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Time trends of syphilis and HSV-2 co-infection among men who have sex with men in the German HIV-1 seroconverter cohort from 1996-2007

Nadine Spielmann,¹ Dieter Münstermann,² Hans-Jochen Hagedorn,² Matthias an der Heiden,¹ Claudia Houareau,¹ Barbara Gunsenheimer-Bartmeyer,¹ Claudia Kücherer,³ Katrin Keeren,³ Osamah Hamouda,¹ Ulrich Marcus,¹ the German HIV-1 Seroconverter Study Group

¹ Department of Infectious Disease Epidemiology, HIV/AIDS, STI Unit, Robert Koch Institute, Berlin, Germany

² Labor Krone, Bad Salzungen, Germany

³ Project HIV Variability and Molecular Epidemiology, Robert Koch Institute, Berlin, Germany

Correspondence to: Ulrich Marcus, Department of Infectious Disease Epidemiology, HIV/AIDS, STI Unit, Robert Koch Institute, Robert Koch Institute, DGZ-Ring 1, Berlin 13086, Germany; MarcusU@rki.de

Objectives: Numbers of newly diagnosed HIV infections among men who have sex with men (MSM) in Germany increased after the year 2000. We sought to explore trends in STI co-infections around the time of HIV seroconversion in patients from the German HIV-1 seroconverter cohort from 1996-2007.

*Methods: MSM from the cohort were included for secondary analysis, if seroconversion occurred between 1996 and 2007 and if a blood sample taken within 2 y after HIV infection was available for further testing. Samples were tested for antibodies against *Treponema pallidum* and HSV-2. A classification system was developed to assign the chronology of syphilis and HIV-1 infection.*

Results: Data of 1052 MSM were eligible for analysis. Overall seroprevalence of syphilis markers was 26%, increasing from 10% (1996-1999) to 35% (2005). Among HIV seroconverters with positive syphilis antibodies, 32% (n=88) were rated as having had coincident infections with HIV and syphilis. Coincident syphilis infection at HIV diagnosis increased substantially ($p<0.001$) from 2.3% in 2000 to 16.9% in 2003; and thereafter declined to 4.3% in 2007. Mean HSV-2 antibody prevalence was 40.5%, mean anti-HSV-2 IgM prevalence was 11.2%, with no significant change over time.

Discussion: We found a stable prevalence of HSV-2 infection and increasing prevalence of syphilis infection around the time of HIV acquisition among MSM in Germany. Time course and rate of co-infections suggest that a re-emerging syphilis co-epidemic among MSM after 2000 could have contributed to an increase of HIV incidence by enhancing HIV transmission probability.

Objectives

Epidemiological data show an increase in newly diagnosed HIV infections among men who have sex with men (MSM) in Germany as well as other countries in Western Europe, North America and Australia after the year 2000.¹ Simultaneously, increasing syphilis prevalence and incidence have been identified in the same subpopulation group.² In Germany, the number of newly reported syphilis cases more than doubled since 2001 and reached mean values of approximately 4/1000 MSM in 2004 and the following years.^{3,4}

It has been hypothesised that a rise in infections with HIV can be caused by an increase of the per-contact probability for HIV transmission due to ulcerative sexually transmitted infections (STIs) like syphilis and anogenital herpes.⁵ In this report, we sought to explore trends in coincident HIV, syphilis and herpes simplex virus 2 (HSV-2) infection in HIV patients from the German HIV-1 seroconverter cohort from 1996-2007.

