

EDITORIAL REVIEW

HIV infections in sub-Saharan Africa not explained by sexual or vertical transmission

David Gisselquist PhD¹, Richard Rothenberg MD, MPH²,
John Potterat BA¹ and Ernest Drucker PhD³

¹Independent consultant, ²Department of Family and Preventive Medicine, Emory University School of Medicine, Atlanta, Georgia, ³Department of Epidemiology and Social Medicine, Montefiore Medical Center/Albert Einstein College of Medicine, NYC, USA

Summary: An expanding body of evidence challenges the conventional hypothesis that sexual transmission is responsible for more than 90% of adult HIV infections in Africa. Differences in epidemic trajectories across Africa do not correspond to differences in sexual behaviour. Studies among African couples find low rates of heterosexual transmission, as in developed countries. Many studies report HIV infections in African adults with no sexual exposure to HIV and in children with HIV-negative mothers. Unexplained high rates of HIV incidence have been observed in African women during antenatal and postpartum periods. Many studies show 20%–40% of HIV infections in African adults associated with injections (though direction of causation is unknown). These and other findings that challenge the conventional hypothesis point to the possibility that HIV transmission through unsafe medical care may be an important factor in Africa's HIV epidemic. More research is warranted to clarify risks for HIV transmission through health care.

Keywords: iatrogenic, nosocomial, HIV, AIDS, sub-Saharan Africa

INTRODUCTION

Within two years after the first AIDS cases were described in homosexual men in Los Angeles in 1981, AIDS was diagnosed in Haitians¹ and among Africans in Europe², Zaire³ (now Democratic Republic of Congo [DRC]), Rwanda⁴, and Zambia⁵. Unlike AIDS in the US and Europe, which seemed concentrated among injection drug users (IDUs), men-who-have-sex-with-men (MSM), and haemophiliacs, AIDS in Haitians and Africans occurred about equally in women and men, and was found among the well-to-do, including those who could afford to go to Europe for medical care.

Experts at a World Health Organization (WHO) meeting on AIDS in November 1983 puzzled over possible channels for HIV transmission among Africans and Haitians⁶. While noting that spouses of AIDS patients were at risk, experts were undecided about heterosexual promiscuity, concluding that 'whether persons with multiple heterosexual sex partners are at greater risk of acquiring AIDS is unknown...'. Meeting participants considered that 'injections with unsterile needles and syringes may play a role...'. WHO's

1983 recommendations focused on sterilization of medical equipment, blood safety, and MSMs.

During 1983–88, researchers in Africa found high rates of HIV prevalence among female commercial sex workers (CSWs) and patients at sexually transmitted disease (STD) clinics^{7–9}. By the end of the 1980s, a consensus emerged among AIDS experts dealing with Africa that over 90% of adult HIV infections in sub-Saharan Africa were acquired through heterosexual contact and less than 2% through unsafe injections^{10–13}. Unfortunately, this consensus was achieved without research to address confound between sexual and medical exposures. As Packard, Epstein, Minkin, and others have noted, CSWs and STD patients have relatively high levels of medical exposures that may be channels for transmission of blood borne pathogens^{14,15}. Further, the consensus ignored evidence from 1980s research suggesting non-trivial levels of HIV transmission to African children and adults through unsafe injections and other medical care^{16–19}.

OBSERVATIONS ON HETEROSEXUAL TRANSMISSION

During the past decade, researchers have struggled to fit emerging facts about Africa's evolving HIV epidemic into the consensus view that heterosexual transmission accounts for nearly all adult infections

Correspondence and reprint requests to: David Gisselquist, 29 West Governor Road, Hershey, Pennsylvania 17033, USA
E-mail: david_gisselquist@yahoo.com

and that iatrogenic transmission is minimal. Many facts do not fit well.

Divergent epidemic trajectories

Differences in sexual behaviour across countries do not explain differences in epidemic trajectories. In some countries and regions with high HIV prevalence during the second half of the 1980s, such as DRC, Uganda, and Kagera in Tanzania, the epidemic has been stable or declining during the 1990s. In others, such as South Africa and Botswana, the epidemic reportedly doubled in less than two years among the low risk population (*viz.*, antenatal women) during the early 1990s. A series of sexual behaviour surveys in 12 African countries during 1989–93 shows no apparent correlation between the per cent of adults in a country reporting non-regular sexual partners in the last year and HIV prevalence²⁰. A more recent study of sexual behaviour and HIV prevalence in four African cities reports that partner change, contacts with sex workers, and concurrent partnerships were no more common in the two high prevalence cities studied than in the two low prevalence cities^{21,22}.

Unexplained high implicit rates of heterosexual transmission in Africa

The assumption that historic and continuing high rates of epidemic increases among African adults are almost exclusively due to sexual transmission requires much higher rates of heterosexual transmission in Africa than in the developed world. However, a recent study of HIV incidence in serodiscordant couples in Africa (only 1.2% reported consistent condom use) estimated a rate of transmission per coital act of only 0.0011²³, comparable to rates of 0.0003–0.0015 from similar studies in the US and Europe^{24–26}. In four other studies of HIV transmission in serodiscordant African couples (with most individuals not aware of their HIV status and/or with continuing unprotected sex), the unweighted average HIV-incidence for men (women) was 7.6 (10.0) per 100 person years (PYs)^{27–30}, comparable to an incidence of 4.8–7.2 per 100 PYs in European men and/or women with HIV-positive partners who continued unprotected sex^{25,31,32}. Moreover, these data may overstate heterosexual transmission in African couples; a Zambian study that sequenced viruses to determine epidemiological linkage reported at least 13% of sequences in newly infected persons were not related to their partner's HIV³³.

In the US, recent estimates of average lifetime heterosexual transmission (from a survey of sexual behaviour and research-based estimates of per coital act transmission) from infected heterosexual and bisexual males to females range from 0.19–0.40 with various assumptions and from infected females to males range from 0.09–0.18³⁴. With these

estimates, the HIV epidemic in the US does not reproduce—much less expand—through heterosexual transmission alone. In contrast, Anderson *et al.* estimated average unconstrained (assuming all partners are susceptible) lifetime heterosexual transmission of 4.7 new infections per infected person to explain observed epidemic growth in Africa³⁵.

