ORIGINAL RESEARCH ARTICLE

Diverse blood exposures associated with incident HIV infection in Calabar, Nigeria

E J Peters MBBCh FWACP*, **D D Brewer** PhD†, **N E Udonwa** MBBS FWACP*, **G T A Jombo** MBBCh FWACP*, **O E Essien** MBBS FWACP*, **V A Umoh** MBBS*, **A A Otu** MBBCh*, **D U Eduwem** MBBCh FWACS* **and J J Potterat** BA‡

*University of Calabar Teaching Hospital, Calabar, Cross River State, Nigeria; †Interdisciplinary Scientific Research, PO Box 15110, Seattle, WA 98115, USA; ‡Colorado Springs, CO 80909, USA

Summary: Few types of blood exposures have been assessed in relation to incident HIV infection in sub-Saharan Africa, despite evidence that penile–vaginal sex cannot account for the epidemic in the region. To investigate correlates of incident HIV infection in Calabar, Nigeria, we surveyed clients at voluntary HIV counselling and testing centres. Participating clients who tested multiple times were generally similar to those testing only once in terms of demographic characteristics, sexual and blood exposures and HIV prevalence. Blood exposures were common. Serial testers had a 10% annual incidence of HIV infection. Seroconverters and seronegative serial testers were similar on most demographic characteristics and sexual exposures. However, seroconverters were more likely than seronegatives to report blood exposures during the test interval, both for most specific exposures as well as summary measures of blood exposures. In particular, seroconverters were substantially more likely to report one of a set of blood exposures that cannot be explained as a consequence of unprotected vaginal sex or of health care for symptoms of HIV infection (adjusted odds ratio = 6.6, 95% confidence interval = 1.2–38). The study design we used is an inexpensive approach for describing the local epidemiology of HIV transmission and can also serve as the foundation for more definitive investigations that employ contact tracing and sequencing of HIV DNA.

Keywords: HIV, Africa, iatrogenic disease, incidence, voluntary counselling and testing

INTRODUCTION

Penile–vaginal sex does not explain the extent and patterns of the HIV epidemic in sub-Saharan Africa.[1,2] Blood exposures may account for a much larger share of HIV transmission than conventionally believed,[3] but researchers rarely assess them in African studies, especially in relation to incident infection. Blood transfusions and therapeutic (curative) injections are the two blood exposures that have been measured in several HIV incidence studies in sub-Saharan Africa. With very few exceptions, transfusions and injections have been associated with incident HIV infection in these studies.[3–6] However, with the available evidence, it is difficult to determine whether the associations reflect HIV transmission through these exposures or infected persons seeking treatment, particularly injections, for HIV-related symptoms ('reverse causation').

Consequently, there is a serious need to assess the relationship between a broad array of blood exposures (especially those not received in response to HIV-related symptoms or complications) and incident HIV infection in sub-Saharan Africa. We report a study of the association between blood and sexual exposures and incident HIV infection in Calabar, a southeastern Nigerian city with moderate HIV prevalence (6.3% in 2005).[7]

Correspondence to: E J Peters *or* D D Brewer
Email: etetepeters@yahoo.com (Dr Peters) *or* interscientific@yahoo.com (Dr Brewer)

METHODS

Participants

We examined correlates of incident HIV infection in Calabar, Nigeria, between August 2007 and February 2008. On days during this period when interviewers were available, we invited all clients at the HIV voluntary counselling and testing (VCT) centres at the University of Calabar Teaching Hospital (UCTH)/University Medical Centre to participate in a study about factors related to HIV infection. We estimate that approximately 75% of clients invited to participate decided to participate in the study. Participating clients gave informed consent to participate, and participation or non-participation did not affect any services or care clients received. Most of our analyses focus on the participants who had previously tested HIV negative at the VCT centres.

Procedures

Participants were interviewed face-to-face in private rooms prior to HIV pre-test counselling. Interviewers were medical

students and clinical support staff trained by UCTH faculty and were assisted by interpreters when necessary. Interview questions focused on demographics, reasons for testing, sexual behaviours and potential exposures to blood. Participants reporting a particular blood or sexual exposure were asked when the most recent exposure of that type occurred; for some blood exposures, they were also asked whether the sharp involved had been used previously by another person. Blood exposures that typically occur only during childhood in Nigeria (e.g. circumcision and scarification) were not assessed. No identifying information was collected from participants, and interview responses were kept strictly confidential and not shared with clinical providers or staff.

