

Original article

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Analysis of risk factors affecting the HIV epidemic process in the penitentiary system

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Abstract

Introduction. For more than 10 years, the Tyumen Region has been reporting steadily high rates of HIV infection prevalence. Among the groups at risk for HIV infection, a special place is occupied by the group of incarcerated individuals. This group is mostly represented by drug users, men who have sex with men, commercial sex workers. Diseases acquired during imprisonment or exacerbated in a prison setting become a problem not only for released inmates, but also for communities outside the prison system. Epidemiologically, it is critically important to identify the prison-related factors contributing to HIV progression, considering their unequal significance among incarcerated individuals and civilian population.

The aim of the study is to identify and assess the risk factors affecting the HIV epidemic process in the high risk-group density areas.

Materials and methods. The study was performed using epidemiological study and stepwise logistic regression methods.

Results. Since 2008, the epidemiological situation in prison settings has become increasingly severe, being characterized by higher rates of detection of HIV cases and HIV prevalence among inmates. The situation has also been aggravated by high death rates among HIV-infected inmates. Our study found that the high risk of fatal outcomes in HIV-infected inmates was associated with multiple parameters: the male gender, parenteral (injection drug use) HIV transmission, existing comorbidities – viral hepatitis and thoracic diseases.

Keywords: HIV infection, epidemic process, penitentiary system, inmates, risk factors, fatal outcome

Ethics approval. The study was conducted with the informed consent of the patients. The research protocol was approved by the Ethics Committee of the Tyumen State Medical University (Protocol No. 88, 23 December, 2019).

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Научная статья

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Анализ факторов риска, определяющих проявление эпидемического процесса ВИЧ-инфекции в пенитенциарной системе

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Аннотация

Введение. В Тюменской области уже более 10 лет отмечается устойчиво высокий уровень поражённости ВИЧ-инфекцией. Особняком среди рискованных групп по заражению ВИЧ стоит группа заключённых под стражу лиц. В обозначенной группе максимально сосредоточены потребители наркотических веществ, мужчины, имеющие половой контакт с мужчинами, работники коммерческого секса. Болезни, приобретённые в период отбывания срока наказания либо усугубившиеся в условиях лишения свободы, становятся

проблемой не только освободившихся заключённых, но и сообщества за пределами пенитенциарной системы. С эпидемиологической точки зрения считается принципиально важным выявление в среде осуждённых лиц факторов, способствующих прогрессированию ВИЧ-инфекции с учётом их неравноценного значения среди заключённых и гражданского населения.

Цель исследования — выявление и оценка совокупности факторов риска, определяющей развитие эпидемического процесса ВИЧ-инфекции в зоне высокой концентрации групп риска.

Материалы и методы. Применены методы эпидемиологического исследования, метод логистической регрессии пошагового включения.

Результаты. Наиболее сложная эпидемиологическая ситуация в местах лишения свободы в части выявления случаев ВИЧ-инфекции и поражённости ВИЧ среди осуждённых обозначилась с 2008 г. При этом эпидемиологическую обстановку ухудшали и высокие показатели смертности ВИЧ-инфицированных. При проведении исследования нами установлено, что вероятность летального исхода у осуждённых, инфицированных ВИЧ, ассоциирована с совокупностью параметров: мужской пол, парентеральный (наркотический) путь заражения ВИЧ, наличие сопутствующего заболевания — вирусного гепатита и заболевания органов грудной клетки.

Ключевые слова: ВИЧ-инфекция, эпидемический процесс, пенитенциарная система, заключенные, факторы риска, летальный исход

Этическое утверждение. Исследование проводилось при добровольном информированном согласии пациентов. Протокол исследования одобрен Этическим комитетом Тюменского государственного медицинского университета (протокол № 88 от 23.12.2019).

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

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Introduction

The Russian penitentiary system is a unique system combining institutions and facilities performing penal sanctions, implementing criminal justice measures, administrative penalties, and having a preventive effect on offenders. People serving a sentence in prisons represent a group having a distinct system of relationships with different characteristics and qualities. Numerous literature sources and statistical data show that the penitentiary system poses a major epidemiological threat associated with spread of infectious diseases [1–5]. The prison population constitutes the only social group characterized by deviant behavior and a concentration of drug users, commercial sex workers, and men who have sex with men [6–12]. Most of the people taken into custody learn about their diagnosis in pre-trial detention centers or at penitentiary facilities [13–20]. Experts estimate that penal and correctional facilities continually hold over 23,000 people with active tuberculosis, over 60,000 HIV-infected individuals, over 6,000 individuals with HIV and tuberculosis coinfection [21–23]. In UN countries, the mortality rate in the prison population is 144 deaths per 100,000 people [24–26].

