.e., 15% (range, 10–20%). Annual cohorts of HIV-infected newborns were obtained by multiplying the perinatal transmission rates by the estimated number of infants (infected or uninfected) born annually to HIV-infected mothers.

The cohorts of HIV-1-infected newborns were assumed to progress cumulatively to AIDS as follows: 25% after 1 year, 45% after 2 years, 60% after 3 years, 70% after 4 years, and 80% after 5 years (8). The rates for HIV-2 infection were assumed to be half those for HIV-1, e.g., a cumulative rate of 40% after 5 years.

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The AIDS epidemic in Côte d’Ivoire

To account for competing mortality risks, we reduced all the estimates of AIDS-related childhood mortality by 10%. The assumptions about the year of onset of the epidemic spread of HIV and the survival rates after diagnosis of AIDS were the same as those made in the model for adults.

Results

Estimates of HIV prevalence in adults

Approximately 342,000 adults aged 15–49 years were estimated to be infected with HIV in Côte d’Ivoire in 1989. Almost half (43–44%) the total number of HIV infections occurred in rural areas and 56–58% of all HIV infections were due to HIV-1 (Table 1).

Estimated and projected AIDS cases in adults aged 15–49 years

It was estimated that about 15,000 cases of AIDS have occurred in adults aged 15–49 years in Côte d’Ivoire since 1980. By 1994, we project that the cumulative total of AIDS cases among adults of this age group will have risen to about 89,000. Our projections indicate that five-to-six times more cases of AIDS (57,000–91,000) will occur between 1990 and 1994 than have occurred between 1980 and 1989 (Fig. 1). About 11,000 persons had died of AIDS in

![Fig. 1. Estimates and projections of the cumulative number of AIDS cases in adults aged 15–49 years, Côte d’Ivoire, 1989–94 (the curves show the range).](image)

Table 1: Estimated prevalence of HIV infection among adults aged 15–49 years, Côte d’Ivoire, mid-1989

<table>
<thead>
<tr>
<th></th>
<th>Urban areas</th>
<th>Rural areas</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIV-1</td>
<td>105,000</td>
<td>89,000</td>
<td>194,000</td>
</tr>
<tr>
<td>(80,000–130,000)</td>
<td>(70,000–109,000)</td>
<td>(150,000–239,000)</td>
<td></td>
</tr>
<tr>
<td>HIV-2 + HIV-1/2</td>
<td>87,000</td>
<td>61,000</td>
<td>148,000</td>
</tr>
<tr>
<td>(65,000–112,000)</td>
<td>(45,000–75,000)</td>
<td>(110,000–187,000)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>192,000</td>
<td>150,000</td>
<td>342,000</td>
</tr>
<tr>
<td>(145,000–242,000)</td>
<td>(115,000–184,000)</td>
<td>(260,000–426,000)</td>
<td></td>
</tr>
</tbody>
</table>

* Figures in parentheses are the 95% confidence limits.

Table 2: Estimated and projected data for AIDS cases among adults aged 15–49 years, Côte d’Ivoire, 1989–94

<table>
<thead>
<tr>
<th></th>
<th>AIDS cases</th>
<th>AIDS deaths</th>
<th>AIDS prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>15,000</td>
<td>11,000</td>
<td>4,000 (3,000–5,000)</td>
</tr>
<tr>
<td>(11,000–19,000)</td>
<td>(8,000–14,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>35,000</td>
<td>27,000</td>
<td>8,000 (6,000–10,000)</td>
</tr>
<tr>
<td>(26,000–42,000)</td>
<td>(20,000–33,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>89,000</td>
<td>72,000</td>
<td>16,000 (13,000–21,000)</td>
</tr>
<tr>
<td>(68,000–110,000)</td>
<td>(55,000–90,000)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Figures in parentheses are the range.
Table 3: Estimated and projected number of cases of HIV/AIDS among infants and children, Côte d’Ivoire, 1989-94