Epidemiologists who design computer models to support heterosexual transmission's role in fuelling Africa's HIV epidemic characteristically choose and/or adjust assumptions about sexual behaviour, rates of heterosexual transmission, and/or other parameters to allow the model to reproduce observed prevalence^{35–38}. These assumptions are often distant from empiric observations from African studies. While such models show that it is possible to imagine patterns of heterosexual transmission that can 'explain' the epidemic, they do not show that imagined patterns are realistic.

In one model, for example, Anderson and colleagues assumed a mean rate of annual partner change of 3.4³⁵. In contrast, surveys in 12 African countries show unweighted averages of 74% of men and 91% of women aged 15–49 years with no non-regular sex partners in the past year, and only 3.7% of men and 0.7% of women with more than four non-regular partners²⁰. At about the same time, a survey in Denmark found that 19% of adults aged 18–59 years reported more than one sex partner in the past year³⁹; a survey in France found that 17% of men and 7.9% of women aged 18–44 years reported more than one sex partner in the past year⁴⁰; and a survey in the UK found that 17% of men and 8.4% of women aged 16–44 years reported more than one sex partner in the past year⁴¹. Studies of sexual behaviour do not show as much partner change in Africa as modellers have assumed, nor do they show differences in heterosexual behaviour between Africa and Europe that could explain major differences in epidemic growth.

Model-builders often use the transmission co-factor effect imputed to STDs to generate desired rates of heterosexual propagation. For example, Korenromp and colleagues³⁷ assumed that genital ulcers from syphilis or chancroid in either partner enhance HIV transmission by a factor of 100, implying an HIV transmission risk from a single coital act of 30% from men to women and 8% from women to men. These rates are at odds with most empiric studies. Assumed high co-factor effects for STDs are based on findings from two prospective studies in Kenya that enrolled cohorts of CSWs and male clients visiting STD clinics⁴². In such studies, the cohort are not representative, and STD treatments—through injections—may be a source of risk.

Although information about the structure of sexual networks in Africa is sparse, many studies of incidence show over two-thirds of HIV occurring in African adults reporting only one

sexual partner in the reporting period^{27,43-45}. The network geometry of such a pattern would be predominantly dendritic, with open ends formed by infected spouses with no outside partners. Rapid STD/HIV transmission has been associated with cyclic (with closed loops providing network cohesion) rather than dendritic networks^{46,47}.

Adult HIV without sexual exposure to HIV

During the last 14 years, a number of studies have reported adults contracting HIV without sexual exposures to HIV. A study in Zimbabwe in the 1990s found 2.1% HIV prevalence among 933 women with no sexual experience⁴⁸. In a 1988 study of discordant couples in Rwanda, 15 of 25 HIV-positive women with HIV-negative partners reported only one lifetime sex partner⁴⁹. In a 1990 study of teenagers in Uganda, 6.9% of women with no sex partners in the last five years were HIV-positive *vs* 23% for those with one or more partners; for men, 1% with no partners in the last five years were HIV-positive *vs* 2.5% of those reporting partners⁵⁰. Among young adults 15-24 years old in Tanzania, a 1995 study found HIV prevalence of 5.6% among men and 3.6% among women who did not report any lifetime sexual activity *vs* 4.8% and 12% for men and women reporting one or more sexual partners⁵¹. In a 1999 study in South Africa, 6.8% of women and 1.2% of men 14-24 years old who reported never having sex were HIV positive; however, a validation study found some under-reporting of sexual activity⁵². In a case-control study in Uganda, in two of seven cases with only one lifetime sexual partner, the partner was HIV-negative, three were HIV-positive, and two others not tested⁵³.

When HIV prevalence or incidence is found in adults and adolescents with no reported sexual exposures to HIV, it may be assumed that a proportion of the HIV in those who are sexually exposed comes from non-sexual transmission as well. Moreover, that proportion may be larger than observed HIV prevalence or incidence in those who are not sexually exposed, since whatever exposures are responsible for non-sexual transmission—injections or vaginal examinations, for example—may well increase with age and sexual activity.

OBSERVATIONS SUGGESTING MEDICAL TRANSMISSION

HIV-positive children with HIV-negative mothers

A study in Kinshasha in 1985 found 39% (16 of 44) of HIV-positive inpatient and outpatient children 1-24 months old to have HIV-negative mothers; only five of 16 had been transfused¹⁷. A study in Rwanda in 1984-86 found that 20% (15 of 76) of children 1-48 months old with AIDS or AIDS related complex had HIV-negative mothers

(initially 18 mothers were HIV-negative, but three were positive on a later test); only six of the 15 children had been transfused¹⁸. In a later report from Rwanda, 7.3% (54 of 704) of mothers of children with AIDS were HIV-negative; transfusions were identified as the risk factor for 22 of the 54 children⁵⁴. Of 26 children less than 15 years old admitted to the Uganda Cancer Institute with Kaposi's sarcoma during 1989-94 for which the mother was tested for HIV, 19% (five of 26) had HIV-negative mothers⁵⁵. A study in Burkina Faso in 1989-90 found 23% (11 of 48) of HIV-positive children to have HIV-negative mothers; six of 11 had been transfused, and the others reported multiple injections⁵⁶. In a 1994 report from Côte d'Ivoire, De Cock and colleagues report that 21% (three of 14) of children with HIV-1 had mothers without HIV-1, and one of two with HIV-2 had a mother without HIV-2⁵⁷. Tests of stored sera from 1994 in Ethiopia found three HIV-positive children less than five years old, of which one had an HIV-negative mother; HIV status for the other mothers was not known⁵⁸. Two of 654 children tested in Guinea Bissau in 1989 were HIV-positive; the mother of one was HIV-negative, while the other mother was not tested⁵⁹. These and other findings suggest that a significant proportion of paediatric HIV in Africa—as much as a fifth or more in many studies—has been acquired through health care rather than through vertical transmission from mothers.

