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Keywords
Acquired immunodeficiency syndrome, epidemiology#. Hepatitis, epidemiology#. HIV seroprevalence#. Prisoners#. Substance-related disorders. Risk factors. Seroepidemiologic studies. – Drug usage. Male prisioners.

Abstract

Objective
It is an accepted fact that confinement conditions increase the risk of some infections related to sexual and/or injecting drugs practices. Mathematical techniques were applied to estimate time-dependent incidence densities of HIV infection among inmates.
Methods
A total of 631 prisoners from a Brazilian prison with 4,900 inmates at that time were interviewed and their blood drawn. Risky behavior for HIV infection was analyzed, and serological tests for HIV, hepatitis C and syphilis were performed, intended as surrogates for parenteral and sexual HIV transmission, respectively. Mathematical techniques were used to estimate the incidence density ratio, as related to the time of imprisonment.
Results
Prevalence were: HIV – 16%; HCV – 34%; and syphilis – 18%. The main risk behaviors related to HIV infection were HCV prevalence (OR=10.49) and the acknowledged use of injecting drugs (OR=3.36). Incidence density ratio derivation showed that the risk of acquiring HIV infection increases with the time of imprisonment, peaking around three years after incarceration.
Conclusions
The correlation between HIV and HCV seroprevalence and the results of the mathematical analysis suggest that HIV transmission in this population is predominantly due to parenteral exposure by injecting drug, and that it increases with time of imprisonment.

Descritores
Síndrome de imunodeficiência adquirida, epidemiologia#. Hepatite, epidemiologia#. Soroprevalência de HIV#. Prisioneiros#. Transtornos relacionados ao uso de substâncias psicoativas. Fatores de risco. Estudos soroepidemiológicos. – Uso de drogas. Prisioneiros masculinos.

Resumo

Objetivo
É um fato correntemente aceito que as condições de confinamento aumentam o risco de algumas infecções relacionadas às práticas sexuais e/ou ao uso de drogas injetáveis. Realizou-se estudo para estimar a densidade de incidência da infecção pelo HIV na população prisional com aplicação de técnicas matemáticas.

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Métodos
Foram entrevistados em São Paulo, SP, 631 prisioneiros da maior prisão da América do Sul, que abrigava aproximadamente 4.900 presos na ocasião do estudo. Foi colhido sangue da população entrevistada, analisado o risco para a infecção pelo HIV e realizados testes sorológicos para HIV, HCV e sífilis. Técnicas matemáticas foram usadas para se estimar a densidade de incidência do HIV relacionada ao tempo de encarceramento.
Resultados
As prevalências gerais encontradas foram: HIV – 16%; HCV – 34%; sífilis – 18%. Os principais fatores associados à infecção pelo HIV foram a soropositividade ao HCV (OR=10,49) e a confissão do uso de drogas injetáveis (OR=3,36). A análise matemática mostrou que o risco de adquirir a infecção pelo HIV aumenta com o tempo de detenção, atingindo o máximo por volta de 3 anos de aprisionamento.
Conclusões
A correlação entre a soroprevalência do HIV e do HCV e os resultados da análise matemática sugerem que a transmissão do HIV nestsa população se dá preferencialmente pela via parenteral e que seu risco aumenta com o tempo de encarceramento.

INTRODUCTION

It is accepted that confinement conditions increase the risk of some infections related to sexual and/or injecting drug practices. In addition to confinement, other risk factors like marginal social status, drug addiction, low socioeconomic level and precarious health services contribute to the observed high prevalence of HIV, hepatitis, syphilis and tuberculosis, to name a few. This represents a potential public health problem in the sense that penal system acts as a concentrator of those infections and as a spreading focus for the population at large.[11,18,22]

Several works have reported high levels of HIV seroprevalence in prison institutions.[11,19,22] In Brazil, a study carried out in 1987 found an HIV seroprevalence of 12.5% among inmates.[15] Another survey demonstrated a seroprevalence of 14.9% in 1990 and 17.3% in 1991.[7] In a more recent study, there was an HIV seroprevalence of 15.6% in a sample of prisoners from São Paulo State.[11]In addition to the high prevalence of HIV among recent admitted individuals, it is well-known that in some prisons risk behavior for HIV infection can be very high.[14,16] A number of studies conducted in the United States and elsewhere have found that a substantial proportion of prisoners engage in high-risk sexual activity and/or intravenous drug use while in prison.[14,16,17] In a recent Scottish study[5] it was demonstrated that 27% of the inmates reported injecting drug usage any time in life. Of those, 59% admitted using it inside the prison, of which a quarter had their first experience with injecting drugs in prison.