Methods

The German HIV-1 Seroconverter Study is a national prospective multi-centre observational cohort that started in 1997. The study was approved by the ethics committee of the Charité University Clinic in Berlin. The study design has been described in detail elsewhere.⁶ In brief, as of 31 December 2007, a total of 1285 blood samples of HIV-1 seroconverters were available for screening for syphilis, HSV-1 and HSV-2 co-infection. The first blood sample taken after enrollment was used for analysis if the blood sample was taken within 2 y after the estimated date of HIV seroconversion. The serological tests for syphilis, HSV-1 and HSV-2 were performed with frozen plasma samples, including ARCHITECT Syphilis TP chemiluminescence microparticle immunoassay (Abbott, Wiesbaden, Germany) for screening and fluorescent treponemal antibody absorption (FTAABS) test for confirmation, and the *Treponema pallidum* particle agglutination (TPPA) assay for the determination of treponemal antibody titres in reactive samples. The presence of HSV-1, HSV-2 IgG and HSV-2 IgM antibodies in the samples were tested using ELISA test kits for the quantitative determination of type-specific antibodies against the glycoproteins G-1 (HSV-1) and G-2 (HSV-2).

For the assessment of syphilis disease activity in reactive samples, two additional tests were performed: as a lipoidal antibody test a modification of the Venereal Disease Research Laboratory (VDRL) test, the RPR reditest (Biokit, Barcelona, Spain) was used. Treponemal IgM antibodies were determined quantitatively by the IgM-FTA-ABS test after elimination of the IgG fraction from the sample with an anti-IgG serum, using the same antigen and sorbent as for the IgG-FTA-ABS test and a rabbit anti-human IgM-FITC conjugate. IgM antibody titres <1:10 were classified as negative, titres of 1:10 as borderline, titres of 1:20 as weak positive and titres \geq 1:40 as positive. Serological testing was performed at Labor Krone, Bad Salzuflen, Germany.

Further information on the study subjects were provided by their respective HIV healthcare provider, including information on gender and the supposed route of HIV transmission (injecting drug user, migrant from a country with high HIV prevalence, heterosexual, MSM, unknown). For the calculation of a chronological relation between HIV seroconversion and syphilis infection, analysis was restricted to male subjects reported to be MSM or with unknown route of HIV transmission (MSM/u).

Based on (i) antibody patterns for syphilis, (ii) the time interval between blood sampling and estimated date of HIV infection and (iii) information about a history of syphilis within the previous 2 y (yes/ no), provided by the study subjects' HIV healthcare facility, HIV seroconverters were assigned to the following three groups: (1) active syphilis predated HIV seroconversion, (2) active syphilis coincident with HIV seroconversion and (3) syphilis acquired after HIV seroconversion. If a history of syphilis was reported, we assumed that adequate antibiotic treatment had been provided.

If the blood sample was taken within 3 months after the estimated time point of HIV infection, groups were defined as follows:

- Group 1: IgM titre <1:40 and VDRL titre <1:8
- Group 2: IgM titre \geq 1:40 or VDRL titre \geq 1:8
- Group 3: not applicable.

If the blood sample was taken between 4 and 24 months after the estimated time of HIV infection, groups were defined as follows:

- Group 1: IgM titre <1:10 and VDRL titre <1:2
- Group 2: IgM titre >1:10 or VDRL titre >1:2 and not meeting definition for group 3
- Group 3: IgM titre \geq 1:80 if blood sample was taken between 12 and 24 months after infection, IgM titre \geq 1:320 if sample was taken within 7-12 months after infection, IgM titre \geq 1:1280 if sample was taken within 4-6 months after infection.

Seroconverters with IgM titre=1:10 or VDRL titre=1:2 were individually grouped based on information about history of syphilis in the previous 2 y.

- Group 1: no history of syphilis within the previous 2 y
- Group 2: history of syphilis within the previous 2 y.

To evaluate potential confounders for the observed trends on HIV syphilis co-infection, we analysed time trends in the study sample of HIV-1 seroconverters for the following parameters: As surrogate markers for 'recruitment bias': age at HIV infection and proportion of HIV seroconverters recruited in

Berlin (largest city in Germany); as markers of a 'group assignment bias': ratio of documented (last negative/ first positive HIV test result) versus acute (according to laboratory criteria: i) detectable HIV-1 RNA or p24 antigen combined with a negative or indeterminate ELISA result or ii) reactive HIV-1-ELISA combined with a negative or indeterminate immunoblot result followed by confirmation of complete seroconversion within 6 months) HIV seroconversion; mean time between last negative and first positive HIV test result; mean time between calculated date of infection and first available blood sample; as an indicator for changes in sexual risk behaviour: proportion of seroconverters with HSV-1 and HSV-2 antibodies and with HSV-2 IgM antibodies (it has been shown that incident infection with HSV-2 in MSM is significantly associated with a variety of anal sex practices with casual partners).⁷

We used a log-linear regression model (Poisson regression⁸) to detect trends in the syphilis co-infection rate in the group of MSM/u seroconverters. We investigated coincident and preceding episodes of syphilis separately and checked whether other variables had a significant influence. Statistical significance was defined as a p value of <0.05. STATA version 10.1 was used for statistics.