Shortfalls in accounting for incidence during antenatal and postpartum periods

Studies from seven African countries over the last 15 years show rates of HIV incidence during antenatal and/or post-partum periods exceeding what could be expected solely from sexual transmission (Table 1)^{43,45,60-68}. The risk of infection from sexual transmission for women in these studies can be estimated as $I_{WD} \times D$, where I_{WD} is incidence for women in serodiscordant couples and D is the per cent of women in the studies who are in serodiscordant couples. We can estimate I_{WD} at 10 per 100 PYs from studies of serodiscordant African couples with continuing unprotected sex²⁷⁻³⁰. In one of the seven studies of antenatal and post-partum women⁶⁸, 30 of 634 women had HIV positive partners; three of these 30 women seroconverted in a year. Unfortunately, the study did not say how many other husbands were negative or were tested, and none of the other studies report husbands' HIV status. Nevertheless, an upper bound estimate for D can be set at P_W , HIV prevalence among women in the population from which the study cohort is drawn. HIV prevalence in African men is generally lower than in women, and many infected men are partnered with infected women. In eight studies of African couples with HIV in one or both partners^{27-29,49,69-72}, the average per cent of women

Table 1. HIV incidence in antenatal and post-partum periods vs expected incidence from heterosexual transmission

Location and years of study	Number of HIV-negative women	Incidence observed during ANC and PP (per 100 PYs)	Maximum expected incidence from sexual transmission* (per 100 PYs)	Incidence not explained by sexual transmission (per 100 PYs)
Blantyre, Malawi, 1990–95 (43, 60)	>1,000	21 during ANC and PP in 1990 12 during ANC and PP in 1991 8.0 during ANC 1990–93	2.2–3.3	19 during ANC and PP in 1990 10 during ANC and PP in 1991 5 during ANC 1990–93
Harare, Zimbabwe, 1990–94 (61, 62)	372	17 during ANC [†] ≥13 during 0–6 months PP	2.4–3.0	14 during ANC ≥10 during 0–6 months PP
Durban, South Africa, 1993 (63)	178	9.0 during ANC [†]	0.7	8 during ANC
Nairobi, Kenya, 1986–91 (64, 65)	353	6.2 during 0–6 months PP	0.27–1.6	5 during 0–6 months PP
Kigali, Rwanda, 1988–90 (66, 67)	216	7.2 during 0–6 months PP 4.2 during 7–18 months PP	3.0–3.2	4 during 0–6 months PP 1 during 7–18 months PP
Rakai, Uganda, 1994–96 (45)	1,305	3.2 during pregnancy	1.4 [‡]	1.8 during pregnancy
Lusaka, Zambia, 1987–88 (68)	634	3.0 during first year PP	1.2	1.8 during first year PP

*See text

[†]Estimated from reported seroconversions from first antenatal visit to delivery, assuming three months in antenatal care[‡]Observed incidence in women during all other intervals

ANC = Antenatal care; PP = post-partum period; PYs = person years

with HIV was more than double the per cent without HIV who had HIV-positive partners. Hence, $D < P_w$, and expected HIV incidence from sexual transmission for antenatal and postpartum women—when one does not know the HIV status of their partners—is less than 10 per 100 PYs times P_w , or 10% of HIV prevalence among women from which the cohort of HIV-negative women is selected.

A study in Malawi reported incidence of 8.0 per 100 PYs for more than 1000 HIV-negative women from first antenatal visit in 1990 or 1993 to delivery, with an odds ratio of 1.4 for spending more than the median 3.4 months in antenatal care⁴³. Combined antenatal and postpartum incidence in 1990, 1991, 1992, 1993, and 1994–95 was 21.3, 12.8, 8.2, 3.3, and 1.1 per 100 PYs⁶⁰. HIV prevalence in antenatal women rose from 22% in 1990 to 26% in 1991 and 33% in 1996⁶⁰, so that maximum expected annual incidence from sexual transmission rose during the period from 2.2% to 3.3% (i.e. from 2.2 to 3.3 per 100 PYs) only. The study shows average unexplained incidence during antenatal care of about five (8.0 minus 3) per 100 PYs, with unexplained or excess incidence of 19 (21.3 minus 2.2) and 10 (12.8 minus 2.6) per 100 PYs in 1990 and 1991, respectively, for antenatal and postpartum periods combined. The study also shows a large fall in antenatal and post-partum incidence during 1990–95 despite increasing HIV prevalence in the community—and presumably rising heterosexual transmission. No mention is made of the introduction of a remarkably effective intervention, but such a trend raises the possibility, at least, of a change in medical practice.

In a 1990–94 study in Harare, Zimbabwe, 18% (66 of 372) of women seronegative at first antenatal visit seroconverted within two years post-partum (many were lost to follow-up, so that average follow-up was much less, but no details are available)⁶¹. Sixteen women seroconverted by delivery; the report does not state the period; if average time from enrolment to delivery was three months, incidence during antenatal care was 17 per 100 PYs ($[12 \times 16/3]/372$). Another 23 seroconverted in the first six months post-partum; if all women HIV-negative at birth were followed to six months post-partum, incidence during this period would be 13 per 100 PYs ($[2 \times 23]/[372 - 16]$). During 1990–94, the maximum reported HIV prevalence in Harare antenatal clinics rose from 24% to 30%⁶², so that maximum expected incidence from heterosexual transmission was 2.4–3.0 per 100 PYs. The study suggests unexplained or excess incidence in antenatal and post-partum women, respectively, of at least 14 (17 minus 3) and 10 (13 minus 3) per 100 PYs.

Overall, four studies—in Malawi, Zimbabwe, South Africa, and Kenya—show unexplained HIV-incidence ranging from 5–19 per 100 PYs during antenatal and post-partum periods (see Table 1). These rates of unexplained incidence among African women are comparable to rates of maternal mortality from puerperal fever of 6% to 16% observed by Semmelweis during 1841–46 in the First Clinic at the University of Vienna's obstetric department⁷³. For three other studies—in Uganda, Rwanda, and Zambia—unexplained incidence during antenatal and post-partum

periods ranged from 1.8–4 per 100 PYs, lower but still worrisome (see Table 1).

Variation of unexplained incidence from country-to-country and over time—most notably within the Malawi study—suggests that something more than simply heterosexual transmission is involved. Excess HIV incidence associated with pregnancy—whatever its cause—helps to explain the spread of HIV among low-risk populations in many African countries. In Malawi, for example, antenatal and post-partum women seroconverted at the rate of 21.3 and 12.8 per 100 PYs in 1990 and 1991, so that within one year, prevalence among women who were HIV-negative at first antenatal visit was well over half of observed prevalence from sentinel surveys of 22% and 26% in 1990 and 1991⁶⁰. In Zimbabwe during 1990–94, HIV prevalence among women who were HIV-negative at first antenatal visit reached 18% within two years postpartum, which is more than half of observed prevalence of 30% in antenatal clinics in 1994^{61,62}. In other words, whatever happens during one or two pregnancies and post-partum periods—whether iatrogenic or sexual or something else—may largely account for observed high levels of HIV among low risk women in at least some African communities.

