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Review

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e-mail: [zaherkhazaei@yahoo.com](mailto:zaherkhazaei@yahoo.com)**Abstract**

**Background:** Viral hepatitis is still considered as a major cause of burden of disease in the world, and is the most common cause of cirrhosis and liver cancer. Prisoners are one of the groups most at risk for hepatitis. This study aimed to investigate the prevalence of hepatitis B and C in prisons worldwide during the years 2005-2015. **Method:** In order to find relevant articles published from 2005 to 2015, two members of the research team searched the databases of PubMed, Scopus, and Web of Science. The study was conducted using the random effects model and the fixed effects model. In order to examine heterogeneity, Cochran Q test was used at an error level of less than 10%; its quantity was estimated using the I<sup>2</sup> indicator. The publication bias was measured using Begg's rank correlation test and Egger's linear regression method. After extracting the required data, the meta-analysis was performed using the software Stata 12. **Results:** A total of 43 studies which met the inclusion criteria were analyzed. The results showed that the overall prevalence of hepatitis B in prisoners was 5.17% (95% CI: 2.19-9.30). The highest prevalence, that is, 13.14% (95% CI: 11.99-14.36), was observed in Africa. According to the World Health Organization (WHO) classification, the highest prevalence, that is, 5.04% (95% CI: 4.45-5.67), was observed in the Western Pacific region. The prevalence of hepatitis B in men and women were, respectively, 6.70% (95% CI: 6.52-6.88) and 4.34% (95% CI: 3.98-4.79). The results showed that the overall prevalence of hepatitis C in prisoners was 13.22% (95% CI: 8.95- 8.16). The highest prevalence, that is, 26.4% (95% CI: 25.05-27.87), was observed in Australia. According to the WHO classification, the highest prevalence of hepatitis C, that is, 24.26% (95% CI: 21.6-27.02), was observed in the Southeast Asia region. The prevalence of hepatitis B in men and women were, respectively, 9.33% (95% CI: 1.56-1.98) and 6.25% (95% CI: 5.78-6.74). **Conclusion:** The prevalence of hepatitis B and C in prisoners was greater than that in the general population, and the prevalence in men was greater than that in women. Appropriate and effective interventions to reduce transmission of hepatitis B and C in the prisons worldwide is essential.

**Prevalence of Hepatitis B and C in prisons worldwide: A meta-analysis during the years 2005-2015**Ghobad Moradi<sup>1</sup>, Elham Goodarzi<sup>2</sup> and Zaher Khazaei<sup>3</sup>

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## 1. Introduction

Hepatitis, after tuberculosis and malaria, is the most common liver disease and the most common infectious disease in the world. Among the most important forms of hepatitis are hepatitis B and hepatitis C [1]. Hepatitis is a common cause of cirrhosis, liver failure and liver cancer, leading to approximately two million deaths annually [2]. More than 350 million people in the world have chronic hepatitis B, who constitutes 5% of the world population [3]. Each year, about 4 million people worldwide are infected with acute hepatitis B, and about 1 million people die due to chronic hepatitis infection [4]. Hepatitis B virus (HBV) exists in all the fluids and secretions of the body, and the transmission routes include sexual contact, intravenous drug injection, mother to fetus, needle stick, etc. [5]. The prevalence of hepatitis varies in different countries, ranging from 0.1% to 20%. The prevalence of hepatitis B ranges from 0.1% to 0.5% in Europe and North America, and from 5% to 20% in the Far East and tropical countries [6]. Vaccination is currently the most effective and cost-effective means of the prevention of hepatitis B [7].

Hepatitis C has a prevalence of approximately 3%, affecting more than 170 million chronic cases in the world. It is considered as one of the world's current and significant problems, as it leads to severe complications such as liver cirrhosis, liver cancer, and early mortality [8]. The prevalence of hepatitis C in the general population varies from 2% to 18%. Currently, America and Europe are among the areas with lowest prevalence of hepatitis C, while Africa, the Eastern Mediterranean, the Southeast Asia and West Pacific have the highest prevalence. In fact, the lowest and the highest prevalence of the disease belong, respectively, to England, with 0.5%, and Egypt, with 12-15% [9].

One of the groups that is at highest risk for hepatitis are prisoners [10]. Studies have reported that the prevalence of hepatitis in prisoners is higher than that of the general population; it is also worth mentioning that the risk of individuals with hepatitis C being imprisoned is 9 times higher than that of the general population [11].

In prisons, prisoners are kept in a closed environment for a long time under conditions prone to overcrowding, poor nutrition, lack of medical care, and homosexuality. Thus, prisoners are susceptible to infectious diseases and, after release from prison, they might spread the disease in the community [9]. People referred to correctional centers often experience drug injection, needle sharing, and sexual risk behavior (often continued during their detention), which all contribute to a high risk of transmission of viruses such as human immunodeficiency virus (HIV), HBV, and hepatitis C virus (HCV) [9].

In a study conducted from 1993 to 2003 among prisoners, various risk factors were investigated for the transmission of diseases, including sexually transmitted diseases, hepatitis, HIV, and tuberculosis. Drug use and sexual risk behavior were reported to be the most important factors [12]. Since prisoners suffer from lack of proper health care, criminal systems can serve as a reservoir for HBV, HCV, and other viral diseases [11]. Indeed, the prevalence of chronic hepatitis B and chronic hepatitis C infection in prisoners have been found to be 2-6 fold and up to 10 fold greater, respectively, than that in the community [13].

A research study in the US among prisoners indicated that the prevalence of infection with hepatitis B was more than 20%, suggesting that prisons are a predominant source for infection and may facilitate transmission of infectious diseases in the society [14]. The prevalence of chronic hepatitis C infection among prisoners in the US ranged from 16-41%, which was 8-20 fold greater than that of the general population [15]. In a study carried out in Ghana in 2006, which included 281 prisoners, 17.4% of the prisoners were infected with hepatitis B [16]. It is estimated that, annually, approximately 2 million HCV infections occur through infected injections, which might account for up to 40% of all HCV infections in the world. The percentage of infection among the prisoners in different parts of the world is reported to be from 27% to more than 90% [17].

On the other hand, studies show that HIV infection and illnesses, such as sexually transmitted diseases and hepatitis, are increasing in prisons and the global need for a cohesive program is needed to reduce the risk of transmission of these diseases [12]. Greater knowledge of the

prevalence of infection in correctional centers could aid in proper prevention, management and planning of infectious diseases. Since one of the high-risk groups of individuals is prisoners and since viral hepatitis is one of the most important health issues for prisoners, the aim of this study was to obtain an estimate of the prevalence of viral hepatitis among prisoners in the world.