Results

Of 1285 HIV-1 seroconverters included in the cohort, 1105 were reported as MSM/u, among these 1052 had a blood sample taken within 2 y after the estimated date of HIV infection. In total, 276 MSM/u (26.2%) were positive for treponemal antibodies (TPPA), the median distance to the estimated time point of HIV infection was 5 months. A single subject could not be assigned to one of the three groups as described above. Out of the remaining 275 MSM/u (MSM=270; unknown risk=5), 88 (31.9%) were assigned to the group with coinciding infections with HIV and syphilis (group 2), 176 men (63.8%) to the group with treponemal infection preceding HIV infection (group 1) and 11 men to the group where HIV infection was followed by syphilis infection (group 3; see figure 1).

The overall proportion of syphilis seromarkers among MSM/u HIV seroconverters significantly increased ($p<0.001$) from 9.8% (1996-1999) to 34.7% (2005) and thereafter declined to 23.4% (2007). The proportion of men with syphilis infection preceding HIV infection (group 1) increased from 6.1% (1996-1999) to 22.7% (2004) ($p<0.001$) and thereafter slightly declined to 19.1% (2007).

Coincident syphilis infection at HIV seroconversion (group 2) increased from 2.3% (1996-1999) to 16.9% (2003) ($p<0.001$) and thereafter declined to 4.3% (2007) (see table 1 and figure 2).

The mean age at HIV infection increased from 32 to 35 y over the observation period. The proportion of seroconverters recruited in Berlin, the city with the largest gay population in Germany, remained stable around 70%. The proportion of documented to acute HIV seroconversion and the mean time interval between HIV infection and blood sample declined stepwise over time. In all seroconverters, time between last negative and first positive test result did not change significantly during the observation period. The proportion of seroconverters with antibodies against HSV-1 fluctuated around 90%, the proportion with HSV-2 antibodies around 40%, with no clear trends over time. The same was observed regarding the proportion with HSV-2 IgM antibodies (prevalence between 7 and 16%; see table 1).

Analysing time trends by Poisson regression, we found a significant increase of coincident syphilis infections in MSM/useroconverters in the time period from 1996 up to 2003: on average the incidence rate increased by 51.8% (95% CI 20.6% to 91.1%) per year. Other variables showed no significant influence on the incidence of coincident syphilis.

For syphilis preceding HIV infection we found a significant increase between 1996 and 2004. Moreover, in a multivariate model we found in the same period an additional influence of age at seroconversion and place of residence. On average, the syphilis antibody prevalence rate increased by 19.0% (95% CI 6.6% to 32.8%) per year; for each year of age the prevalence of a preceding syphilis infection increased by 2.9% (95% CI 0.4% to 5.5%); seroconverters from Berlin had a 84.9% (95% CI 2.1% to 234.8%) higher prevalence compared to other seroconverters (see table 2).

Discussion

We found a significant increase in the prevalence of syphilis antibodies in MSM HIV-seroconverters between 2000 and 2005. During this period, the number of reported syphilis cases in Germany more than doubled. A more detailed analysis of syphilis antibody patterns suggested that a large proportion (~2/3) of these syphilis antibody positive HIV seroconverters may have acquired syphilis before HIV, but also the proportion of probably coincident HIV and syphilis infections increased significantly from before 2000 to 2003 with levelling off and decline thereafter. Interestingly, in contrast to increasing prevalence of syphilis antibodies in HIV seroconverters, we did not find any consistent changes for HSV-2 antibody prevalence. The presence of HSV-1 antibody was almost universal (~90%). Prevalence of HSV-1 and HSV-2 antibodies was comparable to reports about HIV-positive MSM from the Netherlands and the United Kingdom.^{9 10}