By the beginning of 2019, the penitentiary facilities in the Tyumen Region (TR) had reported 5,707 HIV infection cases, out of which 248 cases were recorded in 2018 (14.6% of all the HIV infection cases recorded in 2018). The cumulative percentage of the HIV-positive inmates was 24.4%.

The **aim of the study** was to identify and assess the risk factors affecting the HIV epidemic process among inmates.

Materials and methods

In our study, we used the statistical monitoring data from the Tyumen Center for AIDS Prevention and Control, the Inpatient Department of Healthcare Facility No. 72 of the Federal Penitentiary Service of Russia, and the Tyumen Regional Infectious Disease Clinic. The study included questionnaires as well as statistical, description, estimation, continuous observation, retrospective, stepwise logistic regression methods and ROC (receiver operating characteristic) analysis [27]. The computation of mean values of the time series included the computation of the mean error and Pearson's chi-squared test (χ^2) [28, 29].

The relationship between variables was measured with Pearson's correlation coefficient (r_{xy}). The strength of relationship of the coefficients was measured using the Chaddock scale [30].

The object of the study

The study was performed in two groups whose characteristics are presented in **Table 1**.

Results

For 20 years, the prison population has been occupying the leading place in the social structure of HIV-infected individuals, accounting for at least 24.4%

of all reported cases. The correlation analysis has demonstrated a direct and strong relationship ($r_{xy} = 0.87$) between the HIV incidence in the TR population and the HIV incidence among the incarcerated individuals. Note that the latter are still significantly contributing to the invariably high HIV prevalence rates in the TR population. In the last 10 years, the HIV prevalence rate among the incarcerated individuals has been 3,113.2 per 100,000 prison population, exceeding 32.3 times the prevalence rate in the region's population (96.5 per 100,000 population). In 2018, the percentage of HIV-infected individuals among the inmates was 15.4%, while the average percentage recorded from 2008 was 12.3%. The highest HIV prevalence rate among the TR inmates was recorded in 2018, reaching 15,447.3 per 100,000 prison population and exceeding 13.7 times the regional rate (1,129.5 per 100,000 population).

In 2019–2020, to assess the knowledge level regarding HIV infection risks in prisons, we conducted an anonymous questionnaire survey among 60 HIV-negative inmates (men) at penitentiary facilities in Tyumen. The age of the respondents ranged from 20 to 50 years; most of them had specialized secondary education (61.7%). Prior to the survey, each respondent was informed about the aspects of the survey. The results of the survey are as follows:

- information about HIV infection is generally received from mass media (56.7%), through communication with healthcare workers (33.3%), by reading special literature (18.3%); or much more rarely – from friends and relatives, from handouts such as leaflets and brochures (11.7% and 8.3%, respectively);
- 26.7% of the respondents are aware of the actual HIV prevalence rate in the Tyumen Region;
- 58.3% of the respondents know what to do in case of an accidental needlestick injury, for example, in the street; however, only 50.5% of them know where to go and be tested in urgent

situations, while 55% of the respondents hardly know the time limits within which they should be tested for HIV after the suspected exposure event;

- 50% of the respondents are sure that they will not contract an infection, while 48.3% of the respondents believe that they are not at risk of contracting HIV;
- 95% of the respondents do not think that in their present setting they are exposed to HIV infection; 63.3% of the respondents do not deny they have IDU acquaintances, and 16.6% of the respondents used "mild" psychoactive substances prior to incarceration;
- 51.7% of the respondents needed more information about HIV infection.

Based on the findings, we can conclude that inmates do not see themselves as part of the high-risk group for HIV infection and spread. Furthermore, 20% of the inmates believe that there is a vaccine against HIV infection and HIV is curable, thus being at risk of non-compliance with preventive measures against contraction and transmission of HIV infection.

Death rates are among the most significant epidemiological criteria measuring the successful implementation of national programs for prevention of HIV spread among the population. Our analysis of the groups showed that in 2008–2018, in the group of the HIV-positive deceased incarcerated people (DIP), the average life expectancy after HIV infection had been detected was 6.7 years, while in the control group of deceased free people (DFP), it was 5 years. The median life expectancy from the positive immunoblot test to the time of death was 7 years and 3 years for DIP and DFP, respectively ($p < 0.001$). The gender profile of the studied groups is presented in **Table 2**.