## 2. Materials and Methods

### (a) Search Strategy

In this study, a meta-analysis was done for the prevalence of hepatitis B and C in prisons in the world during the years 2005-2015. In this study, two members of the research team extracted all the relevant articles published from 2005 to 2015 by searching the medical information databases of PubMed, Scopus, and Web of Science. Additionally, a search was conducted using the following keywords: ("Hepatitis B" [Mesh]) AND ("prisons" [Mesh: No exp]) AND ("prevalence" [Mesh]), ("Hepatitis C" [Mesh]) AND ("prisons" [Mesh: No exp]) AND ("prevalence" [Mesh]), as well as their derivatives. The reference entries used in all the articles found during the search were evaluated so that other possible sources could also be included in the study.

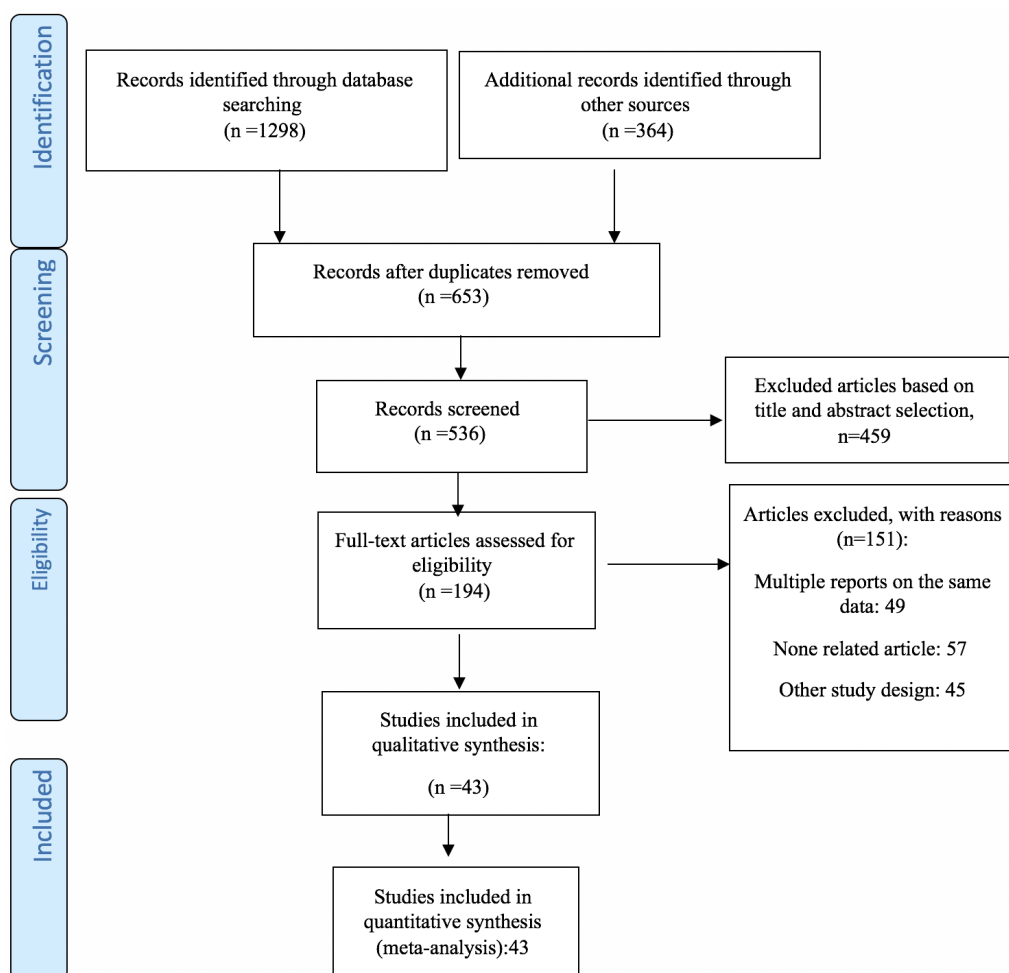


Figure 1. Flow diagram of the literature search for studies included in meta-analysis.

**(b) Study selection**

The data extracted from the articles are shown in **Figures 1 and 2**. A final total of 43 articles were eligible and included in the study. All the articles (during the three stages) were evaluated by two independent researchers and, in case of any disagreement, a third examiner to arrive at the final analysis. With respect to the articles included in the data analysis phase, all information related to type of study, first author's name, year of study, year of publication, participants' gender, country of study, number of participants, and hepatitis type (B and C) by sex, were entered on the spreadsheet forms designed in the software Excel. The data, after the cleaning phase, were transferred from Excel to the Stata 12 software program.

Table 1: Characteristics of Studies on the Prevalence of HBV and HCV in Prisons

Author, Year	Country	Sample	HBV+(N)	HCV+(N)	Sex	Design
Lai 2006 [18]	Taiwan	285	63	4	Male	Cross-sectional
Reekie 2014	Australia	1742	40	505	Male	Cross-sectional
Bautista-Arredondo 2015 [19]	Mexico	17084	26	548	Both	Cross-sectional
Macalino 2009 [20]	Australia	544	25	135	Male	Cross-sectional
Daneshmand 2013 [21]	Iran	970	32	—	Male	Cross-sectional
Azbel 2013 [22]	Ukraine	402	40	21	Both	Cross-sectional
Azbel 2015 [23]	Azerbaijan	510	14	195	Both	Cross-sectional
Butler 2006 [24]	Australia	612	88	157	Both	Cross-sectional
Adjei 2006 [25]	Ghana	1366	—	255	Both	Cross-sectional
Babudieri 2005 [26]	Italy	973	65	370	Both	Cross-sectional
Adjei 2008 [27]	Ghana	1366	349	—	Both	Cross-sectional
Barros 2013 [28]	Brazil	148	28	—	Female	Cross-sectional
Azarkar 2010 [29]	Iran	358	22	29	Both	Cross-sectional
Amin-Esmaeili 2012 [30]	Iran	895	22	31	Both	Cross-sectional
Roux 2015 [31]	France	5957	—	308	Both	Cross-sectional
Saiz de la Hoya 2011 [10]	Spain	370	9	84	Both	Cross-sectional
Kirwan 2011 [32]	England	10723	107	2413	Both	Cross-sectional
Falquetto 2013 [33]	Brazil	730	9	84	Male	Cross-sectional
Kassaian 2011 [34]	Iran	943	—	390	Both	Cross-sectional
Fox 2005 [35]	America	467	—	160	Both	Cross-sectional
Nelwan 2010 [36]	Indonesia	679	37	118	Both	Cross-sectional
Macalino 2005 [37]	America	297	86	119	Male	Cross-sectional
Adoga 2009 [38]	Nigeria	300	69	37	Male	Cross-sectional
Maerrawi 2014 [39]	America	546	115	29	Male	Cross-sectional
Taylor 2012 [40]	Scotland	5076	—	933	Both	Cross-sectional
Miller 2009 [41]	Australia	382	—	240	Both	Cross-sectional

