










## BRIEF REPORT

## PREVALENCE OF RETROVIRUS, HEPATITIS B AND D INFECTION IN THE MATSÉS ETHNIC GROUP IN LORETO, PERU

César Cabezas <sup>1,2,a</sup>, Omar Trujillo <sup>2,c</sup>, Johanna Balbuena <sup>2,b</sup>, Luis Marin <sup>2,d</sup>, Magna Suárez <sup>2,b</sup>, Max Themme <sup>3,c</sup>, Hugo Rodriguez <sup>3,c</sup>, Pedro Valencia <sup>2,a</sup>, Luis Crispin-Huamani <sup>2,4,c</sup>

<sup>1</sup> Centro Nacional de Salud Pública, Instituto Nacional de Salud, Lima, Perú.

<sup>2</sup> Facultad de Medicina Humana, Universidad Nacional Mayor de San Marcos, Lima, Perú.

<sup>3</sup> Dirección Regional de Salud de Loreto, Perú.

<sup>4</sup> Asociación para el Desarrollo de la Investigación Estudiantil en Ciencias de la Salud, Universidad Nacional Mayor de San Marcos, Lima, Perú.

<sup>a</sup> Specialist in Infectious and Tropical Diseases; <sup>b</sup> Biologist; <sup>c</sup> Physician; <sup>d</sup> Medical Technologist

## ABSTRACT

Observational, cross-sectional, populational study to determine the prevalence of infection by hepatitis B virus (HBV), hepatitis D virus (HDV), human immunodeficiency virus (HIV) and human T-lymphotropic virus type 1 and 2 (HTLV-1/2) in the Matsés ethnic group, after immunization against HBV. ELISA and qPCR tests were used in 963 residents. The prevalence of HBsAg, Anti-HBc and Anti-HBs was 3.32%, 36.03% and 58.67% respectively. In 3.1% of the population the viral load was greater than 2000 IU/mL. In children under 10 years, the prevalence of HBsAg and anti-HBc was 0.0% and 2.6%, respectively, while protective antibodies were found in 94.4%. The prevalence of HIV and HTLV-1/2 infection was 1.5% and 0.6%, respectively. It is therefore concluded that there are low rates of HBV and HDV infection in the Matsés child population. Likewise, the presence of HIV and HTLV-1/2 infection is confirmed.

**Keywords:** Hepatitis B; Immunization; HIV; HTLV; Indigenous Population (source: MeSH NLM).

## INTRODUCTION

Infection by hepatitis B and D virus (HBV and HDV) is known to be endemic in several regions worldwide <sup>(1)</sup>, mainly in Africa <sup>(2)</sup>. Although South America is considered to have low endemicity, there are indigenous communities in the Peruvian Amazon <sup>(6)</sup> and also in Brazil, Colombia and Venezuela which have a high prevalence of this type of infection <sup>(3-5)</sup>.

HBV co-infections with retroviruses such as human immunodeficiency virus (HIV) and human T-cell lymphotropic virus (HTLV) types 1 and 2, further complicate the prevention and control of these infections <sup>(7)</sup>. Especially in rural areas with poor access to health services, such as the indigenous Amazonian communities <sup>(8)</sup>. Prevalence values of 5.9% and 3.8% of HTLV-1 and HTLV-2 infections, respectively, have also been described in these communities <sup>(9,10)</sup>. Although these infections can negatively influence in the survival of these communities, there is already an HBV vaccination program that has shown a decrease of cases presenting the disease, mainly in the infant population <sup>(11)</sup>.

In this context, it is necessary to understand the current situation of HBV and HDV infections (preventable by vaccination), and HIV and HTLV-1/2 infections in indigenous populations of the Peruvian Amazon. Similar studies have been conducted in other countries of the Amazonian region, such as Colombia and Venezuela <sup>(12,13)</sup>.

