Incidence of HIV-1 Infection in Adults and Socio-Demographic Characteristics of Seroconverters in a Rural Population in Uganda: 1990–1994

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Background. To evaluate HIV-1 incidence among adults and socio-demographic risk factors in a rural population in Uganda, a prospective cohort study was carried out.

Methods. All consenting adult residents in a cluster of 15 neighbouring villages of the Masaka District of south-west Uganda have been participating in annual socio-demographic and serological surveys since November 1989. Those who had a negative serostatus when they were first tested and had at least one serostatus assessment during the 4 years of follow-up (1990–1994) have been evaluated for HIV-1 seroconversion. Incidence rates have been calculated per 1000 person-years of observation and socio-demographic characteristics assessed for association with recent seroconversion.

Results. At the baseline survey, of 4175 adults with assessable serostatus (79% of all censused adults), 342 (8.2%) were seropositive. During 12 588.2 person-years of follow-up 89 seroconversions were identified corresponding to an incidence rate of 7.1 (95% CI: 5.6–8.5). Overall rates were highest in females aged 20–24 years (15.2) and in males aged 20–44 years (11.6). There was a significant interaction between age and sex; the ratio of the rate in females to that in males decreased from 3.3:1 to 0.5:1 with increasing age. Rates for males aged ≥20 years were four times higher than those for younger males. Other significant socio-demographic correlates with risk included not belonging to the majority tribe, non-Muslim religion and length of stay on compound of less than 10 years. Incidence rates did not show any clear trends with time.

Conclusion. These findings further emphasize the need for targeted interventions.

Keywords: HIV-1, incidence, trends in incidence, risk factors, rural population, Uganda

Studies of HIV incidence are important for the understanding of the population dynamics of the infection, planning and evaluation of preventive programmes and for more realistic projections of the progress of the epidemic as well as its various impacts on populations. Such data have remained scarce for general populations of Africa because prospective cohort studies are costly and not feasible in many African countries, and the authors are aware of only a few such reports in the literature.1–4 In this paper HIV-1 incidence in adults during 4 years of follow-up and socio-demographic characteristics of the seroconverters is reported. Socio-demographic and risk characteristics of AIDS patients are regularly included in reports of Ministries of Health. In addition, data on these factors have been documented by several workers in the region for seropositive individuals whose date of seroconversion is not known but occurred by the end of the last decade.5–9 While these data are important and have formed the basis for intervention programmes, the need to characterize recent seroconverters must be realized in order to design better targeted interventions.
METHODS

Study Population
The area of study was a subcounty of Masaka district in south-west Uganda, situated approximately 16 km from Masaka town and 8 km from the trans-African highway at its nearest point. The inhabitants are mainly peasants who grow bananas as a subsistent crop and cultivate coffee for sale. Households are scattered, although some are concentrated around the trading village at the centre of the study area. Usually each compound contains one household and about half of the inhabitants are >13 years. The predominant ethnic group, the Baganda, constitute approximately 70% of the population; a substantial number of Rwandese immigrants who settled in the area 30–40 years ago now constitute 20% of the population. A mixture of other tribes makes up the remainder. The main local language is Luganda which is spoken and understood by all the tribes. The majority of the population are Roman Catholics; about one-quarter are Muslims. At the start of the study medical facilities in the area were limited to two government dispensaries and a mission health centre. A study clinic was started in late 1990 mainly to serve specific research activities and to improve on the management of sexually transmitted diseases (STD). The nearest hospital is in Masaka town.

House-to-House Annual Surveys
Between November 1989 and October 1990, all adult (≥13 years) residents (a resident was defined as any person who had stayed in the study area for at least the last 3 months or had recently moved to the area with the intention of staying) of 15 adjoining villages were visited in their homes by locally trained census takers and subsequently by a paramedical team. Enrollment procedures consisted of informed consent, the administration of a socioeconomic questionnaire, a medical interview and a serological survey. These were repeated annually thereafter using the same definition of residency as earlier mentioned thus enabling enrolment of individuals who migrated into the study area (semi-closed cohort). In addition to individual’s HIV serostatus, information on socio-demographic factors such as gender, age, marital status, religion, ethnic group, mobility and migration patterns was collected. The total population of the study villages is about 10,000; about 50% are adults and over 90% of them were enrolled into the survey. At the baseline survey, 4175 adults had their HIV-1 status assessed and the seroprevalence rate was 8.2%.

Serology
HIV-1 status was determined using two independent ELISA assays; Recombigen HIV-1 EIA (Cambridge Biotech, Corporation, Worcester, Massachusetts, USA) and Wellcozyme HIV-1 Recombinant (Wellcome Diagnostics, Dartford, England, UK) following set algorithms and rigorous quality control procedures. Incident sera were reconfirmed by Western blot using Novopath HIV Immunoblot (Bio-Rad Laboratories, Watford, England, UK).