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Prasetyo 2013 [42]	Indonesia	375	12	128	Male	Cross-sectional
Alvarez 2014 [43]	America	2788	—	295	Both	Cross-sectional
Lin 2010 [44]	Taiwan	15007	3258	—	Both	Cross-sectional
Brandolini 2013 [45]	Italy	695	30	156	Both	Cross-sectional
Pompilio 2011 [46]	Brazil	686	—	33	Both	Cross-sectional
Salem 2013 [47]	Iran	3000	122	—	Male	Cross-sectional
Nokhodian 2012 [48]	Iran	163	2	12	Female	Cross-sectional
Mahfoud 2010 [49]	Lebanon	580	6	12	Male	Cross-sectional
Rosa 2012 [50]	Brazil	195	—	19	Both	Cross-sectional
Miller 2005 [51]	Australia	1347	—	561	Both	Cross-sectional
Kolaric 2010 [52]	Croatia	601	5	—	Male	Cross-sectional
Kazi 2010 [53]	Pakistan	365	21	55	Male	Cross-sectional
Adjei 2006 [54]	Ghana	281	49	54	Both	Cross-sectional
Gilles 2008 [55]	Australia	185	5	7	Both	Cross-sectional
Jovanovska 2014 [56]	Macedonia	200	34	40	Both	Cross-sectional
Semaille 2013 [57]	france	1876	—	105	Both	Cross-sectional
Ziaee 2014 [58]	Iran	881	61	68	Both	Cross-sectional

### (c) Statistical analysis

In this study, the pooled weighted average (derived from results of individual studies) were used in the evaluations. The weighted average for each study was calculated based on the sample size and variance. In this study, the random effects model (the DerSimonian and Laird method) and the fixed effects model (the Mantel-Haenszel method) were used; the indicator under study was "prevalence", which was calculated as the ratio of ( $p$ ) with a 95% CI. In order to examine heterogeneity, Cochran's Q test was used at an error level of less than 10%; its quantity was estimated using the  $I^2$  indicator ( $I^2$  is the percentage of total variation across studies due to heterogeneity rather than chance). A value of 0% indicates no heterogeneity among the studies. If  $p < .01$  and  $I^2 > 50\%$ , the random effects model was used; otherwise, the fixed effects model was used.

The publication bias was measured using Begg's rank correlation test and Egger's linear regression method. After extracting the required data, the meta-analysis was performed using the software Stata 12.

## 3. Results

Of the 43 articles that were evaluated in our study, these were the following countries which were represented: Iran, Brazil, Azerbaijan, Indonesia, England, Scotland, Italy, France, Ghana, Spain, America, Croatia, Lebanon, Pakistan, Mexico, Nigeria, Ukraine, Australia, and Macedonia. The sample size in these studies varied from 200 to 17084 people **Table 1**.

Table 2: Prevalence of HBV Stratified by Different Factors

	Stratified factors	Prevalence rate	Lower limit	Upper limit	Heterogeneity I2 (%)	Model	
Country	Taiwan	6.42	4.97	8.15	99.8	Random	
	Australia	4.70	4.07	5.40	99.6	Random	
	Mexico	0.15	0.09	0.22	99.7	Random	
	Indonesia	4.83	3.59	6.33	99.3	Random	
	Azerbaijan	2.74	1.50	4.56	99.7	Random	
	Brazil	4.12	3.62	4.66	99.8	Random	
	England	1.13	0.93	1.37	99.2	Random	
	Spain	2.43	1.11	4.56	99.5	Random	
	France	0.89	0.68	1.14	99.45	Random	
	Ghana	12.13	10.97	13.37	99.60	Random	
	Italy	3.91	3.03	4.96	99.8	Random	
	Croatia	5.75	3.59	8.66	98.9	Random	
	Pakistan	2.71	2.17	3.33	99.8	Random	
	Nigeria	23	18.35	28.18	99.6	Random	
	Ukraine	9.95	7.20	13.30	98.9	Random	
	America	21.20	20.56	21.84	98.8	Random	
	Iran	2.62	2.27	3.00	99.4	Random	
	Continent	Asia	3.05	2.76	3.35	99.9	Random
		Australia	4.70	4.07	5.40	99.7	Random
America		9.34	9.05	9.63	98.9	Random	
Europe		1.16	1.03	1.30	99.6	Random	
Africa		13.14	11.99	14.36	99.8		
WHO		Oceania	5.04	4.45	5.67	99.8	Random
	America	9.34	9.05	9.63	99.8	Random	

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Year	Europe	1.19	1.06	1.33	99.7	Random
	Africa	3.59	11.99	14.36	99.6	Random
	Asia	2.60	2.31	2.91	99.8	Random
Year	2005	6.67	5.69	7.76	99.8	Random
	2006	6.37	5.43	7.41	99.9	Random
	2008	24.45	22.34	26.66	99.7	Random
	2009	7.67	6.25	9.31	99.8	Random
	2010	5.09	4.26	6.02	99.9	Random
	2011	1.65	1.47	1.86	99.5	Random
	2012	1.01	0.81	1.24	99.8	Random
	2013	3.72	3.30	4.19	99.7	Random
	2014	17.80	17.26	18.35	99.8	Random
	2015	1.03	0.12	1.23	99.9	Random
Gender	Male	6.70	6.52	6.88	99.99	Fix
	Female	4.37	3.98	4.79	99.98	Fix
Injection	Yes	12.68	4.65	23.9	99.8	Random
	No	7.4	0.06	29.9	99.8	Random
Total		5.17	2.19	9.30	99.8	Random