**Citation:** Cabezas C, Trujillo O, Balbuena J, Marin L, Suárez M, Themme M, *et al.* Prevalence of retrovirus, hepatitis B and D infection in the matsés ethnic group in Loreto, Peru. *Rev Peru Med Exp Salud Publica.* 2020;37(2):259-64. doi: <https://doi.org/10.17843/rpmesp.2020.372.4696>

**Correspondence to:** César Cabezas Sánchez; [ccabezas@ins.gob.pe](mailto:ccabezas@ins.gob.pe)

**Received:** 24/07/2019  
**Approved:** 06/05/2020  
**Online:** 01/06/2020

Therefore, the objective of this study was to determine the prevalence of HBV, HDV, HIV and HTLV-1/2 infection in the Matsés ethnic group, an indigenous population residing in the Peruvian Amazon.

## THE STUDY

### Population and sample size

Cross-sectional and population-based study was carried out on the 14 indigenous communities of the Matsés ethnic group, located in the basins of Yavari, Yaquerana, Gálvez and the Chobayacu stream, in the district of Yaquerana, province of Requena, region of Loreto (Figure 1). According to the 2007 census of the National Institute of Statistics and Information (INEI), the estimated population was 1,724 people. Health personnel visited these communities during 2012 for data collection.

All the inhabitants who were in their homes during the visits were included in the study. No sample was calculated beforehand, as the intention was to include the entire indigenous population, considering both sexes and all age groups. Health personnel confidentially applied a structured epidemiological survey in each inhabitant's home, which collected information on personal history (sex, age, date of birth, origin) and immunization status registered in the individual's vaccination card. Translators were present to ensure that the questions were understood.

Chronic HBV infection was considered when HBsAg (hepatitis B surface antigen) and anti-HBc (antibody to

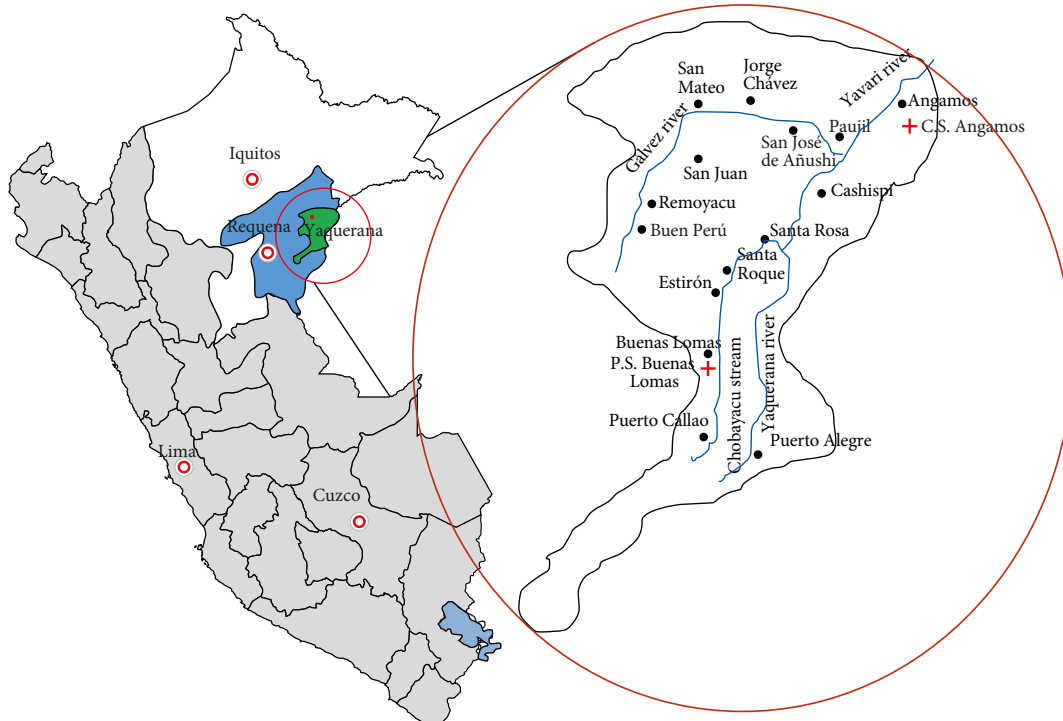
## KEY MESSAGES

**Motivation for the study:** Indigenous populations of the Peruvian Amazon could still have high rates of infection by the hepatitis B and D viruses, despite immunization.