We were able to analyse time trends for only a limited set of other parameters in the seroconverter cohort. We observed a slightly increasing trend for age at HIV seroconversion (reflected as well in the national surveillance data for HIV and syphilis in MSM), a trend for improved recognition of acute seroconversion (declining ratio of documented/ acute seroconversion) and faster recruitment of seroconverters into the cohort (declining time delay between seroconversion and blood sample) over time. Data outliers in 2007 for both of these parameters are likely due to a cohort effect (over-representation of acute seroconversions with shorter time between seroconversion and recruitment into the cohort). For HIV seroconverters classified as having had syphilis before HIV infection we found a statistically significant association with age and place of residence for the time period until 2004—a finding reflecting the time-space evolution of the syphilis co-epidemic in MSM in Germany. This association with age and residence was not detected for HIV seroconverters classified as coincident syphilis/HIV infection. Otherwise, we could find no indication for any significant interaction of other identified time trends on the time trends for HIV-syphilis co-infection.

Syphilis circulation in the MSM population in Western Europe and North America reached a historic nadir during the 1990s. HSV-2, although declining in HIV-negative MSM as well, remained prevalent at high levels in HIV-positive men.⁹ Epidemiological dynamics for these two STIs are quite different: syphilis usually becomes symptomatic, can be cured by antibiotics and remains infectious only for a limited time period even without treatment. HSV-2 can only be suppressed but not cured by antiviral drugs and it establishes a persistent infection with recurrent viral shedding. Due to these differences, maintaining endemic levels of syphilis circulation requires a certain degree of delayed diagnosis and core groups with high partner numbers at least in countries with free access to healthcare, diagnosis and treatment.

The reasons for the re-emergence of syphilis in MSM populations in the last decade are not fully understood. Observations in Germany argue for the re-establishment of an endemic level of syphilis circulation in a population in which the infectious agent transiently almost had disappeared.¹¹ The transient disappearance may have been at least partly due to the shrinking of a core group that maintains uninterrupted syphilis circulation.¹² The re-establishment of this core group after 1996, rather than general increases in sexual risk behaviours of HIV negative and untested MSM (eg, increase of partner numbers and unprotected anal intercourse), may feed continuous syphilis circulation. Once the infectious agent *T. pallidum* became prevalent in these core groups again, it quickly re-established a new level of endemicity (comparable to the pre-AIDS era). In the core groups, partner numbers and prevalence of unprotected anal intercourse are high but unprotected sex takes place mostly within a context of HIV serosorting.¹³

Syphilis and HIV surveillance data from Germany demonstrate transient increases in syphilis cases and newly diagnosed HIV in MSM levelling off since 2004 (syphilis) and 2007 (HIV) (see supplemental online figure 3). An increasing prevalence of syphilis in subpopulations at risk for HIV during this period could have resulted in an increase of HIV transmission probability due to effects of coincident syphilis on HIV susceptibility and infectivity. If our hypothesis is correct, the increase of HIV incidence in MSM should level off as soon as the new endemic level of syphilis circulation is reached with a certain time delay due to a longer gap between infection and diagnosis for HIV compared with syphilis.

There are several limitations to our analysis. The analysis of the impact of other STIs on the risk of HIV seroconversion was not a primary aim of the HIV Seroconverter Cohort. Therefore, the amount of data and information about the participants to investigate this issue is limited and in this respect the study suffers from the general drawbacks of a retrospective case-note review. The estimated dates of

HIV infection in those cases in which no acute HIV infection was observed but the date was defined as the midpoint between the last negative and the first positive HIV antibody test⁶ do not necessarily represent the actual date of infection.

