SUPPLEMENT 1. Overview data sources used for HIV estimation tools

Table 1. Data sources for parameters in Table 2A–2B in the main document

a	For Amsterdam: data from the Amsterdam Health Monitor, a random sample of the Amsterdam population in 2004. For Rotterdam: data from the Rotterdam Health Monitor, a random sample of the Rotterdam population in 2008.
b	PIENTER is a random sample of the Dutch population, 2006-2007 (separate sub-analyses for respondents from Amsterdam and the rest of the Netherlands).
c	Zessen & Sandfort, first national sample on sexual health (1991).
d	RUTGERS-NISSO GROUP: study on sexual health of the Netherlands (in 2006), national sample (separate sub-analyses for respondents from Amsterdam, Rotterdam, and the rest of the Netherlands).
e	Schorer Monitor 2007, internet based study on Sexual Health of MSM, separate sub-analyses for respondents from Amsterdam, Rotterdam, and the rest of the Netherlands.
f	National registry of all new STI consultations in STI clinics (SOAP) in 2007; separate sub-analyses for respondents from Amsterdam, Rotterdam, and the rest of the Netherlands.
g	Data source DWAR: anonymous unlinked HIV testing among STI clinic attendees in STI clinic in Amsterdam in 2007.
h	Data of all registered HIV cases in HIV treatment centres, as of 1 January 2007; data from the HIV Monitoring Foundation (SHM).
i	Municipal Health Service Amsterdam: registration of opiate users and methadone treatment registries.
j	Data from department for research & statistics of the city of Amsterdam, data derived from website http://www.os.amsterdam.nl/ absolute numbers of inhabitants of the city of Amsterdam in January 2008 and, by (some) ethnicity groups in 2007.
k	Data from anonymous unlinked HIV survey among IDU in different cities in the Netherlands, recruited in- and out-side treatment facilities for IDU. In Amsterdam, recruitment was in 1998, in Rotterdam in 2002-2003, and in seven other cities (data used for the rest of the Netherlands) in the period 1996-2000.
l	van der Helm T, van Mens L. Mobility in prostitution in The Netherlands 1998-1999. Technical report, Municipal Health Service Amsterdam, 1999. An Inventory Done Under the Auspices of EUROPAP-TAMPEP 1998-1999.
m	Data from screening of pregnant women in 2006. For Amsterdam, obtained by the Municipal Health Service of Amsterdam; for Rotterdam, obtained from the Municipal Health Service Rotterdam-Rijnmond; for the rest of the Netherlands, obtained from RIVM (www.rivm.nl).
n	Data from blood donor screening in 2007 in the Netherlands.
p	Amsterdam Cohort Study on drug users (since 1985); data used from drug users who have ever injected drugs and were in follow-up in 2007 (www.amsterdamcohortstudies.org).
q	Data from anonymous unlinked HIV survey among commercial sex workers in the Netherlands. For Amsterdam, data from sex workers recruited at street sites, window prostitution and drugs relief centre in Amsterdam in 2003/2004; also, the total estimated number was derived from report on prostitution policy of the municipality of Amsterdam. For Rotterdam, sex workers were recruited in brothels, clubs and street-based prostitution zone in 2002-2003. For the rest of the Netherlands, data were available only for sex workers recruited in brothels, clubs and street-based prostitution zone in The Hague (used as proxy for the rest of the Netherlands) in 2005.
r	HIV prevalence among adult population aged 15-49 years in Sub-Sahara Africa and in Ghana in 2007 (www.unaids.org).
s	Data from Amsterdam Cohort Study in MSM since 1984, data used for MSM who were in follow-up in 2007 (www.amsterdamcohortstudies.org).
t	Data from anonymous unlinked HIV survey among migrants (from Sub-Sahara Africa and the Caribbean), recruited at (multicultural) social venues. Migrants living in Amsterdam were recruited in 2003-2004, in Rotterdam in 2006, and in the Hague (used as proxy for the rest of the Netherlands) in 2005.
u	Data from National Office of Statistics (CBS) (www.statline.nl).
v	Institute for Addiction Research (IVO), report on addiction and homelessness in Rotterdam in 2007.
w	Data from department for research & statistics of the city of Rotterdam, data derived from website http://www.cos.rotterdam.nl/ absolute numbers of inhabitants of the city of Rotterdam, by age and (some) ethnicity groups of January 2008.
x	Data source ROTan: anonymous unlinked HIV testing among STI clinic attendees in largest STI clinic in Rotterdam in 2007.
y	Data from IVO, institute for research into drugs and drug addiction. National prevalence study into drug use (2005) in population aged 15-64 years.
z	Trimbos Institute, National Drug Monitor (report 2007).