As part of their routine VCT visit, participants provided blood specimens drawn by venipuncture. HIV status was determined with two rapid tests of each specimen performed by the UCTH haematology department. A third test was performed to resolve serostatus if the first two tests showed discordant results. We used anonymous codes to link participants' interview responses to their HIV test results from their prior and current visits. Participants were offered compensation for transportation (up to approximately US$5) and refreshments, but most participants declined these incentives. All study procedures were approved by the UCTH ethical committee before the study began.

Statistical analysis

We assessed the representativeness of participants who had tested multiple times at the VCT centres (serial testers) relative to those who were testing for the first time at the VCT centres (single testers) in terms of their characteristics and lifetime exposures. For these comparisons, we used chi-square tests of independence and multiple logistic regression (when adjusting for age). We estimated HIV incidence in serial testers by dividing the number of seroconverters by the sum of serial testers' person-years of observation (sum of intervals between most recent HIV-negative test and the current test visit). To assess correlates of incident HIV infection, we computed odds ratios, Goodman and Kruskal's tau[8] (proportional reduction in error measure of association for nominal scale variables), gamma correlations (for ordinal scale variables), point biserial correlation coefficients (for ratio scale variables), and multiple logistic regressions and the associated 95% confidence intervals (or inferential tests) between serial testers' characteristics and incident exposures and their serostatuses (seroconversion/HIV positive versus HIV negative). We maintained at least a 15:1 case:variable ratio for all logistic regression analyses. We also summarized the perceived reuse of sharps for some blood exposures with simple percentages. All analyses were performed with SPSS 7.5 (SPSS Inc., Chicago, IL, USA).

The incident exposure variables refer to reported exposures that occurred between a serial tester's two HIV tests. When dates of exposures were reported crudely (e.g. year only), these were converted to the midpoint of that period. We coded participants who reported that their last exposure occurred within three weeks before testing as unexposed (because of the HIV tests' window periods). Two exposures (enema and shaving with a razor used previously by someone else) appeared to occur regularly, given the recency of many reported events. Consequently, we created alternate codings of these exposures such that participants with very recent (<3 weeks) enema or shaving exposures were recoded as exposed. We excluded phlebotomy as an incident exposure, because we were often unable to distinguish serial testers' most recent reported phlebotomy events from their prior HIV tests.

RESULTS

Participant characteristics

Three hundred and twenty-one clients participated, and 45 of these were serial testers. Single and serial testers were similar in terms of many demographic characteristics, sexual and blood exposures and HIV prevalence (Table 1). Overall, the sample was highly educated. Serial testers tended to have more education and were somewhat more likely to be female than single testers. Serial testers were also more likely than single testers to report a desire to know their serostatuses for personal reasons and less likely to report illnesses, symptoms or doctor's request as reasons for testing. However, single and serial testers were similar in age (single testers: mean = 32 years, median = 29, standard deviation [SD] = 12, range = 11–83; serial testers: mean = 30, median = 29, SD = 8.0, range = 20–65). Many types of blood exposures were common.

In both single and serial testers, more female subjects had had induced abortions than had given birth. Among female subjects who had given birth, serial testers were more likely to report having had a caesarean section than single testers. Serial testers reported significantly ($P < 0.05$) more lifetime vaginal sex partners (female mean/median = 2.9/2, male mean/median = 8.3/4) than did single testers (female mean/median = 2.3/2, male mean/median = 4.2/3), but these differences were statistically non-significant ($P > 0.05$) after adjusting for age.

Serial testers were less likely to report receiving a therapeutic injection or an incision for administering medicines/herbal remedies than single testers. Serial testers were more likely to report prior phlebotomy than single testers (96% versus 67%), as might be expected, because they at least had prior blood draws for their previous HIV tests. No participants reported illicit injection drug use.

HIV seroincidence

The 45 serial testers had a median of 629 days between tests (mean = 793, inter quartile range = 258–1038, range = 89–2900), for a total of 97.8 person-years of observation. The 10 incident infections represent a 10% annual incidence rate among serial testers. The annual incidence rate declined with increasing test intervals: 17% for intervals <1 year, 14% for intervals 1–2 years long and 8% for intervals >2 years.