Our group definitions based on antibody patterns are quite crude since there was no possibility to get information on the timing of suspicious clinical manifestations and antibody titres at the time of syphilis diagnosis and treatment initiation were not available. Since the duration of infection and the baseline titres of syphilis antibodies at treatment initiation determine the time course of their following declines there is certainly room for misclassifications. Misclassifications may occur in both directions: falsely classifying cases as coincident and falsely classifying cases as syphilis preceding HIV infection. Particularly in those patients in which the analysed blood sample was collected more than 3 months after the estimated time of HIV infection, IgM and VDRL antibodies may have been eliminated already after adequate syphilis treatment even if syphilis coincided with HIV transmission. Hence, we feel that our classification system results in a rather conservative estimate of the proportion of coincident infections. Accordingly, group 1 with syphilis preceding HIV infection was the largest group.

A comparison of syphilis antibody prevalence in the group of HIV seroconverters presented here with a control group of HIV negative sexually active MSM from Berlin tested in 2006 showed a threefold higher syphilis seroprevalence in HIV seroconverters in 2006 (29% vs 9%) (unpublished own data). These data support the view that coincident infections might be underestimated by the algorithm applied here.

Furthermore, the biological basis for the impact of syphilis on an individual's susceptibility for HIV infection has not yet been clearly defined. Besides direct interactions like breaks to the mucosal integrity, immunological interactions like increased concentration of potential HIV target cells at the portal of entry and increased CCR5 co-receptor expression may play a role. The evolution of these immunological factors over time and their dependence and interaction with syphilis treatment has not yet been elucidated in detail.¹⁴ As demonstrated for HSV-2 infection, the period of hyper-susceptibility for HIV infection may extend beyond the active stage of disease.¹⁵

One further aspect of syphilis as a HIV transmission co-factor, which is not reflected in this analysis, is an enhancing effect of syphilis co-infection in HIV infected individuals that results only in HIV transmission but not in syphilis transmission.

Participants of the HIV seroconverter study are primarily recruited in Germany's largest cities and, thus, do not represent HIV seroconverters in smaller cities and rural areas. Hence, our findings may not be generalisable to all MSM. However, German surveillance data show that HIV and syphilis diagnosis incidence increased coincidentally in all parts of Germany: the rise in syphilis incidence occurred first among gay communities in metropolitan areas, where a first peak occurred in 2003/2004, followed by transient declines (see surveillance data for Berlin, supplemental online figure 3). However, it could also be observed outside of the largest cities with a time delay of 1 to 2 y.² In nonmetropolitan areas, the increase of newly diagnosed HIV infections in parallel with increasing syphilis incidence was even more pronounced.

In summary, we found a considerable overlap of HSV-2 and syphilis infection and HIV acquisition among MSM/u in the German HIV Seroconverter Cohort. The time course and rate of co-infections suggest that the re-emergence of a syphilis coepidemic among MSM after 2000 could have contributed to an increase of HIV incidence. Our data support the hypothesis that the increase of newly diagnosed HIV infections in MSM after the year 2000 may at least partly be a result of enhanced HIV transmission probability rather than general and widespread changes of HIV-related risk behaviours.^{5,16}

At the same time, the high prevalence of previous syphilis episodes before HIV seroconversion argues for targeted interventions to strengthen HIV protective behaviour in HIV negative MSM who are diagnosed with newly acquired syphilis.

Experiences so far with addressing STI co-factors as a means to reduce HIV incidence have often been disappointing.¹⁷ However, the high incidence and prevalence of syphilis in definable and accessible MSM subpopulations is by itself a reason for concern and should prompt increasing efforts to get this epidemic under control. Including syphilis into regular monitoring of HIV infected patients and improving sexual healthcare for at risk populations by low threshold sites for HIV/STI- diagnosis and treatment might be an approach that could be promoted and tested.

