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Spatial analysis of vaccination against Hepatitis B in pregnant women in an urban Brazilian area

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Abstract *The objective of this article is to analyze the spatial distribution of Hepatitis B vaccine (HBVAC) of pregnant women. This is a cross-sectional study carried with 266 puerperae. The HBVAC record was obtained through the prenatal care booklet. The spatial scanning technique was used to detect a cluster of risk for the presence or absence of an HBVAC record. After this cluster identification, the individual and environmental variables were compared between the Coverage Areas of Basic Health Units (CAs-BHUs). The mean prevalence of non-HBVAC was 88.34%. Scan spatial scan analysis observed a cluster of a high prevalence of puerperae with a HBVAC record. Comparative analyses have shown that paid work and the number of prenatal visits are positively associated with an HBVAC record. Given the above, this work brings a reflection on possible disparities with other CAs-BHUs, besides the influence of the environmental perspective. It should be emphasized that the vaccination situation is influenced not only by factors intrinsic to the individuals. However, in this study, the results indicate that individual variables are predominantly mandatory in the decision of HBVAC uptake among pregnant women.*

Key words *Hepatitis B, Pregnant women, Vaccination, Spatial analysis, Women's Health*

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Introduction

Hepatitis B virus (HBV) infection is one of the major global health problems[1,2]. In 2015, the worldwide prevalence of HBV infection was 3.5%[2]. The World Health Organization (WHO) note that approximately 257 million people are living with HBV infection and 25.3% (65 million) of women of reproductive age are chronically infected[2]. It is noteworthy that infected women of childbearing age can transmit HBV to their babies[3].

Pregnant women and their concepts are the population group with the highest risk of complications due to vaccine-preventable and potentially fatal diseases[4] because, during the pregnancy-puerperal cycle, women undergo immunological and physiological changes typical of this period, which predispose pregnant women to the highest susceptibility to infections[5].

In this context, immunization programs contribute to improved quality of life of pregnant women and an increased world life expectancy due to the reduction, control, or eradication of some vaccine-preventable diseases[6]. It is emphasized that hepatitis B (recombinant) vaccine (HBVAC) is the most effective way to prevent hepatitis B virus infection[7].

In March 2012, the Strategic Advisory Group of Experts (SAGE) established a task force that sought to understand the determinants of the vaccination[8]. The group developed a model organized in three main realms: 1. Contextual influences - historical, socio-cultural, environmental, health system/institutional, economic, or political factors; 2. Individual and group influences - arising from the personal perception of the vaccine or influences of the social environment; and 3. Specific issues of vaccines and directly related to their characteristics or the vaccination process[8]. The vaccine situation is, therefore influenced by factors extrinsic to individuals. Contextual (environmental) factors are also responsible for the success (or not) of immunization[9,10]. In the context of vaccination, lower economic and socio-cultural levels are associated with lower vaccine coverage[11]. However, in the emerging world scenario, there is a growing hesitation to vaccinate people with high economic and cultural conditions, which is a public health problem[10,12].

The georeferencing of health outcomes becomes relevant in the analysis and evaluation of risks to collective health since it incorporates variables related to the environment and the socioeconomic profile of a given population[13]. The use of spatial analysis techniques, streamlined through the georeferencing process, has been widely used in public health, since it allows the identification of possible critical nodes in the propagation of a specific problem, defined in time and specific geographic locations, and understanding certain episodes of diseases or illnesses, and predict and plan actions for more assertive future interventions[14].

In the context of gestation, few studies use spatial analysis to verify the spatial distribution of cases of absence of registration and vaccination record of Hepatitis B in pregnant women. Given the above, this study aimed to analyze the spatial distribution of HBVAC in pregnant women in a Brazilian urban area.

Methods

This is a cross-sectional study developed with data from the research: "Born in Belo Horizonte: Delivery and birth survey", which adopted the same criteria of the national survey entitled "Born in Brazil: Delivery and birth survey"[15]. Data were collected from November 2011 to March 2013 and included the puerperae attended in seven maternities that attend the public health network and four maternity hospitals that serve the supplementary health network in Belo Horizonte, Minas Gerais, Brazil.