SUPPLEMENT 2. Additional data sources used for the Estimation and Projection Package (EPP) and Spectrum

For the use of EPP available retrospective prevalence data from the beginning of the HIV epidemic are required. In our case-study for the Netherlands, we have used data from prevalence surveys available since 1985. Most data sources are mentioned in Supplement 1; additional sources are listed below.

GGD Amsterdam. Annual report(s) of the Department of Infectious Diseases, Health Service Amsterdam, 1988–1997.

GGD Amsterdam. Annual reports of the STI clinic of Amsterdam, Health Service Amsterdam, 1990–2006. HIV en AIDS in Nederland 1999. Uitgave t.g.v. Wereld Aidsdag. Stichting Aidsfonds, Amsterdam, 1999 [in Dutch].

Schorer Monitor 2000-2006; internet based study on Sexual Health of MSM, separately analysed for respondents of the 3 different regions.

Erasmus Medical Centre, Data STI clinic of Rotterdam, 1993-2006.

RIVM. Annual reports on national STI and HIV consultations and diagnoses 1993-2006; National Institute for Public Health and the Environment (RIVM), Bilthoven, 1993-2006.

SOAP. Nationwide data on STI consultations, 2004-2006.

Sanquin Blood Supply Amsterdam; national data on HIV testing among blood donors, 1985-2006.

RIVM-reports. Anonymous unlinked HIV surveys among (injecting) drug users in different cities across the Netherlands, 1994-2003. RIVM-reports 44100. 1995-2004. National Institute for Public Health and the Environment (RIVM), Bilthoven, The Netherlands.

Fennema JSA, Ameijden EJC van, Coutinho RA, Doornum GJJ van, Cairo I, Hoek JAR van den. HIV surveillance among sexually transmitted disease clinic attenders in Amsterdam, 1991-1996. AIDS 1998;12:931-8.

Hoek JAR van den, Mulder-Folkerts DFK, Dukers NHTM, Fennema JSA, Coutinho RA. [Surveillance of AIDS and HIV infections in Amsterdam 1997]. Ned Tijdschr Geneeskd 1998;142:2861-5.[in Dutch]

Van Duynhoven YTHP, Wiessing LG, Katchaki JN, Nieste HLJ, Esveld MI, Houweling H. [Laboratory surveillance of HIV infections, Arnhem, 1989-1994]. RIVM-Report 214670002. Bilthoven/Arnhem: RIVM/Streeklaboratorium voor de Volksgezondheid, 1995. [in Dutch]

Esveld MI, Pelt W van, Duynhoven YTHP van, Nohlmans MKE, Houweling H. [Laboratory surveillance of HIV infections, Arnhem, 1989-1995]. Bilthoven: RIVM Report 214670003, 1996. [in Dutch]

Postema EJ, Willems PWJM, Ridder MAJ de, Meijden WI van der. Comparison of patients refusing with patients accepting anonymous HIV testing in an outpatient STD department in the Netherlands. Int J STD AIDS 1997;8:368-72.

Snoek EM van der, Chin-a-Lien RAM, Ridder MAJ de, Willems PWJM, Verkooyen RP, Meijden WI van der. [Prevalence of sexually transmitted infections (STI) and HIV infections among attendees of the STI clinic in the Academic Hospital Rotterdam-Dijkzigt; comparison of 1993 and 1998]. Ned Tijdschr Geneeskd 2000;144(28):1351-5. [in Dutch]

Gras MJI, Helm ThCM van der, Schenk R, Doornum GJJ van, Coutinho RA, Hoek JAR van den. [HIV infection and risk behaviour among prostitutes in the Amsterdam streetwalkers' district; indications of raised prevalence of HIV among transvestites / transsexuals] Ned Tijdschr Geneeskd 1997;141(25):1238-41. [in Dutch]

Roosmalen MS van, Wiessing LG, Meer J van der, Koedijk P, Houweling H. [HIV-infection and risky behaviour among transvestites and transsexuals in the Rotterdam streetbased prostitution]. RIVM-Report. RIVM-rapport 441100003. Bilthoven, RIVM, 1996. [in Dutch]

Hoek JAR van den, Haastrecht HJA van, Scheeringa-Troost B, Goudsmit J, Coutinho RA. HIV infection and STD in drug addicted prostitutes in Amsterdam: potential for heterosexual HIV transmission. Genitourin Med 1989;65:146-50.