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Author footnote Participating collaborators of the German HIV-1 Seroconverter Study Group Aachen: Drs Habets and Knechten; Augsburg: Dr Hammond (Klinikum Augsburg); Berlin: Drs Mayr, Schmidt, Speidel and Strohbach (Medizinisches Versorgungszentrum, Ärzteforum Seestraße), Dr Arastéh (Auguste-Viktoria-Krankenhaus/Vivantes), Drs Bieniek and Cordes, Dr Claus, Drs. Baumgarten, Carganico and Dupke, Drs Freiwald and Rausch, Drs Gölz, Klausen, Mol, and Schleeauf, Dr Hintsche, Drs Jessen and Jessen, Drs Köppe and Krauthausen, Dr Reuter; Bielefeld: Dr Pfaff (Krankenhaus MARA II); Bochum: Prof Dr Brockmeyer (St Joseph-Hospital); Bonn: Prof Dr Rockstroh (Universitätsklinik Bonn); Dortmund: Prof Dr Gehring and Dr Schmalöer and Dr Hower (Klinikum Dortmund, ID27 Ambulanz); Dresden: Prof Dr Spornraft-Ragaller (Universitätsklinikum Dresden); Duisburg: Dr Becker-Boost, Dr Wirant; Düsseldorf: Prof Dr Häussinger and PD Dr Reuter (Universitätsklinik Düsseldorf); Frankfurt/Main: Prof Dr Helm (Universitätsklinik Johann-Wolfgang-Goethe-Universität); Frankfurt/Oder:

Dr Markus; Halle/Saale: Dr Kreft (Universitätsklinik Martin-Luther-Universität); Hamburg: Prof Dr Plettenberg, Dr Stoehr, Dr Graefe and Dr Lorenzen (Institut für Infektionsmedizin, ifi, Allgemeines Krankenhaus St. Georg); Drs Adam, Schewe and Weitner, Dr Fenske, Dr. Hansen, Prof Dr Stellbrink (Infektionsmedizinisches Zentrum Hamburg, ICH); Hannover: Prof Dr Schmidt (Medizinische Hochschule Hannover), Drs Buck and Leugner; Koblenz: Prof Dr Eisenhauer and Dr Rieke (Krankenhaus Kemperhof); Köln: Dr Bihari, Dr Ferdinand, Prof Dr Fätkenheuer (Universitätsklinik Köln); Prof Dr Oette, Krankenhaus der Augustinerinnen, Köln; Leipzig: Dr Pfeil (Universitätsklinik Leipzig); Magdeburg: Prof Dr Malfertheiner and Dr Wolle (Universitätsklinik Otto-v-Guericke-Universität); Mainz: Prof Dr Galle (Klinikum der Joh-Gutenberg-Universität); München: Drs Jäger and Jägel-Guedes, Dr Malm, Dr Rieger, Städtisches Krankenhaus 12 München-Schwabing, Prof Dr Fröschl (Technische Universität München); Münster: Prof Dr Rahn (Universitätsklinik Münster); Norderstedt: Dr Soldan; Nürnberg: Dr Brockhaus (Klinikum Nürnberg); Osnabrück: Dr Mutz (Städtische Klinik Natruper Holz); Regensburg: Prof Dr Salzberger, Prof Dr Schölmerich and Dr Schneidewind (Universitätsklinik Regensburg); Remscheid: Dr Steege; Rostock: Dr Kreft, Prof Dr Ziegler and Prof Dr Reisinger (Universitätsklinik Rostock); Stuttgart: Drs Ißler, Schaffert, Schnaitmann and Trein, Drs Frietsch, Müller and Ulmer; Dr Wagner-Wiening (Landesgesundheitsamt Stuttgart); Ulm: Prof Dr Kern and Prof Dr Kreidler (Universitätsklinik Ulm); Viernheim: Dr van Treek; Wiesbaden: Dr Starke.

Competing interests None.

Ethics approval This study was conducted with the approval of the Charite University Clinic Berlin, 2005.

Contributors The study was conceived and supervised by UM. NS analysed the data and drafted the manuscript. DM and H-JH supervised the antibody testing of the blood samples and participated in the development of the classification system for group assignment based on the antibody patterns. MH was responsible for the statistical and interaction analyses. CH extracted the relevant data from the HIV seroconverter cohort database. BG-B, CK and KK coordinate and supervise the HIV seroconverter cohort and the sample collection and testing. OH supervises the HIV seroconverter cohort and critically revised the manuscript. All authors contributed to the final manuscript.