This study included all the women admitted to the maternity units selected for the delivery, who had a pregnant woman's booklet at the time of admission and were residents of Belo Horizonte. The final sample consisted of 266 puerperae.

Research data were collected through an interview with the puerperae at least 6 hours after delivery – this time was preset as the minimum interval defined for postpartum rest – and a record of labor and delivery of these women. This stage was carried out with the help of a standardized questionnaire with identification, sociodemographic, life habits, nutritional information, clinical and obstetric history variables, as well as variables related to the health insurance. Also, during the hospital stay, pictures were taken of the puerperae's prenatal care booklets, which contained data of the vaccination of pregnant women, such as vaccines applied, number of doses and serological tests. It should be emphasized that all stages of data collection were performed by previously trained nurses.

For this study, information about the vaccination of the puerperae or the record of only one

dose of the HBVAC present in the prenatal care booklet was used as an indirect measure of the immunization of pregnant women and considered as an outcome variable.

Geographical coordinates (latitude and longitude) were assigned to each of these addresses from the residence address of study participants, and they were allocated to the Geographic Information Systems (GIS). This process allowed the accurate georeferencing of the puerperae in the Belo Horizonte area, as well as the organization of the environmental variables by Area of Coverage of the Primary Healthcare Facility (CAs-BHUs). It should be emphasized that the physical and social environment of the puerperae was defined by the CAs-BHUs principle because it was inferred that residing in these CAs-BHUs means having similar characteristics of the social and physical environment.

The contextual variables were characterized by elaborating a geocoded base with the environmental data selected through literature review[8], to which the individual data of each participant of the sample were incorporated. These data were georeferenced from the address and ZIP code of the place, obtained from several commercial and governmental sources, such as: Integrated Social Protection Information Center (CINDS) of the Military Police of Minas Gerais, Brazilian Institute of Geography and Statistics (IBGE), Municipal Health Secretariat (SMS) and IT and Information Company of the Municipality of Belo Horizonte S/A (PRODABEL).

The geoprocessing of the environmental variables was based on the addresses of the census tracts and then gathered by the CAs-BHUs of Belo Horizonte. The contextual variables refer to the constructed environment (population density of CAs-BHUs) and social environment (CAs-BHUs crime rate and CAs-BHUs mean Health Vulnerability Index (HVI)).

The crime rate was generated from data including rape, racketeering through kidnapping, homicide, robbery, kidnapping and private jail.

Concerning the IVS, this is a synthetic indicator based on socioeconomic and demographic and basic sanitation characteristics from the Brazilian Institute of Geography and Statistics (IBGE). Thus, it evaluates the vulnerability of the city of Belo Horizonte spatially in four indices, as follows: low health vulnerability area, medium health vulnerability area, high health vulnerability area and very high health vulnerability area[16].

The ggmap package in R, version 3.4.3 was used for the address geocoding process. The identification of the CAs-BHUs from the puerperae was given through the QGIS program version 2.18.14. The population was described with statistical package Statistical Software for Professional (Stata), version 14.0.

Firstly, a description of the study population was made and the estimates were shown in proportions (%), with a 95% confidence interval (95%CI). Concerning the quantitative variables, after verifying asymmetry through the Shapiro-Wilk test, data were shown through the median and interquartile range (IQ).

Coroplast maps were built to verify the spatial distribution of the prevalence of absence of vaccine records.

The Kernel technique was employed to identify areas of higher concentration of absence of registration and vaccination record of Hepatitis B in pregnant women. The Kernel map allows estimating the number of events per unit area in each cell of a regular grid that covers the studied region. A Kernel map was generated for the absence of record and another for hepatitis B vaccine record in pregnant women through Normal Estimation method (Quadratic, Gaussian) and bandwidth size or radius was set at 800 meters for both maps. The QGIS program version 2.18.14 was used for this analytical procedure.