HIV infections associated with induced abortions and assisted delivery

In addition to these prospective studies of pregnant and postpartum women, some other studies also suggest that health care for pregnant women may be a risk factor for HIV. In Congo, among 1770 women at an antenatal clinic in 1987–88, 17 of 282 with a history of induced abortions were HIV-positive *vs* 54 of 1488 without for a crude population attributable fraction (PAF) of HIV associated with induced abortions of 5%; complications from abortions were a common cause of hospitalization, which was also associated with HIV infection⁷⁴. Among 4548 wives of workers in Kinshasha in 1987–88, 9.2% of 175 HIV-positive women *vs* 3.9% of 4373 HIV-negative women reported induced abortions for a crude PAF of 10%⁶⁹. In a study among pregnant women in Ethiopia in 1993–95, 28 of 92 HIV-positive cases and 14 of 173 controls reported induced abortions for a crude PAF of 24% (calculated from the odds ratio and per cent of controls with induced abortions)⁷⁵.

Finally, a study of 5690 pregnant women in Rwanda in 1989–91 reports an odds ratio of 2.7 (95% confidence interval 1.9–3.6) for last delivery with assistance by medical personnel *vs* unassisted delivery⁷⁶. From reported data (221 HIV-positive out of 1872 with last delivery assisted by medical personnel *vs* 130 HIV positive out of 2422 with assistance by traditional birth assistant or no one), the crude PAF for last delivery assisted by medical personnel can be calculated as being 34%.

Studies associating African HIV infections with injections

At least 15 large studies (with more than 500 subjects or 50 cases in a case-control study) of risk factors for HIV prevalence or incidence in a general population sample (i.e. not CSWs or patients seeking treatment for an STD or other illness) in Africa have reported sufficient data to calculate crude PAFs associated with one or more *vs* no injections over some period ranging from 4 months to lifetime (see Table 2)^{16,19,77–89}. Of the 20 PAFs calculated from these 15 studies (with PAFs for two samples in five studies), only four are below 22%, and the unweighted average is 29%. In the four studies of HIV incidence, the unweighted average of five PAFs is 28%^{19,80,86,87}. Six of the studies report a positive (but not always significant) dose-response for seropositivity associated with injection frequency^{16,77,83–85,87}. High PAFs are in most cases due to high exposures with relatively modest risk ratios. Although the crude PAFs in Table 1 ignore the associated influence of other potential risks, they provide first estimates for comparison with other studies and risks.

Several investigators^{19,85,90} noted that some of the association may be due to people seeking treatment for HIV/AIDS symptoms or STDs, but the assertion is not adequately supported by research. A study that provides sufficient information to separate risk due to heterosexual transmission while infected with an STD from risk due to injections for STD indicates a much greater risk associated with injections (although the data have arguably been misinterpreted to support the opposite conclusion): among 302 factory workers in Rwanda in 1985, HIV prevalence for those with STDs in the last two years but without injections for STDs in that period (9.7%) was lower than for those without STDs (11%), while those with injections for STDs had much higher prevalence (27%). In a parallel survey among 150 health workers, prevalence for those with STDs and injections for STDs (47%) was almost double prevalence for those with STDs only (24%)⁹⁰.

DISCUSSION

The recognition that significant proportions of HIV in African adults and children cannot be explained on the basis of current knowledge about sexual and vertical transmission leaves open several transmission hypotheses. There may, for example, be co-factors for sexual transmission not yet identified that are particularly influential during pregnancy or for young women. However, an accumulating body of evidence from Africa and other countries suggests that iatrogenic transmission may explain many if not most of the observations previously held to be anomalous and detailed in this review.

Table 2. Crude population attributable fractions (PAFs) associated with medical injections in studies of HIV prevalence and incidence in Africa

Location, year of study	Type of data	Type of cohort	RR for >0 vs 0 injections	ρ with >0 injections* (%)	PAF
DRC, 1984 (16)	P	Adults	1.82	81	40
DRC, 1984–86 (19)	I	Adults	1.54 [†]	73 [†]	28 [†]
Uganda, 1987 (77)	P	Adults	1.68	66.0	31
Zimbabwe, 1987 [†] (78)	P	Men	3.61 [†]	95.0 [†]	71 [†]
Tanzania, 1987 (81)	P	Rural adults	2.6	79.2	56
		Urban adults	3.0	89.7	64
Uganda, 1989 (79)	P	Men	1.67	41.8	22
		Women	1.75	57.2	30
Uganda, 1989–90 (80)	I	Adults	1.12	75.7	8
Malawi, 1989–90 (88)	P	Women	0.91	64	–6
Kenya, 1989–90 (89)	P	Women	0.73	96.6	–3–
					5
Tanzania, 1990–91 (82)	P	Men	1.98	42.9	30
		Women	1.66	58.2	28
Tanzania, 1991–92 (83)	P	Women	1.38	98.9	27
Tanzania, 1991–92 (84)	P	Men	2.19	36.8	30
Tanzania, 1991–92 (84)	P	Men	2.24	32.7	29
		Women	1.59	46.9	22
Rwanda, 1989–93 (86)	I	Women	2.42 [†]	58.6 [†]	45 [†]
Uganda, 1990–97 [†] (87)	I	Men	5.21 [†]	16.9 [†]	41 [†]
		Women	1.60 [†]	32.2 [†]	16 [†]

*During an interval which varies from four months to lifetime

[†]Case-control studies, for which the table shows the odds ratio instead of the rate ratio and ρ is per cent exposed to injections among controls only. The PAF is approximated from the standard formula: $(\rho[OR-1])/(1+\rho[OR-1])$

[‡]In calculating RR, ρ , and PAF, seroconversion is assumed to have occurred at the mid-point of the observation interval

DRC=Democratic Republic of Congo; P=prevalence; I=incidence; RR=rate ratio; ρ =per cent of study cohort

HIV survival and transmission through medical instruments

HIV can survive in syringes at room temperature for more than four weeks⁹¹. One study found HIV-RNA in three of 80 syringes after subcutaneous or intramuscular injections of infected patients; since the volume of blood in the syringes was too low to explain the observed HIV-RNA, the study team hypothesized that the RNA had been released by follicular dendritic cells into interstitial fluid⁹².

