OPEN ACCESS

Analysis of duration of risk behaviour for key populations: a literature review

Erika Fazito,¹ Paloma Cuchi,² Mary Mahy,² Tim Brown³

► Additional supplementary tables are published online only. To view these files please visit the journal online (<http://dx.doi.org/10.1136/sextrans-2012-050647>).

¹University of Brasília, Brasília, Brazil

²Department of Epidemic Analysis and Monitoring, UNAIDS, Geneva, Switzerland

³Research Program, East-West Center, Honolulu, Hawaii, USA

Correspondence to

Erika Fazito, University of Brasília, 26 Chemin Colladon, 1209 Genève, Suisse, Brasília, Brazil; erikafazito@gmail.com

UNAIDS Report 2012

Guest Editors

Karen Stanecki
Peter D Ghys
Geoff P Garnett
Catherine Mercer

Accepted 27 August 2012

ABSTRACT

Background The objective of this paper is to review literature in order to calculate regional estimates of the average duration of time individuals maintain a specific high-risk behaviour.

Methods The review targeted the key populations of female sex workers (FSW), male clients of female sex workers (MCFSW), people who inject drugs (injecting drug users (IDU)) and high-risk men who have sex with men (MSM). To be included in the review the study had to provide information on (1) the time a person spent at risk until death or cessation of the risk behaviour, (2) the percentage of the sample who initiated the risk behaviour in less than a year or (3) the mean or median duration of the behaviour from a representative sample.

Results 49 papers were found for the FSW population describing the period of time FSW stay in sex work to be between 2.9 years (Asia) and 12 years (Latin America). Eight papers were found for MCFSW showing the duration of the risk behaviour in this category varying from 4.6 years in Africa to 32 years in Asia. 86 papers were reviewed for the population of IDU showing that the average time a person injects illegal drugs varies from 5.6 years (Africa) to 21 years (South America). No information was found for duration of high-risk behaviour among MSM; instead, the definitions found in the literature for high- and low-risk behaviour among MSM were described.

Conclusions There is high variability of estimates of duration of high-risk behaviours at regional level. More research is needed to inform models and prevention programmes on the average duration of time individuals maintain a specific high-risk behaviour.

INTRODUCTION

Public health policies must be based on estimates that can support informed decision making and guide HIV prevention resource allocation. The extremely dynamic nature of the HIV epidemic and the various forms it takes in different countries challenge public health managers to find ways to accurately monitor and evaluate its trends. Mathematical modelling plays a central role in this process. It contributes to the understanding of the dynamics of HIV spread, provides the information needed to guide responses, helps to identify gaps in existing knowledge and suggests directions for future research.¹

The Joint United Nations Programme on HIV/AIDS (UNAIDS) develops models (Spectrum² and Estimation and Projection Package (EPP)³) to analyse HIV epidemics and their impacts for incountry application. These models allow countries to estimate HIV incidence, HIV prevalence, numbers of people living with HIV, numbers of AIDS related

deaths, numbers of people in need of antiretroviral therapy (ART), numbers of HIV-positive pregnant women in need of ART prophylaxis and numbers of children orphaned by HIV, along with other programmatically relevant outputs.

In concentrated epidemics, HIV tends to be focused in a small number of groups with elevated behavioural risk of HIV and their immediate sexual partners. Thus, models of such epidemics must be largely based on information about those key populations: injecting drug users (IDU), high-risk men who have sex with men (MSM), female sex workers (FSW) and their clients (male clients of female sex workers (MCFSW)). However, these populations are often not static. Each year some individuals initiate the behaviours that place them in a behavioural risk group, while others terminate these behaviours, leaving the group; that is, the groups have turnover. Such turnover has significant impacts on the prevalence and incidence in the at-risk population and also in the typically lower-risk populations to which they return.

Because those entering an elevated risk population are typically coming from a lower-risk, lower prevalence group, they tend to dilute the current prevalence in the at-risk population. Similarly, those leaving the group are often a higher prevalence than the group as a whole because many of them have longer histories of exposure to risk. Both of these effects mean that in order to maintain a fixed prevalence level in an at-risk population, the incidence in the at-risk population must be higher than it would be otherwise. If models are to correctly estimate the incidence in the group for a given pattern of prevalence, then they need to account for these effects. When turnover effects are included, the prevalence curve over time is generally found to flatten out relative to what it would be with no turnover (see figure 1). This is because most HIV mortality that would normally bring down the prevalence in a closed population occurs outside of the at-risk population if the turnover is high, leading to a flatter curve.

In addition, if the prevalence in the group is high, substantial numbers of those leaving the group and returning to a lower-risk population are HIV-positive. This drives prevalence up in the receiving population without incurring additional incidence. In some cases, 10%–20% of the overall prevalence in the receiving population may result from risk behaviours which occurred outside of that population.

It is essential in concentrated epidemics that models take this into account. Recognising the importance of turnover, the UNAIDS EPP allows users to specify turnover in specific populations.

Figure 1 HIV prevalence (%) in the injecting drug users (IDU) population by year and turnover input, Thailand.

This is done by specifying three things: (1) that turnover does occur in this population; (2) the average time, that is, duration that individuals remain in the at-risk population; and (3) the lower-risk population to which they will return.

This creates additional data needs for concentrated epidemics where turnover is high and is affecting epidemic dynamics. In addition to data on the size of key populations, data are also required on the average time that people remain in the group. That is, one needs to know how many years a person injects drugs, how many years women stay employed in sex work, how many years MSM engage in unprotected, high-risk anal sex and how many years an MCFSW remains a client. The expectation is that, on average, at the end of that time period a person returns to a lower-risk population group, stopping the behaviours that put the person at a higher risk of contracting HIV.

In 2009 and 2010, the estimated average duration was based on experts' opinion because currently countries have very little data on such movements of people in and out of the populations. But given the great impact that this can have on incidence and prevalence, it is critical that the durations used in such models be based on scientific evidence. The objective of this paper is to conduct a review of the literature to generate regional estimates of the average duration that individuals maintain a specific high-risk behaviour before returning to a lower-risk population.

METHODS

The study is a literature review that aimed to compile the limited available data on duration of high-risk behaviour among key populations.

The review was performed using PubMed in October 2010. To identify additional pertinent publications, the references listed in the papers found in the search were hand-searched and researchers were contacted to obtain non-published information. Grey literature was also reviewed.

The studies had to meet the following criteria to be included in the review: (1) to be an original work instead of a literature review; (2) to be studies of one of the key populations important in concentrated epidemics (high-risk MSM, IDU, FSW and MCFSW); and (3) to include information on the duration of risk behaviour or information that could be converted into estimates of duration. Papers in English, Spanish, French and Portuguese were searched with no limits on date. The following search criteria were used:

- FSW: (((((((sex workers[Title]) OR sex worker[Title]) OR commercial sex worker[Title]) OR commercial sex workers[Title]) OR sex-trafficked women[Title]) OR

prostitutes[Title]) OR prostitution[Title]) OR duration sex work[Title]) OR sex work[Title]

- IDU: idu[All Fields] OR (inject[All Fields] AND "drugs"[All Fields]) AND users[All Fields] OR (inject[All Fields] AND "drugs"[All Fields] AND user[All Fields])
- MSM: high [title] AND risk [title] AND "men who have sex with men" [title]
- CFSW: ("clients"[Title/Abstract] AND prostitutes[Title/Abstract]) OR ("clients"[Title/Abstract] AND ("female"[Title/Abstract] AND "sex"[Title/Abstract] AND workers"[Title/Abstract])

Information on the study design, year of data collection, location, turnover, sample definition, age and gender was collected and summarised in tables that can be accessed online as supplementary tables for this paper (see online supplementary tables S1, S2 and S3).

The ideal studies to assess duration of high-risk behaviour would be surveys of former members of these key populations. The question asked would be how long they had engaged in the high-risk behaviour. In the literature review, for all groups except for IDU, no papers on former members of these key populations were found. Hence, instead of searching for data from which to actually estimate average duration of behaviour, it was necessary to search for data from surveys of current key populations that included information indicating how long the respondent had been at risk. This information was given in three different ways, depending on the study. Some authors calculated the mean or median time the respondents had been at risk, some demonstrated the percentage of the sample who started the risk behaviour in the last year and a few described the duration of the behaviour as the amount of time a person spent in the risk behaviour group until death or cessation.

Because of the diverse presentation of results, it was necessary to create an algorithm to decide how to use the results and choose the best estimate for each region. The first method of choice was direct estimation of duration (the time a person spent at risk until death or cessation of risk behaviour). This required that the person had already discontinued the behaviour that put them in that group.