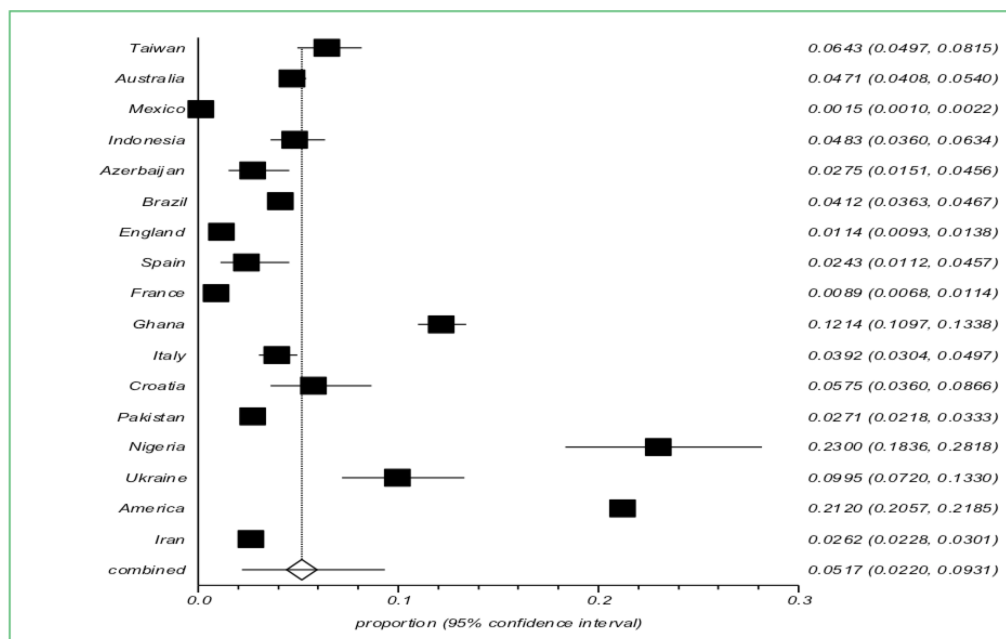


Figure 2. Forest plot of prevalence of HBV studies by country from 2005 to 2015.

### (a) Prevalence of hepatitis B

From the 43 studies included in our analysis, 31 studies reported on the prevalence of hepatitis B in prisons during the years 2005-2015. For each study, the prevalence of hepatitis B according to country, continent, the WHO designated region, year of study, gender, and history of injection were obtained Table 2. Analysis of these studies showed that, overall, the prevalence of hepatitis B in prisoners around the world was 5.17% (95% CI: 2.19-9.30). The results also indicated that among the studies conducted in different countries, the highest prevalence of hepatitis B was in America, at 21.2% (9% CI: 20.6-21.84), and the lowest rate was in Mexico, at 0.15% (95% CI: 20.56-21.84) (Figure 1). The highest prevalence of hepatitis B, according to continent, was in Africa, at 13.14% (95% CI: 11.99-14.36), and the next lowest prevalence was in Europe, at 1.16% (95% CI: 1.03-1.30) Figure 3. When considering the prevalence of hepatitis B in prisons according to the WHO's classification of regions, the results showed that the highest prevalence was observed in Oceania, with a rate of 5.04% (95% CI: 4.45-5.67), and the lowest prevalence was seen in Europe, with a rate of 1.19% (95% CI: 1.06-1.33). When the prevalence of hepatitis B in prisons was assessed according to the year of study, highest prevalence was seen in studies conducted in 2014, with a rate of 17.8% (95% CI: 17.26-18.35), and the lowest prevalence was seen in 2012, with a rate of 1.01% (95% CI: 0.81-1.24). Analysis related to gender revealed that the prevalence of hepatitis B in men and women was 6.70% (95% CI: 6.52-6.88) and 4.34% (95% CI: 3.98-4.79), respectively. The prevalence of hepatitis B among people with a history of injection was 12.68% (95% CI: 4.65-23.9), and the prevalence among those without a history of injection was 7.4% (95% CI: 0.06-29.9) Table 2.

### (b) Prevalence of hepatitis C

Among the 43 studies included in our investigation, 38 studies reported on the prevalence of hepatitis C in prisons around the world during the years 2005-2015. For each, the prevalence of hepatitis C according to country, continent, the WHO classified region, year of study, gender, and

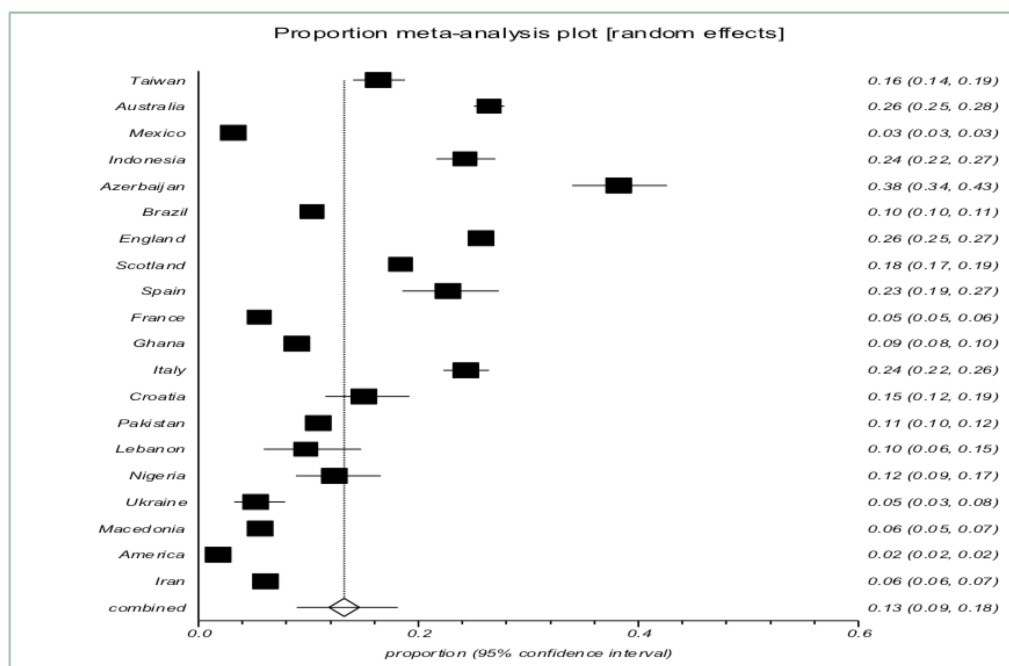


Figure 3. Forest plot of prevalence of HCV by country from 2005 to 2015.