Haan HA, Hoek JAR van den, Haastrecht HJA van, Meer CW van der, Coutinho RA. [Relatively low HIV prevalence among drug users, despite risky injecting behaviour]. Ned Tijdschr Geneeskd 1991;135:218-21.[in Dutch]

Houweling H, Coutinho RA and the Study Group on HIV Infections among Dutch Expatriates in Africa. Risk of HIV infection among Dutch expatriates in sub-Saharan Africa. Int J STD AIDS 1991;2:252-7.

Bindels PJE, Mulder-Folkerts DK, Boer K, Schutte MF, Velde WJ van der, Wong FJ. The HIV prevalence among pregnant women in the Amsterdam region (1988-1991). Eur J Epidemiol 1994;10:331-8.

Roosendaal FR, Smit C, Varekamp I, Suurmeyer Th, Bröcker-Vriends A, Briët E. [Haemophilia and AIDS, results of a national study among patients with haemophilia]. Vianen: Nederlandse Vereniging van Hemofiliepatiënten, 1986.[in Dutch]

College for blood transfusions. [Overview of blood transfusion in the Netherlands, 1986-1994]. Amsterdam: College for blood transfusions of the Dutch Red Cross, 1987(-1995).[in Dutch]

Gras MJI, Weide JF, Langendam MW, Coutinho RA, Hoek JAR van den. HIV prevalence, sexual risk behaviour and sexual mixing patterns among migrants in Amsterdam, the Netherlands. AIDS 1999;13:1953-62.

SUPPLEMENT 3. MPES HIV Model Assumptions

A number of assumptions regarding both the MPES model structure and the data informing it were required, typically in order to supplement weak (where not missing) information about some subgroup-region-gender combinations. In the absence of evidence to the contrary, epistemic uncertainty around all parameters is modelled by means of vague (typically Uniform with allowed bounds) prior distributions.

Assumptions used for subgroup proportions

1. Information on number of all men who have sex with men (MSM) in Rotterdam (sources: Rutgers Nisso Group, Rotterdam Health Monitor) and the rest of the Netherlands (sources: Pienter, Rutgers Nisso Group), number of injecting drug users (IDU) in Amsterdam (source: AMS Health Service) and female sex workers (FSW) in the rest of the Netherlands consists of pairs of bounding counts. Such pairs were modelled so that effective subgroup proportions are equally likely to lie within 5% (an even less conservative upper bound for either $\rho_{RTD,MSM,ALL}$ and $\rho_{RNL,MSM,ALL}$) and correspondingly estimated lower bounds.
2. Due to likely over-reporting of number of IDU in the rest of the Netherlands (NL) (source: Pienter), data were assumed to actually inform an upper bound for IDU subgroup proportions.
3. Official statistics on number of migrants in Amsterdam, Rotterdam and the rest of the Netherlands (source: national bureau of statistics (CBS)) are not classified by STI clinic attendance status, nor do they include illegal immigrants. These issues are addressed first by assuming the proportions of sub-Saharan African (SSA)-born and Caribbean (CRB)-born migrants legally residing in the Netherlands (regardless of STI clinic attendance) to be equally likely to lie within 80%-90% and 95%-100% respectively; then by adjusting for the proportions of SSA-born and CRB-born STI clinic attendees.
4. The model enforces the following inequality chain:

   $\rho_{AMS,MSM,ALL} \geq \rho_{RTD,MSM,ALL} \geq \rho_{RNL,MSM,ALL}$

   moreover it incorporates the belief that the population mix of MSM STI clinic attendees in Rotterdam lies much closer to its estimated minimum (source: Rotterdam Health Monitor) than to its conservatively estimated maximum (source: Rutgers Nisso Group).