If the first method was not available, the second method of choice would be used. This consisted of estimating the duration of risk behaviour by the percentage of the sample who initiated the risk behaviour in less than a year. If the population is not changing size, that is, is in a steady state, this percentage will equal the percentage who stopped the behaviour in the last year. In a steady state the entries must equal exits and thus the duration will be $1/(\text{the proportion})$, so if 10% entered, then the average duration will be $1/0.1 = 10$ years.

If data to apply the first two methods were not available, a third method was used to estimate turnover. The third method consisted of doubling the median or mean time the people remained in the risk behaviour group in the moment of the study interview. This assumes that the duration of time in the key population is randomly distributed and has a normal distribution. It is recognised that this assumption may often be violated as the distribution of time in a group is often heavily skewed toward lower durations, with many people entering the groups for a short period and then ceasing the corresponding risk behaviours. Because of that assumption we used primarily the median and in its absence the mean to calculate duration. The results for the third method are presented in a range formed by the mean and the median of the duration of the datasets.

If data were available, all three methods were applied for all the regions and key populations. The duration of high-risk

behaviour has been derived for the following geographic regions: America, Europe, Asia, Australia/Oceania and Africa. When possible, the basic regions were unfolded to depict more specific information.

RESULTS

Female sex workers

In all, 31 papers were found for Africa and they generated information about 47 different datasets.

- ▶ Four papers described the percentage of FSW who started selling sex in the last year.^{4–7} Based on these studies the mean duration for FSW is estimated to be 5.5 years.
- ▶ Using the third method proposed, 43 datasets provided the average duration of sex work.^{8–29} This period ranged from 0.3 to 6.0 years, with a mean and a median of 2.9 years which resulted in an average duration of 5.5 years.

A total of 40 papers were found on Asia which generated information from 48 different datasets.

- ▶ Twelve papers described the percentage of FSW who started selling sex in the last year. Based on that information, the mean duration for FSW was 2.94 years and ranged from 1.35 to 12.05 years according to the dataset.^{30–40}
- ▶ Thirty-one datasets showed the average duration spent in sex work. This period ranged from zero to 6.5 years, with a mean of 2 years and a median of 1.4 years which would lead to a duration between 2.8 and 4.0 years.^{37 41–63}

Nine papers were found on Europe and they generated information on 10 different datasets, showing the average duration of sex work. This period ranged from 1.5 to 12 years, with a mean of 5 years and a median of 4.2 years, which would lead to a duration between 8.4 and 10 years.^{64–72}

Six papers were found for Latin America, describing the average time FSW spend in business. This period varied from 3.5 to 8.8 years according to the dataset, with a mean of 6 years and a median of 5.6 years, which would lead to a duration of risk behaviour between 11.2 and 12 years.^{73–79}

Three papers were found in North America, showing the duration of sex work up to the interview in median years. The median ranged from 5 to 6.4 years with a mean of 5.5 years and a median of 5.1 years. If we consider this distribution to be normal and double the values to reach turnover, the estimated duration of risk behaviour is between 10.2 and 11 years.^{80–82}

No papers were found for Oceania/Australia.

In summary, it was possible to generate estimates for duration of risk behaviour for five regions. The results are presented in table 1.

Male clients of female sex workers

Eight papers were found describing the median or mean duration during which men routinely bought sex: three in America^{83–85} (two in Mexico and one in Haiti), three for Asia/Oceania^{86–88} (China, India and Australia) and two for Africa^{89 90} (Benin and Kenya).

In America this period ranged from 6.3 to 10.8 years, with a mean of 8 years which leads to an estimated duration of risk behaviour of 16 years. For Asia/Oceania, the estimated duration ranged from 9.0 to 30 years, with a mean of 16.2 years which leads to a duration of 32.4 years.

One paper from Africa described the percentage of men who started paying for sex in the year prior to the survey (21.9%) suggesting a duration of 4.6 years.

Estimates on duration of risk behaviour are presented in table 2. However, given the low number of studies and wide variability, these findings must be interpreted with caution.

Table 1 Regional estimates of duration of risk behaviour for FSW by the method of calculation

Region	Duration of risk behaviour for female sex workers		
	First method of calculation: based on time from beginning of sex work until death or cessation	Second method of calculation: based on percentage of FSW who started selling sex in the last year	Third method of calculation: based on the median/mean time spent in sex work up to the moment of the study*
Africa	NA	5.5 (4)†	5.5 (43)
Asia	NA	2.9 (12)†	2.8–4.0 (31)
Australia/Oceania	NA	NA	NA
North America (studies conducted in the USA)	NA	NA	10.2–11.0 (3)†
Europe	NA	NA	8.4–10.0 (10)†
Latin America (studies conducted in Mexico, Brazil and Peru)	NA	NA	11.2–12.0 (6)†

(1) In parenthesis, number of datasets used for calculation.

*Considering the median equals mean (primarily the median and, in its absence, the mean).

†Best estimate for the population.

NA, not available.

More country-specific data are urgently needed for this population.

Injecting drugs users

In most of the world, more duration information was available for IDU compared with other key populations; however, there was substantial geographic variation in the number of studies conducted. Only two papers were found on IDU in Africa^{91 92} and one provided the percentage of IDU who started injecting drugs in the year prior to the survey: 18%.⁹³ Based on that information, the turnover for IDU was estimated to be 5.6 years.

Table 2 Regional estimates of duration of risk behaviour for MCFSW by the method of calculation

Region	Duration of risk behaviour for MCFSW		
	First method of calculation: based on time from beginning of risk behaviour until death or cessation	Second method of calculation: based on percentage of MCFSW who started paying for sex in the last year	Third method of calculation: based on the median/mean time clients spent paying for sex up to the moment of the study*
Africa	NA	4.6 (1)†	5.5 (2)
Asia/Oceania	NA	NA	32.4 (3)†
Europe	NA	NA	NA
America	NA	NA	16.2 (3)†

(1) In parenthesis, number of datasets used for calculation.

*Considering the median equals mean (primarily the median and, in its absence, the mean).

†Best estimate for the population.

NA, not available.

Overall, 16 papers were found on IDU in Asia and they generated information on 23 different datasets.

- ▶ Six datasets described the percentage of IDU who started injecting drugs in the year prior to the survey.^{92–94} Based on that information, the mean turnover for IDU was estimated to be 8.7 years with a range from 3.7 to 22.2 years.
- ▶ In all, 17 datasets showed the average time a person spent injecting drugs.^{95–107} This period ranged from 1.9 to 17.0 years, with a mean of 6.8 years and a median of 4.4 years suggesting turnover between 8.8 and 13.6 years.

A total of 12 papers were found in Oceania, all conducted in Australia, generating 15 different datasets.

- ▶ A study conducted in Australia¹⁰⁸ aimed to examine mortality within the 626 IDU from the Victorian Injecting Drug Users Cohort Study (VICS). They retrospectively examined mortality comparing data from the VICS, recruited from 1990 to 1995, to data from the National Death Index containing records of all deaths in Australia from 1990 to 2006. A total of 26 IDU died before the end of 2006 and the average length of injecting career at death was 17.0 years (SD=7.05, min 3.86, max 29.79); 18 of the 26 deaths were drug-related.
- ▶ One paper¹⁰⁹ described the percentage of IDU who started injecting drugs in the last year. Based on that information, the turnover for IDU was estimated to be 5.2.
- ▶ Thirteen datasets showed the average time a person spent injecting drugs.^{110–119} This period ranged from 2.4 to 15 years, with a mean of 9.1 years and a median of 8 years suggesting a turnover between 16 and 18.2 years.

A total of 24 papers were found in Europe generating 37 different databases.

- ▶ A study conducted in Scotland aimed to identify the mortality risk and explore the causes of death in all IDU who attended a family medical practice in northwest Edinburgh.¹²⁰ They were followed for 21 years, and the mean time from first injection until death was 13.9 years.
- ▶ Four datasets described the percentage of IDU who started injecting drugs in the year prior to the survey.^{121–123} Based on that information, the mean turnover for IDU was estimated to be 8.9 years.
- ▶ Thirty-two datasets^{124–142} described the mean duration of injecting career up to the moment of the interview. It varied from 1.3 to 14.3 years, leading to a mean and a median of 8.6 years. If we consider this distribution to be normal and double the value to reach turnover, the estimated turnover would be 17.2 years.

Six papers were found on South America generating nine different datasets and they all described the duration of injecting career up to the moment of the interview by medians and means. This period ranged from 2.2 to 21 years, with a mean of 10.5 years and a median of 9.8 years suggesting turnover between 21 and 19.6 years.^{143–148}

A total of 26 papers were found in North America generating 34 different datasets.