An early prospective study among health care workers estimated the probability of seroconversion after work-related percutaneous exposure to HIV of approximately 0.3%⁹³. However, a case-control study of percutaneous exposures by the Centers for Disease Control (CDC) and health authorities in the United Kingdom and France assessed risks for deep injuries (6.8% of controls vs 52% of cases) to be 15 times greater than for other percutaneous exposures^{94,95}. Furthermore, many health care workers were treated with zidovudine for post-exposure prophylaxis, which reportedly reduced seroconversion rates by over 80%⁹⁵. Because medical injections occasion a deep injury and are not countered by antivirals, HIV transmission during unsafe injections may well be an order of magnitude greater than 0.3%⁹⁶.

Epidemic of unsafe injections in much of Africa and South Asia

In a recent review, Simonsen *et al.*⁹⁷ concluded that the average person in the developing world received 1.5 injections per year (range 0.9 to 8.5). In the majority of studies reviewed, the proportion of injections that were unsafe was greater than 50%. Despite the lack of systematic data collection noted by the authors, these findings were consistent over a range of developing world settings. In a companion piece, Kane *et al.*⁹⁸ estimated that 80 000 to 160 000 HIV infections occur worldwide each year (two-thirds of these in Africa) from unsafe injections. These model-based estimates assume a transmission efficiency of 0.5% through unsafe injections, which as noted above, may be an order of magnitude too low. Further, these estimates do not consider the concentration of medical injections in certain groups (e.g., CSWs, STD patients, pregnant women) and settings with high HIV prevalence.

Starting in the 1950s Africans experienced a massive increase in medical injections associated with mass injection campaigns targeted at yaws, with introduction and spread of parenteral therapies to treat other diseases, and with plummeting prices for antibodies and injection equipment⁹⁹. For example, UNICEF administered 12 million injections

for yaws in Central Africa alone during 1952–57⁹⁹. From the 1950s into the 1980s, unsafe injections may have contributed to the silent spread of HIV in Africa in much the same way that unsafe injections for schistosomiasis and other treatments in Egypt established hepatitis C as a major blood-borne pathogen, infecting about 15% to 20% of the general population at the end of the 1990s¹⁰⁰.

Documented iatrogenic outbreaks

The unexpected discovery of HIV in a 12-year-old Romanian girl in a Bucharest hospital in June 1989 led to extensive testing to uncover the extent and channels for iatrogenic transmission¹⁰¹. Tests during 1989–90 found 1086 HIV-positive Romanian children less than four years old. Medical injections were the only apparent risk factor for more than half of these children; fewer than 40% had been transfused with untested blood (even so, in 1990 only 0.0006% of Romanian blood donors were HIV-positive), and fewer than 8% of tested mothers were infected^{101,102}.

In the former Soviet Union, about 250 children reportedly acquired HIV from hospital exposures in 1988–89¹⁰³. More recently, nearly 400 children attending a single hospital in Libya apparently contracted HIV^{104,105} and thousands of paid plasma donors in China may have been iatrogenically infected¹⁰⁶. Smaller iatrogenic outbreaks have been reported among patients and plasma donors in other countries.

CONCLUSION

Taken together, our observations raise the serious possibility that an important portion of HIV transmission in Africa may occur through unsafe injections and other unsterile medical procedures. After some early interest and research on iatrogenic transmission in Africa, most notably in Kinshasha during the 1980s, the topic all but vanished from the research agenda. Considering the aggressive reactions to evidence of iatrogenic HIV infections in Russia, Romania, Libya, and China, and considering as well international attention to the transmission of Ebola virus through health care practice, the absence of thorough investigation into documented incidents of multiple HIV infections suspected from health care in Africa (e.g. HIV-positive children with HIV-negative mothers cited above) is noteworthy. Fortunately, there are recent indications, at WHO^{97,98} and elsewhere, of increasing attention to iatrogenic risks of blood-borne microbes. To the extent that unsterile procedures in routine medical care represent a possibly major route of HIV transmission in countries with high HIV prevalence, the current tenets on which HIV prevention programmes in Africa are based need reassessment. Though promotion of safe sexual practices remains a priority, new interventions may be required to minimize risk from iatrogenic transmission.

References

- 1 Pape JW, Liautaud B, Thomas F, *et al.* Characteristics of the acquired immunodeficiency syndrome (AIDS) in Haiti. *N Engl J Med* 1983;**309**:945–50
- 2 Clumeck N, Sonnet J, Taelman H, *et al.* Acquired immunodeficiency syndrome in African patients. *N Engl J Med* 1984;**310**:492–7
- 3 Piot P, Quinn TC, Taelman H, *et al.* Acquired immune deficiency syndrome in a heterosexual population in Zaire. *Lancet* 1984;**ii**:65–9
- 4 Van de Perre P, Rouvroy D, Lepage P, *et al.* Acquired immunodeficiency syndrome in Rwanda. *Lancet* 1984;**ii**:65–9
- 5 Bayley A. Aggressive Kaposi's sarcoma in Zambia, 1983. *Lancet* 1984;**i**:1318–20
- 6 WHO. Acquired immunodeficiency syndrome—an assessment of the present situation in the world: memorandum from a WHO meeting. *WHO Bull* 1984;**62**:419–32
- 7 Van de Perre P, Clumeck N, Carael M, *et al.* Female prostitutes: a risk group for infection with human T-cell lymphotropic virus type III. *Lancet* 1985;**ii**:524–7
- 8 Kreiss JK, Loech D, Plummer FA, *et al.* AIDS virus infection among Nairobi prostitutes. *N Engl J Med* 1986;**314**:414–19
- 9 Mann JM, Nzilambi N, Piot P, *et al.* HIV infection and associated risk factors in female prostitutes in Kinshasha, Zaire. *AIDS* 1988;**2**:249–54
- 10 Chin J, Sato PA, Mann JM. Projections of HIV infections and AIDS cases to the year 2000. *WHO Bull* 1990;**68**:1–11
- 11 Mann JM. Heterosexual transmission of HIV: a global view a decade later. *Int J STD AIDS* 1993;**4**:353–6
- 12 N'Galy B, Ryder RW. Epidemiology of HIV infection in Africa. *J Acquir Immune Defic Syndr* 1988;**1**:551–8
- 13 Johnson AM, Laga M. Heterosexual transmission of HIV. *AIDS* 1988;**2**(suppl 1):S49–S56
- 14 Packard RM, Epstein P. Epidemiologists, social scientists, and the structure of medical research on AIDS in Africa. *Soc Sci Med* 1991;**33**:771–83
- 15 Minkin, SF. Iatrogenic AIDS: unsafe medical practices and the HIV epidemic. *Soc Sci Med* 1991;**33**:786–90
- 16 Mann JM, Francis II, Quinn TC, *et al.* Seroprevalence among hospital workers in Kinshasha, Zaire. *JAMA* 1986;**256**:3099–102
- 17 Mann JM, Francis II, Davachi F, *et al.* Risk factors for immunodeficiency virus seropositivity among children 1–24 months old in Kinshasha, Zaire. *Lancet* 1986;**ii**:654–7
- 18 Lepage P, Van de Perre P, Carael M, Butzler JP. Are medical injections a risk factor for HIV infection in children? *Lancet* 1986;**ii**:1103–4
- 19 N'Galy B, Ryder RW, Bila K, *et al.* Human immunodeficiency virus infection among employees in an African hospital. *N Engl J Med* 1988;**319**:1123–7
- 20 Carael M, Cleland J, Deheneffe JC, Ferry B, Ingham R. Sexual behaviour in developing countries: implications for HIV control. *AIDS* 1995;**9**:1171–5
- 21 Lagarde E, Auvert B, Carael M, *et al.* Concurrent sexual partnerships and HIV prevalence in five urban communities of sub-Saharan Africa. *AIDS* 2001;**15**:877–84
- 22 Buve A, Carael M, Hayes RJ, *et al.* The multicentre study on factors determining the differential spread of HIV in four African cities: summary and conclusions. *AIDS* 2001;**15**(suppl 4):S127–S131
- 23 Gray RH, Wawer MJ, Brookmeyer R, *et al.* Probability of HIV-1 transmission per coital act in monogamous, heterosexual, HIV-1 discordant couples in Rakai, Uganda. *Lancet* 2001;**357**:1149–53