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Tables and Figures

Figure 1 Flowchart of analysis and group assignments.

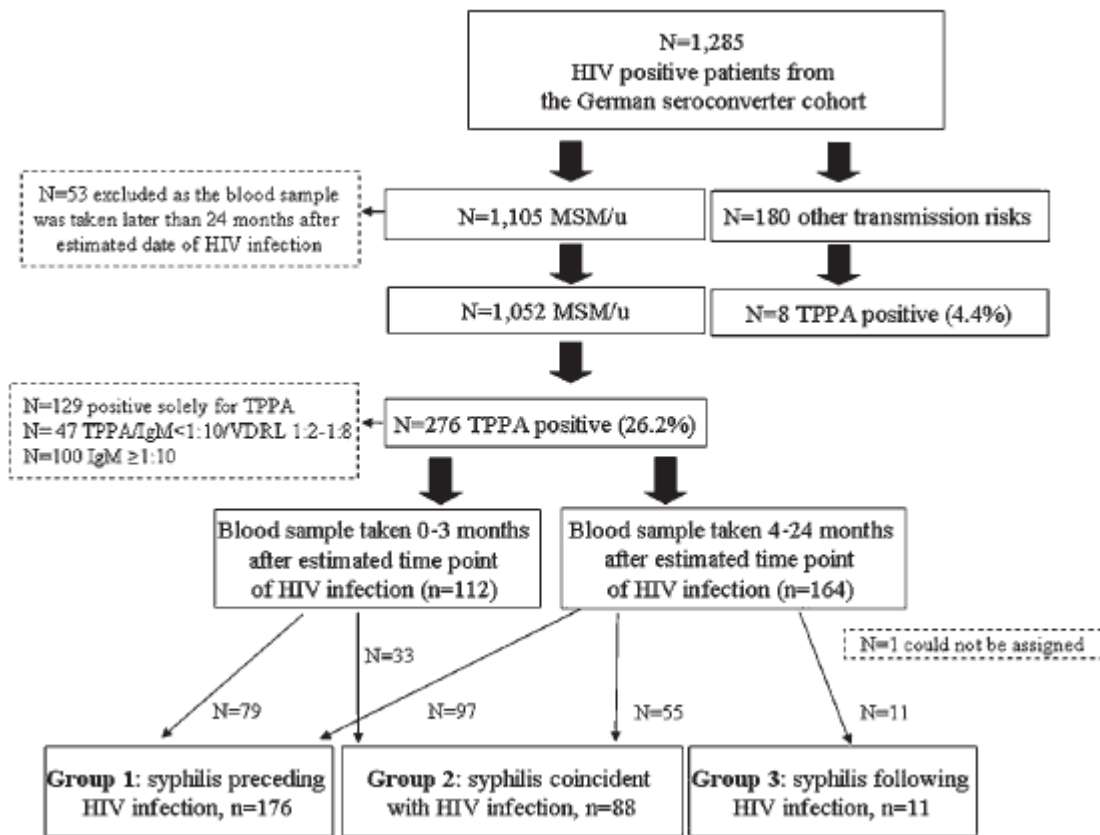


Figure 2 Trends for syphilis co-infection in HIV seroconverters from Germany, 1996-2007. Proportions of HIV seroconverters with probable coincident syphilis, and syphilis infection preceding HIV infection, from 1996-2007 (with 95% CI). The declining proportion of HIV seroconverters with coincident syphilis after 2003 reflects the course of the epidemic in Berlin (see supplemental online figure 3). The transient drop of coincident syphilis in 2004 may suggest a recruitment bias or group misclassification.