The spatial scanning technique was used[17] to detect the cluster of risk for the presence of records HBVAC in the puerperae's prenatal care booklets. Such a technique is based on the maximum likelihood ratio between the areas. Thus, a risk conglomerate is a group of events, limited geographically, in concentration and size, and of distinct risk[18]. Thus, the null hypothesis of this technique is the spatial randomness of the cases.

The significance level adopted was α=0.05 and the analyses were performed using the Software for the spatial, Temporal and Space-time scan statistics (SaTScan), version 9.2.

After the identification of the cluster, the cluster of the presence of HBVAC record and the other CAs-BHUs were compared among the environmental variables, using the Mann-Whitney test. The comparative analysis of socioeconomic and obstetric characteristics was used to verify possible differences between the puerperae belonging to the cluster of the presence of HBVAC records and the other CAs-BHUs. Fisher's exact test for categorical variables and the Mann-Whitney test for continuous variables were used for comparison, considering a significance level of 5%.

Statistical Software for Professional (Stata), version 14.0 was used to analyze data. A signifi-

cance level of $\alpha<0.05$ was considered for all analytical procedures.

The research regarding "Vaccination of pregnant women: evaluation of epidemiological and clinical aspects in the city of Belo Horizonte" was approved by the Ethics Committee of the Federal University of Minas Gerais.

Results

The final sample consisted of 266 puerperae. Table 1 shows the sociodemographic and obstetric profile. The median age was 27.5 years (IQ 23-32). When analyzing the sociodemographic profile of the puerperae, 69.17% lived with a partner, 49.63% had completed secondary school, and 53.75% had some paid work. Regarding the obstetric history, 58.64% were not primiparous, and 62.17% did not have pre-pregnancy abortions at the time of the study. The median gestational age at delivery was 39 weeks (IQ 38-40) (Table 1).

The mean prevalence of HBVAC non-recording was 88.34%, varying among CAs-BHUs. Figure 1 shows the prevalence of the absence of records of HBVAC per CAs-BHUs. Apparent homogeneous distribution of the absence of records of HBVAC was observed as per the 115 CAs-BHUs, ranging from 0.0 to 100.00%. The darker red areas show a higher concentration of puerperae without the record of HBVAC in the pregnant women's booklet.

Figure 2 shows the kernel maps of absence and presence of HBVAC records in the pregnant women's booklets. A preliminary analysis evidenced that the probability of density for the absence of HBVAC records shows a higher non-recording prevalence for suburban regions of Belo Horizonte. The density probability map for the presence of HBVAC revealed a higher prevalence of cases in more distant and more central areas of Belo Horizonte.

The Scan spatial analysis is shown in Figure 3. A cluster of a high prevalence of puerperae with the HBVAC record in their booklets was observed, with significant evidence (p=0.014). It was emphasized that Scan scanning analysis was performed for non-recording of HBVAC and no statistically significant cluster was found.

The cluster of high prevalence for HBVAC recording has a radius of 2,008.1 meters, with 83.3% of cases of HBVAC records in the pregnant women's booklets and a relative risk of 8.33, showing the probability of finding a puerpera with an HBVAC record in the cluster is 8.33 times more likely compared to areas outside the cluster (Table 2).

A comparative analysis of the environmental variables among the cluster of HBVAC records in the booklets evidenced no differences for the environmental variables. This aspect showed that, possibly, the environmental variables available in this study could not explain the differences between the cluster and other CAs-BHUs (Table 3).

Finally, comparative analyses of the individual characteristics and the cluster of HBVAC records in the booklets were carried out. There was a difference between paid work and the number of prenatal care visits (Table 4).