Based on HIV transmission routes, the groups showed the following distribution:

- injection drug use (parenteral) transmission — reported in 94.1% of DIP and in 51.7% of DFP;

Table 1. Study groups of HIV-infected people

Study group	<i>n</i>	Inclusion criteria	Data sources	Coverage percentage
Group 1 (study)	222	1) People serving a prison sentence; 2) immune blot test for HIV (+); 3) hospitalization of HIV (+) individuals in 2008–2018; 4) availability of autopsy reports from the Office of the Chief Medical Examiner	Hospital admission logbooks, death record logbooks, medical source records (form 003/u), autopsy reports	The groups were selected by screening
Group 2 (control)	143	1) Civilians; 2) immune blot test for HIV (+); 3) hospitalization of HIV (+) individuals in 2011–2018; 4) availability of autopsy reports from the Office of the Chief Medical Examiner		

- sexual transmission — reported in 5.9% of DIP and in 46.9% of DFP;
- vertical transmission — reported in 1.7% of DFP ($p < 0.001$).

Other parameters used in the analysis of the factors increasing the risk of a fatal outcome in the study and control groups of HIV-infected people are shown in **Table 3**.

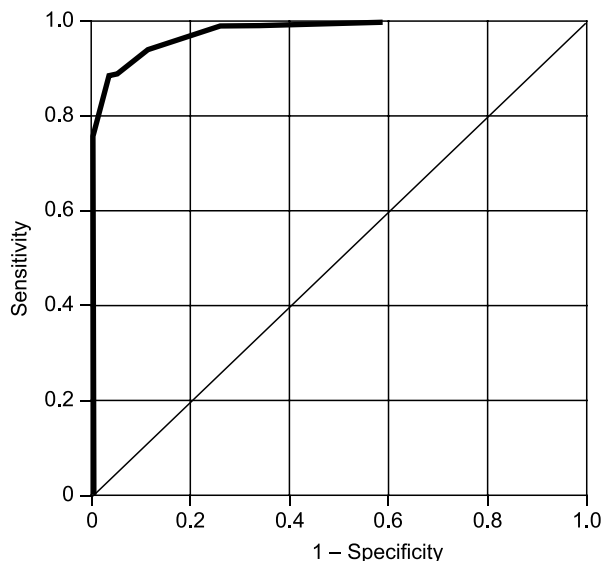
Based on the autopsy reports, we have found that in the DIP group, most of the deaths ($n = 178$; 80.2%) were caused by generalized tuberculosis ($\chi^2 = 127.12$; $p < 0.001$), in 61.7% of cases ($n = 137$), this cause of death was identified by autopsy findings. The confirmed cases of viral hepatitis among DIP accounted for 72.1% ($n = 160$; $\chi^2 = 34.41$; $p < 0.001$). Thoracic diseases (pulmonary tuberculosis, including fibro-cavernous tuberculosis; viral and bacterial pneumonia) accounted for 9.0% ($n = 20$; $\chi^2 = 72.78$; $p < 0.001$).

In the DFP group, most deaths (53 cases; 37.1%) were caused by thoracic diseases ($\chi^2 = 72.78$; $p < 0.001$), having exceeded 4 times the death rate in the DIP group; 59 (41.3%) cases were diagnosed with viral hepatitis ($\chi^2 = 34.42$; $p < 0.001$); 29 (20.3%) cases were diagnosed with generalized tuberculosis ($\chi^2 = 127.12$; $p < 0.001$), being 4 times as low as the similar rates in the DIP group; 29 (20.3%) cases were diagnosed with CNS diseases (meningoencephalitis, encephalitis of mixed etiology (toxoplasmosis + cytomegalovirus infection), toxoplasmosis) ($\chi^2 = 42.03$; $p < 0.001$).

The last lifetime tests evaluating the immune status in the study and control groups showed that the CD4 lymphocyte count was < 200 cells/ μL in $75.2 \pm 2.9\%$ of DIP and $91.2 \pm 2.4\%$ of DFP; 200–350 cells/ μL - in $15.6 \pm 2.5\%$ of DIP and $3.6 \pm 1.6\%$ of DFP; more than 350 cells/ μL - in $9.2 \pm 1.9\%$ of DIP and $5.1 \pm 1.8\%$ of DFP. The difference in the HIV-infected group was most significant, when the CD4 count of 200–350 cells/ μL ($\chi^2 = 10.7$; $p < 0.001$) was recorded among DIP 4.3 times as often as among DFP.

The HIV viral load greater than 100,000 copies/mL, which strongly correlates with intensive depletion of CD4 lymphocyte population, was detected in $63.3 \pm 8.80\%$ of cases among DIP and in $60.0 \pm 5.2\%$ of cases among DFP.