Assumptions used for HIV prevalences

1. STI clinics across the Netherlands enact an opt-out policy on HIV testing, which leads to biases in the evidence (source: SOAP) reported around STI clinic attendees on HIV prevalence due to the missing information about individuals opting out of HIV testing. Opt-in and opt-out contributions to HIV prevalence, with only the former being actually observed, were modelled separately, depending on the specific region-exposure combination, in line with prior beliefs. In particular, opt-out HIV prevalences in Amsterdam and Rotterdam were assumed to be evenly distributed between opt-in HIV prevalence[1] and a 50% (STI-non migrants, STI-SSA and STI-CRB) or 100% (MSM-STI) figure. In the rest of the Netherlands, where HIV testing is less encouraged than in main urban areas, such prevalence was instead assumed to lie between opt-in HIV prevalence[1] (MSM-STI, STI-SSA and STI-CRB) or 0% (STI-non migrants) and a 100% (MSM-STI), 25% (STI-SSA and STI-CRB) or opt-in HIV prevalence (STI-non migrants) figures.
2. The model incorporates the expectation that MSM HIV prevalence in the rest of the Netherlands should not exceed that observed in the same subgroup in Amsterdam and Rotterdam, regardless of their STI clinic attendance status.
3. Since HIV-positive IDU individuals in Amsterdam have steadily declined over time to ageing or mortality, data available this at-risk subgroup (source: anonymous unlinked HIV survey) inform an upper bound for its HIV prevalence.
4. HIV prevalence in low-risk individuals is assumed across regions not to exceed the prevalence in other at-risk subgroups with the same region-gender profile.
5. Evidence collected on HIV prevalence in SSA-born individuals in Rotterdam not attending STI clinics (source: UA survey) is limited to Cape Verdean migrants only. Since Cape Verde is an non-HIV endemic country, those data were assumed to inform a lower bound for the HIV prevalence characterising the wider SSA-born at-risk subgroup.
6. Evidence available on HIV prevalence of Caribbean migrants in Rotterdam (source: anonymous HIV survey) is thought of as informing an upper bound for such parameter which is less conservative than that instead implied by UNAIDS statistics.
7. HIV prevalences among migrant subgroups across the Netherlands not attending STI clinics and SSA-born STI clinic attendees outside Amsterdam and Rotterdam are assumed to be bounded above by corresponding UNAIDS estimates.
8. The model reflects the intuition that HIV prevalence observed in STI clinic attendees from HIV-endemic countries across the Netherlands would be expected to exceed that featured by immigrants of same background who instead do not attend a STI clinic; the same is assumed to hold within the MSM at-risk subgroup.
9. Data available on HIV prevalence in Caribbean migrants both attending STI clinics (source: SOAP) and not (source: anonymous HIV survey) in the rest of the Netherlands are assumed to inform a lower bound for such parameter.

[1] Such lower bound is motivated by the assumption that individuals opting out of HIV testing are likely to be at higher risk than those instead opting in.

10. The model establishes the following ranking between cross-country HIV prevalences in MSM not attending STI clinics:

$$\pi_{\text{AMS,MSM,NON-STI}} \geq \pi_{\text{RTD,MSM,NON-STI}} \geq \pi_{\text{RNL,MSM,NON-STI}}$$

11. Information available on HIV prevalence in pregnant women from either non-HIV-endemic or endemic background living in Amsterdam (source: AMS Health Service screening system) and Rotterdam (source: Rotterdam screening system) is utilised as a proxy for HIV prevalence in low-risk women. More specifically, under the assumption that pregnant and general women exhibit the same population mix – in other words, assuming similarly to Presanis et al. (2008) that pregnant women are representative of the wider women population with respect to their exposure – then HIV prevalence in pregnant women from non-HIV-endemic countries is given by a weighted average of HIV prevalences in female STI clinic attendees from non-HIV-endemic background and low-risk females, with weights given by their respective subgroup proportions. Analogously, HIV prevalence in pregnant women from HIV-endemic countries is taken to be a weighted average of HIV prevalences in female SSA-born and Caribbean-born migrants, regardless of their STI clinic attendance status.
12. To supplement weak evidence on HIV prevalence among low-risk individuals (especially outside Amsterdam and Rotterdam), male-to-female prevalence log-odds ratios were assumed to be homogeneous (that is similarly distributed) across all subgroups – albeit not across regions – excluding MSM and FSW.
13. Prevalence data available at national level on pregnant women from HIV-endemic background were assumed to be representative of pregnant women of corresponding ethnicity outside of Amsterdam and Rotterdam only (source: RIVM). Information on prevalence in blood donors (source: Sanquin), which is not made available by region nor gender, is utilised to inform minimum prevalence of low-risk individuals of either gender across the country, since blood donors are thought of as being at especially low risk of HIV infection.