- ▶ A prospective study conducted in the USA aimed to examine both the incidence of injection cessation and the change in injection frequency among those who did not quit injection.¹⁴⁹ The study included 901 IDUs who were recruited from a Needle Exchange Program (NEP) or an area with no NEP in Chicago between 1997 and 2002. Cessation of injection, the main outcome variable, was defined as no injection drug use since the last interview (1 year prior). In all, 116 IDUs ceased injection during the

Table 3 Regional estimates of duration of risk behaviour for IDU by the method of calculation

Region	Duration of risk behaviour		
	First method of calculation: based on time from beginning of drug injection until cessation	Second method of calculation: based on percentage of IDU who started drug injection in the last year	Third method of calculation: based on the median/mean time spent in drug injection up to the moment of the study*
Africa	NA	5.6 (1)	5.6 (1)
Asia	NA	8.7 (6)	8.8–13.6 (17)
Oceania	17.0 (1)†	5.2 (1)	16.0–18.2 (13)
North America	9.5 (1)†	4.7 (5)	8.8–14.0 (33)
Europe	13.9 (1)†	8.9 (4)	17.2 (32)
South America	NA	NA	19.6–21.0 (9)

The number of datasets used for each calculation are given in parenthesis.

*Considering the median equals mean (primarily the median and in its absence the mean).

†Best estimate for the population.

NA, not available.

study, and the median number of years from first injection until cessation was 9.5 years.

- ▶ Five datasets described the percentage of IDU who started injecting drugs in the last year.^{150–153} Based on that information, the mean duration for IDU was 4.7 years.
- ▶ 33 datasets showed the average time a person spent injecting drugs.^{133 152–173} This period ranged from 1.3 to 23.9 years, with a median of 4.4 years and mean of 7 years, suggesting a duration between 8.8 and 14 years.

Duration estimates were generated for six regions. The results are presented in table 3.

High-risk MSM

MSM are also a key population because of the increased risk of HIV transmission through anal intercourse. However, anal intercourse can be safe when between faithful, uninfected partners or when consistent condom use is practiced. A literature review was completed of surveys of MSM looking for the turnover between high-risk MSM and low-risk MSM. However, no studies assessing turnover for this population were found. At this point it is not possible to estimate average duration in the high-risk MSM population. We decided then to compile the different definitions used in surveys for high- and low-risk MSM to contribute to the characterisation of these two different patterns of sexual behaviour among the MSM population. The MSM sexual practices are described below according to the risk of exposure to HIV.^{174–181}

High-risk sexual behaviours

- ▶ Barebacking
- ▶ Unprotected anal intercourse (UAI) with an HIV-seropositive partner
- ▶ Rimming (anal/oral sex play)
- ▶ Fisting (insertion of the hand into the anus)
- ▶ Use of sex toys and shared drug implements
- ▶ UAI with casual partners
- ▶ UAI with partners of an unknown or discordant HIV status
- ▶ Having multiple sex partners

- ▶ Trading sex
- ▶ Having unprotected anal sex and anal sex while drunk or high in the past 6 months

Low-risk sexual behaviours

- ▶ Men who had been involved in a mutually monogamous relationship for 2 or more years with a male partner known to be negative for HIV antibodies.
- ▶ Men who had been involved in a mutually monogamous relationship for 2 or more years with a male partner under ART treatment.

Very few studies cover duration of risk behaviours for male sex workers and transvestites and therefore were not included in the study.

DISCUSSION

This literature review provides estimates of the average duration people spend in high-risk behaviours categories by mode of exposure and geographical region. As described earlier, mathematical models of the HIV epidemic can use this information to estimate changes in the epidemic due to new susceptibles entering (ie, the population newly joining the high-risk populations) and older, higher prevalence members leaving. Spectrum/EPP, a model used by over 150 countries, requires this as an input for countries with concentrated HIV epidemics if the user wishes to apply turnover in their fits. This paper provides a more scientific basis for making turnover estimates using published and unpublished data that can be used by countries as inputs for the Spectrum/EPP model.

The results of the review showed that average duration of female sex work varies dramatically by region with the shortest durations (and highest turnover) found in Asia and the longest average duration of sex work found in the Americas.

Similarly, the average duration of injecting drug use varies by region. In Africa, average duration of injecting drug use was approximately 6 years while in South America and Oceania the duration was closer to 20 years. Large differences in turnover have important implications for prevention activities and services for key populations. In areas with very high turnover more frequent outreach activities and surveillance activities are required. Where turnover is slower, activities can focus more on reaching divergent subgroups of the key populations to ensure the entire population is reached with services.

The variability of these estimates at regional level suggests that there are substantial differences at national levels as well. Differences in duration might be due to different public health interventions by region, country or subnational level or due to different reasons for the high-risk behaviour such as financial need for sex work or poor future prospects for injecting drug use. Also, duration of injecting drug use is highly dependent on mortality, thus the differences in average injecting drug duration could be associated with differences in healthcare for the injecting drug population.

This study has several limitations. First, the definitions of key populations present minor variations among the different surveys analysed. Also, it is important to highlight that for the calculation of duration of risk behaviour for FSW, some studies that included FSW who practice injecting drug use were included. Similarly, studies on IDU who practice commercial sex work were included in the calculations of the average duration of time of injecting drugs. It was decided not to separate such information because the estimates of duration of risk behaviour calculated in this study are intended to serve

as input for mathematical HIV/AIDS models. In such models, the stratification of an epidemic structure, in terms of populations, can be made as far as strategic information is available for each population. And rarely do countries have detailed information about HIV prevalence and population size for, for example, the sex workers who use injected drugs and the ones who do not.

Another point to be addressed is the differences found between the estimates generated by methods 2 and 3. These methods generated most of the time similar estimates of duration of risk behaviour, except for the population of IDU in Asia, Oceania and North America. In these regions, the estimates of duration calculated by method 2 are lower than the ones calculated by methods 1 and 3. One possible explanation is that the assumption of stability is being violated. In this case, method 2 may be underestimating duration. Given the limited number of studies allowing method 2 to be used, another likely explanation is that the specific populations of IDU being examined in the different papers have widely varying durations. In those few cases where data were available to apply both methods 2 and 3 the variation was not as extreme as the table averages would imply. And as (1) populations of IDU and FSW are likely to fluctuate due to economic changes, legal changes, changes in demand and changes in supply for the behaviour and (2) many samples are censored, the estimates of duration calculated by methods 2 and 3 among FSW and IDU should be compared which determine whether violations of the assumption of a steady state have a significant impact on the estimates.

Another limitation is that the estimates for MCFSW must be interpreted cautiously due to two reasons. First, to the low number of studies found. And second, because in many countries, young men may go through a period during which they frequent sex workers often, but then this behaviour ceases or slows once they marry. In countries where this is the most common male behavioural pattern, a better estimator of duration of high-risk behaviour for this population may be the difference between average age at first intercourse and average age at marriage.

Last, it is important to highlight that very few surveys collect data on duration of high-risk behaviour and thus the analysis was limited to the countries that have been collecting these data. Therefore, the geographical coverage in this review is limited to a few countries that have collected information on duration or time since initiation of risk behaviour.

Despite the many limitations to the calculations presented in this paper, these are, to the authors' knowledge, the best available estimates of durations of risk behaviours. One important implication of this review is the need to include questions from which to estimate duration of risk behaviour in surveys among members of key populations in concentrated epidemics. These questions should be, for example: How long have you been exchanging sex for money? How long have you been injecting illegal drugs? How long have you been buying sex from FSW? From these questions, it is possible to demonstrate the proportion of members who have had the behaviour for less than 12 months and easily calculate duration of risk behaviour.

More research on turnover among key populations is needed to inform both models and prevention programmes. Future reviews on this subject should attempt to identify surveys in other databases such as Embase and Medline, rather than PubMed, and should also search for additional grey literature.

Key messages

- This paper provides a more scientific basis for making turnover estimates using data that can be used by countries as inputs for the Spectrum/Estimation and Projection Package model.
- There is high variability of estimates of duration of high-risk behaviours at regional level.
- More research is needed to inform models and prevention programmes on the average duration of time individuals maintain a specific high-risk behaviour.

Contributions EF: Conception and design of the study, acquisition of data, analysis and interpretation of data, article draft, paper review for important intellectual content, final approval of the version to be published. PC and MM: Conception and design of the study, analysis and interpretation of data, paper review for important intellectual content, final approval of the version to be published. TB: Interpretation of data, paper review for important intellectual content, final approval of the version to be published.

Competing interests None.

Provenance and peer review Commissioned; externally peer reviewed.