Table 1. Sociodemographic and obstetric profile of the puerperal sample. Belo Horizonte, 2011-2013.

	n (%)	95%CI
Socioeconomic profile		
Age*	27.5(23-32)	
Marital status		
Living with a partner	184(69.17)	63.32-74.46
Not living with a partner	82(30.83)	25.53-36.67
Schooling**		
Primary school	90(33.83)	28.36-39.77
Secondary school	132(49.62)	43.61-55.64
Higher education	44(16.54)	12.52-21.53
Self-reported skin color		
White	76(28.57)	23.43-34.33
Non-white***	190(71.43)	65.66-76.56
Paid work		
No	123(46.24)	40.29-52.29
Yes	143(53.76)	47.70-49.70
Obstetric profile		
Number of prenatal care visits*	9(7-10)	
Primiparous		
Yes	110(41.35)	35.54-47.40
No	156(58.65)	52.59-64.45
Abortion***		
No	97(62.18)	54.23-69.51
Yes	59(37.82)	30.48-45.76
Gestational age at delivery	39(38-40)	

Notes: *Median (IQ); **Non-white includes Black, Yellow, Oriental, Indigenous, Brown and Dark; ***Abortion in previous gestations.

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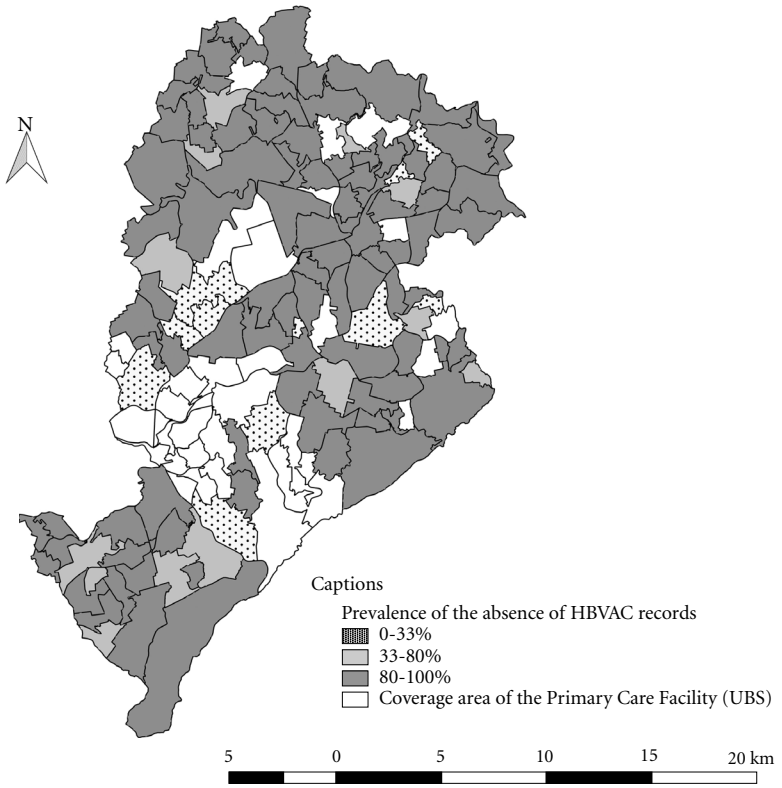

Figure 1. Spatial distribution of non-registration prevalence for (recombinant) HBVAC (%) by AA-UBS of the UBS. Belo Horizonte, 2011-2013.

Source: Elaborated for this study.

Discussion

This study analyzed the spatial distribution of HBVAC in pregnant women in Belo Horizonte and found that the prevalence of non-registration and, consequently, non-vaccination for Hepatitis B virus was 88.34%, showing low adherence by pregnant women to HBVAC. The low adherence to HBVAC is similar to that found in other studies[19-21]. In Brazil, work performed with adolescent pregnant women in Pará showed that 70.4% had not received HBVAC[22]. However, a study carried out with pregnant women from São Paulo, and that considered more than one vaccine – besides HBVAC – found a vaccination rate of 68.4%[23].

It is known that HBVAC is the most effective method for the prevention of Hepatitis B infection[7]. Therefore, it is necessary to increase the immunization coverage of the pregnant population in order to increase vaccination coverage rates for this population. Vaccination should be a practice incorporated in the daily life of health units and is a priority, effective and strategic Primary Health Care (PHC) action[23].

Two main organizational factors of PHC can influence vaccination coverage: the health system (vaccination policy) and the structuring level of vaccine-related activities (training of providers and service organization). However, individual factors cannot be suppressed from the vaccination decision-making process[24].