**Main findings:** The prevalence of HBsAg, total anti-HBc and anti-HBs was 3.3%, 36.0% and 58.7%, respectively, with HBsAg and anti-HBc being higher in the adult population. In children under 10, the prevalence of HBsAg and anti-HBc was 0.0% and 2.6% respectively, while 94.4% were found to have protective antibodies.

**Implications:** There is need to perform culturally appropriate interventions to control and timely diagnose infectious diseases in the indigenous population.

hepatitis B core antigen) were positive and anti-HBc-IgM was negative. Past infection was considered when, anti-HBc and anti-HBs (antibody to HBsAg) were positive and HBsAg was negative. Acute infection, when HBsAg and anti-HBc-IgM were positive. Patient was considered susceptible, when HBsAg, anti-HBc and anti-HBs were negative. If only anti-HBs was positive, it was considered a protective condition. The levels of anti-HBs  $\geq 10$  mUI/mL were also considered protective.



**Figure 1.** Geographical location of the Matsés ethnic group in the Peruvian Amazon.

## Laboratory tests

Blood samples of 10 mL were obtained from inhabitants over 6 years old, and 5 mL from those under 6 years old. These samples were processed at the National Reference Laboratory of Hepatitis and HIV of the Instituto Nacional de Salud (INS acronym in Spanish). The ELISA technique was used to determine the serological markers of HBV, HDV, HIV and HTLV-1/2.

The HBsAg, anti-HBc, and anti-HBs (BioElisa) markers were evaluated for HBV infection. HBsAg-positive samples were tested for HBeAg and anti-HBc-IgM (Wantai), and anti-HBc-positive samples were tested for anti-HDV-IgM and anti-HDV-IgG (Wantai). All tests were performed in the ELISA cleaner and reader (Robonik). The viral load of participants with chronic HBV infection was determined by the quantitative real-time polymerase chain reaction (qPCR) method using the COBAS® TaqMan® HBV Test-High Pure System (Roche) kits on the Cobas TaqMan 48 thermal cycler, with a lower detection limit of 29 IU/mL. ELISA (BioElisa) and LIA (Immunogenetic) tests were used to determine HIV and HTLV-1/2 infection.

## Statistical analysis

The statistical analysis was performed using Stata 14.0 (College Station, Texas) for Windows. The prevalence of HBV, HDV, HIV, and HTLV-1/2 was calculated in indigenous populations by age, sex, and origin, as well as with 95% confidence intervals (95% CI).

## Ethical considerations

Collective informed consent was obtained from the representative indigenous regional organizations and the highest authorities (Apus), and individual informed consent was obtained from the Matsés people, and an informed assent from children over 6 years of age. The study protocol was approved by the INS Ethics and Research Committee. At the end of the laboratory tests the results were given to the community and to the participants of the study.

## FINDINGS

A total of 963 blood samples were obtained. The average age of the population was 23 years old (ranging from 1 to 80) and 52.1% were women. Children under 5 accounted for 11.7% (102/871) and children under 10 accounted for 26.75% (233/871).

The prevalence of HBsAg, anti-HBc and anti-HBs was 3.3% (n=32), 36.0% (n=347) and 58.7%(n=565), respectively. Higher prevalence of HBsAg and anti-HBc was found

in adults aged 30-59 years. In children under 10, the prevalences of HBsAg and anti-HBc were 0.0% and 2.6% (6/233), respectively. Protective antibodies (anti-HBs) were found in 94.4% (220/233) of children under 10, all of whom did not have antibodies indicating past infection (anti-HBc) (Table 1).