To identify the totality of risk factors associated with mortality among HIV-infected incarcerated people, we, using the odds ratio, included variables, which were significantly different in the DIP and DFP groups, in the logistic regression (95% CI). These variables



The ROC curve of assessment of the logistic regression model for fatal outcome prognosis in HIV-infected inmates (95% CI).

were gender, age at the time of an HIV diagnosis, average life expectancy after the HIV diagnosis, HIV transmission route, stages and categories of HIV infection: stages 3, 4A, 4B; stages 4C, 5 ($\chi^2 = 195.75$; $p < 0.001$); comorbidities: viral hepatitis, CNS diseases, generalized tuberculosis, thoracic diseases, CD4-cell counts by categories: under 200 cells/ μL ; 200–350 cells/ μL ; over 350 cells/ μL .

The analysis showed that the risk of fatal outcomes among HIV-positive incarcerated people was associated with the following parameters: male gender (OR = 4.68; $p = 0.022$), parenteral (injection drug use) HIV transmission route (OR = 14.64; $p < 0.001$), confirmed comorbidities — viral hepatitis (OR = 4.75; $p < 0.001$) and thoracic diseases (OR = 20.03; $p < 0.001$).

Discussion

The findings for the group of HIV-infected inmates demonstrate that the risk of a fatal outcome among men is 4.7 times higher than among women, and the death rate among the infected with HIV through the injection drug use (parenteral) transmission is 14.6 as high. The co-infection with viral hepatitis increases mortality among the HIV-infected inmates 4.8 times and thoracic diseases increase it 20 times as compared to the HIV-infected free people. The quality of the prognostic model was assessed and confirmed as excellent (**Fig. 1, Table 4**).

Table 2. Distribution of HIV-infected people by gender

Study group	Men, abs (%)	Women, abs (%)	Total, people
Deceased free people	87 (60,8)	56 (39,2)	143
Deceased incarcerated people	213 (95,9)	9 (4,1)	222

Note. $p < 0.001$ compared to deceased incarcerated people.

Table 3. Parameters to be investigated by category

Parameters		Deceased free people, % (n = 143)	Deceased incarcerated people, % (n = 222)	Significance of differences (p < 0,05)
Stage of HIV infection	3	0.7	3.2	<0.001
	4A	1.4	0.5	
	4B	–	73.4	
	4C	93.7	23.0	
	5	4.2	–	
HIV infection is the main diagnosis	No	7.7	1.8	<0.01
	Yes	92.3	98.2	
Associated conditions				
HIV infection	No	92.3	98.2	<0.01
	Yes	7.7	1.8	
viral hepatitis	No	58.7	27.9	<0.001
	Yes	41.3	72.1	
generalized tuberculosis	No	79.7	19.8	<0.001
	Yes	20.3	80.2	
gastrointestinal disease	No	99.3	99.5	0.753
	Yes	0.7	0.5	
central nervous system diseases	No	79.7	99.1	<0.001
	Yes	20.3	0.9	
cancer	No	100	95.9	<0.05
	Yes	–	4.1	
thoracic disease	No	62.9	91.0	<0.001
	Yes	37.1	9.0	
generalized bacterial infections	No	95.1	100	<0.01
	Yes	4.9	–	
cardiovascular disease	No	99.3	99.5	0.753
	Yes	0.7	0.5	
generalized lymphadenopathy	No	99.3	97.3	0.254
	Yes	0.7	2.7	
cytomegalovirus generalized infection	No	97.9	100	0.059
	Yes	2.1	–	
fungal infections	No	94.4	100	<0.001
	Yes	5.6	–	

Among DIP, 5.4% inmates matched all the parameters associated with the likelihood of a fatal outcome.

Conclusion

The continuous study in the DIP group during 2008–2018 has identified risk factors affecting the epidemic process of HIV infection in prisons and has found that progression of HIV infection and, consequently, mortality among incarcerated people require constant attention of all the concerned services. The questionnaire survey results suggest that the inmates tend to be

Таблица 4. Характеристика прогностической значимости
Table 4. Characteristics of prognostic significance

Площадь под ROC-кривой, p < 0,001 Area under the ROC curve, p < 0.001	0,977
Чувствительность модели, % Sensitivity of the model, %	93,6
Специфичность модели, % Model specificity, %	89,6
Предсказывающая точность, % Predictive accuracy, %	92,1

lieve they are most unlikely to get infected and there is no risk of HIV spread. Special attention should be given to better availability of information about preventive measures against HIV infection among inmates. The measures aimed at monitoring of the HIV epidemic process in prisons should also include prevention of co-infection and progression of thoracic diseases and viral hepatitis, giving priority attention to men infected with HIV through the injection drug use transmission.

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