Correlates of incident HIV infection

Among the serial testers, seroconverters and seronegatives did not differ significantly or meaningfully in terms of most demographic factors or reason for testing (Table 2). However, seroconverters had non-significantly longer test intervals (mean = 972 days, median = 921) than seronegatives (mean = 742, median = 485; $P > 0.05$ on Mann-Whitney and *t*-tests). Similarly, seroconverters (mean = 37 years, median = 34) tended to be older than seronegatives (mean/median = 28; point biserial $r = 0.47$, $P < 0.01$).

Table 1 **Comparison between single and serial testers at VCT clinics in Calabar, Nigeria, 2007–2008**

Variable	Single testers *n* (%)	Serial testers *n* (%)
Sex – female[1]	165 (60)	34 (76)
Education[2]		
Primary	74 (26)	4 (9)
Secondary	88 (32)	9 (20)
Some undergraduate	65 (24)	12 (27)
Undergraduate degree	49 (18)	20 (44)
Ethnicity		
Efik	56 (20)	9 (20)
Ibibio	81 (29)	15 (33)
Ibo	39 (14)	12 (27)
Other	100 (36)	9 (20)
Marital status		
Married	110 (40)	16 (36)
Never married	155 (56)	26 (58)
Widowed/divorced	10 (4)	3 (7)
Religion – Christian	272 (99)	45 (100)
Incarcerated in jail/prison*	6 (2)	3 (7)
Reason for testing[2]		
Doctor's request	89 (32)	7 (16)
Personal†	61 (22)	27 (60)
Symptoms	105 (38)	5 (11)
Other	21 (8)	6 (13)
HIV status – positive	63 (23)	10 (22)
Anal sex*	1 (0.4)	0 (0)
Genital ulcer disease*	22 (8)	4 (9)
Enema*	92 (34)	16 (36)
Shave*,‡	66 (24)	12 (27)
Incision*,§,[1]	23 (9)	0 (0)
Dental surgery*	19 (7)	5 (11)
Medical surgery*	33 (12)	9 (20)
Finger prick phlebotomy*	104 (38)	18 (40)
Vaccination injection*,**	18 (7)	5 (11)
Transfusion*	16 (6)	5 (11)
Infusion*	72 (26)	11 (25)
Therapeutic injection*,[1]	172 (63)	20 (44)
Injection with syringe/medicine kept at home*	5 (2)	1 (2)
Other sharp exposure*,††	8 (3)	4 (9)
Women only		
Ear piercing*	47 (29)	15 (46)
Tetanus vaccination*	45 (35)	11 (46)
Injectable contraception*	11 (7)	0 (0)
Pregnant*	119 (73)	25 (76)
Induced abortion*	80 (49)	18 (53)
Childbirth*	57 (35)	14 (42)
Cesarean section*	1 (1)	3 (9)
Episiotomy/Gishiri cut*	8 (5)	3 (9)

VCT = voluntary counselling and testing

Note: There were 276 single testers and 45 serial testers. Some percentages do not sum to 100 due to rounding error. The amount of missing data differed across variables

[1] $P < 0.05$; [2] $P < 0.001$

*In the prior 15 years (since 1993)

†Includes 'want to know status'

‡Shaved with a razor previously used by another person

§For administering a medicine or remedy

**Excluding tetanus toxoid vaccination during pregnancy

††Used another type of sharp (beyond those described elsewhere in this article) previously used by another person

Table 2 **Demographic comparison of HIV seroconverters and seronegative serial testers, Calabar, Nigeria, 2007–2008**

Variable	Seronegatives	Seroconverters	OR (95% CI)/ tau* (*P*)
Sex – female	28 (80)	6 (60)	0.4 (0.1–1.7)
Education			
Primary	3 (9)	1 (10)	−0.24 (0.27)
Secondary	4 (11)	5 (50)	
Some undergraduate	12 (34)	0 (0)	
Undergraduate degree	16 (46)	4 (40)	
Ethnicity			
Efik	6 (17)	3 (30)	0.05 (0.54)
Ibibio	13 (37)	2 (20)	
Ibo	10 (29)	2 (20)	
Other	6 (17)	3 (30)	
Marital status			
Married	12 (34)	4 (40)	0.01 (0.81)
Never married	21 (60)	5 (50)	
Widowed/divorced	2 (6)	1 (10)	
Reason for testing			
Doctor's request	7 (20)	0 (0)	0.13 (0.13)
Personal†	22 (63)	5 (50)	
Symptoms	3 (9)	2 (20)	
Other	3 (9)	3 (30)	