- 24 Downs AM, De Vicenzi I, European Study Group on Heterosexual Transmission of HIV. Probability of heterosexual transmission of HIV: relationship to the number of unprotected sexual contacts. *J Acquir Immune Defic Syndr* 1996;**11**:388-95
- 25 Pedraza MA, del Romero J, Roldan F, *et al.* Heterosexual transmission of HIV-1 is associated with high plasma viral load levels and a positive viral isolation in the infected partner. *J Acquir Immune Defic Syndr* 1999;**21**:120-5
- 26 Mastro TD, Kityaporn D. HIV type 1 transmission probabilities: estimates from epidemiological studies. *AIDS Res Hum Retrovir* 1998;**14**:S223-7
- 27 Senkoro KP, Boerma JT, Klokke AH, *et al.* HIV incidence and HIV-associated mortality in a cohort of factory workers and their spouses in Tanzania, 1991 through 1996. *J Acquir Immune Defic Syndr* 2000;**23**:194-202
- 28 Serwadda D, Gray RH, Wawer MJ, *et al.* The social dynamics of HIV transmission as reflected through discordant couples in rural Uganda. *AIDS* 1995;**9**:745-50
- 29 Carpenter LM, Kamali A, Ruberantwari A, Malamba SS, Whitworth JAG. Rates of HIV-1 transmission within marriage in rural Uganda in relation to the HIV sero-status of the partners. *AIDS* 1999;**13**:1083-9
- 30 Quinn TC, Wawer MJ, Sewankambo N, *et al.* Viral load and heterosexual transmission of human immunodeficiency virus type 1. *N Engl J Med* 2000;**342**:921-9
- 31 di Vicenzi I, European Study Group on Heterosexual Transmission of HIV. A longitudinal study of human immunodeficiency virus transmission by heterosexual partners. *N Engl J Med* 1994;**331**:341-6
- 32 Saracco A, Musicco M, Nicolosi A, *et al.* Man-to-woman sexual transmission of HIV: longitudinal study of 343 steady partners of infected men. *J Acquir Immune Defic Syndr* 1993;**6**:497-502
- 33 Fideli US, Allen SA, Musoda R, *et al.* Virologic and immunologic determinants of heterosexual transmission of human immunodeficiency virus type 1 in Africa. *AIDS Res Hum Retrovir* 2001;**17**:901-10
- 34 Pinkerton SD, Abramson PR, Kalichman SC, Catz SL, Johnson-Masotti AP. Secondary HIV transmission rates in a mixed-gender sample. *Int J STD AIDS* 2000;**11**:38-44
- 35 Anderson RM, Gupta S, Ng W. The significance of sexual partner contact networks for the transmission dynamics of HIV. *J Acquir Immune Defic Syndr* 1990;**3**:417-29
- 36 Robinson NJ, Mulder DW, Auvert B, Hayes RJ. Proportion of HIV infections attributable to other sexually transmitted diseases in a rural Ugandan population: simulation model estimates. *Int J Epidemiol* 1997;**26**:180-9
- 37 Korenkamp EL, Van Vliet C, Grosskurth H, *et al.* Model-based evaluation of single-round mass treatment of sexually transmitted diseases for HIV control in a rural African populations. *AIDS* 2000;**14**:573-93
- 38 Robinson NJ, Mulder DW, Auvert B, Hayes RJ. Modelling the impact of alternative HIV intervention strategies in rural Uganda. *AIDS* 1995;**9**:1263-70
- 39 Melbye M, Biggar RJ. Interactions between persons at risk for AIDS and the general population in Denmark. *Am J Epidemiol* 1992;**135**:593-602
- 40 Spira A, Bajos N, Bejin A, *et al.* AIDS and sexual behaviour in France. *Nature* 1992;**360**:407-9
- 41 Johnson AM, Wadsworth J, Wellings K, Bradshaw S, Field J. Sexual lifestyles and HIV risk. *Nature* 1992;**360**:410-12
- 42 Hayes RJ, Schulz KF, Plummer FA. The cofactor effect of genital ulcers on the per-exposure risk of HIV transmission in sub-Saharan Africa. *J Trop Med Hygiene* 1995;**98**:1-8
- 43 Taha TE, Hoover DR, Dallabetta GA, *et al.* Bacterial vaginosis and disturbances of vaginal flora: association with increased acquisition of HIV. *AIDS* 1998;**12**:1699-706
- 44 Kapiga SH, Lyamula EF, Lwihula GK, Hunter DJ. The incidence of HIV-1 infection among women using family planning methods in Dar es Salaam, Tanzania. *AIDS* 1998;**12**:75-84
- 45 Wawer MJ, Sewankambo NK, Serwadda D, *et al.* Control of sexually transmitted diseases for AIDS prevention in Uganda: a randomized community trial. *Lancet* 1999;**353**:525-35
- 46 Potterat JJ, Muth SQ, Rothenberg RB, *et al.* Network structure as an indicator of epidemic phase. *Sex Transm Infect* 2000;**78**(suppl 1):52-8
- 47 Potterat JJ, Phillips-Plummer L, Muth SQ, *et al.* Risk network structure in the early epidemic phase of HIV transmission in Colorado Springs. *Sex Transm Infect* 2000;**78**(suppl 1):59-63
- 48 Zaba BW, Carpenter LM, Boerma JT, Gregson S, Nakiyingi J, Urassa M. Adjusting ante-natal clinic data for improved estimates of HIV prevalence among women in sub-Saharan Africa. *AIDS* 2000;**14**:2741-50
- 49 Allen S, Tice J, Van de Perre P, *et al.* Effect of serotesting with counselling on condom use and seroconversion among HIV discordant couples in Africa. *BMJ* 1992;**304**:1605-9
- 50 Konde-Lule JK, Wawer MJ, Sewankambo NK, *et al.* Adolescents, sexual behavior and HIV-1 in rural Rakai district, Uganda. *AIDS* 1997;**11**:791-9
- 51 Tengia-Kessy A, Msamanga GI, Moshiro CS. Assessment of behavioural risk factors associated with HIV infection among youth in Moshi rural district, Tanzania. *East Afr Med J* 1998;**75**:528-32
- 52 Auvert B, Ballard R, Campbell C, *et al.* HIV infection among youth in a South African mining town is associated with herpes simplex virus-2 seropositivity and sexual behavior. *AIDS* 2001;**15**:885-98
- 53 Malamba SS, Wagner HU, Maude G, *et al.* Risk factors for HIV-1 infection in adults in a rural Ugandan community: a case-control study. *AIDS* 1994;**8**:253-7
- 54 Commenges D, Alioum A, Lepage P, Van de Perre P, Msellati P, Dabis F. Estimating the incubation period of paediatric AIDS in Rwanda. *AIDS* 1992;**6**:1515-20
- 55 Zeigler JL, Katongole-Mbidde E. Kaposi's sarcoma in childhood: an analysis of 100 cases from Uganda and relationship of HIV infection. *Int J Cancer* 1996;**65**:200-3
- 56 Prazuck T, Tall F, Nacro B, *et al.* HIV infection and severe malnutrition: a clinical and epidemiological study in Burkina Faso. *AIDS* 1993;**7**:103-8
- 57 De Cock KM, Zadi F, Adjorlolo G, *et al.* Retrospective study of maternal HIV-1 and HIV-2 infections and child survival in Abidjan, Côte d'Ivoire. *BMJ* 1994;**308**:441-2
- 58 Fontanet AL, Messele T, Dejene A, *et al.* Age and sex-specific HIV-1 prevalence in the urban community setting of Addis Ababa, Ethiopia. *AIDS* 1998;**12**:315-22
- 59 Poulsen AG, Aaby P, Gottschau A, *et al.* HIV-2 infection in Bissau, West Africa, 1987-89: incidence, prevalence, and routes of transmission. *J Acquir Immune Defic Syndr* 1993;**6**:941-8
- 60 Taha TE, Dallabetta GA, Hoover DR, *et al.* Trends of HIV-1 and sexually transmitted diseases among pregnant and postpartum women in urban Malawi. *AIDS* 1998;**12**:197-203
- 61 Olayinka BA, Obi CL. Symptomatic HIV-infection in infants according to serostatus of mothers during pregnancy. *East Afr Med J* 1999;**76**:566-70
- 62 UNAIDS. Zimbabwe. *Epidemiological Fact Sheet [2000 update]*. Geneva: WHO, 2000
- 63 Qolohle DC, Hoosen AA, Moodley J, Smith AN, KP Mlisana. Serological screening for sexually transmitted infections in pregnancy; is there any value in re-screening