A counselling service was established for those who wished to know their HIV serostatus and details of this service have been described elsewhere.

Data Analysis
Data were double entered and verified using IBM personal computers and Dbase III plus software. Data were checked for consistency and completeness. The overall incidence of HIV-1 infection per 1000 person-years of observation was estimated from the number of seroconversions and the total person-years of follow-up. In calculating person-years of observation, individuals were included from the time of their first negative test until their last available serological result. For those who seroconverted the date of seroconversion was estimated to be the mid-point between the date of the last negative test and the first positive test. It was assumed that incidence rates had a Poisson distribution both for calculating confidence intervals and for testing differences between rates.

At the baseline survey we collected data on length of time that individuals had lived on the compound. Unfortunately the answer ‘always lived on this compound’ was incorrectly translated as ‘always lived in this area’. Since it was not possible to reclassify those giving this response it was necessary to exclude them from the analysis of the association between sero-incidence and duration of residency on compound.

Rates in the tables are crude incidence rates per 1000 person-years. Multivariate incidence analysis was performed using the EGRET package.

RESULTS

Rates of HIV-1 Seroconversion by Age and Sex
A total of 89 seroconversions were identified during 12,588.2 person-years of observation; this corresponds to a seroconversion rate of 7.1 (95% CI: 5.6–8.5) per 1000 person-years. Table 1 shows the conversion rates by age and sex. Highest rates for males were in the 20–44 year age group and for females in the 20–24 year age group, 11.6 (not tabulated) and 15.2 per 1000 person-years respectively.

There was no statistically significant difference between the rate for males and females, however, there was a significant interaction with age (P = 0.03); the
TABLE 1 Rates of HIV-1 seroconversion by age and sex

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Person-years</th>
<th>Males</th>
<th>Rate (95% CI)</th>
<th>Females</th>
<th>Person-years</th>
<th>Rate (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13–19</td>
<td>1933.7</td>
<td>4</td>
<td>2.1 (0.0–4.1)</td>
<td></td>
<td>1849.3</td>
<td>12</td>
</tr>
<tr>
<td>20–24</td>
<td>678.3</td>
<td>7</td>
<td>10.3 (2.7–18.0)</td>
<td></td>
<td>649.1</td>
<td>10</td>
</tr>
<tr>
<td>25–34</td>
<td>957.7</td>
<td>12</td>
<td>12.5 (5.4–19.6)</td>
<td></td>
<td>1309.4</td>
<td>13</td>
</tr>
<tr>
<td>35–44</td>
<td>688.4</td>
<td>8</td>
<td>11.6 (3.6–19.7)</td>
<td></td>
<td>887.1</td>
<td>4</td>
</tr>
<tr>
<td>45+</td>
<td>1813.3</td>
<td>13</td>
<td>7.2 (3.3–11.1)</td>
<td></td>
<td>1813.0</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>6071.3</td>
<td>44</td>
<td>7.2 (5.1–9.4)</td>
<td></td>
<td>6516.9</td>
<td>45</td>
</tr>
</tbody>
</table>

NB Rates per 1000 person-years of observation.
Total person-years of observation = 12 588.2; overall incidence rate = 7.1 (5.6–8.5).

TABLE 2 Rates of HIV-1 seroconversion by selected socio-demographic variables: 1990–1993

<table>
<thead>
<tr>
<th>Variable</th>
<th>Person-years</th>
<th>No. seroconverted</th>
<th>Rate/1000 person-years (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calendar year</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990</td>
<td>2197.5</td>
<td>18</td>
<td>8.2 (4.4–12.0)</td>
</tr>
<tr>
<td>1991</td>
<td>3210.7</td>
<td>22</td>
<td>6.9 (4.0–9.7)</td>
</tr>
<tr>
<td>1992</td>
<td>3162.6</td>
<td>18</td>
<td>5.7 (3.1–8.3)</td>
</tr>
<tr>
<td>1993</td>
<td>2912.9</td>
<td>26</td>
<td>8.9 (5.5–12.4)</td>
</tr>
<tr>
<td>1994*</td>
<td>1104.5</td>
<td>5</td>
<td>4.5 (0.6–8.5)</td>
</tr>
<tr>
<td>Tribe</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bagandan</td>
<td>8433.1</td>
<td>48</td>
<td>5.7 (4.1–7.3)</td>
</tr>
<tr>
<td>Other Ugandan</td>
<td>578.4</td>
<td>9</td>
<td>15.6 (5.4–25.7)</td>
</tr>
<tr>
<td>Rwandese</td>
<td>2318.6</td>
<td>16</td>
<td>6.9 (3.5–10.3)</td>
</tr>
<tr>
<td>Other tribe</td>
<td>866.0</td>
<td>12</td>
<td>13.9 (6.0–21.7)</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslim</td>
<td>3313.5</td>
<td>9</td>
<td>2.7 (0.9–4.5)</td>
</tr>
<tr>
<td>Other</td>
<td>8882.7</td>
<td>76</td>
<td>8.6 (6.6–10.5)</td>
</tr>
<tr>
<td>Duration of residency on compound (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Joined after baseline</td>
<td>692.4</td>
<td>9</td>
<td>13.0 (4.5–21.5)</td>
</tr>
<tr>
<td>Resident at baseline</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;5</td>
<td>2093.0</td>
<td>21</td>
<td>10.0 (5.7–14.3)</td>
</tr>
<tr>
<td>5–9</td>
<td>1417.0</td>
<td>15</td>
<td>10.6 (5.2–15.9)</td>
</tr>
<tr>
<td>10+</td>
<td>4105.0</td>
<td>19</td>
<td>4.6 (2.5–6.7)</td>
</tr>
</tbody>
</table>