From the participants, 3.0% (7/233) did not have protective antibodies or serological markers of past infection for hepatitis B; 0.4% (1/233) had HBV-HDV coinfection; and 3.3% (n=32) had chronic HBV infection. All participants tested negative for HBeAg. Only 1/32 (3.1%) had an HBV viral load was greater than 2000 IU/mL in chronic carriers. Only 3.2% (31/963) had HBV-HDV coinfection.

The prevalences of HIV infection and HTLV-1/2 were 1.5% (12/806) and 0.6% (5/806), respectively. Prevalence of HTLV-1/2 in men was 1.1% (4/368) and HIV prevalence in children under 10 years old was 2.7% (6/220). Those infected with HIV were over 2 years old, while those infected with HTLV-1/2 were over 21 years old. The prevalence by sex and age, as well as the results of markers of HIV infection and HTLV-1/2 in the total population studied are shown in Table 2.

As for coinfections, 0.5% (4/806) had HBV-HIV coinfection, and 0.4% (3/808) had HBV-HTLV-1/2 coinfection. While for those who had HBV infection, HDV, HIV, and HTLV-1/2 coinfections were found in 8.9% (31/347), 1.4% (4/285), and 1.0% (3/286), respectively.

History of HBV vaccination, referred by mothers of children under 5 years of age with a vaccination card, was 33.0% (9/27).

## DISCUSSION

Hepatitis virus infections, as well as their consequences, have always been a concern in Amazon communities such as the Matsés, located between Brazil and Peru. The findings of this study are encouraging when comparing the prevalence obtained from the child population with other studies carried out in the area<sup>(14)</sup> and in other indigenous communities of the Peruvian Amazon<sup>(6)</sup>. The prevalence of infection in the Matsés is similar to that described in other Amazonian communities in Colombia and Venezuela, where a significant reduction in the rates of carriers and HBV infection are also observed<sup>(12,13)</sup>.

This study shows that 91.6% of children under 5 years of age have anti-HBs, which means they are in a protected condition, which is compatible with the absence of carriers and the very low rate of HBV infection in relation to the total population. This finding is consistent with what was described in an Amazon region of Colombia<sup>(15)</sup>, where 93% of the children were vaccinated, which explains the low rate of infection (3.6%) and the low percentage of chronic HBsAg carriers (0.5%), although no anti-HBs antibodies were determined in this study.

**Tabla 1.** Prevalence of markers for hepatitis B and D virus in the Matsés ethnic group, district of Yaquerana, province of Requena, department of Loreto, Peru, 2012