OR = odds ratio; CI = confidence interval

Note: The columns for seroconverters ($n = 10$) and seronegatives ($n = 35$) show frequencies with percentages in parentheses. Some percentages do not sum to 100 due to rounding error

*Goodman and Kruskal's tau and probability value from Fisher's exact test

†Includes 'want to know status'

Vaginal sex during the test intervals was almost universally reported by both seroconverters and seronegatives (Table 3); no serial testers reported anal sex during the test intervals. After adjusting for age, there were no differences between seroconverters and seronegatives in their reported lifetime number of sex partners (Table 3). Seroconverters and seronegatives were also equally likely to have had symptoms of genital ulcer disease (GUD) during the test intervals (Table 4). However, the seroconverter who had GUD also had injection treatment for the symptoms, while only one of the three seronegatives with GUD had such treatment.

Because of the differences in test intervals between seroconverters and seronegatives, we adjusted for test interval in all analyses of the association between incident blood exposures and HIV infection (clients with longer test intervals would be expected to be more likely to have any kind of exposure). In each of these analyses, seroconversion was the outcome variable, the particular exposure measure was the predictor variable, and test interval was the covariate. During the test intervals, seroconverters were more likely than seronegative participants to have shaved with a razor used previously by another person and to have had medical surgery, blood transfusions, enemas, vaccinations (apart from tetanus toxoid vaccination during pregnancy) and infusions (Table 4). Seronegatives were slightly more likely to have had finger prick phlebotomy and therapeutic injections than seroconverters during the test intervals. None of the serial testers reported dental surgery, incisions for administering medicines/herbal remedies or incarceration during their test intervals. Seroconverters were also more likely than seronegatives to have blood exposures involving sharps not specified in the other exposures assessed.

Among female serial testers, seroconverters were much more likely than seronegatives to have had tetanus vaccinations (recoded), given birth, and had a caesarean section during their test intervals. Seroconverters and seronegatives had similar likelihoods of induced abortion during their test intervals, and very few serial testers had ear piercings or episiotomies during their test intervals. No female serial testers reported the use of injectable contraception during the test intervals.

Table 3 **Comparison of HIV seroconverters and seronegative serial testers on sexual exposures, Calabar, Nigeria, 2007–2008**

Exposure	Seronegatives	Seroconverters	AOR (95% CI)*	*P*
Vaginal sex during test interval	32/35 (91%)	10/10 (100%)	—	0.83
Females, *n*	28	6		
Lifetime number of vaginal sex partners, mean (SD)/median	3.00 (1.96)/2.5	2.33 (1.37)/2	0.77 (0.43–1.41)	0.40
Males *n*	7	4		
Lifetime number of vaginal sex partners, mean (SD)/median	3.14 (1.46)/4	17.3 (19.0)/9.5	–†	–

AOR = adjusted odds ratio; CI = confidence interval; SD = standard deviation

*Adjusted for age

†Model estimation process did not converge. The almost non-overlapping distributions of lifetime numbers of female vaginal sex partners for male seroconverters (range = 5–45) and seronegatives (range = 1–5) is paralleled by the almost non-overlapping distributions of age for seroconverters (range = 33–65) and seronegatives (range = 21–42; only one participant overlaps). Thus, lifetime number of vaginal sex partners is strongly confounded with age in male serial testers

For all summary measures of blood exposure – whether a participant had any blood exposures, the diversity (number of types) of blood exposures and alternate codings of such – seroconverters were substantially more likely to have been exposed than seronegatives. The most conservative summary measure of blood exposure refers to any of three blood exposures (vaccination [excluding tetanus vaccination during pregnancy], shaving with a razor used previously by another and medical surgery) that cannot be explained as a possible consequence of unprotected vaginal sex or diagnosis of/treatment for symptoms of HIV infection. (The only medical surgery reported by a serial tester was unrelated to pregnancy, childbirth, or potential HIV symptoms or complications.) On this measure of blood exposure, seroconverters were significantly more likely to be exposed than seronegatives.