Notwithstanding, one significant obstacle in planning control strategies against HIV spread is the lack of reliable markers of the route of HIV transmission. Most studies rely on interviews based on standard questionnaires,[14,17,21] which are limited tools for assessing patterns of transmission in the sense that a great number of individuals report both parenteral and sexual exposure practices. On the other hand, in particular situations, like imprisonment, it should be expected that individuals conceal, due to fear of legal consequences, the use of illicit drugs.

To circumvent such limitations, hepatitis C and syphilis seroprevalence were used in this study as surrogates[2,11,18] of parenteral and sexual transmission of HIV, respectively, besides the classical questionnaires of risky behavior.

There have been also some concern in the literature about the possibility and/or importance of the occurrence of HIV transmission inside prisons, but there are still few studies and the majority of them provides only indirect evidence of in-prison HIV transmission.[13,19] Mutter et al[13] carried out a seroprevalence survey in 87 inmates before 1977. They found a positivity of 21%, indicating a likely HIV transmission inside the penal system.

Mathematical techniques were applied to estimate time-dependent incidence densities of HIV infection among inmates. The analysis was based upon the results of a cross-sectional survey carried out in a sample of 631 prisoners of a major penitentiary institution of São Paulo, who were interviewed and their blood drawn for determining the seroprevalences of HIV, hepatitis C and syphilis.[11,18]

METHODS

A detailed description of the clinical and epidemiological findings of this study can be found in the paper by Massad et al.[11] Follows a brief description of the study for the sake of completeness only.

The target population

This work was carried out in one of the prisons of the largest penal institution of Latin America (10,000 prisoners), the so-called "Casa de Detenção" (Detention House, DH). Although this is supposed to be a transitory step for those individuals who are waiting for a final judicial decision, they stay in fact for several years in this institution.

The sampling method

The sample was selected by drawing the numbered individual prison files in intervals determined by a random number generator. In addition, there were included all inmates admitted to the institution during the two weeks period of the study. Participation in the study was voluntary and confidentiality was guaranteed. The sample size was determined based on an expected seroprevalence to HIV (P^+) of 15%, with specified relative precision (ε) of 20% and confidence level (α) of 95% according to:[8,11]

$$n = \frac{1.96^2 P^+}{(1 - P^+)\varepsilon^2}$$

which, after correction for a finite population and assuming 20% of refusal, resulted in 670 individuals. Thirty-seven individuals refused to participate in the study, so only 631 inmates were available for analysis.

The fieldwork

The inmates were interviewed, clinically examined and their blood drawn for serological examination. The fieldwork took place from December 1993 to April 1994. The interview consisted of answering a standard questionnaire including specific questions relative to their imprisonment history and HIV-related risk behavior, besides clinical aspects related to HIV/AIDS infection.[11] The interviews were conducted by physicians.

Laboratory tests

Serological examinations for HIV and hepatitis C were performed by standard ELISA techniques with commercial kits from Embrabio® and Abbot Diagnostics Division® (second generation kit), respectively. Syphilis was screened by standard TPHA technique with the Bio-Mérieux® commercial kit. Those tests with a positive ELISA reaction to HIV were confirmed by Western Blot technique, using commercial kit by Diagnostic Pasteur®.

Data analysis

The association between risk behavior and HIV infection was evaluated by multivariate analysis using logistic regression, and its details are described elsewhere.[11] The fitting of the prevalence curves of the infections studied in the period of time since admission at DH, *t*, was performed by the least-square method, applying the software Tablecurve,[6] resulting in third order logistics (hepatitis C and HIV) and straight line (syphilis).