Groups	N (%)	HBsAg		Anti-HBc total		Anti-HBs in patients protected against VHB <sup>a</sup>		N (%)	VHD	
		Positives	Prevalence	Positives	Prevalence	Positives	Prevalence		Positives	Prevalence
		n (%)	95% CI	n (%)	95% CI	n (%)	95% CI		n (%)	95% CI
All participants	963 (100)	32 (3.3)	(2.3 - 4.6)	347 (36.0)	(33.0 - 39.2)	565 (58.7)	(55.5 - 61.8)	335 (100)	31 (9.2)	(6.4 - 12.9)
Gender	502 (52.1)	15 (3.0)	(1.7 - 4.9)	177 (35.3)	(31.1 - 39.7)	301 (59.9)	(55.5 - 64.3)	170 (50.7)	12 (7.1)	(3.7 - 12.0)
Female	461 (47.9)	17(3.7)	(2.16 - 5.84)	170 (36.9)	(32.4 - 41.4)	264 (57.3)	(52.6 - 61.8)	165 (49.2)	19 (11.5)	(7.1 - 17.4)
Age group (years) <sup>b</sup>										
From 0 to 10	259 (29.1)	0 (0.0)	(0.0 - 0.0)	6 (2.3)	(0.8 - 4.9)	245 (94.6)	(91.1 - 97.0)	5 (1.6)	1 (0.2)	(0.5 - 71.6)
From 11 to 18	176 (19.8)	3 (1.7)	(0.3 - 4.9)	14 (7.9)	(4.4 - 12.9)	158 (89.8)	(84.3 - 93.8)	14 (4.6)	1 (7.1)	(0.2 - 33.9)
From 19 to 29	175(19.7)	10 (5.7)	(2.8 - 10.3)	85 (48.6)	(40.9 - 56.2)	73 (41.7)	(34.3 - 49.4)	83 (27.2)	14 (16.9)	(9.5 - 26.7)
From 30 to 59	251 (28.2)	17 (6.8)	(3.9 - 10.6)	184 (73.3)	(67.4 - 78.7)	55 (21.9)	(16.9 - 27.5)	179 (58.7)	14 (7.8)	(4.3 - 12.8)
Over 60	29 (3.3)	2 (6.9)	(0.8 - 22.8)	25 (86.2)	(68.3 - 96.1)	3 (10.3)	(2.2 - 27.3)	24 (7.9)	0 (0.0)	(0.0 - 0.0)
Under 5 years										
Yes	102 (11.7)	0 (0.0)	(0.0 - 0.0)	3 (2.8)	(0.6 - 7.9)	98 (91.6)	(84.6 - 96.1)	2 (0.7)	1 (50.0)	(1.3 - 98.7)
No	769 (88.3)	32 (4.2)	(2.9 - 5.8)	311 (40.4)	(36.9 - 44.0)	432 (56.1)	(52.6 - 59.7)	303 (99.3)	29 (9.6)	(6.5 - 13.5)
River basin <sup>c</sup>										
Yavari	481 (50.1)	14 (2.9)	(1.6 - 4.8)	208 (43.2)	(38.8 - 47.8)	252 (52.3)	(47.8 - 56.9)	29 (8.7)	3 (10.3)	(2.2 - 27.4)
Gálvez	68 (7.1)	4 (5.9)	(1.6 - 14.4)	29 (42.6)	(30.7 - 55.2)	33 (48.5)	(36.2 - 60.9)	52 (15.6)	4 (7.7)	(2.1 - 18.5)
Yaquerana	165 (17.2)	7 (4.2)	(1.7 - 8.5)	53 (32.1)	(25.1 - 39.8)	107 (64.8)	(57.0 - 72.1)	53 (15.9)	6 (11.3)	(4.3 - 23.0)
Chobayacu stream	248 (25.8)	7 (2.8)	(1.1 - 5.7)	56 (22.6)	(17.5 - 28.3)	173 (69.8)	(63.6 - 75.4)	200 (59.9)	18 (9.0)	(5.4 - 13.8)

<sup>a</sup> It corresponds to 565 participants (HBsAg=negative, anti-HBc=negative, anti-HBs=positive).

<sup>b</sup> The age group report was obtained from 871 participants.

<sup>c</sup> Basin reports were obtained from 962 participants.

The prevalence of HDV infection in HBsAg-positive cases was 9.3%, which would be related to the decrease in HBV carriers in response to immunization. A similar result was observed in a study in Tunisia<sup>(16)</sup>.

The prevalence of HIV in this ethnic group was 1.5%; however, prevalence of 2.9% and 2.3% were found in children under 10 and under 5, respectively. These findings are higher than the 0.7% found by Bartlett *et al.*<sup>(14)</sup> in Yurimaguas and the 0.16% found by Ormaeche *et al.* However, a prevalence of 7.5% has been found in the Chayahuita people of the Peruvian Amazon<sup>(18)</sup>.

This study found a 0.5% HBV-HIV coinfection and a 0.4% HBV-HTLV coinfection prevalence, which is less than the 7.0% HBV-HIV coinfection observed by Matthews *et al.* in African communities<sup>(19)</sup>.