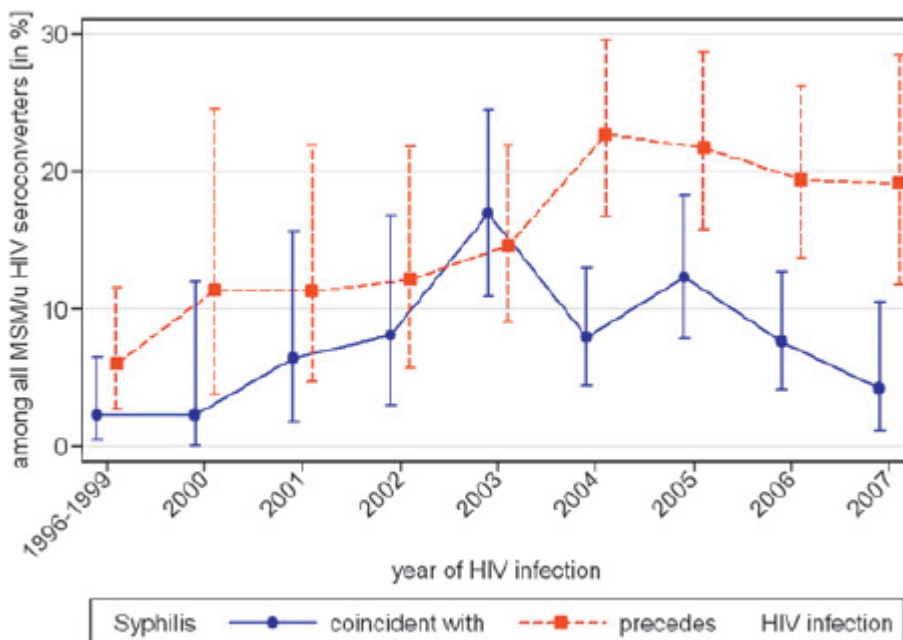


Table 1 Time trends for syphilis co-infection and other potentially confounding parameters in the German HIV-1 seroconverter cohort

	1996–1999	2000	2001	2002	2003	2004	2005	2006	2007
HIV seroconverters	132	44	62	74	130	176	170	170	94
Mean age at seroconversion (y)	32.15	31.48	32.37	32.50	33.38	33.68	34.01	33.19	35.04
Proportion recruited in Berlin (%)	69.0	81.4	77.4	68.0	77.9	79.2	72.4	60.4	67.0
Ratio of documented/acute seroconversion	2.8	1.9	2.7	2.0	2.0	1.4	1.5	1.6	0.5
Mean time (months) from last negative to first positive HIV test (n=969)	11.95	12.14	13.63	13.93	14.13	15.97	14.49	14.46	14.68
Mean time (days) between calculated HIV seroconversion and blood sample (n=275)	340	190	317	161	228	193	204	158	60
Proportion with syphilis antibodies (%)	9.8	13.6	21.0	23.0	33.1	30.7	34.7	28.2	23.4
Proportion with syphilis preceding HIV infection (%)	6.1	11.4	11.3	12.2	14.6	22.7	21.8	19.4	19.1
Proportion with syphilis coinciding with HIV infection (%)	2.3	2.3	6.5	8.1	16.9	8.0*	12.4	7.6	4.3
Proportion with HSV-2 antibodies (%)	44.7	31.8	33.3	42.7	42.0	39.8	39.4	42.9	38.3
Proportion with HSV-2 IgM (%)	7.0	7.1	12.7	12.3	10.1	10.1	12.3	12.8	16.1
Proportion with HSV-1 IgG antibodies (%)	86.9	95.5	95.2	91.5	89.1	90.1	90.4	88.8	92.5

*The transient drop of coincident syphilis in 2004 may suggest a recruitment bias or group misclassification.

Table 2 Results of Poisson regression for interaction of time dependent parameters (1996-2004) with proportion of HIV seroconverters with syphilis preceding HIV (n=610)

	Prevalence ratio*	(95% CI)	p Value
Date of infection (y)	1.190	(1.066;1.328)	0.002
Berlin versus other regions	1.849	(1.021;3.348)	0.043
Age at infection	1.029	(1.004;1.055)	0.023

*How to read prevalence ratios: syphilis antibody prevalence rate increased by 19.0% per year; seroconverters from Berlin had a 84.9% higher prevalence compared to other seroconverters; for each year of age the prevalence of a preceding syphilis infection increased by 2.9%.