*a Data on tribe, religion and duration of residency are based on a subset of the total population.
*b Because the seroconversion date is backdated to half-way between the last negative lest and the first positive test, figures for 1994 are likely to be an underestimate.

ratio of incidence rates in the female to male population decreasing steadily from 3.3 : 1 in the 13–19 year old age group to 0.5 : 1 in those aged ≥45 years.

For males aged ≥20 years there was no significant difference in rates between the age groups but the combined rate for those aged ≥20 years was significantly higher than in the 13–19 year age group, 9.7 compared to 2.1 per 1000 person-years. Among females there was no difference in rates except when those aged 20–24 years were compared to the remainder (P = 0.02).

Incidence Rates by Calendar Year, Ethnic Group, Religion and Duration of Residence on Compound

Table 2 shows rates of HIV-1 seroconversion by calendar year, ethnic group, religion and duration of residence on the compound. During the 4 years 1990–1993
annual incidence rates did not show any clear trends as they declined from 8.2 in 1990 to 5.7 in 1992 but rose to 8.9 the following year.

There were significant differences according to ethnic group, the lowest rates being in the Baganda, 5.7 per 1000 person-years and the highest in those of other Ugandan tribes, 15.6 per 1000 person-years. The Baganda had a significantly lower rate when compared to the other categories combined, $P = 0.01$.

Non-Muslims had a significantly higher rate than Muslims, 8.6 and 2.7 respectively ($P < 0.001$), a relative risk of 3.15 (95% CI: 1.58-6.29).

People who had been resident on their compound for <10 years at the time of enrolment were twice as likely to seroconvert as those who had been present for longer, relative risk (RR) = 2.31 (95% CI: 1.35-3.96).

**Incidence Rates by Marital Status**

Seroconversion rates by age, sex and marital status are shown in Table 3. For both males and females aged <25 years marriage appeared to be a risk factor in that incidence rates were significantly higher in those who had ever married compared to those who had never married, $RR = 4.05$ (95% CI: 2.02-8.09). In older people, however, the numbers of those who had never married were small and the difference between their rates and the rates of those who had ever married was not significant.

**Multivariate Analysis**

Because of differences in the pattern of seroconversion rates in the two sexes with respect to age, a multivariate analysis was performed separately for males and females for the socio-demographic factors found to correlate with sero-incidence. For males, after fitting the two age groups <20 years and ≥20, being a non-Muslim carried a considerably higher risk than being Muslim ($RR = 3.94$, 95% CI: 1.22-12.75), those aged ≥20 having an RR of 4.15 (95% CI: 1.48-11.61). When time on the compound was added, on the smaller population with complete data on this variable, age was no longer significant and the RR for the two significant factors were, for being a non-Muslim 10.22 (95% CI: 1.40-74.8) and for being resident for <10 years 3.70 (95% CI: 1.67-8.33). For women the only factor of significance in addition to age was religion. The RR for those aged 20–24 years compared to those of other ages was 2.52 (95% CI: 1.20-5.29) and for non-Muslims compared to Muslims 2.54 (95% CI: 1.07-6.05).

**DISCUSSION**

A 4-year follow-up period has resulted in an overall incidence rate of 7.1 per 1000 person-years, highest in females aged 20–24 and males aged 20–44. Rates among males aged ≥20 years were four times lower than in older males. Socio-demographic correlates with seroconversion included tribe, religion, duration of residency and recent marriage. No time trends were observed.