A HTLV-1/2 infection prevalence of 0.6% was found in the Matsés ethnic group, lower than the one found in the Shipibo-Konibo communities of the Peruvian Amazon, where Blas *et al.*<sup>(10)</sup> found a prevalence of 9.7%. Thus, our findings are similar to the 1.5% prevalence observed by Medot *et al.* in communities of the Peruvian Amazon<sup>(9)</sup> and to the 0.8% found by Bittencourt *et al.* in Brazil<sup>(20)</sup>.

History of HBV vaccination was found in 33.0% of the children under 5 years old. Nonetheless, if we take into account the results regarding the presence of protective anti-HBs antibodies and the low prevalence of infection markers, the data found is not consistent with the serological results, which represent the best evidence of both protection and infection status. This was described by Fiestas *et al.*, who showed that the information on vaccination coverage obtained from the Demographic and Family Health Survey is not consistent with the levels of protection against measles, rubella and HVB<sup>(21)</sup>.

Some limitations of the study should be mentioned. First, the population studied represented 57% of the estimated population, because at the time of the intervention many people were not at home. Second, no study was conducted prior to the immunization program, which would have served to objectively assess a more accurate variation. And third, the lack of accurate information on vaccination coverage limits the final estimate, although HBV serological markers provide information on the infection status of the study population.

**Table 2.** HIV and HTLV-1/2 prevalence in the Matsés ethnic group, district of Yaquerana, province of Requena, department of Loreto, Peru, 2012

Groups	N (%)	VIH <sup>b</sup>		HTLV-1/2 <sup>c</sup>		
		Positive	Prevalence	N (%)	Positive	Prevalence
		n (%)	95% CI		n (%)	95% CI
All participants	806 (100)	12 (1.5)	(0.8 - 2.6)	807 (100)	5 (0.6)	(0.2 - 1.4)
Female	439 (54.5)	7 (1.6)	(0.6 - 3.3)	439 (54.5)	1 (0.2)	(0.0 - 1.3)
Male	367 (45.5)	5 (1.4)	(0.4 - 3.1)	368 (45.5)	4 (1.1)	(0.3 - 2.8)
Age group (years) <sup>a</sup>						
From 0 to 10	220 (29.1)	6 (2.7)	(1.0 - 5.8)	221 (27.8)	0 (0.0)	(0.0 - 0.0)
From 11 to 18	141 (18.6)	0 (0.0)	(0.0 - 0.0)	141 (18.1)	0 (0.0)	(0.0 - 0.0)
From 19 to 29	156 (20.6)	2 (1.3)	(0.2 - 4.5)	156 (19.3)	2 (1.3)	(0.2 - 4.5)
From 30 to 59	216 (28.6)	4 (1.8)	(0.5 - 4.7)	217 (26.9)	3 (1.4)	(0.3 - 4.0)
≥ 60	23 (3.0)	0 (0.0)	(0.0 - 0.0)	23 (2.8)	0 (0.0)	(0.0 - 0.0)
River basin <sup>b</sup>						
Yavarí	352 (43.7)	10 (2.8)	(1.4 - 5.2)	354 (43.9)	4 (1.1)	(0.3 - 2.9)
Gálvez	68 (8.4)	0.0	(0.0 - 0.0)	68 (8.4)	0 (0.0)	(0.0 - 0.0)
Yaquerana	138 (17.1)	1 (0.7)	(0.0 - 4.0)	138 (17.1)	1 (0.7)	(0.0 - 3.9)
Quebrada Chobayacu	247 (30.7)	1 (0.4)	(0.0 - 2.2)	247 (30.6)	0 (0.0)	(0.0 - 0.0)

<sup>a</sup> The age group report was obtained from 756 volunteer participants.

<sup>b</sup> The river basin report was obtained from 805 volunteer participants.

<sup>c</sup> The river basin report was obtained from 807 volunteer participants.