<table>
<thead>
<tr>
<th>Cumulative number of:</th>
<th>Newborns of HIV-infected mothers</th>
<th>HIV-infected newborns</th>
<th>AIDS cases</th>
<th>AIDS-related deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>107 000</td>
<td>25 000</td>
<td>10 000</td>
<td>8000</td>
</tr>
<tr>
<td></td>
<td>(80 000–132 000)*</td>
<td>(13 000–41 000)</td>
<td>(5000–16 000)</td>
<td>(4000–12 000)</td>
</tr>
<tr>
<td>1991</td>
<td>196 000</td>
<td>46 000</td>
<td>20 000</td>
<td>16 000</td>
</tr>
<tr>
<td></td>
<td>(148 000–244 000)</td>
<td>(24 000–76 000)</td>
<td>(10 000–32 000)</td>
<td>(8000–26 000)</td>
</tr>
<tr>
<td>1994</td>
<td>371 000</td>
<td>87 000</td>
<td>41 000</td>
<td>35 000</td>
</tr>
<tr>
<td></td>
<td>(283 000–467 000)</td>
<td>(44 000–145 000)</td>
<td>(18 000–68 000)</td>
<td>(16 000–58 000)</td>
</tr>
</tbody>
</table>

* Figures in parentheses are the range.

Côte d’Ivoire up to 1989, and it is projected that by 1994 about 72 000 of those who progress to AIDS will have died of the disease (Table 2). The prevalence of AIDS cases in adults aged 15–49 years was estimated to be around 4000 in 1989, and this is projected to rise to about 16 000 by 1994.

**Estimated and projected HIV infections and AIDS cases in infants and children**

By 1989 a cumulative total of about 25 000 infants had been born in Côte d’Ivoire with HIV infection, and allowing for competing mortality risks, by 1989 an estimated 10 000 had progressed to AIDS. Of those who developed AIDS, an estimated 8000 have already died. Our projections indicate that by 1994 the cumulative number of HIV-infected infants will have increased to approximately 87 000, of whom about 41 000 will probably have progressed to AIDS (Fig. 2), and that 35 000 will have died. Up to 1989, about 107 000 uninfected infants had been born to HIV-infected mothers, and this cumulative total is projected to increase to 371 000 by 1994 (Table 3).

**Comparison of reported and estimated and projected AIDS cases**

Up to 1 October 1991 a total of 6836 cases of AIDS had been reported to WHO by the Côte d’Ivoire National AIDS Programme, 3189 of which had been diagnosed in 1990. The cumulative total diagnosed and reported up to the end of 1989 was therefore 3647. The WHO “Bangui” clinically-oriented AIDS case definition, supplemented by a requirement where possible for confirmation of HIV infection status, is used in Côte d’Ivoire for surveillance purposes. The age distribution of 2664 (73%) of the cases reported up to 1989, all of which had been diagnosed and reported in 1988 and 1989, was as follows: 63 (2.4%) were under 5 years of age, 2280 (85%) were aged 15–49 years, and 313 (12%) were 50 years.

Table 4 compares the results of the study with the number of reported AIDS cases. We estimated that

Table 4: Comparison of the reported and estimated cumulative number of AIDS cases in Côte d’Ivoire up to the end of 1989

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Number of cases:</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Reported*</td>
</tr>
<tr>
<td>0–4</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>15–49</td>
<td>2280</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Other/unknown</td>
<td>991</td>
</tr>
<tr>
<td>Total</td>
<td>3647</td>
</tr>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

* Number of cases diagnosed and reported for 1989, as reported to WHO by the National AIDS Programme, Côte d’Ivoire, up to 1 October 1991.

b Figures in parentheses are the range.
the ratio of reported to estimated cases was 1:6.9. For AIDS in infants and children, the ratio of reported to estimated cases was approximately 1:160.

Discussion

Short-term projections can be important for public health purposes, since government health planning tends also to be on this time scale. For rational planning and resource allocation, such projections must often be made based on the best information available, even though the results are potentially erroneous. Therefore, they should be the focus of continuous critical review and revision at the appropriate time.