Table 4 **Comparison of HIV seroconverters and seronegative serial testers on blood exposures, Calabar, Nigeria, 2007–2008**

Exposure	Seronegatives	Seroconverters	AOR (95% CI)*	*P*
All serial testers	*n* = 35	*n* = 10		
Enema	6 (17)	4 (40)	2.80 (0.46–16.9)	0.26
Enema recoded†	8 (23)	4 (40)	1.80 (0.34–9.52)	0.49
Shaving with razor used previously by another	2 (6)	2 (20)	4.25 (0.50–35.9)	0.18
Shaving with reused razor recoded†	6 (17)	4 (40)	3.40 (0.71–16.3)	0.13
Medical surgery‡	0 (0)	1 (10)	–	0.82
Blood transfusion	1 (3)	2 (20)	7.41 (0.42–130)	0.17
Vaccination	1 (3)	2 (20)	6.92 (0.48–99.0)	0.15
Finger prick	9 (26)	2 (20)	0.50 (0.07–3.41)	0.48
Therapeutic injection	6 (17)	2 (20)	0.78 (0.10–5.85)	0.81
Infusion	3 (9)	2 (20)	1.75 (0.14–21.5)	0.66
GUD symptoms	3 (9)	1 (10)	1.03 (0.09–11.5)	0.98
GUD injection treatment	1 (3)	1 (10)	2.94 (0.16–54.8)	0.47
Other sharp	1 (3)	1 (10)	4.54 (0.25–83.3)	0.31
Females only	*n* = 28	*n* = 6		
Tetanus vaccination	4 (14)	1 (17)	1.18 (0.09–16.1)	0.90
Vaccination recode†	5 (18)	3 (50)	10.2 (0.81–128)	0.07
Ear piercing	1 (4)	0 (0)	–	0.87
Induced abortion	5 (18)	1 (17)	0.86 (0.07–11.2)	0.91
Childbirth	5 (18)	3 (50)	16.9 (0.86–332)	0.06
Episiotomy/Gishiri cut	2 (7)	0 (0)	–	0.66
Caesarean section	1 (4)	2 (33)	42.5 (0.83–2180)	0.06
Females who gave birth	*n* = 5	*n* = 3		
Episiotomy/Gishiri cut	2 (40)	0 (0)	–	–
Caesarean section	1 (20)	2 (67)	–	–
Summary measures	*n* = 35	*n* = 10		
Any blood exposure§	18 (51)	8 (80)	3.38 (0.56–20.4)	0.19
Any blood exposure recoded†,§	19 (54)	8 (80)	2.94 (0.49–17.8)	0.24
Any of vaccination/shaving with reused razor/medical surgery**	3 (9)	4 (40)	6.58 (1.15–37.8)	0.03
Any of vaccination/shaving with reused razor/medical surgery recoded†,**	7 (20)	5 (50)	3.85 (0.86–17.3)	0.08
Diversity of blood exposures§,†† Mean (SD)/median	1.22 (1.75)/1	2.30 (1.89)/2.5	1.45 (0.81–2.57)	0.21
Diversity of blood exposures recoded†,§,†† Mean (SD)/median	1.43 (1.84)/1	2.70 (2.06)/3.5	1.54 (0.89–2.67)	0.13

AOR = adjusted odds ratio; CI = confidence interval; SD = standard deviation; GUD = genital ulcer disease

Note: The second and third columns show frequencies with percentages in parentheses, unless otherwise noted

*Odds ratio adjusted for test interval

†Coding clients as 'exposed' even if last reported exposure was within the window period of the test (<3 weeks) and the exposure was likely to reflect somewhat regular/typical behaviour (shaving with a razor used previously by someone else and receiving an enema). Tetanus vaccination coded as 'exposed' for those women with very recent exposures (<3 weeks prior) and who reported more than one such vaccination in her lifetime and had given birth during the test interval

‡Excludes dental surgery, Caesarean section and episiotomy/Gishiri cut

§Covers all blood exposures listed in Table 4 except for childbirth and GUD symptoms

**Whether exposed to vaccination, shaving with a razor used previously by someone else, or medical surgery during the test interval