In this study, an apparent homogeneous distribution of the absence of HBVAC records among the CAs-BHUs. Despite the assurance of universal access by the National Immunization Program (PNI), vaccination coverage is still below that recommended by the WHO (95% for the maintenance of eradication, elimination or control of vaccine-preventable diseases)[25], suggesting that certain groups remain with low vaccine coverage possibly due to similar individual and environmental characteristics.

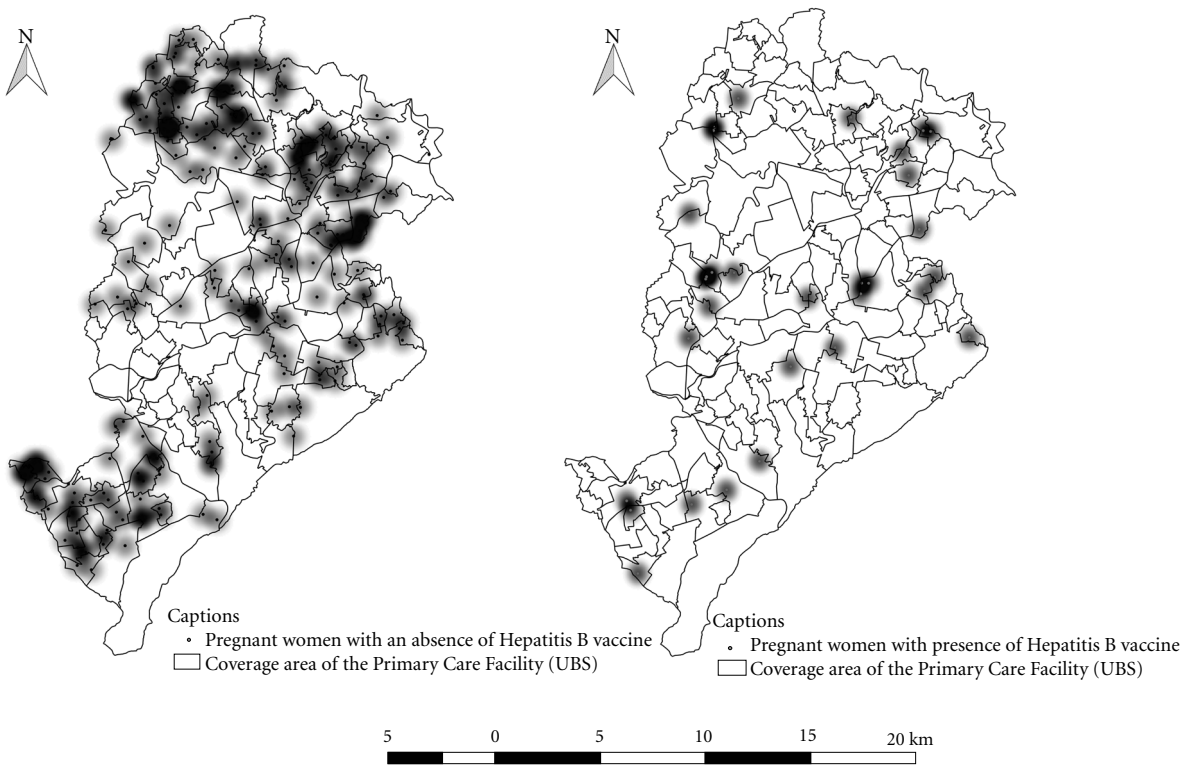

Figure 2. Estimation of the Kernel density of absence and presence of records in the booklet of pregnant women for HBVAC. Belo Horizonte, 2011-2013.

Source: Elaborated for this study.