REFERENCES

1. Clark SJ, Morris M. Mathematical models for HIV transmission dynamics: tools for social and behavioral science research. *J Acquir Immune Defic Syndr* 2008;**47** (Suppl 1):S34–9.
2. Stover J, Johnson P, Hallett T, et al. The Spectrum projection package: improvements in estimating incidence by age and sex, mother-to-child transmission, HIV progression in children and double orphans. *Sex Transm Infect* 2010;**86**(Suppl 2):ii16–21.
3. Brown T, Bao L, Raftery AE, et al. Modeling HIV epidemics in the antiretroviral era: the UNAIDS estimation and projection package 2009. *Sex Transm Infect* 2010;**86**(Suppl 2):ii3–10.
4. Delaporte E, Buvé A, Nzila N, et al. HTLV-I infection among prostitutes and pregnant women in Kinshasa, Zaire: how important is high-risk sexual behavior? *J Acquir Immune Defic Syndr Hum Retroviral* 1995;**8**:511–15. PubMed PMID: 7697449.
5. Nagot N, Ouangré A, Ouedraogo A, et al. Spectrum of commercial sex activity in burkina faso: classification model and risk of exposure to HIV. *J Acquir Immune Defic Syndr* 2002;**29**:517–21.
6. Kayembe PK, Mapatano MA, Busangu AF, et al. Determinants of consistent condom use among female commercial sex workers in the Democratic Republic of Congo: implications for interventions. *Sex Transm Infect* 2008;**84**:202–6. Epub 2007 Nov 30.
7. Pepin J, Dunn D, Gaye I, et al. HIV-2 infection among prostitutes working in The Gambia: association with serological evidence of genital ulcer diseases and with generalized lymphadenopathy. *AIDS* 1991;**5**:69–75.
8. Dada AJ, Ajayi AO, Diamondstone L, et al. A Serosurvey of Haemophilus ducreyi, Syphilis, and Herpes Simplex Virus Type 2 and their association with human immunodeficiency virus among female sex workers in Lagos, Nigeria. *Sex Transm Dis* 1998;**25**:237–42.
9. Fowke KR, Nagelkerke NJ, Kimani J, et al. Resistance to HIV-1 infection among persistently seronegative prostitutes in Nairobi, Kenya. *Lancet* 1996;**348**:1347–51. PubMed PMID: 8918278.
10. Jennes W, Sawadogo S, Koblavi-Dème S, et al. Cellular human immunodeficiency virus (HIV)-protective factors: a comparison of HIV-exposed seronegative female sex workers and female blood donors in Abidjan, Côte d'Ivoire. *J Infect Dis* 2003;**187**:206–14. Epub 2002 Dec 30. PubMed PMID: 12552445.
11. Lavreys L, Chohan V, Overbaugh J, et al. Hormonal contraception and risk of cervical infections among HIV-1-seropositive Kenyan women. *AIDS* 2004;**18**:2179–84. PubMed PMID: 15577651373.
12. Kaul R, Kimani J, Nagelkerke NJ, et al. Risk factors for genital ulcerations in Kenyan sex workers. The role of human immunodeficiency virus type 1 infection. *Sex Transm Dis* 1997;**24**:387–92. PubMed PMID: 9263358.
13. Jennes W, Vuylsteke B, Borget MY, et al. HIV-specific T helper responses and frequency of exposure among HIV-exposed seronegative female sex workers in Abidjan, Côte d'Ivoire. *J Infect Dis* 2004;**189**:602–10. Epub 2004 Jan 29. PubMed PMID: 14767812.
14. Ghys PD, Diallo MO, Ettiègne-Traoré V, et al. Increase in condom use and decline in HIV and sexually transmitted diseases among female sex workers in Abidjan, Côte d'Ivoire, 1991–1998. *AIDS* 2002;**16**:251–8. PubMed PMID: 11807310.
15. Asamoah-Adu C, Khonde N, Avorklah M, et al. HIV infection among sex workers in Accra: need to target new recruits entering the trade. *J Acquir Immune Defic Syndr* 2001;**28**:358–66. PubMed PMID: 11707673.
16. Mulanga-Kabeya C, Morel E, Patrel D, et al. Prevalence and risk assessment for sexually transmitted infections in pregnant women and female sex workers in Mali: is syndromic approach suitable for screening? *Sex Transm Inf* 1999;**75**:358–60.
17. Cameron DW, Ngugi EN, Ronald AR, et al. Condom use prevents genital ulcers in women working as prostitutes: influence of human immunodeficiency virus infection. *Sex Transm Dis* 1991;**18**:188–91.
18. Ramjee G, Williams B, Gouws E, et al. The impact of incident and prevalent herpes simplex virus-2 infection on the incidence of HIV-1 infection among commercial sex workers in South Africa. *J Acquir Immune Defic Syndr* 2005;**39**:333–9. PubMed PMID: 15980695.
19. Phillipon M, Saada M, Ali Kamil M, et al. Fréquentation de un centre de santé par les prostituées clandestines à Djibouti. *Cahiers Santé* 1997;**7**: 5:10.
20. Nzila N, Laga M, Thiam MA, et al. HIV and other sexually transmitted diseases among female prostitutes in Kinshasa. *AIDS* 1991;**5**:715–21.
21. Kanki P, Mboup S, Marlink R, et al. Prevalence and risk determinants of human immunodeficiency virus type 2 (HIV-2) and human immunodeficiency virus type 1 (HIV-1) in west African female prostitutes. *Am J Epidemiol* 1992;**136**:895–907. PubMed PMID: 1442755.
22. Willerford D, Bwayo JJ, Hensel M, et al. Human immunodeficiency virus infection among high-risk seronegative prostitutes in Nairobi. *JID* 1993;**167**:1414–7.
23. Simonsen JN, Plummer FA, Ngugi EN, et al. HIV infection among lower socioeconomic strata prostitutes in Nairobi. *AIDS* 1990;**4**:139–44. PubMed PMID: 2328096.
24. Baeten JM, Richardson BA, Martin HL, et al. Trends in HIV-1 incidence in a cohort of prostitutes in Kenya: implications for HIV-1 vaccine efficacy trials. *J Acquir Immune Defic Syndr* 2000;**24**:458–64.
25. Anzala OA, Nagelkerke NJ, Bwayo JJ, et al. Rapid progression to disease in African sex workers with human immunodeficiency virus type 1 infection. *J Infect Dis* 1995;**171**:686–9. Erratum in: *J Infect Dis* 1996;**173**:1529. PubMed PMID: 7876618.
26. Ngugi EN, Plummer FA, Simonsen JN, et al. Prevention of transmission of human immunodeficiency virus in Africa: effectiveness of condom promotion and health education among prostitutes. *Lancet* 1988;**2**:887–90.
27. Mann JM, Nzilambi N, Piot P, et al. HIV infection and associated risk factors in female prostitutes in Kinshasa, Zaire. *AIDS* 1988;**2**:249–54.
28. Langley CL, Benga-De E, Critchlow CW, et al. HIV-1, HIV-2, human papillomavirus infection and cervical neoplasia in high-risk African women. *AIDS* 1996;**10**:413–17.
29. Alary M, Mukenge-Tshibaka L, Bernier F, et al. Decline in the prevalence of HIV and sexually transmitted diseases among female sex workers in Cotonou, Benin, 1993–1999. *AIDS* 2002;**16**:463–70.
30. Ohshige K, Morio S, Mizushima S, et al. Cross-sectional study on risk factors of HIV among female commercial sex workers in Cambodia. *Epidemiol Infect* 2000;**124**:143–52. PubMed PMID: 10722142; PubMed Central PMCID: PMC2810895.
31. Ohshige K, Morio S, Mizushima S, et al. Behavioural and serological human immunodeficiency virus risk factors among female commercial sex workers in Cambodia. *Int J Epidemiol* 2000;**29**:344–54. PubMed PMID: 10817135.
32. Sarkar K, Bal B, Mukherjee R, et al. Young age is a risk factor for HIV among female sex workers—an experience from India. *J Infect* 2006;**53**:255–9. Epub 2005 Dec 27. PubMed PMID: 16386307.
33. Lau JT, Zhang J, Zhang L, et al. Comparing prevalence of condom use among 15,379 female sex workers injecting or not injecting drugs in China. *Sex Transm Dis* 2007;**34**:908–16. PubMed PMID: 18049424.
34. Sarkar K, Bhattacharya S, Bhattacharyya S, et al. Oncogenic human papilloma virus and cervical pre-cancerous lesions in brothel-based sex workers in India. *J Infect Public Health* 2008;**1**:121–8. Epub 2008 Nov 12. PubMed PMID: 20701853.
35. Silverman JG, Decker MR, Gupta J, et al. HIV prevalence and predictors among rescued sex-trafficked women and girls in Mumbai, India. *J Acquir Immune Defic Syndr* 2006;**43**:588–93. PubMed PMID: 17019369.
36. Celentano DD, Akarasew P, Sussman L, et al. HIV-1 infection among lower class commercial sex workers in Chiang Mai, Thailand. *AIDS* 1994;**8**:533–7. PubMed PMID: 8011259.
37. Nakashima K, Kashiwagi S, Hayashi J, et al. Sexual transmission of hepatitis C virus among female prostitutes and patients with sexually transmitted diseases in Fukuoka, Kyushu, Japan. *Am J Epidemiol* 1992;**136**:1132–7.
38. Wang H, Chen RY, Ding G, et al. Prevalence and predictors of HIV infection among female sex workers in Kaiyuan City, Yunnan Province, China. *Int J Infect Dis* 2009;**13**:162–9. Epub 2008 Aug 20. PubMed PMID: 18718801; PubMed Central PMCID: PMC2650737.
39. Taneepanichskul S, Phuapradit W, Chaturachinda K. Association of contraceptives and HIV-1 infection in Thai female commercial sex workers. *Aust N Z J Obstet Gynaecol* 1997;**37**:86–8. PubMed PMID: 9075554.