††The number of different types of blood exposures reported during the test interval. AOR indicates change in odds with each additional kind of exposure

Perceived sharps reuse

We restricted our analysis of perceived sharps reuse to recent exposures (those reported as occurring in 2007 or 2008). The percentages of all participants who reported that a syringe or needle had been reused or did not know whether reuse occurred for their most recent exposure in this period were 14% (10/73) for phlebotomy, 50% (4/8) for tetanus vaccination and 11% (5/46) for therapeutic injection. The question for phlebotomy asked whether the participant saw the health-care provider take the syringe and needle from a sealed sterile package; responses other than 'yes' were coded as 'possible reuse'. (Fewer than 3 participants reported injectable contraception or incisions for administering medicines/herbal remedies in the 2007–2008 period, thus their reports are not summarized here.)

DISCUSSION

To investigate correlates of incident HIV infection in Calabar, Nigeria, we surveyed clients at voluntary HIV VCT centres. Participating clients who tested multiple times were generally similar to those testing only once in terms of demographic characteristics, sexual and blood exposures, and HIV prevalence. Blood exposures were fairly common. Serial testers had a 10% annual incidence of HIV infection. Seroconverters and seronegative serial testers were similar on most demographic characteristics and sexual exposures. However, seroconverters were more likely than seronegatives to report blood exposures during the test interval, both for most specific exposures and summary measures of blood exposures. In particular, seroconverters were substantially and significantly more likely to report one of a set of blood exposures that cannot be explained as a result of unprotected vaginal sex or health care for symptoms of HIV infection. Furthermore, noteworthy proportions of participants reported that sharps for specific blood exposures had been used previously by another person or reported they did not know whether the sharps had been used previously.

Because so many types of blood exposures were associated with incident HIV infection in our small sample, it is impossible to determine the independent associations for particular blood exposures. Nonetheless, even blood exposures that cannot be explained as possible responses to HIV-related symptoms were associated with incident HIV infection. Associations between blood exposures and HIV infection in several other studies in sub-Saharan Africa also cannot be accounted for by such 'reverse causation.'[9–13] The findings from these studies and the present one provide the most direct evidence suggesting significant iatrogenic HIV transmission in sub-Saharan Africa. Our results are also consistent with observations of unhygienic health care and cosmetic care in Nigeria, including unscreened or insufficiently screened blood for transfusions,[14–16] reused unsterilized razors,[17,18] reused syringes,[19] reused gloves[19] and unsterilized dental equipment.[20] Moreover, Nigerians' vulnerability to bloodborne HIV transmission may be increased by many patients', cosmetic care providers' and informal health-care providers' lack of knowledge about blood exposures as HIV risks.[17,21–28]

Our study has several limitations because of resource constraints and our attempts to minimize response burden. We did not assess the frequency or magnitude of any blood or sexual exposures during serial testers' test intervals. We also did not measure participants' condom use, although the relatively high rate of induced abortion and childbirth for female serial testers and participants' low number of lifetime partners suggest that condom use was low. Anal sex may have been underreported, given the taboo nature of the practice in the region.[29,30] Indeed, 14–15% of adolescents and young adults elsewhere in southern Nigeria reported ever having had anal sex,[25,31] compared with <1% of the generally older participants in our study. In addition, although serial testers were similar to single testers, it is unknown how representative they are of residents of Calabar and environs. Furthermore, we did not assess several types of blood exposures, such as skin contact with blood (e.g. in fights, in sporting events, from bloody noses or from assisting with childbirth), wound care, jigger removal, reused and unsterilized clippers for haircutting, and other potential routes of transmission.

To identify HIV transmission modes with confidence, three study design elements are required: (1) comprehensive assessment of blood and sexual exposures in uninfected persons and persons with incident infection; (2) tracing, testing and assessment of infected and uninfected persons' contacts to those exposures; and (3) sequencing of infected persons' HIV DNA to detect genetically related infections.[32–34] Our study incorporates only the first element, yet represents a marked improvement over prior research on the epidemiology of HIV transmission in sub-Saharan Africa. If sufficient resources are not available to implement all three elements of the full study design, researchers can still advance understanding of local HIV epidemiology relatively quickly and inexpensively by employing the simplified study design we used. Both the simplified and full study designs are well-suited for use in clinical and blood donation settings where routine HIV testing occurs. While research efforts are reoriented towards a more comprehensive HIV epidemiology, the African public must be educated about the HIV risks from blood exposures and anal sex and how these risks can be avoided or reduced.[29,35–38]

ACKNOWLEDGEMENTS

We received no funding for this study. We thank John M Roberts, Jr, for helpful comments on an earlier version of this manuscript. A de-identified data-set is available at http://dvn.iq.harvard.edu/dvn/dv/ejpeters.