- for HIV and syphilis at the time of delivery? *Genitourin Med* 1995;**71**:65–7
- 64 Datta P, Embree J, Kreiss JK, *et al.* Mother-to-child transmission of human immunodeficiency virus type 1: report from Nairobi study. *J Infect Dis* 1994;**170**:1134–40
- 65 UNAIDS. Kenya. *Epidemiological Fact Sheet [2000 update]*. Geneva: WHO, 2000
- 66 Leroy V, Van de Perre P, Lepage P, *et al.* Seroincidence of HIV-1 infection in African women of reproductive age: a prospective cohort study in Kigali, Rwanda, 1988–92. *AIDS* 1994;**8**:683–6
- 67 UNAIDS. Rwanda. *Epidemiological Fact Sheet [2000 update]*. Geneva: WHO, 2000
- 68 Hira SK, Mangrola UG, Mwale C, *et al.* Apparent vertical transmission of human immunodeficiency virus type 1 by breast-feeding in Zambia. *J Pediatr* 1990;**117**:421–4
- 69 Roth DL, Stewart KE, Clay OJ, van der Straten A, Karita E, Allen S. Sexual practices of HIV discordant and concordant couples in Rwanda: effects of a testing and counselling programme for men. *Int J STD AIDS* 2001;**12**:181–8
- 70 Ryder RW, Ndilu M, Hassig SE. Heterosexual transmission of HIV-1 among employees and their spouses at two large businesses in Zaire. *AIDS* 1990;**4**:725–32
- 71 McKenna ST, Muyinda GK, Roth D, *et al.* Rapid HIV testing and counselling for voluntary testing centers in Africa. *AIDS* 1997;**11**(suppl 1):S103–10
- 72 King B, Allen S, Serufilira A, Karita E, Van de Perre P. Voluntary confidential testing for couples in Kigali Rwanda [letter]. *AIDS* 1993;**7**:1393
- 73 Pittet D, Boyce JM. Hand hygiene and patient care: pursuing the Semmelweis legacy. *Lancet Infectious Diseases* 2001;**9**:9–20
- 74 Lallemand M, Lallemand-Le Coeur S, Cheynier D, *et al.* Characteristics associated with HIV-1 infection in pregnant women in Brazzaville, Congo. *J Acquir Immune Defic Syndr* 1992;**5**:279–85
- 75 Chamiso D. Pregnancy outcome in HIV-1 positive women in Gandhi Memorial Hospital Addis Ababa, Ethiopia. *East Afr Med J* 1996;**73**:805–9
- 76 Chao A, Bulterys M, Musanganire F, *et al.* Risk factors associated with prevalent HIV-1 infection among pregnant women in Rwanda. *Int J Epidemiol* 1994;**23**:371–80
- 77 Konde-Lule J, Berkeley SF, Downing R. Knowledge, attitudes and practices concerning AIDS in Ugandans. *AIDS* 1989;**3**:513–18
- 78 Bassett MT, Latif AS, Katzenstein DA, Emmanuel JC. Sexual behavior and risk factors for HIV infection in a group of male factory workers who donated blood in Harare, Zimbabwe. *J Acquir Immune Defic Syndr* 1992;**5**:556–9
- 79 Serwadda D, Wawer MJ, Musgrave SD, Sewankambo NK, Kaplan JE, Gray RH. HIV risk factors in three geographic strata of rural Rakai District, Uganda. *AIDS* 1992;**6**:983–9
- 80 Wawer MJ, Sewankambo NK, Berkley S, *et al.* Incidence of HIV-1 infection in a rural region of Uganda. *BMJ* 1994;**308**:171–3
- 81 Killewo J, Nzamurukunge K, Sanstrom A, *et al.* Prevalence of HIV-1 infection in the Kagera region of Tanzania: a population based study. *AIDS* 1990;**4**:1081–5
- 82 Barongo LR, Borgdorff ME, Moshia FF, *et al.* The epidemiology of HIV-1 infection in urban areas, roadside settlements and rural villages in Mwanza Region, Tanzania. *AIDS* 1992;**6**:1521–8
- 83 Kapiga SH, Shao JF, Lwihula GK, *et al.* Risk factors for HIV infection among women in Dar-es-Salaam, Tanzania. *J Acquir Immune Defic Syndr* 1994;**7**:301–9
- 84 Barongo LR, Borgdorff MS, Newell JN, *et al.* Intake of a cohort study of urban factory workers in northwest Tanzania. *Trop Geogr Med* 1994;**46**:157–62
- 85 Grosskurth H, Moshia F, Todd J, *et al.* A community trial of the impact of improved sexually transmitted disease treatment on the HIV epidemic in rural Tanzania: 2. Baseline survey results. *AIDS* 1995;**9**:927–34