This study has attempted to estimate systematically and project the short-term course of the AIDS epidemic in Côte d’Ivoire, based on the following: the results of a seroepidemiological survey of HIV prevalence carried out in 1989; the epidemiology of AIDS and HIV infection; the estimated perinatal HIV transmission rates; and the estimated rates for the progression from HIV infection to AIDS. We estimate that for 0–4-year-olds and 15–49-year-olds alone, about 25 000 cases of AIDS had occurred in Côte d’Ivoire up to 1989. By 1994, we project a cumulative total of 130 000 cases of AIDS for these two age groups. Based on the reported number of cases of AIDS, about 12% will occur in adults aged ≥50 years. When data are taken into consideration that suggest slower progression from HIV-2 infection to AIDS (4) our findings indicate that AIDS in adults aged ≥50 years may contribute at least another 15% to the projected cumulative totals for adults aged 15–49 years. Cases of AIDS among 5–14-year-olds will probably add a further 2–3% to the total.

These projections are based on the results of the 1989 national survey of HIV prevalence in the general adult population, with probability proportionate to the size of the cluster sampled. The representativeness of the results of this survey may be questioned for the following reasons: Abidjan, which contains about a third of the total urban population of the country, was not included; the survey was not stratified to give greater weight to population groups at higher-than-average risk of HIV infection; and the methods used may not have allowed for potential differences in participation bias in the survey as a function of an individual’s risk of HIV infection (9).

In view of the non-uniform distribution of AIDS and HIV infection by behaviours and practices, as well as geographically, it is likely that populations at higher risk of HIV infection were significantly undersampled in the 1989 survey. In addition, the variance probably underestimated the true cluster sample variance, since there was probably a positive correlation within a cluster for the risk of HIV infection (10). The estimates of the prevalence of HIV in Côte d’Ivoire based on the 1989 national survey may well therefore be conservative.

The natural history of HIV-1 infection in sub-Saharan Africa is not fully established, although there is little evidence to suggest that the rates of progression to AIDS are different from those observed elsewhere (6). Perinatal transmission of HIV-1 may depend on various viral and host factors, including the severity of maternal immunodeficiency. In general, the 20–40% range used in the study to estimate HIV-1, perinatal transmission appears to be reasonable.

Less is known about the natural history of HIV-2 infection in adults, and about HIV-1 and HIV-2 infection in infants and children in sub-Saharan Africa. Data on survival following onset of AIDS are also incomplete. In the absence of such information, the HIV-2 progression and perinatal transmission rates assumed in the study are reasonable. The AIDS survival rates are based on data from the USA. Survival after onset of AIDS in sub-Saharan Africa is likely to be shorter than for comparable cases in the USA; the projections and estimates of AIDS-related mortality made in this study are therefore likely to be conservative.

The range of estimates given are intended to convey the uncertainty inherent in projections. As more data on the natural history of HIV infection accumulate, revised projections will be possible.

In making projections of AIDS cases to 1994, we assumed that the incidence of HIV infection was at a peak in 1989. This assumption has relatively little influence on short-term projections of the number of AIDS cases among adults, since such projections are largely independent of the future incidence because of the relatively slow rate of progression from HIV infection to AIDS in adults (2). However, because cases of HIV infection/AIDS in infants and children in sub-Saharan Africa are largely due to transmission from HIV-infected women to their fetus or infants, assumptions about the future HIV incidence among adults, and hence among women aged 14–49 years, do have an important influence on AIDS projections for infants and children. A gradually declining future HIV incidence was assumed for the model and resulted in reasonably conservative short-term AIDS projections for infants and children. Overall, the projection for infants and children should, however, be considered to be of lower precision than those for adults.

The study results should thus be viewed with caution. However, we believe that they reflect,
within a factor of ten, the serious challenge faced by Côte d'Ivoire as a consequence of HIV infection and AIDS. In 1988–89, by which time the estimated cumulative number of cases of AIDS among 15–49-year-olds was 15 000, a study in the two largest hospitals in Abidjan indicated that 40% of all patients in the medical wards were HIV infected (1/7). The capacity of any health infrastructure to cope with a disease projected to increase almost sixfold over the next 5 years must be questioned, when already in 1989 up to 40% of medical-ward beds were occupied by HIV-infected persons.

Mortality among infants, children, and adults in the most socially and economically important age group is expected to increase dramatically in Côte d'Ivoire over the next few years: this is consistent with the results of other studies (12, 13) (K. M. De Cock, personal communication, 1990). The implications for maternal and child health are potentially serious; not only because of the projected 41 000 cases of AIDS among infants and children by 1994, but also because of an expected cumulative total of 371 000 uninfected infants born to HIV-infected mothers. These infants face the prospect of being orphaned in childhood as a result of the deaths from AIDS of their mothers or of both parents.