To estimate the occurrence of HIV transmission inside the prison, HIV incidence was calculated from prevalence data. This is done by applying the so-called catalytic approach as described below. First, however, the observed prevalence of HIV has to be corrected by taking into account the prevalence at entry at different times of imprisonment and the AIDS-specific mortality in the last 15 years.

The prevalence at admission, *Pentry*, for the inmates who had been imprisoned 13, 6, 4 and 2 years before the study,[7,15] and that estimated in our study[11] were fitted to a continuous function. Expected prevalence of HIV as related to the time of imprisonment were also corrected by the estimated number of deaths due to HIV, αHIV, during the same period of time. The latter was based on records from the DH's health service. The correction consisted in the following:

$$p_{adjusted}(t) = p_{observed}(t) + \alpha HIV(t) - p_{entry}(t)$$

The catalytic approach[9,12] was applied to estimate the time-dependent force of infection (λ) for HIV among the inmates, according to the formula:

$$\lambda = \frac{\frac{dP^+(t)}{dt}}{1 - P^+(t)}$$

where $P^+(t)$ is the continuous function representing the adjusted prevalence of the infection considered. The force of infection corresponds to the incidence density ratio of the disease, and represents the *per capita* rate of acquisition of new infection. In this sense it reflects the time-dependent risk of getting the infection.

RESULTS

Between the months of December 1993 and April 1994, 631 inmates were interviewed, clinically examined and their blood drawn for serological examination. Their average age was 30.8 years (median 29 years), and 35% of them had been incarcerated for at

least 2 years before admission at DH. The average time of imprisonment in DH was 2.8 years. Overall prevalence found were as follows: HIV – 16% (95% CI: 13-19%); HCV – 34% (95% CI: 30-38%); syphilis – 18% (95% CI: 15-21%). The undetermined reactions on Western-Blot and immunoblot were considered negative to HIV and HCV respectively, for the purposes of the risk analysis. Table resumes the results of the risk analysis to HIV infection. Its results are presented in detail elsewhere.[11]

Table – Risk analysis to HIV infection among inmates of Detention House.

Risk factor	OR (CI-95%) (bivariate analysis)	Adjusted OR (CI-95%) (multivariate analysis)
Injecting drug use	8.2(5.0-13.3)	3.36(1.82-6.21)
Homo/bisexual behaviour	2.7(1.5-4.8)	2.41(1.07-5.43)
Heterosexual risk behaviour	1.6(1.01-2.5)	1.64(0.93-2.92)
Anti-HCV positivity	15.4(8.5-27.9)	10.49(5.06-21.72)
TPHA positivity	1.3(0.8-2.4)	1.57(0.79-3.12)

The first three variables presented in Table were assessed through a standardized questionnaire and represent the acknowledged behavior of the inmates. On the other hand, the last two variables were obtained by serological testing and therefore are less prone to uncertainties.

Figure 1 shows the fitting of the seroprevalences of HIV, HCV and syphilis among inmates, as related to their time of imprisonment. It is noteworthy the striking parallelism between the HIV and HCV curves.

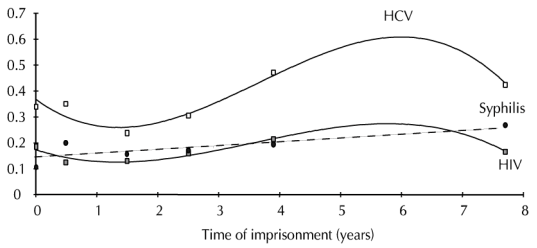

Figure 1- Fitting of the seroprevalences of HIV, HCV and Syphilis to real data, as related to the time (in years) since imprisonment.

It can be noted from Figure 1 that HIV and HCV seroprevalences are highly correlated (r=0.98). On the other hand, the correlation between HIV and syphilis seroprevalences is rather poor (r=0.25).

In Figure 2 it is shown the fitting of HIV seroprevalence to a continuous function, $P^{+}(t)$, as related to the time of imprisonment. It was simultaneously corrected by the expected prevalence at admission at DH in the last decade and by the estimated number of deaths due to HIV during the same period of time, as mentioned above. The resultant force of infection to HIV was then calculated according to equation (1) and is shown in Figure 3.