REFERENCES

1 Gisselquist D, Rothenberg R, Potterat J, Drucker E. HIV infections in sub-Saharan Africa not explained by sexual or vertical transmission. *Int J STD AIDS* 2002;**13**:657–66
2 Leclerc PM, Garenne M. Inconsistencies in age profiles of HIV prevalence: a dynamic model applied to Zambia. *Demogr Res* 2008;**16**:121–40
3 Gisselquist D. *Points to Consider: Responses to HIV/AIDS in Africa, Asia, and the Caribbean*. London: Adonis and Abbey Publishers Ltd, 2007
4 Gisselquist D, Potterat JJ, Brody S, Vachon F. Let it be sexual: how health care transmission of AIDS in Africa was ignored. *Int J STD AIDS* 2003;**14**:148–61
5 Watson-Jones D, Baisley K, Weiss HA, *et al.* Risk factors for HIV incidence in women participating in an HSV suppressive treatment trial in Tanzania. *AIDS* 2009;**23**:415–22
6 Mermin J, Musinguzi J, Opio A, *et al.* Risk factors for recent HIV infection in Uganda. *JAMA* 2008;**300**:540–9
7 Federal Ministry of Health. 2005 National HIV/Syphilis Sero-prevalence Sentinel Survey Among Pregnant Woment Attending Antenatal Clinics In Nigeria, Technical Report. Abuja: Federal Ministry of Health; 2006. Available at: http://www.naca.gov.ng/index2.php?option=com_docman&task=doc_view&gid=3&Itemid=99999999
8 Goodman LA, Kruskal WH. Measures of association for cross classifications. *J Am Stat Assoc* 1954;**49**:732–64

9 St. Lawrence JS, Klaskala W, Kankasa C, West JT, Mitchell CD, Wood C. Factors associated with HIV prevalence in a pre-partum cohort of Zambian women. *Int J STD AIDS* 2006;**17**:607–13

10 Deuchert E, Brody S. The role of health care in the spread of HIV/AIDS in sub-Saharan Africa: evidence from Kenya. *Int J STD AIDS* 2006;**17**:749–52

11 Deuchert E. Maternal health care and the spread of AIDS in Burkina Faso and Cameroon. *World Health Popul* 2007;**9**:55–72

12 Brewer DD, Potterat JJ, Roberts JM, Brody S. Male and female circumcision associated with prevalent HIV infection in adolescents in Kenya, Lesotho, and Tanzania. *Ann Epidemiol* 2007;**17**:217–26

13 Okinyi M, Brewer DD, Potterat JJ. Horizontally acquired HIV infection in Kenyan and Swazi children. *Int J STD AIDS* 2009;**20**:852–7

14 Ahmed SG, Ibrahim UA, Hassan AW. Adequacy and pattern of blood donations in north-eastern Nigeria: the implications for blood safety. *Ann Trop Med Parasitol* 2007;**101**:725–31

15 Odaibo GN, Taiwo A, Aken'Ova YA, Olaleye DO. Detection of HIV antigen and cDNA among antibody-negative blood samples in Nigeria. *Trans R Soc Trop Med Hyg* 2008;**102**:284–7

16 Utulu SN, Lawoyin TO. Epidemiological features of HIV infection among pregnant women in Makurdi, Benue State, Nigeria. *J Biosoc Sci* 2007;**39**:397–408

17 Peters EJ, Immananagha KK, Essien OE, Ekott JU. Traditional healers' practices and the spread of HIV/AIDS in south eastern Nigeria. *Trop Doct* 2004;**34**:79–82

18 Salami KK, Titiloye MA, Brieger WR, Otusanya SA. Observations of barbers' activities in Oyo State Nigeria: implications for HIV/AIDS transmission. *Int Q Community Health Educ* 2005;**24**:319–30