history of injection were obtained **Table 3**. Analysis of these studies indicated that, overall, the prevalence of hepatitis C in prisoners worldwide was 13.22% (95% CI: 8.95-18.16). The results also showed that according to countries, the highest prevalence of hepatitis C was related to Azerbaijan, with a rate of 38.23% (9% CI: 33.99-42.06), with the lowest rate in America, at 1.76% (95% CI: 20.56-21.84) **Figure 2**. The analyses related to gender showed that the prevalence of hepatitis C in men and women was 9.33% (95% CI: 1.56-1.98) and 6.25% (95% CI: 5.78-6.74), respectively. The highest prevalence of hepatitis C, according to continent, was in Australia, at 26.4% (95% CI: 25.05-27.87), and the lowest was in the Americas, at 3.68% (95% CI: 3.5-3.87). When the prevalence of hepatitis C in prisons was examined according to the WHO classification of regions, the results showed that the highest prevalence was in Southeast Asia, at 24.26% (95% CI: 21.6-27.02) and the lowest was in America, at 3.68% (95% CI: 3.5-3.87). When the prevalence of hepatitis C in prisons was examined according to the year of study, the highest prevalence was seen in the studies conducted in 2009, with a rate of 33.66% (95% CI: 31.01-36.38), and the lowest prevalence was seen in those carried out in 2008, with a rate of 2.55 (95% CI: 1.83-3.46). Regarding the prevalence of hepatitis C and the history of injection, the results showed that the prevalence for those with such a history was 19.32% (95% CI: 3.51-43.65), and the prevalence among those without a history of injection was 12.99% (95% CI: 1.03-35.24) **Table 3**.

#### 4. Discussion

The population of prisoners consists of groups facing greater health problems influenced by unstable economy, history of drug abuse, and other instances of risk behavior. One of the main health-related concerns among prisoners is blood-borne infections, including hepatitis B and C [59].

This study aimed to investigate the prevalence of hepatitis B and C in prisons worldwide. In the present study, 43 studies were evaluated to examine the prevalence of hepatitis B and C in prisons around the world. In the final meta-analysis, 31 articles were included in the investigation

Table 3. Prevalence of HCV Stratified by Different Factors

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	Stratified factors	Prevalence rate	Lower limit	Upper limit	Heterogeneity I2 (%)	Model
<b>Country</b>	Taiwan	16.32	14.06	18.79	99.7	Random
	Australia	26.40	25.05	27.78	99.8	Random
	Mexico	3.20	2.94	3.48	99.7	Random
	Indonesia	24.26	21.65	27.02	99.9	Random
	Azerbaijan	38.23	33.99	42.06	99.5	Random
	Brazil	10.34	9.57	11.15	99.8	Random
	England	25.69	24.81	26.58	99.8	Random
	Scotland	18.38	17.32	19.47	99.9	Random
	Spain	22.70	18.53	27.31	99.7	Random
	France	5.49	4.97	6.06	99.5	Random
	Ghana	8.98	7.96	10.07	99.6	Random
	Italy	24.29	22.24	26.42	99.7	Random
	Croatia	15.06	11.55	19.15	99.5	Random
	Pakistan	10.87	9.82	12.00	99.6	Random
	Lebanon	9.74	5.96	14.79	99.7	Random
	Nigeria	12.33	8.83	16.59	99.9	Random
	Ukraine	5.22	3.26	7.87	99.8	Random
	Macedonia	5.60	4.60	6.74	99.7	Random
	America	1.76	1.56	1.98	99.7	Random
	Iran	6.05	5.53	6.61	99.5	Random
<b>Continent</b>	Asia	10.57	10.06	11.10	99.99	Random
	Australia	26.40	25.05	27.78	99.7	Random
	America	3.68	3.50	3.87	99.8	Random
	Europe	16.9	16.44	17.36	99.5	Random
	Africa	9.26	8.31	10.35	99.8	Random
<b>WHO</b>	Oceania	24.4	23.27	25.66	99.9	Random
	America	3.68	3.5	3.87	99.9	Random
	Europe	17.31	16.85	17.77	99.8	Random
	Africa	9.29	8.31	10.35	99.9	Random
	Southeast Asia	24.26	21.65	27.02	99.8	Random
	Asia	7.52	7.03	8.03	99.8	Random
	Asia	7.52	7.03	8.03	99.8	Random
<b>Year</b>	2005	27.7	25.95	29.62	99.8	Random
	2006	17.27	15.80	18.83	99.9	Random
	2008	2.55	1.83	3.46	99.8	Random
	2009	33.66	31.01	36.38	99.8	Random
	2010	17.01	15.57	18.53	99.7	Random
	2011	19.13	18.53	19.73	99.9	Random
	2012	18.28	17.47	19.10	99.85	Random
	2013	2.62	2.27	3.02	99.9	Random
	2014	3.33	3.08	3.59	99.8	Random
	2015	4.46	4.20	4.73	99.7	Random
	<b>Gender</b>	Male	9.33	9.12	9.54	99.9
Female		6.25	5.78	6.74	99.8	Fix
<b>Injection</b>	Yes	19.32	3.51	43.65	99.9	Random
	No	1.25	1.03	35.24	99.8	Random
<b>Total</b>		13.22	8.95	18.16	99.7	Random

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of the prevalence of hepatitis B, with the average sample size being 2014. The prevalence of hepatitis B was calculated. The heterogeneity of the prevalence rates was 99.5%, indicating high heterogeneity according to the related cut-off points (less than 25%: low heterogeneity, 25-75%: average heterogeneity, and more than 75%: high heterogeneity). The random effects model was, therefore, used for further examination. According to this model, it is assumed that the observed differences are due to different sampling as well as the differences in the measured parameters (prevalence of hepatitis B and C) in different studies.

The search results revealed that the 31 studies in our analysis had been conducted in different countries from 2005 to 2015 in order to investigate the prevalence of hepatitis B. Overall, the prevalence of hepatitis B in the prisons worldwide was 5.17% (95% CI: 2.19-9.30). The highest prevalence of hepatitis B was related to the studies conducted by Macalino et al. in 2005, with a sample size of 297 and a prevalence of 28.95% (95% CI: 23.86-34.47) [20]. Moreover, hepatitis B was associated with a study conducted in Mexico by Bautista-Arredondo et al. in 2015, with a sample of 17,000 and a prevalence of 0.15% (95% CI: 0.09-0.22) [19].

The search results also showed that 38 studies had been carried out in different countries from 2005 to 2015 in order to investigate the prevalence of hepatitis C. The sample size of these studies varied from 200 to 17,000. The smallest and largest sample sizes (i.e., 200 and 17000) were associated with Macedonia and Mexico, respectively. The highest estimated prevalence of hepatitis C was observed in a study by Miller et al., conducted in Australia in 2009 and with a prevalence of 62.82% (95% CI: 57.76-67.68) [60]. Overall, the prevalence of hepatitis C in prisons around the world was estimated to be 13.22% (95% CI: 8.95-18.16). The highest prevalence of hepatitis B, according to continent, was seen in Africa, at 13.14% (95% CI: 11.99-14.36), and the lowest was in Europe, at 1.16% (95% CI: 1.03-1.30). However, the highest prevalence of hepatitis C in prisons, according to the WHO's classification of regions, was in Australia, at 26.4% (95% CI: 25.05-27.87), and the lowest was seen in the Americas, at 3.68% (95% CI: 3.5-3.87). Health organizations should, therefore, seek to modify the existing patterns and halt the growing trend of hepatitis infection by implementing proper vaccination programs and/or preventative education to lower risk and prevalence.