Assumptions used for Proportions Diagnosed

1. Lack of knowledge on *actual* number of infections among STI clinic attendees across the Netherlands (due to some of them opting out of HIV testing) required the utilisation of number of infections *predicted* elsewhere within the model for estimating proportions in the corresponding at-risk subgroups diagnosed with HIV. Moreover the model takes into account the belief that correspondingly estimated proportions diagnosed are all expected to exceed 20%.
2. Since HIV-positive IDU individuals in Amsterdam have steadily declined over time to ageing or mortality, data available this at-risk subgroup in Amsterdam (source: anonymous unlinked HIV survey) inform a lower bound for corresponding proportion diagnosed with HIV.
3. Because of their intrinsic design characteristics, evidence collected on IDU across regions in the Netherlands (sources: anonymous HIV surveys) and on all STI clinic attendees in Amsterdam (source: DWAR) was assumed to inform a lower bound for corresponding subgroup proportions diagnosed with HIV.
4. The model encodes the intuition that proportions of STI clinic attendees from HIV-endemic countries diagnosed with HIV should be greater than those featured by immigrants of same background instead not attending a STI clinic; the same is assumed to hold within the MSM at-risk subgroup. This is also thought to be generally connected to cultural profiling, because of generally better integration of immigrants of Caribbean origin into the Netherlands compared to SSA-born migrants: in other words, proportions of Caribbean migrants diagnosed with HIV would be expected to be larger than of those of SSA background irrespective of STI clinic attendance status. This cosideration too is accounted for by the model.
5. To corroborate weak evidence on proportions diagnosed with HIV among low-risk individuals (especially outside Amsterdam and Rotterdam), male-to-female log-odds ratios of these parameters were assumed to be homogeneous across all subgroups – albeit not across regions – excluding MSM and FSW.
6. Data available on proportions of pregnant women diagnosed with HIV from either migrant or non-migrant origin living in Amsterdam (source: AMS Health Service screening system) was assumed to be representative of low-risk women. More specifically, under the assumption that pregnant and general women exhibit the same population mix (analogously to what already assumed for the estimation of HIV prevalences in low-risk women) then proportions of pregnant women from non-HIV-endemic countries diagnosed with HIV are given by a weighted average of diagnosed HIV prevalences among female STI clinic attendees from non-HIV-endemic background and low-risk females, with weights given by their respective subgroup proportions. Analogously, proportions of pregnant women from HIV-endemic countries diagnosed with HIV are taken to be a weighted average of diagnosed HIV prevalences among female SSA-born and Caribbean-born migrants, regardless of their STI clinic attendance status.
7. Due to their higher level of health consciousness and access to health-care facilities across the Netherlands, MSM not attending STI clinics are expected to be diagnosed in higher proportions than SSA- and Caribbean-born males likewise not attending a STI clinic.

Assumptions used for Diagnosed HIV Prevalences

1. Due to separate evidence about HIV infection among low risk individuals, data on MSM attending STI clinics in the rest of the Netherlands (source: Pienter) are assumed to inform a lower bound for HIV prevalence diagnosed.

Assumptions used for Diagnosed HIV Infections

1. Since not all individuals diagnosed with HIV are actually in care, under-reporting biases affect region-specific records (source: SHM) notably in relation to all MSM across the Netherlands and IDU in Amsterdam. Resulting predicted numbers of diagnosed HIV infections were adjusted upwards in the light of information available (source: Schorer Monitor) around corresponding proportions not in care.
2. Due to differences between the observed and modelled classifications of exposures in number of diagnosed HIV infections, the 'SSA/Caribbean migrants (heterosexual)' class was assumed to comprise immigrants irrespective of STI clinic attendance status; on the other hand, 'heterosexual men/women other than SSA and Caribbean (including Dutch)' were taken to consist of IDU, FSW (women only), STI clinic attendees from non-HIV-endemic countries and low-risk individuals.
3. Information available on newly diagnosed infections by place of diagnosis in 2007 among migrants in the rest of the Netherlands (source: RIVM) was utilised to inform an upper bound for the fraction of such infections which were diagnosed in STI clinics. This in turn was utilised to distinguish from migrants in care those diagnosed with HIV in a STI clinic.

References

AM Presanis, D De Angelis, DJ Spiegelhalter, S Seaman, A Goubar, and AE Ades. Conflicting Evidence in a Bayesian Synthesis of Surveillance Data to Estimate HIV Prevalence. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 171(4):915–937, 2008

T van der Helm, L van Mens. Mobility in Prostitution in The Netherlands 1998-1999. Technical report, Municipal Health Service Amsterdam, 1999. An Inventory Done Under the Auspices of EUROPAP-TAMPEP 1998–1999.