In conclusion, the prevalences of HBV and HDV infection were 3.3% and 9.3%, respectively, in the Matsés ethnic group. In addition, 94.6% of children under 10 years old are protected by anti-HBs, the latter may be related to previous immunization. The presence of HIV and HTLV 1/2 infection has been confirmed, which is a risk for the same ethnic group and for other groups on the Peruvian-Brazilian border, and it is necessary to adopt culturally appropriate interventions in order to make a timely diagnosis, to provide antiretroviral treatment, to monitor cases and to take preventive measures. Qualitative studies on sexual and risk behaviors should be conducted so that the interventions de-

veloped have a better chance of success, in addition to continuing HBV immunization programs.

**Authors' contributions:** CC conceived and designed the study. CC, OT, JB, LM, MS, MT, HR and PV contributed to the information gathering and writing of the article. CC and LCH provided critical review of the article. OT, JB and LM analyzed and interpreted data, and provided statistical advice. MS, MT, HR, and PV contributed to patient information or study material, funding, and technical or administrative advice. CC, OT, JB, LM, MS, MT, HR, PV and LCH approved the final version of the article.

**Funding:** National Institute of Health of Peru.

**Conflicts of Interest:** The authors have no conflict of interest to declare.

## REFERENCES

- World Health Organization. Global hepatitis report, 2017 [Internet]. Geneva: Department of HIV and Global Hepatitis Programme of the World Health Organization, WHO; 2017 (cited on November 6, 2019). Available at: <http://apps.who.int/iris/bitstream/10665/255016/1/9789241565455-eng.pdf?ua=1>.
- Musa BM, Bussell S, Borodo MM, Samaila AA, Femi OL. Prevalence of hepatitis B virus infection in Nigeria, 2000-2013: a systematic review and meta-analysis. *Niger J Clin Pract.* 2015;18(2):163-72. doi: 10.4103/1119-3077.151035.
- Dutra F. Distribution of hepatitis B infection in Brazil: the epidemiological situation at the beginning of the 21st century. *Revista da Sociedade Brasileira de Medicina Tropical.* 2016;49(1):11-23. doi: 10.1590/0037-8682-0176-2015.
- di Filippo Villa D, Cortes-Mancera F, Payares E, Montes N, de la Hoz E, Arbelaez MP, *et al.* Hepatitis D virus and hepatitis B virus infection in Amerindian communities of the Amazonas state, Colombia. *Virology.* 2015;52:172. doi: 10.1186/s12985-015-0402-5.
- Graham S, Guy RJ, Cowie B, Wand H, Donovan B, Akre S, *et al.* Chronic hepatitis B prevalence among Aboriginal and Torres Strait Islander Australians since universal vaccination: a systematic review and meta-analysis. *BMC Infect Dis.* 2013;13:403. doi: 10.1186/1471-2334-13-403.
- Cabezas C, Suarez M, Romero G, Carrillo C, García M, Reátegui J, *et al.* Hiperendemicidad de hepatitis viral B y Delta en pueblos indígenas de la Amazonía Peruana. *Rev Peru Med Exp Salud Publica.* 2006;23(2):114-22.
- Alves da Costa C, Okamura L. Molecular epidemiology of hepatitis B virus among the indigenous population of the Curuçá and Itaquai Rivers, Javari Valley, State of Amazonas, Brazil. *Rev Soc Bras Med Trop.* 2012;45(4):457-62. doi: 10.1590/s0037-86822012000400008.
- Kourtis A, Bulterys M, Hu D, Jamieson D. HIV-HBV coinfection—a global challenge. *N Engl J Med.* 2012;366(19):1749-52. doi: 10.1056/NEJMp1201796.