The results showed that the overall prevalence of hepatitis B in men was 6.7% (95% CI: 6.52-6.88). The highest prevalence of hepatitis B in men in Italy, at 35.19% (95% CI: 32.58-37.87), and the lowest was in Mexico, at 0.13% (95% CI: 0.08-0.2). The results showed that the overall prevalence of hepatitis B in female prisoners was 4.34% (95% CI: 3.98-4.79). The highest prevalence of hepatitis B in women was in Spain, at 29.03% (95% CI: 14.22-48.03), and the lowest was in Mexico, at 0.28% (95% CI: 0.09-0.67).

According to the results, it could be argued that the prevalence of hepatitis among male prisoners is greater when compared with that among female prisoners. Given the higher prevalence of risk behavior and drug injection among men, these findings affirm the greater need for training in this group. Drug use is currently a global problem; indeed, nearly 5% of the world's population (200 million people) use drugs [61]. Injection is one of the most harmful ways of drug use. It is estimated that there are 13 million injection drug users in the world, 75% of which live in developing countries [59]. Drug injection and needle sharing in closed environments, such as prisons, could exacerbate the transmission of blood-borne diseases. The results of the present study showed that the prevalence of hepatitis B among the people with a history of injection was 12.68% (95% CI: 4.65-23.9), and the prevalence among those without a history of injection was 7.4% (95% CI: 0.06-29.9). With respect to the prevalence of hepatitis C and the history of injection, the results showed that the prevalence for those with such a history was 19.32% (95% CI: 3.51-43.65), and the prevalence among those without a history of injection was 12.99% (95% CI: 1.03-35.24).

## 5. Conclusion

The results suggest that the prevalence of hepatitis B and C, in general, and that of hepatitis C, in prisons, are of particular concern. The prevalence of hepatitis is higher among men than women

in prisons (due to men's higher rate of risky sexual behavior) as well as among those with a history of injection. Therefore, adequate training should be given to prisoners in health planning and prevention in order to prevent further spread of the disease in prisons and the community.

## 6. Open Access

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## 7. List of abbreviations

CI: Confidence Interval, WHO: World Health Organization

## 8. Ethics approval and consent to participate

Not be applied

## 9. Competing interests

The authors declare that no competing interests exist.

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## 11. Authors' contributions

All authors contributed to the design of the research. ZKH, EG, and GM collected the data. ZKH, and EG conducted analysis and interpretation of data. All authors drafted the first version. ZKH, EG and GM edited the first draft. All authors reviewed, commented and approved the final draft.

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## References

1. Alvarado-Esquivel C, Sablon E, Martinez-Garcia S, Estrada-Martínez S. 2005 Hepatitis virus and HIV infections in inmates of a state correctional facility in Mexico. *Epidemiology & Infection* **133**, 679–685.
2. A A, K A, and OT. 2015 Hepatitis B Virus Infection: Characteristics of Patients, Frequency and Significance of Viral Markers. *Journal of Hepatitis Research*. **2**, 1021.
3. Lavanchy D. 2004 Hepatitis B virus epidemiology, disease burden, treatment, and current and emerging prevention and control measures. *Journal of viral hepatitis* **11**, 97–107.
4. Ali SA, Donahue RM, Qureshi H, Vermund SH. 2009 Hepatitis B and hepatitis C in Pakistan: prevalence and risk factors. *International journal of infectious diseases* **13**, 9–19.
5. Bwogi J, Braka F, Makumbi I, Mishra V, Bakamutumaho B, Nanyunja M, Opio A, Downing R, Biryahwaho B, Lewis RF. 2009 Hepatitis B infection is highly endemic in Uganda: findings from a national serosurvey. *African health sciences* **9**.
6. Martinot-Peignoux M, Boyer N, Colombat M, Akremi R, Pham BN, Ollivier S, Castelnau C, Valla D, Degott C, Marcellin P. 2002 Serum hepatitis B virus DNA levels and liver histology in inactive HBsAg carriers. *Journal of hepatology* **36**, 543–546.