19 Olaleye AO, Adeokun LA, Oronsaye F, Ladipo OA, Delano GE. Assessing the level of preparedness of private health providers for clinical management of HIV/AIDS epidemic in Nassarawa State, Nigeria. *Afr J Reprod Health* 2006;**10**:90–7

20 Taiwo JO, Aderinokun GA. Assessing cross infection prevention measures at the Dental Clinic, University College Hospital, Ibadan. *Afr J Med Med Sci* 2002;**31**:213–7

21 Ola TM, Oludare BA. Sexual practices and knowledge about HIV/AIDS among Nigerian secondary school students. *Int J Health Res* 2008;**1**:197–205

22 Arulogun OS, Adesoro MO. Potential risk of HIV transmission in barbering practice among professional barbers in Ibadan, Nigeria. *Afr Health Sci* 2009;**9**:19–25

23 Isaac WE, Iawali M. Evaluation of HIV occupational risk amongst traditional barbers and itinerent nail cutters in North West Nigeria, abstract no. D10381. 15th International Conference on AIDS, Bangkok, 2004

24 Ibrahim MT, Opara WE, Tanimomo T. Knowledge of HIV/AIDS, infection prevention practices and accidental skin cuts in barbing saloons in Sokoto, Nigeria. *Nig Med Pract* 2007;**51**:123–7

25 Manafa OU, Ahmed OA, Omotola BD. Post-intervention survey on the knowledge, attitude, beliefs and practices of people in Lagos State, Nigeria about HIV/AIDS. *World Health Popul* 2006;**8**:35–45

26 Kayode CM, Adeyemo AA, Omotade OO. Beliefs and perceptions about HIV infection and AIDS among mothers of infants in Ibadan, Nigeria. *West Afr J Med* 2002;**21**:43–7

27 van der Maas F, Otte WM. Evaluation of HIV/AIDS secondary school peer education in rural Nigeria. *Health Educ Res* 2008; DOI:10.1093/her/cyn056

28 Oyadoke AA, Brieger WR, Adesope A, Salami KK. Migrant farm workers in southwestern Nigeria: implications for HIV transmission. *Int Q Commun Health Educ* 2003;**22**:249–68

29 Obi G. Anal Sex Regarded as a Taboo in South West Nigeria Makes Rectal Microbicides Unacceptable: Human Rights Activist Comes with a Solution! *Presentation at Advancing Prevention Technologies for Sexual and Reproductive Health symposium*, Berkeley, California, 2009

30 Smith DJ. Youth, sin and sex in Nigeria: christianity and HIV/AIDS-related beliefs and behaviour among rural–urban migrants. *Cult Health Sex* 2004;**6**:425–37

31 Morhason-Bello IO, Oladokun A, Enakpene CA, Fabamwo AO, Obisesan KA, Ojengbede OA. Sexual behaviour of in-school adolescents in Ibadan, South-West Nigeria. *Afr J Reprod Health* 2008;**12**:89–97

32 Brewer DD, Rothenberg RB, Potterat JJ, Brody S, Gisselquist D. HIV epidemiology in sub-Saharan Africa: rich in conjecture, poor in data. *Int J STD AIDS* 2004;**15**:63–5

33 Brewer DD, Hagan H, Sullivan DG, *et al.* Social structural and behavioral underpinnings of hyperendemic Hepatitis C virus transmission in drug injectors. *J Infect Dis* 2006;**194**:764–72

34 Brody S, Potterat JJ. Establishing valid AIDS monitoring and research in countries with generalized epidemics. *Int J STD AIDS* 2004;**15**:1–6

35 Soola EO. Communication and education as vaccine against the spread of acquired immune deficiency syndrome (AIDS) in Africa. *Afr Media Rev* 1991;**5**:33–40

36 Gisselquist D, Friedman E, Potterat JJ, Minkin SF, Brody S. Four policies to reduce HIV transmission through unsterile health care. *Int J STD AIDS* 2003;**14**:717–22

37 Brody S, Potterat JJ. Assessing the role of anal intercourse in the epidemiology of AIDS in Africa. *Int J STD AIDS* 2003;**14**:431–6

38 Correa M, Gisselquist D, Gore DH. *Blood-borne HIV: Risks and Prevention*. Chennai: Orient Longman Private Limited, 2008

(Accepted 7 July 2009)