- 86 Bulterys M, Chao A, Habimana P, *et al.* Incident HIV-1 infection in a cohort of young women in Butare, Rwanda. *AIDS* 1994;**8**:1585–91
- 87 Quigley MA, Morgan D, Malamba S, *et al.* Case-control study of risk factors for incident HIV infection in rural Uganda. *J Acquir Immune Defic Syndr* 2000;**23**:418–25
- 88 Dallabetta GA, Miotti PG, Chipangwi JD, *et al.* High socioeconomic status is a risk factor for human immunodeficiency virus type 1 (HIV-1) infection but not for sexually transmitted diseases in women in Malawi: implications for HIV-1 control. *J Infect Dis* 1993;**167**:36–42
- 89 Hunter DJ, Maggwa BN, Mati JKG, Tukei PM, Mbuga S. Sexual behavior, sexually transmitted diseases, male circumcision and risk of HIV infection among women in Nairobi, Kenya. *AIDS* 1994;**8**:93–9
- 90 Van de Perre P, Carael M, Naramba D, *et al.* Risk factors for HIV seropositivity in selected urban-based Rwandese adults. *AIDS* 1987;**1**:207–11
- 91 Abdala N, Stephens PC, Griffith BP, Heimer R. Survival of HIV-1 in syringes. *J Acquir Immune Defic Syndr* 1999;**20**:73–80
- 92 Rich JD, Dickinson BP, Carney JM, Fisher A, Heimer R. Detection of HIV-1 nucleic acid and HIV-1 antibodies in needles and syringes used for non-intravenous injection. *AIDS* 1998;**12**:2345–50
- 93 Tokars JL, Marcus R, Culver DH. Surveillance of HIV infection and zidovudine use among health care workers after occupational exposure to HIV-infected blood. *Ann Intern Med* 1993;**118**:913–19
- 94 Centers for Disease Control and Prevention. Case-control study of HIV seroconversion in health-care workers after percutaneous exposures to HIV-infected blood—France, United Kingdom, and United States, January 1988–August 1994. *MMWR* 1995;**44**:929–33
- 95 Cardo DM, Culver DH, Ciesielski CA, *et al.* A case-control study of HIV seroconversion in health care workers after percutaneous exposure. *N Engl J Med* 1997;**337**:1485–90
- 96 Gisselquist DP. Estimating HIV-1 transmission efficiency through unsafe medical injections. *Int J STD AIDS* 2002;**13**:152–9
- 97 Simonsen L, Kane A, Lloyd J, Zaffran M, Kane M. Unsafe injections in the developing world and transmission of bloodborne pathogens: a review. *WHO Bull* 1999;**77**:789–800
- 98 Kane A, Lloyd J, Zaffran M, Kane M, Simonsen L. Transmission of hepatitis B, hepatitis C, and human immunodeficiency viruses through unsafe injections in the developing world: model-based regional estimates. *WHO Bull* 1999;**77**:801–7
- 99 Drucker EM, Alcabes PG, Marx PA. The injection century: Consequences of massive unsterile injecting for the emergence of human pathogens. *Lancet* 2001;**358**:1989–92
- 100 Frank C, Mohamed MK, Strickland GT, *et al.* The role of parenteral antischistomiasis therapy in the spread of hepatitis C in Egypt. *Lancet* 2000;**255**:1906–11
- 101 Patrascu IV, Dumitrescu O. The epidemic of human immunodeficiency virus infection in Romanian children. *AIDS Res Hum Retrovir* 1993;**9**:99–104
- 102 Hersh BS, Popovici F, Apetrei RC, *et al.* Acquired immune deficiency syndrome in Romania. *Lancet* 1991;**338**:645–9
- 103 Dehne KL, Podrovshiy V, Kobyshecha Y, Schwartlander B. Update on the epidemics of HIV and other sexually transmitted infections in the newly independent states of the former Soviet Union. *AIDS* 2000;**14**(suppl 3):S75–84

- 104 Quadri R, Yerli S, Posfay-Barbe K, *et al.* Outbreak of blood-borne viral infections in children attending a single hospital [abstract]. *Hepatology* 2000;**32**:281A
- 105 Yerly S, Quadri R, Negro F, *et al.* Nosocomial outbreak of multiple bloodborne viral infections. *J Infect Dis* 2001; **184**:369-72
- 106 Rosenthal E. In rural China, a steep price on poverty: dying of AIDS. *The New York Times* 2000 Oct 28; Sect. A: 1 (col 1)

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