7. Gripon P, Rumin S, Urban S, Seyec JL, Glaise D, Cannie I, Guyomard C, Lucas J, Trepo C, Guguen-Guillouzo C. 2002 Infection of a human hepatoma cell line by hepatitis B virus. *Proceedings of the National Academy of Sciences* **99**, 15655–15660.
8. Kaffashian A, Nokhodian Z, Kassaian N, Babak A, Yaran M, Shoaie P, Ataei B, Adibi P. 2011 The Experience of Hepatitis C Screening among Prison Inmates with Drug Injection History. *Journal of Isfahan Medical School* **28**.
9. Antonio SESDC, Afzal GM. 2005 Economic burden of hepatitis C in Canada and the potential impact of prevention. *Eur J Health Econom* **6**, 159–165.
10. Hoya PSDL, Marco A, García-Guerrero J, and AR. 2011 Hepatitis C and B prevalence in Spanish prisons. *European journal of clinical microbiology & infectious diseases* **30**, 857–862.
11. Stief ACF, Martins RMB, de Andrade SMO, Pompilio MA, Fernandes SM, Murat PG, Mousquer GJ, Teles SA, Camolez GR, Francisco RBL. 2010 Seroprevalence of hepatitis B virus infection and associated factors among prison inmates in state of Mato Grosso do Sul, Brazil. *Revista da Sociedade Brasileira de Medicina Tropical* **43**, 512–515.
12. Seal DW. 2005 HIV-related issues and concerns for imprisoned persons throughout the world. *Current Opinion in Psychiatry* **18**, 530–535.
13. Saadany SE, Coyle D, Giulivi A, Afzal M. 2005 Economic burden of hepatitis C in Canada and the potential impact of prevention. *The European Journal of Health Economics* **6**, 159–165.
14. Macalino GE, Vlahov D, Sanford-Colby S, Patel S, Sabin K, Salas C, Rich JD. 2004 Prevalence and incidence of HIV, hepatitis B virus, and hepatitis C virus infections among males in Rhode Island prisons. *American journal of public health* **94**, 1218–1223.
15. Allen SA, Rich JD, Schwartzapfel B, Friedmann PD. 2003 Hepatitis C among offenders-correctional challenge and public health opportunity. *Fed. Probation* **67**, 22.
16. Adjei AA, Armah HB, Gbagbo F, Ampofo WK, Quaye IK, Hesse IF, Mensah G. 2006 Prevalence of human immunodeficiency virus, hepatitis B virus, hepatitis C virus and syphilis among prison inmates and officers at Nsawam and Accra, Ghana. *Journal of medical microbiology* **55**, 593–597.
17. Gates JA, Post JJ, Kaldor JM, Pan Y, Haber PS, Lloyd AR, Dolan KA. 2004 Risk factors for hepatitis C infection and perception of antibody status among male prison inmates in the Hepatitis C Incidence and Transmission in Prisons Study cohort, Australia. *Journal of urban health* **81**, 448–452.
18. Lai SW, Chang WL, Peng CY, Liao KF. 2007 Viral hepatitis among male amphetamine-inhaling abusers. *Internal medicine journal* **37**, 472–477.
19. Bautista-Arredondo S, González A, Servan-Mori E, Beynon F, Juarez-Figueroa L, Conde-Glez CJ, Gras N, Sierra-Madero J, Lopez-Ridauro R, Volkow P. 2015 A cross-sectional study of prisoners in Mexico City comparing prevalence of transmissible infections and chronic diseases with that in the general population. *PLoS one* **10**, e0131718.
20. Macalino GE, Vlahov D, Dickinson BP, Schwartzapfel B, Rich JD. 2005 Community incidence of hepatitis B and C among reincarcerated women. *Clinical infectious diseases* **41**, 998–1002.
21. Dana D, Zary N, Peyman A, Behrooz A. 2013 Risk prison and hepatitis B virus infection among inmates with history of drug injection in Isfahan, Iran. *The Scientific World Journal* **2013**.
22. Azbel L, Wickersham JA, Grishaev Y, Dvoryak S, Altice FL. 2013 Burden of infectious diseases, substance use disorders, and mental illness among Ukrainian prisoners transitioning to the community. *PLoS one* **8**, e59643.
23. Azbel L, Wickersham JA, Wegman MP, Polonsky M, Suleymanov M, Ismayilov R, Dvoryak S, Rotberga S, Altice FL. 2015 Burden of substance use disorders, mental illness, and correlates of infectious diseases among soon-to-be released prisoners in Azerbaijan. *Drug & Alcohol Dependence* **151**, 68–75.
24. Butler T, Boonwaat L, Hailstone S, Falconer T, Lems P, Ginley T, Read V, Smith N, Levy M, Dore G et al.. 2007 The 2004 Australian prison entrants' blood-borne virus and risk behaviour survey. *Australian and New Zealand journal of public health* **31**, 44–50.
25. Adjei AA, Armah HB, Gbagbo F, Ampofo WK, Quaye IK, Hesse IF, Mensah G. 2007 Correlates of hepatitis C virus infection among incarcerated Ghanaians: a national multicentre study. *Journal of medical microbiology* **56**, 391–397.
26. Babudieri S, Longo B, Sarmati L, Starnini G, Dori L, Suligoi B, Carbonara S, Monarca R, Quercia G, Florenzano G et al.. 2005 Correlates of HIV, HBV, and HCV infections in a prison inmate population: results from a multicentre study in Italy. *Journal of medical virology* **76**, 311–317.

27. Adjei AA, Armah HB, Gbagbo F, Ampofo WK, Boamah I, Adu-Gyamfi C, Asare I, Hesse IF, Mensah G. 2008 Correlates of HIV, HBV, HCV and syphilis infections among prison inmates and officers in Ghana: A national multicenter study. *BMC infectious diseases* **8**, 1.
28. Barros LAS, Pessoni GC, Teles SA, de Souza SMB, de Matos MA, Martins RMB, Del-Rios NHA, de Matos MAD, dos Santos Carneiro MA. 2013 Epidemiology of the viral hepatitis B and C in female prisoners of Metropolitan Regional Prison Complex in the State of Goiás, Central Brazil. *Revista da Sociedade Brasileira de Medicina Tropical* **46**, 24–29.
29. Zohreh A, Gholamreza S. 2010 Evaluation of the prevalence of hepatitis B, hepatitis C, and HIV in inmates with drug-related convictions in Birjand, Iran in 2008. *Hepatitis monthly* **2010**, 26–30.
30. Amin-Esmaeili M, Rahimi-Movaghar A, Razaghi E, Razaghi EM, Baghestani A, Baghestani AR, Jafari S. 2012 Factors correlated with hepatitis C and B virus infections among injecting drug users in Tehran, IR Iran. *Hepatitis monthly* **12**, 23–31.
31. Roux P, Sagaon-Teyssier L, Lions C, Fugon L, Verger P, Carrieri MP. 2014 HCV seropositivity in inmates and in the general population: an averaging approach to establish priority prevention interventions. *BMJ open* **4**, e005694.
32. Kirwan P, Evans B, and LB. 2011 Hepatitis C and B testing in English prisons is low but increasing. *Journal of Public Health* **33**, 197–204.
33. Falquetto TC, Endringer DC, de Andrade TU, Lenz D. 2013 Hepatitis C in prisoners and non-prisoners in Colatina, Espírito Santo, Brazil. *Brazilian Journal of Pharmaceutical Sciences* **49**, 737–744.
34. Kaffashian A, Nokhodian Z, Kassaian N, Babak A, Yaran M, Shoaie P, Ataei B, Adibi P. 2011 The Experience of Hepatitis C Screening among Prison Inmates with Drug Injection History. *Journal of Isfahan Medical School* **28**.
35. Fox RK, Currie SL, Evans J, Wright TL, Tobler L, Phelps B, Busch MP, Page-Shafer KA. 2005 Hepatitis C virus infection among prisoners in the California state correctional system. *Clinical Infectious Diseases* **41**, 177–186.
36. Nelwan EJ, Crevel RV, Alisjahbana B, Indrati AK, Dwiyanita RF, Nuralam N, Pohan HT, Jaya I, Meheus A, Ven AVD. 2010 Human immunodeficiency virus, hepatitis B and hepatitis C in an Indonesian prison: prevalence, risk factors and implications of HIV screening. *Tropical Medicine & International Health* **15**, 1491–1498.
37. Macalino GE, Vlahov D, Dickinson BP, Schwartzapfel B, Rich JD. 2005 Community incidence of hepatitis B and C among reincarcerated women. *Clinical infectious diseases* **41**, 998–1002.
38. Adoga MP, Banwat EB, Forbi JC, Nimzing L, Pam CR, Gyar SD, Agabi YA, Agwale SM. 2009 Human immunodeficiency virus, hepatitis B virus and hepatitis C virus: sero-prevalence, co-infection and risk factors among prison inmates in Nasarawa State, Nigeria. *The Journal of Infection in Developing Countries* **3**, 539–547.
39. Maerawati IE, Carvalho HB. 2015 Prevalence and risk factors associated with HIV infection, hepatitis and syphilis in a state prison of Sao Paulo. *International journal of STD & AIDS* **26**, 120–127.
40. Taylor A, Munro A, Allen E, Dunleavy K, Cameron S, Miller L, Hickman M. 2013 Low incidence of hepatitis C virus among prisoners in Scotland. *Addiction* **108**, 1296–1304.
41. Miller ER, Hellard ME, Bowden S, Bharadwaj M, Aitken CK. 2009 Markers and risk factors for HCV, HBV and HIV in a network of injecting drug users in Melbourne, Australia. *Journal of infection* **58**, 375–382.
42. Prasetyo AA, Dirgahayu P, Sari Y, Hudiyo H, Kageyama S. 2013 Molecular epidemiology of HIV, HBV, HCV, and HTLV-1/2 in drug abuser inmates in central Javan prisons, Indonesia. *The Journal of Infection in Developing Countries* **7**, 453–467.
43. Alvarez KJ, Befus M, Herzig CT, Larson E. 2014 Prevalence and correlates of hepatitis C virus infection among inmates at two New York State correctional facilities. *Journal of infection and public health* **7**, 517–521.
44. Lin CF, Twu SJ, Chen PH, Cheng JS, Wang JD. 2010 Prevalence and Determinants of Hepatitis B Antigenemia in 15 007 Inmates in Taiwan. *Journal of epidemiology* **20**, 231–236.
45. Brandolini M, Novati S, Silvestri AD, Tinelli C, Patrino SFA, Ranieri R, Seminari E. 2013 Prevalence and epidemiological correlates and treatment outcome of HCV infection in an Italian prison setting. *BMC public health* **13**, 1.
46. Pompilio MA, Pontes E, Castro A, Andrade SMO, Stief ACF, Martins RMB, Mousquer GJ, Murat PG, Francisco RBL, Pompilio SAL. 2011 Prevalence and epidemiology of chronic