40. **Simoes EA**, Babu PG, Jeyakumari HM, *et al.* The initial detection of human immunodeficiency virus 1 and its subsequent spread in prostitutes in Tamil Nadu, India. *J Acquir Immune Defic Syndr* 1993;**6**:1030–4.
41. **Cambodia Ministry of Health** 1998.
42. **Cambodia Ministry of Health** 1997.
43. **Cambodia Ministry of Health** 1999.
44. **Cambodia Ministry of Health** 2001.
45. **Cambodia Ministry of Health** 2003.
46. **Cambodia Ministry of Health** 2007.
47. **Kao JH**, Chen W, Chen PJ, *et al.* GB virus-C/hepatitis G virus infection in prostitutes: possible role of sexual transmission. *J Med Virol* 1997;**52**:381–4. PubMed PMID: 9260684.
48. **Majid N**, Bollen L, Morineau G, *et al.* Syphilis among female sex workers in Indonesia: need and opportunity for intervention. *Sex Transm Infect* 2010;**86**:377–83.
49. **Mishra S**, Moses S, Hanumaiah PK, *et al.* Sex work, Syphilis, and seeking treatment: an opportunity for intervention in HIV prevention programming in Karnataka, South India. *Sex Transm Dis* 2009;**36**:157–64.
50. **Nhurod P**, Bollen LJ, Smuttrapapoot P, *et al.* Access to HIV testing for sex workers in Bangkok, Thailand: a high prevalence of HIV among street-based sex workers. *Southeast Asian J Trop Med Public Health* 2010;**41**:153–62. PubMed PMID: 20578494.
51. **Reza-Paul S**, Beattie T, Syed HU, *et al.* Declines in risk behaviour and sexually transmitted infection prevalence following a community-led HIV preventive intervention among female sex workers in Mysore, India. *AIDS* 2008;**22**(Suppl 5): S91–100.
52. **Ruan Y**, Cao X, Qian HZ, *et al.* Syphilis among female sex workers in southwestern China: potential for HIV transmission. *Sex Transm Dis* 2006;**33**:719–23. PubMed PMID: 16708055.
53. **Rugpao S**, Pruthithada N, Yutaboot Y, *et al.* Condom breakage during commercial sex in Chiang Mai, Thailand. *Contraception* 1993;**48**:537–47. PubMed PMID: 8131395.
54. **Sawayama Y**, Hayashi J, Etoh Y, *et al.* Heterosexual transmission of GB virus C/hepatitis G virus infection to non-intravenous drug-using female prostitutes in Fukuoka, Japan. *Dig Dis Sci* 1999;**44**:1937–43.
55. **Silverman JG**, Decker MR, Gupta J, *et al.* HIV prevalence and predictors of infection in sex-trafficked Nepalese girls and women. *JAMA* 2007;**298**:536–42. PubMed PMID: 17666674.
56. **Sopheab H**, Gorbach PM, Gloyd S, *et al.* Rural sex work in Cambodia: work characteristics, risk behaviours, HIV, and syphilis. *Sex Transm Infect* 2003;**79**:e2. PubMed PMID: 12902610; PubMed Central PMCID: PMC1744694.
57. **Thuy NT**, Nhung VT, Thuc NV, *et al.* HIV infection and risk factors among female sex workers in southern Vietnam. *AIDS* 1998;**12**:425–32.
58. **Todd CS**, Nasir A, Stanekzai MR, *et al.* HIV, hepatitis B, and hepatitis C prevalence and associated risk behaviors among female sex workers in three Afghan cities. *AIDS* 2010;**24**(Suppl 2):S69–75. PubMed PMID: 20610952.
59. **Tran TN**, Detels R, Long HT, *et al.* HIV infection and risk characteristics among female sex workers in Hanoi, Vietnam. *J Acquir Immune Defic Syndr* 2005;**39**:581–6. PubMed PMID: 16044011; PubMed Central PMCID: PMC2908502.
60. **van den Hoek A**, Yuliang F, Dukers NH, *et al.* High prevalence of syphilis and other sexually transmitted diseases among sex workers in China: potential for fast spread of HIV. *AIDS* 2001;**15**:753–9. PubMed PMID: 11371690.
61. **Wang BO**, Xiaoming LI, Stanton B, *et al.* Vaginal douching, condom use, and sexually transmitted infections among chinese female sex workers. *Sex Transm Dis* 2005;**32**:696–702.
62. **Wong ML**, Chan RK, Koh D, *et al.* A prospective study on condom slippage and breakage among female brothel-based sex workers in Singapore. *Sex Transm Dis* 2000;**27**:208–14. PubMed PMID: 10782742.
63. **Tran TT**, Le CL, Nguyen TL. Factors associated with inconsistent condom use among female sex workers in Nha Trang, Vietnam. *Asia Pac J Public Health* 2008;**20**:370–8.
64. **Baars JE**, Boon BJ, Garretsen HF, *et al.* Vaccination uptake and awareness of a free hepatitis B vaccination program among female commercial sex workers. *Women's Health Issues* 2009;**19**:61–9. Epub 2008 Oct 25. PubMed PMID: 18951815.
65. **Vioque J**, Hernández-Aguado I, Fernández García E, *et al.* Prospective cohort study of female sex workers and the risk of HIV infection in Alicante, Spain (1986–96). *Sex Transm Infect* 1998;**74**:284–8.
66. **Ward H**, Day S, Mezzone J, *et al.* Prostitution and risk of HIV: female prostitutes in London. *BMJ* 1993;**307**:356–8. PubMed PMID: 8374417; PubMed Central PMCID: PMC1678221.
67. **Ward H**, Day S. What happens to women who sell sex? Report of a unique occupational cohort. *Sex Transm Infect* 2006;**82**:413–17. Epub 2006 Jun 21. PubMed PMID: 16790559; PubMed Central PMCID: PMC2563855.
68. **Pineda JA**, Rivero A, Rey C, *et al.* Association between hepatitis C virus seroreactivity and HIV infection in non-intravenous drug abusing prostitutes. *Eu J Clin Microbiol Infect Dis* 1995;**14**:460–4. doi: 10.1007/BF02114907
69. **Uusküla A**, Fischer K, Raudne R, *et al.* A study on HIV and hepatitis C virus among commercial sex workers in Tallinn. *Sex Transm Infect* 2008;**84**:189–91. Epub 2008 Feb 6. PubMed PMID: 18256109.
70. **McKeganey N**, Barnard M. Selling sex: female street prostitution and HIV risk behaviour in Glasgow. *AIDS Care* 1992;**4**:395–407. PubMed PMID: 1493147.
71. **Papaevangelou G**, Roumeliotou A, Kallinikos G, *et al.* Education in preventing HIV infection in greek registered prostitutes. *J Acquir Immune Defic Syndr* 1988;**1**:386–9.
72. **Pineda JA**, Aguado I, Rivero A, *et al.* HIV-1 infection among non-intravenous drug user female prostitutes in Spain. No evidence of evolution to Pattern II. *AIDS* 1992;**6**:1365–9.
73. **Loza O**, Patterson TL, Rusch M, *et al.* Proyecto Mujer Segura. Drug-related behaviors independently associated with syphilis infection among female sex workers in two Mexico-US border cities. *Addiction* 2010;**105**:1448–56. Epub 2010 Apr 27. PubMed PMID: 20456292.
74. **Bucardo J**, Semple SJ, Fraga-Vallejo M, *et al.* A qualitative exploration of female sex work. Tijuana, Mexico. *Arch Sex Behav* 2004;**33**:343–51.
75. **Szwarcwald CL**. Taxas de prevalência de HIV e sífilis e conhecimento, atitudes e práticas de risco relacionadas às infecções sexualmente transmissíveis no grupo das mulheres profissionais do sexo, no Brasil. Study funded by the STD, Aids and Viral Hepatitis Department.
76. **Hyams KC**, Phillips IA, Tejada A, *et al.* Three-year incidence study of retroviral and viral hepatitis transmission in a peruvian prostitute population. *J Acquir Immune Defic Syndr* 1993;**6**:1353–7.
77. **Sánchez J**, Gotuzzo E, Escamilla J, *et al.* Sexually transmitted infections in female sex workers: reduced by condom use but not by a limited periodic examination program. *Sex Transm Dis* 1998;**25**:82–9.
78. **Wignall FS**, Hyams KC, Phillips IA, *et al.* Sexual transmission of human T-lymphotropic virus type I in Peruvian prostitutes. *J Med Virol* 1992;**38**:44–8.
79. **Lowndes CM**, Alary M, Platt L. Injection drug use, commercial sex work, and the HIV/STI epidemic in the Russian Federation. *Sex Transm Dis* 2003;**30**:46–8.
80. **Seidlin M**, Krasinski K, Bebenroth D, *et al.* Prevalence of HIV infection in New York call girls. *J Acquir Immune Defic Syndr* 1988;**1**:150–4. PubMed PMID: 3216302.
81. **Potterat JJ**, Woodhouse DE, Muth JB, *et al.* Estimating the prevalence and career longevity of prostitute women. *J Sex Res* 1990;**27**:233–43.
82. **Casabona J**, Sánchez E, Salinas R, *et al.* Seroprevalence and risk factors for HIV transmission among female prostitutes: a community survey. *Eur J Epidemiol* 1990;**6**:248–52.
83. **Goldenberg SM**, Gallardo Cruz M, Strathee SA, *et al.* Correlates of unprotected sex with female sex workers among male clients in Tijuana, Mexico. *Sex Transm Dis* 2010;**37**:319–24. PubMed PMID: 20081558; PubMed Central PMCID: PMC2861913.
84. **Patterson TL**, Goldenberg S, Gallardo M, *et al.* Correlates of HIV, sexually transmitted infections, and associated high-risk behaviors among male clients of female sex workers in Tijuana, Mexico. *AIDS* 2009;**23**:1765–71. PubMed PMID: 19584699; PubMed Central PMCID: PMC2804438.
85. **Couture MC**, Soto JC, Akom E, *et al.* Clients of female sex workers in Gonaives and St-Marc, Haiti characteristics, sexually transmitted infection prevalence and risk factors. *Sex Transm Dis* 2008;**35**:849–55. PubMed PMID: 18580821.
86. **Jin X**, Smith K, Chen RY, *et al.* HIV prevalence and risk behaviors among male clients of female sex workers in Yunnan, China. *J Acquir Immune Defic Syndr* 2010;**53**:131–5. PubMed PMID: 19730110; PubMed Central PMCID: PMC2799544.
87. **Subramanian T**, Gupta MD, Paranjape RS, *et al.* HIV, sexually transmitted infections and sexual behaviour of male clients of female sex workers in Andhra Pradesh, Tamil Nadu and Maharashtra, India: results of a cross-sectional survey. *AIDS* 2008;**22**(Suppl 5):S69–79. PubMed PMID: 19098481.
88. **Xantidis L**, McCabe MP. Personality characteristics of male clients of female commercial sex workers in Australia. *Arch Sex Behav* 2000;**29**:165–76. PubMed PMID: 10842724.
89. **Lowndes CM**, Alary M, Gnintoungbé CA, *et al.* Management of sexually transmitted diseases and HIV prevention in men at high risk: targeting clients and non-paying sexual partners of female sex workers in Benin. *AIDS* 2000;**14**:2523–34. PubMed PMID: 11101064.
90. **Voeten HA**, Egesah OB, Ondiege MY, *et al.* Clients of female sex workers in Nyanza province, Kenya: a core group in STD/HIV transmission. *Sex Transm Dis* 2002;**29**:444–52. PubMed PMID: 12172528.
91. **McCurdy SA**, Ross MW, Williams ML, *et al.* Flashblood: blood sharing among female injecting drug users in Tanzania. *Addiction* 2010;**105**:1062–70. Epub 2010 Mar 12.
92. **Mahanta J**, Medhi GK, Paranjape RS, *et al.* Injecting and sexual risk behaviours, sexually transmitted infections and HIV prevalence in injecting drug users in three states in India. *AIDS* 2008;**22**(Suppl 5):S59–68.
93. **Ross M**, McCurdy S, Kilongo G, *et al.* Drug use careers and blood-borne pathogen risk behavior in male and female Tanzanian heroin injectors. *Am J Trop Med Hyg* 2008;**79**:338–43.
94. **Wright NH**, Vanichseni S, Akarasevi P, *et al.* Was the 1988 HIV epidemic among Bangkok's injecting drug users a common source outbreak? *AIDS* 1994;**8**:529–32.