Conclusions

In common with many countries of sub-Saharan Africa, Côte d'Ivoire faces a public health crisis brought about by the extensive epidemic spread of HIV infection. The results of the present study, while not definitive, indicate a mounting of HIV-related morbidity and mortality among adults in their most socially and economically productive years, as well as among infants and children. The potentially serious effects of the epidemic on the economic and social fabric of the nation ought not to be underestimated. The implications for children lie not only in the potential reversal of the important gains made in child survival through, for example, immunization, control of diarrhoeal diseases, and nutrition but also in the number of children who may be orphaned in the near future by the death of their mother or of both parents from AIDS. The prevention and control of AIDS and HIV infection must be sustained and strengthened to meet these challenges.

Acknowledgements

We are grateful to the Minister of Public Health, Côte d'Ivoire, for assistance in conducting this study. The seroepidemiological study of HIV infection in 1989 was supported by grants from WHO and UNICEF.

Résumé

L’épidémie de SIDA en Côte d’Ivoire: chiffres actuels et projections

En vue de la planification et de la justification de l’allocation de ressources aux activités de lutte contre le SIDA et les infections à virus de l’immunodéficience humaine (VIH), il était nécessaire de disposer d’informations sur les chiffres actuels et futurs de mortalité et de morbidité par SIDA en Côte d’Ivoire. A cet effet, on a appliqué les résultats de l’enquête nationale de 1989 sur l’infection à VIH au modèle OMS de projection des cas de SIDA. D’après les données disponibles, on a pris comme taux cumulatif d’évolution de l’infection à VIH-1 de l’adulte vers le SIDA environ 20% au bout de cinq ans, 50% au bout de 10 ans, et 75% au bout de 15 ans.

Des taux de 20 à 40% ont été retenus pour la transmission péritonale du VIH-1 et un taux cumulatif de 80% au bout de 5 ans pour l’évolution vers le SIDA chez l’enfant. Pour les infections à VIH-2, on a pris comme taux d’évolution et de transmission péritonale la moitié des taux retenus pour les infections à VIH-1. Comme une double séroactivité vis-à-vis du VIH-1 et du VIH-2 ne signifie pas qu’il y ait infection simultanée par les deux virus, on a considéré comme infections à VIH-2 tous les résultats faisant apparaître une double réactivité. On a supposé que la transmission épidémique des infections à VIH en Côte d’Ivoire avait commencé autour de 1980.

Il a été estimé que jusqu’à 1989, environ 25 000 cas de SIDA s’étaient déclarés en Côte d’Ivoire (15 000 cas adultes et 10 000 cas pédiatriques). Pour 1994, le nombre cumulatif projeté sera de 140 000 (89 000 cas adultes et 41 000 cas pédiatriques). Un total cumulatif d’environ 371 000 enfants non infectés seront nés de mères infectées d’ici 1994 – enfants qui risquent de devenir orphelins du fait du décès de leur mère par SIDA.

L’enquête nationale de 1989 peut ne pas avoir fourni une estimation exacte de la prévalence du VIH, car Abidjan ne figurait pas dans le cadre d’échantillonnage, et la technique de sondage par grappes risque de ne pas avoir rendu compte de la non-homogénéité de la distribution de l’infection à VIH selon les comportements et pratiques à risque. De même, on ne connaît qu’imparfaitement l’histoire naturelle de l’infection.
à VIH-2, de sorte que les hypothèses quant à l'évolution de l'infection à VIH-2 en SIDA et quant à la transmission perinatale du VIH-2 sont sujettes à caution. Ces projections peuvent par conséquent devoir être révisées lorsqu'on disposera de données plus exactes sur l'épidémiologie de l'infection à VIH en Côte d'Ivoire.

Le sextuplement prévu des cas de SIDA de 1989 à 1994 en Côte d'Ivoire constituera probablement un défi majeur pour l'infrastructure sanitaire du pays où, déjà en 1989, jusqu'à 40% des lits d'hôpitaux étaient occupés par des sujets infectés par le VIH.

References