- hepatitis C among prisoners of Mato Grosso do Sul State, Brazil. *Journal of Venomous Animals and Toxins including Tropical Diseases* **17**, 216–222.
47. Salem F, Hekmat S, Aghasadeghi MR, Javadi F, Gholami H, Mostafavi E. 2013 Prevalence and Risk Factors of Hepatitis B Virus Genotype D Amongst Inmates in Alborz Province, Iran: A Cross-Sectional Survey. *Jundishapur Journal of Microbiology* **6**.
  48. Zary N, MohammadReza Y, Majid Y, Parisa S, Mina M, Anahita B, Mehdi A. 2012 Prevalence and risk factors of HIV, syphilis, hepatitis B and C among female prisoners in Isfahan, Iran. *Hepatitis monthly* **2012**, 442–447.
  49. Mahfoud Z, Kassak K, Kreidieh K, Shamra S, Ramia S. 2010 Prevalence of antibodies to human immunodeficiency virus (HIV), hepatitis B and hepatitis C and risk factors in prisoners in Lebanon. *The Journal of Infection in Developing Countries* **4**, 144–149.
  50. da Rosa F, Carneiro M, Duro LN, de Moura Valim AR, Reuter CP, Burgos MS, Possuelo L. 2012 Prevalence of anti-HCV in an inmate population. *Revista da Associação Médica Brasileira* **58**, 557–560.
  51. Miller ER, Bi P, Ryan P. 2006 The prevalence of HCV antibody in South Australian prisoners. *Journal of Infection* **53**, 125–130.
  52. Kolaric B, Stajduhar D, Gajnik D, Rukavina T, Wiessing L. 2010 Seroprevalence of blood-borne infections and population sizes estimates in a population of injecting drug users in Croatia. *Central European journal of public health* **18**, 104.
  53. Kazi AM, Shah SA, Jenkins CA, Shepherd BE, Vermund SH. 2010 Risk factors and prevalence of tuberculosis, human immunodeficiency virus, syphilis, hepatitis B virus, and hepatitis C virus among prisoners in Pakistan. *International Journal of Infectious Diseases* **14**, e60–e66.
  54. Adjei AA, Armah HB, Gbagbo F, Ampofo WK, Quaye IK, Hesse IF, Mensah G. 2006 Prevalence of human immunodeficiency virus, hepatitis B virus, hepatitis C virus and syphilis among prison inmates and officers at Nsawam and Accra, Ghana. *Journal of medical microbiology* **55**, 593–597.
  55. Gilles M, Swingler E, Craven C, Larson A. 2008 Prison health and public health responses at a regional prison in Western Australia. *Australian and New Zealand journal of public health* **32**, 549–553.
  56. Jovanovska T, Kocic B, Stojcevska VP. 2014 Prevalence, Attitudes and Knowledge about HIV, HBV and HCV Infections among Inmates in Prisons Prilep and Bitola-a Pilot Study. *Collegium antropologicum* **38**, 417–422.
  57. Semaille C, Strat YL, Chiron E, Chemlal K, Valantin MA, Serre P, Caté L, Barbier C, Jauffret-Roustide M. 2013 Prevalence of human immunodeficiency virus and hepatitis C virus among French prison inmates in 2010: a challenge for public health policy. *Euro Surveill* **18**, 20524.
  58. Ziaee M, Sharifzadeh G, Namaee MH, Fereidouni M. 2014 Prevalence of HIV and Hepatitis B, C, D Infections and Their Associated Risk Factors among Prisoners in Southern Khorasan Province, Iran. *Iranian journal of public health* **43**, 229.
  59. Ghasemian R, Najafi N, Amir Khanloo K. 2011 The study of infections due to injection drug abuse in the injecting drug users hospitalized at Imam Khomeini Hospital in Sari and Razi Hospital in Ghaemshahr in 2007-2009. *Journal of Mazandaran University of Medical Sciences* **21**, 9–15.
  60. Miller ER, Hellard ME, Bowden S, Bharadwaj M, Aitken CK. 2009 Markers and risk factors for HCV, HBV and HIV in a network of injecting drug users in Melbourne, Australia. *Journal of infection* **58**, 375–382.
  61. Schoener EP, Hopper JA, Pierre JD. 2002 Injection drug use in North America. *Infectious disease clinics of North America* **16**, 535–551.