95. **Buavirat A**, Page-Shafer K, van Griensven GJ, *et al.* Risk of prevalent HIV infection associated with incarceration among injecting drug users in Bangkok, Thailand: case-control study. *BMJ* 2003;**326**:308.
96. **Go VF**, Frangakis C, Nam LV, *et al.* Characteristics of high-risk HIV-positive IDUs in Vietnam: implications for future interventions. *Subst Use Misuse* 2011;**46**:381–9.
97. **Kermode M**, Singh LB, Raju RK, *et al.* Injections for health-related reasons amongst injecting drug users in New Delhi and Imphal, India. *Public Health* 2006;**120**:634–40. Epub 2006 Jun 5.
98. **Lee KC**, Lim WW, Lee SS. High prevalence of HCV in a cohort of injectors on methadone substitution treatment. *J Clin Virol* 2008;**41**:297–300. Epub 2008 Jan 10.
99. **Azim T**, Chowdhury EI, Reza M, *et al.* Prevalence of infections, HIV risk behaviors and factors associated with HIV infection among male injecting drug users attending a needle/syringe exchange program in Dhaka, Bangladesh. *Subst Use Misuse* 2008;**43**:2124–44.
100. **Bautista CT**, Todd CS, Abed AM, *et al.* Effects of duration of injection drug use and age at first injection on HCV among IDU in Kabul, Afghanistan. *J Public Health (Oxf)* 2010;**32**:336–41. Epub 2010 Apr 26.
101. **Beyrer C**, Patel Z, Stachowiak JA, *et al.* Characterization of the emerging HIV type 1 and HCV epidemics among injecting drug users in Dushanbe, Tajikistan. *AIDS Res Hum Retroviruses* 2009;**25**:853–60.
102. **Niccolai LM**, Verevchkin SV, Tousseva OV, *et al.* Estimates of HIV incidence among drug users in St. Petersburg, Russia: continued growth of a rapidly expanding epidemic. *Eur J Public Health* 2011;**21**:613–9.
103. **Quan VM**, Go VF, Nam le V, *et al.* Risks for HIV, HBV, and HCV infections among male injection drug users in northern Vietnam: a case-control study. *AIDS Care* 2009;**21**:7–16.
104. **Todd CS**, Abed AM, Scott PT, *et al.* Correlates of receptive and distributive needle sharing among injection drug users in Kabul, Afghanistan. *Am J Drug Alcohol Abuse* 2008;**34**:91–100.
105. **Altat A**, Shah SA, Zaidi NA, *et al.* High risk behaviors of injection drug users registered with harm reduction programme in Karachi, Pakistan. *Harm Reduct J* 2007;**4**:7.
106. **Azim T**, Chowdhury EI, Reza M, *et al.* Vulnerability to HIV infection among sex worker and non-sex worker female injecting drug users in Dhaka, Bangladesh: evidence from the baseline survey of a cohort study. *Harm Reduct J* 2006;**3**:33.
107. **Zhao M**, Du J, Lu GH, *et al.* HIV sexual risk behaviors among injection drug users in Shanghai. *Drug Alcohol Depend* 2006;**82**(Suppl 1):S43–7.
108. **Stoové MA**, Dietze PM, Aitken CK, *et al.* Mortality among injecting drug users in Melbourne: a 16-year follow-up of the Victorian Injecting Cohort Study (VICS). *Drug Alcohol Depend* 2008;**96**:281–5. Epub 2008 Apr 22.
109. **Maher L**, Li J, Jalaludin B, *et al.* High hepatitis C incidence in new injecting drug users: a policy failure? *Aust N Z J Public Health* 2007;**31**:30–5.
110. **Darke S**, Kelly E, Ross J. Drug driving among injecting drug users in Sydney, Australia: prevalence, risk factors and risk perceptions. *Addiction* 2004;**99**:175–85.
111. **Day C**, Conroy E, Lowe J, *et al.* Patterns of drug use and associated harms among rural injecting drug users: comparisons with metropolitan injecting drug users. *Aust J Rural Health* 2006;**14**:120–5.
112. **Iversen J**, Wand H, Gonnermann A, *et al.* Gender differences in hepatitis C antibody prevalence and risk behaviours amongst people who inject drugs in Australia 1998–2008. *Int J Drug Policy* 2010;**21**:471–6.
113. **Lenton S**, Kerry K, Loxley W, *et al.* Citizens who inject drugs: the 'Fitpack' study. *Int J Drug Policy* 2000;**11**:285–97.
114. **White JM**, Dyer KR, Ali RL, *et al.* Injecting behaviour and risky needle use amongst methadone maintenance clients. *Drug Alcohol Depend* 1994;**34**:113–19.
115. **Miller ER**, Hellard ME, Bowden S, *et al.* Markers and risk factors for HCV, HBV and HIV in a network of injecting drug users in Melbourne, Australia. *J Infect* 2009;**58**:375–82. Epub 2009 Mar 27.
116. **Bryant J**, Treloar C. Initiators: an examination of young injecting drug users who initiate others to injecting. *AIDS Behav* 2008;**12**:885–90. Epub 2007 Dec 21.
117. **Hellard ME**, Nguyen OK, Guy RJ, *et al.* The prevalence and risk behaviours associated with the transmission of blood-borne viruses among ethnic-Vietnamese injecting drug users. *Aust N Z J Public Health* 2006;**30**:519–25.
118. **Cao W**, Treloar C. Comparison of needle and syringe programme attendees and non-attendees from a high drug-using area in Sydney, New South Wales. *Drug Alcohol Rev* 2006;**25**:439–44.
119. **Roxburgh A**, Degenhardt L, Breen C. Drug use and risk behaviours among injecting drug users: a comparison between sex workers and non-sex workers in Sydney, Australia. *Harm Reduct J* 2005;**2**:7.
120. **Copeland L**, Budd J, Robertson JR, *et al.* Changing patterns in causes of death in a cohort of injecting drug users, 1980–2001. *Arch Intern Med* 2004;**164**:1214–20.
121. **Smyth BP**, Keenan E, O'Connor JJ. Evaluation of the impact of Dublin's expanded harm reduction programme on prevalence of hepatitis C among short-term injecting drug users. *J Epidemiol Community Health* 1999;**53**:434–5.