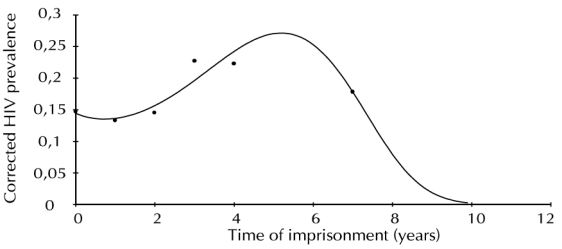

Figure 2 - Fitting of HIV seroprevalence to a continuous function, ***P(t)***, after simultaneously adjusting for the prevalence at entry and the expected number of deaths due to AIDS in the last decade.

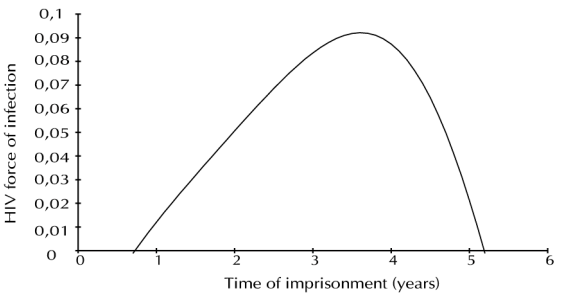

Figure 3 - Time-dependent HIV force of infection, ***λ(t)***, calculated according to equation 1 as applied to the corrected seroprevalence curve (Figure 5).

DISCUSSION

The prison population is markedly characterized by high-risk behavior for the acquisition of sexual transmitted disease (STD) and blood borne infection. Those risky habits are present before and most probably continue after imprisonment. Therefore, suitable techniques for the detection of transmission inside prison are necessary. In this sense, mathematical methods applied to cross-sectional serological surveys to estimate incidence rate have already demonstrated to be a good alternative to cohort studies.[1,9]

Another crucial issue is to determine the main route of HIV transmission in populations exposed to both sexual and parenteral risks. This is particularly true for confined populations for which control strategies can be applied and should be optimized. The use of serological markers of infections acknowledgeable parenterally or sexually transmitted as surrogates for determining the actual route of HIV transmission seems to be a reasonable choice. Hepatitis C and syphilis seroprevalence were chosen as markers for parenteral and sexual transmission of HIV, respectively. This

choice is based on the assumption that those infections are mostly transmitted by one predominant route, making the alternative route negligible for population screening purposes. This assumption, although not indisputable, has sufficient support in the literature.[3,20] In addition, it was already tested the suitability of such markers as surrogates of the HIV route of transmission.[2,11,22]

As pointed before, the use of mathematical techniques to estimate incidence rates from cross-sectional prevalence data has already proved to be reliable enough for epidemiological purposes.[1,9] They can also be used to provide good estimations of the intensity of HIV transmission based upon information collected through risk behavior questionnaires.[10]

The use of such techniques raised the suspicion of active HIV transmission inside the prison. As shown in Figure 3, the incidence rate of HIV (measured as the average number of HIV seroconversion per susceptible individual per year) increases with time of imprisonment, reaching its maximum around 3 years. This finding reflects the growth in time of HIV seroprevalence, after correction by the expected prevalence at entry to DH in previous years. Time-dependent seroprevalence curve was also corrected by the expected mortality due to AIDS in recent years. The latter was necessary because otherwise HIV prevalence of the inmates would be underestimated with more than 5 years of imprisonment. Recently, there was an opportunity to check the accuracy of these estimates since a parallel sample (surveyed one month before the present study) of the same prison have been tested for HIV by a less-sensitive ELISA, which allows the estimation of the prevalence of recent seroconversions.[4] The findings of such study also pointed to an incidence of HIV inside DH peaking around 3.5 years after imprisonment.

Finally, some limitations of this study should be mentioned, such as the assumptions related to the corrections for deaths and prevalence at admission. However, the present results are encouraging in reinforcing cross-sectional seroprevalence surveys as a means to determine incidence rates. Moreover, by applying such techniques it was able to demonstrate the importance of active HIV transmission inside the prison studied, and that intravenous drug use is the likely route of transmission in this penal institution.

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