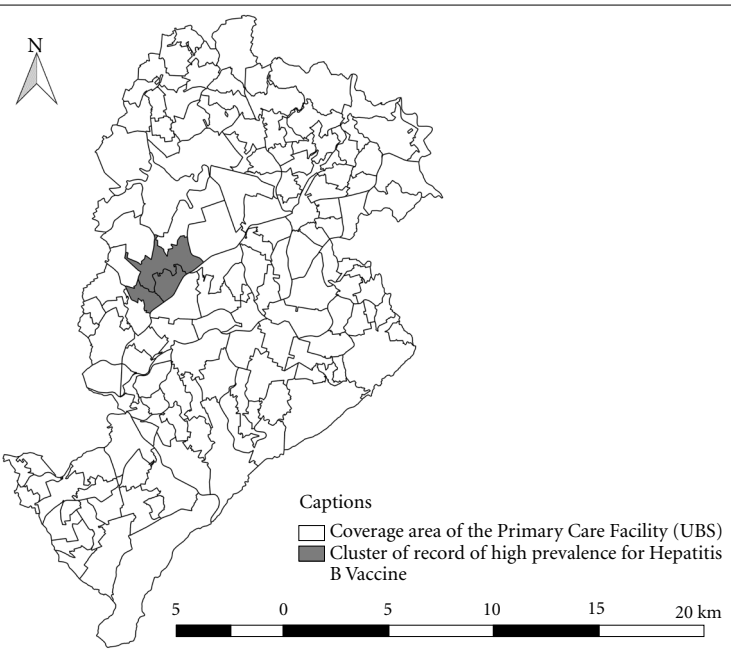

Figure 3. Spatial analysis of the cases of the presence of records in the booklets of pregnant women for the HBVAC. Belo Horizonte, 2011-2013.

Source: Elaborated for this study.

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The probability of density for the absence of HBVAC records was more significant in regions distant from the urban centers. SAGE defines that hesitancy to vaccinate may be due to geographical barriers and distance of the health center from the dwelling place (or hampered access to the health care facility)[8]. A study has shown that population shifts and insecurity may partially explain the hesitancy of vaccines due to the geographical barrier imposed by urban insecurity[26]. However, it should be pointed out that even in the face of vaccination coverage lower than that recommended by the WHO, the PNI has achieved advances in vaccination coverage, since it decentralizes its vaccine-related actions, establishes a partnership and participation of state and municipal managers, with a consequent impact in the epidemiological situation of vaccine-preventable diseases[27].

Table 2. Profile for the high prevalence cluster for the record of (recombinant) HBVAC in pregnant women's booklets. Belo Horizonte, 2011-2013.

	High prevalence cluster
	Record of HBVAC
Range (m)	2,008.10
Nº of people in the cluster	6
% of cases	83.3
Nº of covered areas	3
Relative Risk	8.33
p-value	**0.014**

Notes: p-value<0.05 in bold.

Concerning the individual factors, it was observed that among the pregnant women residing in the cluster of HBVAC records, all of them performed some paid work, showing that such an individual characteristic influences of HBVAC records. Some paid work is positively associated with the early initiation of prenatal visits and a higher number of prenatal visits, resulting in a higher likelihood of maternal immunization[28], since it facilitates the early identification of interventions required by professionals[29].

Another individual factor that was associated with the pregnant women living in the cluster of booklets with HBVAC records was to perform a more significant number of prenatal visits when compared to the pregnant women living in the other CAs-BHUs. It should be emphasized that the median number of prenatal visits of women in this study was above that recommended by the WHO, which is a minimum of eight[30]. However, it is necessary to go beyond the numerical values of the visits during the gestational period, as well as take into account the aspects related to the contents addressed in these visits, including attention and time spent and guidance to pregnant women by the health professionals[31]. The role of health professionals can influence women in their decisions about vaccination during pregnancy and the absence of vaccination recommendation by health professionals during prenatal care is one of the main reasons for non-vaccination[28,32,33]. It is assumed that it is the task of all members of the PHC team, and primarily the prenatal care provider, to check the vaccination status of the pregnant women and, if necessary, update or initiate the vaccination schedule[34].

Table 3. Description of the environmental characteristics, by clusters of absence and presence of records in the booklets of pregnant women for VCHB. Belo Horizonte, 2011-2013.