122. **Karapetyan AF**, Sokolovsky YV, Araviyskaya ER, *et al.* Syphilis among intravenous drug-using population: epidemiological situation in St. Petersburg, Russia. *Int J STD AIDS* 2002;**13**:618–23.
123. **Stormer A**, Tun W, Guli L, *et al.* An analysis of respondent driven sampling with Injection Drug Users (IDU) in Albania and the Russian Federation. *J Urban Health* 2006;**83**(6 Suppl):i73–82.
124. **De los Cobos Calleja T**, Casanueva Gutiérrez M, Jove González C. Perfil de los usuarios de drogas ingresados en un hospital. *An Med Interna (Madrid)* 2003;**20**:504–9.
125. **Cassin S**, Geoghegan T, Cox G. Young injectors: a comparative analysis of risk behaviour. *Ir J Med Sci* 1998;**167**:234–7.
126. **Dolan KA**, Donoghoe MC, Stimson GV. Reductions in HIV risk behaviour and stable HIV prevalence in syringe-exchange clients and other injectors in England. *Drug Alcohol Rev* 1993;**12**:133–42.
127. **Lidman C**, Norden L, Käberg M, *et al.* Hepatitis C infection among injection drug users in Stockholm Sweden: prevalence and gender. *Scand J Infect Dis* 2009;**41**:679–84.
128. **Muga R**, Roca J, Egea JM, *et al.* Mortality of HIV-positive and HIV-negative heroin abusers as a function of duration of injecting drug use. *J Acquir Immune Defic Syndr* 2000;**23**:332–8.
129. **Rhodes T**, Donoghoe M, Hunter G, *et al.* Sexual behaviour of drug injectors in London: implications for HIV transmission and HIV prevention. *Addiction* 1994;**89**:1085–96.
130. **Steffen T**, Blättler R, Gutzwiller F, *et al.* HIV and hepatitis virus infections among injecting drug users in a medically controlled heroin prescription programme. *Eur J Public Health* 2001;**11**:425–30.
131. **Gyarmathy VA**, Neaigus A, Li N, *et al.* Infection disclosure in the injecting dyads of Hungarian and Lithuanian injecting drug users who self-reported being infected with hepatitis C virus or human immunodeficiency virus. *Scand J Infect Dis* 2011;**43**:32–42.
132. **Kolaric B**, Stajduhar D, Gajnik D, *et al.* Seroprevalence of blood-borne infections and population sizes estimates in a population of injecting drug users in Croatia. *Cent Eur J Public Health* 2010;**18**:104–9.
133. **Vlahov D**, Safaie M, Lai S, *et al.* Sexual and drug risk-related behaviours after initiating highly active antiretroviral therapy among injection drug users. *AIDS* 2007;**15**:2311–16.
134. **Hickman M**, Hope V, Brady T, *et al.* Hepatitis C virus (HCV) prevalence, and injecting risk behaviour in multiple sites in England in 2004. *J Viral Hepat* 2007;**14**:645–52.
135. **Folch C**, Meroño M, Casabona J. Factors associated with sharing syringes among street-recruited injecting drug users. *Med Clin (Barc)* 2006;**127**:526–32.
136. **Booth RE**, Kwiatkowski CF, Brewster JT, *et al.* Predictors of HIV sero-status among drug injectors at three Ukraine sites. *AIDS* 2006;**20**:2217–23.
137. **Muga R**, Sanvisens A, Bolao F, *et al.* Significant reductions of HIV prevalence but not of hepatitis C virus infections in injection drug users from metropolitan Barcelona: 1987–2001. *Drug Alcohol Depend* 2006;**82**(Suppl 1):S29–33.
138. **Backmund M**, Meyer K, Schuetz C, *et al.* Factors associated with exposure to hepatitis B virus in injection drug users. *Drug Alcohol Depend* 2006;**84**:154–9. Epub 2006 Feb 14.
139. **Platt L**, Rhodes T, Lowndes CM, *et al.* Impact of gender and sex work on sexual and injecting risk behaviors and their association with HIV positivity among injecting drug users in an HIV epidemic in Togliatti City, Russian Federation. *Sex Transm Dis* 2005;**32**:605–12.
140. **Gyarmathy VA**, Neaigus A. Marginalized and socially integrated groups of IDUs in Hungary: potential bridges of HIV infection. *J Urban Health* 2005;**82**(3 Suppl 4):iv101–12.
141. **Maliphant J**, Scott J. Use of the femoral vein ('groin injecting') by a sample of needle exchange clients in Bristol, UK. *Harm Reduct J* 2005;**2**:6.
142. **Kivelä P**, Krol A, Simola S, *et al.* HIV outbreak among injecting drug users in the Helsinki region: social and geographical pockets. *Eur J Public Health* 2007;**17**:381–6. Epub 2006 Nov 27.
143. **de Azevedo RC**, Botega NJ, Guimarães LA. Crack users, sexual behavior and risk of HIV infection. *Rev Bras Psiquiatr* 2007;**29**:26–30.
144. **Marchesini AM**, Prá-Baldi ZP, Mesquita F, *et al.* Hepatitis B and C among injecting drug users living with HIV in São Paulo, Brazil. *Rev Saude Publica* 2007;**41**(Suppl 2):57–63.
145. **Dourado I**, Andrade T, Carpenter C, *et al.* Risk factors for human T cell lymphotropic virus Type I among injecting drug users in northeast Brazil: possibly greater efficiency of male to female transmission. *Mem Inst Oswaldo Cruz, Rio de Janeiro* 1999;**94**:13–8.
146. **Lima ES**, Friedman SR, Bastos FI, *et al.* Risk factors for HIV-1 seroprevalence among drug injectors in the cocaine-using environment of Rio de Janeiro. *Addiction* 1994;**89**:689–98.
147. **Oliveira Mde L**, Bastos FI, Telles PR, *et al.* Epidemiological and genetic analyses of Hepatitis C virus transmission among young/short- and long-term injecting drug users from Rio de Janeiro, Brazil. *J Clin Virol* 2009;**44**:200–6. Epub 2009 Feb 4.
148. **Caiaffa WT**, Bastos FI, Freitas LL, *et al.* Projeto AJUDE-Brasil I; Projeto AJUDE-Brasil II. The contribution of two Brazilian multi-center studies to the assessment of HIV and HCV infection and prevention strategies among injecting drug users: the AJUDE-Brasil I and II Projects. *Cad Saude Publica* 2006;**22**:771–82. Epub 2006 Apr 5.