9. Medeot S, Nates S, Recalde A, Gallego S, Maturano E, Giordano M, *et al.* Prevalence of antibody to human T cell lymphotropic virus types 1/2 among aboriginal groups inhabiting northern Argentina and the Amazon region of Peru. *Am J Trop Med Hyg.* 1999;60(4):623-629. doi: 10.4269/ajtmh.1999.60.623.
10. Blas MM, Alva IE, García PJ, Carcamo C, Montano SM, Mori N, *et al.* High prevalence of human T-lymphotropic virus infection in indigenous women from the Peruvian Amazon. *PLoS ONE.* 2013;8(9):e73978. doi: 10.1371/journal.pone.0073978.
11. Cabezas-Sánchez C, Trujillo-Villaruel O, Zavaleta-Cortijo C, Cullqui-Lévano D, Suarez-Jara M, Cueva-Maza N, *et al.* Prevalencia de la infección por el virus de hepatitis B en niños menores de 5 años de comunidades indígenas de la Amazonía peruana posterior a intervenciones mediante inmunización. *Rev Peru Med Exp Salud Publica.* 2014;31(2):204-10.
12. De la Hoz F, Perez L, de Neira M, Hall AJ. Eight years of hepatitis B vaccination in Colombia with a recombinant vaccine: factors influencing hepatitis B virus infection and effectiveness. *Int J Infect Dis.* 2008;12(2):183-189. doi: 10.1016/j.ijid.2007.06.010.
13. Blanco RY, Loureiro CL, Villalba JA, Sulbarán YF, Maes M, de Waard JH, *et al.* Decreasing prevalence of Hepatitis B and absence of Hepatitis C Virus infection in the Warao indigenous population of Venezuela. *PLoS One.* 2018;13(5):e0197662. doi: 10.1371/journal.pone.0197662.
14. Bartlett E, Zavaleta C, Fernández C, Razuri H, Vilcarromero S, Vernund S, *et al.* Expansion of HIV and syphilis into the Peruvian Amazon: a survey of four communities of an indigenous Amazonian ethnic group. *Int J Infect Dis.* 2008;12(6):e89–e94. doi: 10.1016/j.ijid.2008.03.036.
15. Garcia D, Porras A, Rico A, Alvis N, Navas MC, De La Hoz F, *et al.* Hepatitis B infection control in Colombian Amazon after 15 years of hepatitis B vaccination. Effectiveness of birth dose and current prevalence. *Vaccine.* 2018;36(19):2721-2726. doi: 10.1016/j.vaccine.2017.11.004.
16. Yacoubi L, Brichler S, Mansour W, Le Gal F, Hammami W, Sadraoui A, *et al.* Molecular epidemiology of hepatitis B and Delta virus strains that spread in the Mediterranean North East Coast of Tunisia. *J Clin Virol.* 2015;72:126-32. doi: 10.1016/j.jcv.2015.10.002.
17. Ormaeche M, Whittombury A, Pun M, Suarez-Ognio L. Hepatitis B virus, syphilis, and HIV seroprevalence in pregnant women and their male partners from six indigenous populations of the Peruvian Amazon Basin, 2007-2008. *Int J Infect Dis.* 2012;16(10):e724-30. doi: 10.1016/j.ijid.2012.05.1032.
18. Zavaleta C, Fernández C, Konda K, Valderrama Y, Vermund S, Gotuzzo E. High prevalence of HIV and syphilis in a remote native community of the Peruvian Amazon. *Am J Trop Med Hyg.* 2007 Apr;76(4):703-5.
19. Matthews PC, Beloukas A, Malik A, Carlson JM, Jooste P, Ogwu A, *et al.* Prevalence and Characteristics of Hepatitis B Virus (HBV) Coinfection among HIV-Positive Women in South Africa and Botswana. *PLoS ONE.* 2015;10(7): e0134037. doi: 10.1371/journal.pone.0134037.
20. Bittencourt A, Dourado I, Filho P, Santos M, Valadão E, Alcantara L, *et al.* Human T-cell lymphotropic virus type 1 infection among pregnant women in northeastern Brazil. *J Acquir Immune Defic Syndr.* 2001;26(5):490-4. doi: 10.1097/00126334-200104150-00016.
21. Fiestas Solórzano V, Gonzáles Noriega M, Fiestas F, Cabezudo E, Suárez M, Suárez V. Evaluación de la seroprotección contra sarampión, rubéola y hepatitis B en niños menores de cinco años del Perú, 2011. *Rev Peru Med Exp Salud Publica.* 2012;29(4):437-43.