Environmental variables	Recombinant vaccine against Hepatitis B virus		p-value
	Other coverage areas	Cluster of the record	
	Median (IQ)	Median (IQ)	
Population density (inhabitants/km2)	9,454.867 (7,148.006 - 11,848.14)	8,311.669 (4,830.148 - 11,360.22)	0.563
Crime Rate*	10.94 (6.26 - 16.34)	8,81 (7,30 - 10,41)	0.629
Total Income**	9,498,225 (5,970,467 - 20,200,000)	8,442,414 (7,277,025 - 31,400,000)	0.759
HVI	0.253 (0.206 - 0.304)	0.256 (0.252 - 0.316)	0.521

Notes: Mann–Whitney Test. IQ - Interquartile Range; HVI - Health Vulnerability Index; *Crime rate per 10,000; **Monthly total nominal income of individuals aged 10 years or over of the AA-UBS of the UBS.
Source: Elaborated for the purpose of this study.

Table 4. Individual factors by clusters of absence and presence of record in the booklet of pregnant women for HBVAC. Belo Horizonte, 2011-2013.

Individual variables	Recombinant vaccine against Hepatitis B virus		p-value
	Other coverage areas	Cluster of the record	
	n (%)	n (%)	
Socioeconomic			
Age	27(22 – 32)	30(26 – 34)	0.295
Marital status			0.182
Living with a partner	178(68.46)	6(100)	
Not living with a partner	82(31.54)	0	
Schooling			0.754
Primary school	89(34.23)	1(16.67)	
Secondary school	128(49.23)	4(66.67)	
Higher education	43(16.54)	1(16.67)	
Self-reported skin color			1.000
White	47(28.46)	2(33.33)	
Non-white***	186(71.54)	4(66.67)	
Paid work			**0.032**
No	123(47.31)	0	
Yes	137(52.69)	6(100)	
Obstetric history			
Number of prenatal care visits*	9 (7 -10)	12 (11 -13)	**0.005**
Primiparous			0.406
Yes	109(41.92)	1(16.67)	
No	151(58.08)	5(83.33)	
Abortion***			1.000
No	94(62.25)	3(60.00)	
Yes	57(37.75)	2(40.00)	
Gestational age at delivery	39(38 – 40)	38.5 (38 – 39)	0.451

Notes: *Median (IQ). Mann-Whitney test. **Non-white includes Black, Yellow, Oriental, Indigenous, Brown and Dark; ***Abortion in previous gestations. Fisher's exact test. Values in bold show $p<0.05$.
Source: Elaborated for this study.

It should be noted that the environmental variables available in this study did not show a statistical difference between clusters.

In this particular case, the lack of statistical significance could be explained by the limited number of environmental variables. Thus, more evidence would explain the factors associated with HBVAC if new variables were available for this particular site.

Finally, this study has some limitations, such as the fact that the georeferenced data of the environmental variables derive from governmental sources, and may be subject to inaccuracies. It should be noted that the data used were checked through other geocoding platforms to minimize such limitation. This study advances in the perspective of vaccination, since it detected a cluster of HBVAC records in the booklets, identifying geographical regions in Belo Horizonte that have a certain similarity.

Conclusion

Given the above, this work raises a reflection on the possible disparities with the other CAs-BHUs, besides the environmental perspective. Other evidence found in this study suggests that paid work and a higher number of visits are determining factors for more significant proportions of HBVAC record. It should be emphasized that the vaccination situation is influenced not only by individual factors. However, in this study, the results show that the individual variables are predominantly mandatory in the decision of the pregnant women to vaccinate.

Collaborations

TPR Silva participated in the research planning, statistical analysis, data interpretation, writing of the article, relevant critical review of the intellectual content and approval of the version to be published. CS Gomes and AS Carmo participated in the interpretation of the data, writing of the article, relevant critical review of the intellectual content and approval of the version to be published. LL Mendes, EM Rezende and G Velásquez-Meléndez participated in the writing of the article, relevant critical review of the intellectual content and approval of the version to be published. FP Matozinhos was responsible for the conception and design, supervision, writing of the article, critical review of the intellectual content and approval of the version to be published.

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