149. **Huo D**, Bailey SL, Ouellet LJ. Cessation of injection drug use and change in injection frequency: the Chicago needle exchange evaluation study. *Addiction* 2006;**101**:1606–13.
150. **Hahn JA**, Page-Shafer K, Lum PJ, *et al.* Hepatitis C virus infection and needle exchange use among young injection drug users in San Francisco. *Hepatology* 2001;**34**:180–7.
151. **Miller CL**, Johnston C, Spittal PM, *et al.* Opportunities for prevention: hepatitis C prevalence and incidence in a cohort of young injection drug users. *Hepatology* 2002;**36**:737–42.
152. **Neaigus A**, Friedman SR, Jose B, *et al.* High-risk personal networks and syringe sharing as risk factors for HIV infection among new drug injectors. *J Acquir Immune Defic Syndr Hum Retrovirol* 1996;**11**:499–509.
153. **Roy E**, Boudreau JF, Boivin JF. Hepatitis C virus incidence among young street-involved IDUs in relation to injection experience. *Drug Alcohol Depend* 2009;**102**:158–61. Epub 2009 Feb 28.
154. **Chitwood DD**, Comerford M, Kitner KR, *et al.* A comparison of HIV risk behaviors between new and long-term injection drug users. *Subst Use Misuse* 2001;**36**:91–111.
155. **Corsi KF**, Lehman WK, Booth RE. The effect of methadone maintenance on positive outcomes for opiate injection drug users. *J Subst Abuse Treat* 2009;**37**:120–6. Epub 2009 Jan 15.
156. **Debeck K**, Kerr T, Bird L, *et al.* Injection drug use cessation and use of North America's first medically supervised safer injecting facility. *Drug Alcohol Depend* 2011;**113**:172–6.
157. **Doherty MC**, Garfein RS, Monterroso E, *et al.* Correlates of HIV infection among young adult short-term injection drug users. *AIDS* 2000;**14**:717–26.
158. **Garfein RS**, Doherty MC, Monterroso ER, *et al.* Prevalence and incidence of hepatitis C virus infection among young adult injection drug users. *J Acquir Immune Defic Syndr Hum Retrovirol* 1998;**18**(Suppl 1):S11–19.
159. **Mehta SH**, Galai N, Astemborski J, *et al.* HIV incidence among injection drug users in Baltimore, Maryland (1988–2004). *J Acquir Immune Defic Syndr* 2006;**43**:368–72.
160. **Pouget ER**, Deren S, Fuller CM, *et al.* Receptive syringe sharing among injection drug users in Harlem and the Bronx during the New York State Expanded Syringe Access Demonstration Program. *J Acquir Immune Defic Syndr* 2005;**39**:471–7.
161. **Schütz CG**, Rapioti E, Vlahov D, *et al.* Suspected determinants of enrollment into detoxification and methadone maintenance treatment among injecting drug users.
162. **Steensma C**, Boivin JF, Blais L, *et al.* Cessation of injecting drug use among street-based youth. *J Urban Health* 2005;**82**:622–37. Epub 2005 Sep 29.
163. **Wood E**, Stoltz JA, Zhang R, *et al.* Circumstances of first crystal methamphetamine use and initiation of injection drug use among high-risk youth. *Drug Alcohol Rev* 2008;**27**:270–6.
164. **Evans JL**, Hahn JA, Lum PJ, *et al.* Predictors of injection drug use cessation and relapse in a prospective cohort of young injection drug users in San Francisco, CA (UFO Study). *Drug Alcohol Depend* 2009;**101**:152–7. Epub 2009 Jan 31. *Drug Alcohol Depend* 2009;**101**:152–7. Epub 2009 Jan 31.
165. **Lum PJ**, Hahn JA, Shafer KP, *et al.* Hepatitis B virus infection and immunization status in a new generation of injection drug users in San Francisco. *J Viral Hepat* 2008;**15**:229–36.
166. **Shaw SY**, Shah L, Jolly AM, *et al.* Determinants of injection drug user (IDU) syringe sharing: the relationship between availability of syringes and risk network member characteristics in Winnipeg, Canada. *Addiction* 2007;**102**:1626–35.
167. **Neaigus A**, Gyarmathy VA, Miller M, *et al.* Injecting and sexual risk correlates of HBV and HCV seroprevalence among new drug injectors. *Drug Alcohol Depend* 2007;**89**:234–43. Epub 2007 Feb 7.
168. **Hagan H**, Campbell J, Thiede H, *et al.* Self-reported hepatitis C virus antibody status and risk behavior in young injectors. *Public Health Rep* 2006;**121**:710–19.
169. **Miller CL**, Kerr T, Strathdee SA, *et al.* Factors associated with premature mortality among young injection drug users in Vancouver. *Harm Reduct J* 2007;**4**:1.
170. **Wylie JL**, Shah L, Jolly AM. Demographic, risk behaviour and personal network variables associated with prevalent hepatitis C, hepatitis B, and HIV infection in injection drug users in Winnipeg, Canada. *BMC Public Health* 2006;**6**:229.
171. **Miller CL**, Strathdee SA, Spittal PM, *et al.* Elevated rates of HIV infection among young Aboriginal injection drug users in a Canadian setting. *Harm Reduct J* 2006;**3**:9.
172. **Lum PJ**, Sears C, Guydish J. Injection risk behavior among women syringe exchangers in San Francisco. *Subst Use Misuse* 2005;**40**:1681–96.
173. **Pugatch D**, Anderson BJ, O'Connell JV, *et al.* HIV and HCV testing for young drug users in Rhode Island. *J Adolesc Health* 2006;**38**:302–4.
174. **Hart TA**, James CA, Hagan CM, *et al.* HIV optimism and high-risk sexual behavior in two cohorts of men who have sex with men. *J Assoc Nurses AIDS Care* 2010;**21**:439–43. Epub 2010 Jul 24. PubMed PMID: 20656521.
175. **Golub SA**, Kowalczyk W, Weinberger CL, *et al.* Preexposure prophylaxis and predicted condom use among high-risk men who have sex with men. *J Acquir Immune Defic Syndr* 2010;**54**:548–55. PubMed PMID: 20512046; PubMed Central PMCID: PMC2908204.
176. **Carey JW**, Mejia R, Bingham T, *et al.* Drug use, high-risk sex behaviors, and increased risk for recent HIV infection among men who have sex with men in Chicago and Los Angeles. *AIDS Behav* 2009;**13**:1084–96. Epub 2008 May 23. PubMed PMID: 18498049.
177. **Dodds JP**, Johnson AM, Parry JV, *et al.* A tale of three cities: persisting high HIV prevalence, risk behaviour and undiagnosed infection in community samples of men who have sex with men. *Sex Transm Infect* 2007;**83**:392–6. Epub 2007 May 1. Erratum in: *Sex Transm Infect* 2007;**83**:500. PubMed PMID: 17472978; PubMed Central PMCID: PMC2659037.
178. **Danta M**, Brown D, Bhagani S, *et al.* HIV and Acute HCV (HAAC) group. Recent epidemic of acute hepatitis C virus in HIV-positive men who have sex with men linked to high-risk sexual behaviours. *AIDS* 2007;**21**:983–91. PubMed PMID: 17457092.
179. **Koblin BA**, Chesney MA, Husnik MJ, *et al.* EXPLORE Study Team. High-risk behaviors among men who have sex with men in 6 US cities: baseline data from the EXPLORE Study. *Am J Public Health* 2003;**93**:926–32. Erratum in: *Am J Public Health* 2003;**93**:1203. PubMed PMID: 12773357; PubMed Central PMCID: PMC1447872.
180. **Thomas SM**, Tse DB, Ketner DS, *et al.* CCR5 expression and duration of high risk sexual activity among HIV-seronegative men who have sex with men. *AIDS* 2006;**20**:1879–83. PubMed PMID: 16954729; PubMed Central PMCID: PMC1630600.
181. **Mansergh G**, Flores S, Koblin B, *et al.* Project MIX Study Group. Alcohol and drug use in the context of anal sex and other factors associated with sexually transmitted infections: results from a multi-city study of high-risk men who have sex with men in the USA. *Sex Transm Infect* 2008;**84**:509–11. PubMed PMID: 19028957.