We are not aware of data from rural African populations for an equivalent length of follow-up; existing data being for follow-up periods of only one year. Killewo et al. have reported an overall incidence rate among rural adults in the Kagera area in Tanzania of the same order as reported here; 8.2 per 1000 person-years after one year of follow-up, against background HIV-1 seroprevalence rates of 10.0%, 4.5% and 0.6% in the three rural regions they studied. In contrast, in Rakai—a district adjoining the one we studied—where HIV prevalence rates among adults in agricultural villages off main and secondary roads were very similar to ours (8.6%), one-year HIV incidence adjusted for oversampling of trading centres was estimated to be considerably higher (21 per 1000 person-years [95% CI = 11-31]) than both the incidence rates we previously reported after one year of follow-up (9.4 [95% CI: 5.5-12.9]) and what we observed after 4 years of follow-up. Possible reasons for variations in incidence rates between populations within the same country and between countries in the same region cannot be exhaustively discussed in this paper and we are in no position to explain why rates in incidence varied between neighbouring districts since both programmes implemented intervention.
efforts which included behaviour change messages, condom distribution and improved treatment for sexually transmitted diseases.

In this rural population with considerable HIV prevalence and a high HIV-associated mortality, overall incidence rates do not show any clear trends and levels of infection with other STD have remained high. In an earlier paper we reported a significant decrease in both HIV-1 prevalence and incidence rates in young men. We have now observed a striking difference in sero-incidence rates between males aged <20 and those ≥20 years. This difference was also observed in females but to a lesser degree. It may be explained by a greater tendency in male than in female adolescents to delay sexual debut or by differences in partner choice, with young females tending to have sex with older infected males. It emphasizes the importance of group-specific rates since trends in overall prevalence and incidence rates may not necessarily reflect rates in subgroups of the population. In Kinshasa, stable overall prevalence among childbearing women masked high incidence in young women. Better targeted interventions are therefore more likely to result in more realistic measures of these indicators as has been reported in a cohort of women of reproductive age (1988–1992) in Kigali, Rwanda, where sero-incidence rates decreased from 7.6 during the first 6 months postpartum to 2.5 per 100 women-years during the last 6 months of the third year of follow-up following counselling, testing and condom provision.

It is unlikely that selection bias resulted in under-estimating incidence. A detailed argument for this has been included in our earlier publication, the main reason being a high rate of compliance. We know, however, from earlier studies of risk factors for adults that in this population the risk of infection is associated with migration and therefore some individuals who seroconverted may have left the area before being retested. It is improbable that the sero-incident cases reported represent false positive results since HIV serology was conducted using strict quality control assurance procedures. Of the 89 incident cases 75 were subsequently enrolled in a study of the natural history of HIV infection and all but one were confirmed to be seropositive, one had a seronegative result on enrolment into the natural history study but died shortly afterwards of an AIDS-like illness.

This paper attempts to explore socio-demographic factors associated with seroconversion. Socio-demographic risk factors among recently infected individuals did not differ from those found among prevalent cases. Non-Muslims had a higher risk than Muslims. This was consistent with our earlier observations. While this may be due to a protective effect of male circumcision, we cannot exclude lifestyle and behavioural effects as very few non-Muslim males in this community are circumcised. Literature on the association between circumcision and risk of HIV infection has been extensively reviewed and found to be inconclusive. The association between circumcision and risk of HIV-1 infection clearly deserves further research. Non-Baganda had a higher risk than Baganda, they included immigrants from Rwanda, from other parts of Uganda, and a small number from other neighbouring countries. These people may be at increased risk because of their relative poverty. We have previously reported an association between relatively low socio-economic status and increased risk of HIV infection. It is also possible that because of language and other factors, AIDS prevention messages have not reached these minority ethnic groups. High HIV infection rates have also been documented for minority subgroups of the US population.

Risk of HIV infection was found to be associated with duration of occupancy of compound. Our data suggest that ‘movers’ have lifestyles that put them at increased risk of infection leading to the already reported association between infection and immigration.

The interaction between marital status and age indicates that in the youngest age group (<25 years) marriage represents a substantial risk factor perhaps because young married people are more likely to engage in extra-marital sex than the older married. It could, however, also mean that starting sexual activity leads to stable partnerships and with this level of background HIV-1 seroprevalence individuals face substantial risk of infection from their first sexual partners and/or spouses.

This paper has raised a number of questions and possibilities for further research on intervention strategies. With only 4 years of follow-up, it is too early to discern time trends in the population dynamics of HIV transmission and to confirm observed trends in young males. The cohort must be followed for a much longer period. The similarities between our observed incidence rate and that reported from neighbouring Tanzania is reassuring but what are the explanations for the discrepancy in incidence rates between our population and that of a neighbouring district? What lifestyle and behavioural differences if any, prevail between Muslims and people of other religions in this population? What role can premarital counselling and testing programmes play in this population in the control of HIV-1 transmission since marriage in younger people is associated with increased risk of infection? What programmes can target young males in order to reinforce and consolidate...
the behaviour changes that are resulting in the observed lower risk of infection in this particular group? How best can minority tribal groups in this population be targeted? These and other related research questions must be addressed in order to design more appropriate and better targeted interventions.

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REFERENCES

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