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Original Article

Infectious diseases during pregnancy in Brazil: seroprevalence and risk factors

Galileu Barbosa Costa[1,2 #], Mário Cézar de Oliveira[1,3 #], Sandra Rocha Gadelha[1], George Rego Albuquerque[4], Marcel Teixeira[5], Mônica Regina da Silva Raiol[1], Sandra Mara Bispo Sousa[1,6], Lauro Juliano Marin[1]

[1] Laboratório de Farmacogenômica e Epidemiologica Molecular, Departamento de Ciências Biológicas, Universidade Estadual de Santa Cruz, Ilhéus, Brazil
[2] Laboratório de Vírus, Departamento de Microbiologia, Instituto de Ciências Biológicas, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil
[3] Laboratório de Imunopatologia, Instituto de Ciências Biomédicas, Universidade Federal de Uberlândia, Uberlândia, Brazil
[4] Laboratório de Doenças Parasitárias, Departamento de Ciências Agrárias e Ambientais, Universidade Estadual de Santa Cruz, Ilhéus, Brazil
[5] Laboratório de Parasitologia, Embrapa Caprinos e Ovinos, Brasília, Brazil
[6] Departamento de Ciências Naturais, Universidade Estadual do Sudoeste da Bahia, Vitória da Conquista, Brazil

# Authors contributed equally to this work.

Abstract

Introduction: Vertically transmitted infections are caused by a diversity of pathogenic microorganisms. Pregnant women are routinely screened to evaluate the risks and reduce the burden of disorders in their unborn children. We assessed the prevalence and possible risk factors for Cytomegalovirus (CMV), Rubella, Human T lymphotropic virus (HTLV), and *Toxoplasma gondii* in pregnant women from the South region of Bahia State, Brazil.

Methodology: Serum samples were obtained from 726 pregnant women aged between 13 and 44 years, with a median age of 24 years. ELISA assays were used to detect CMV, Rubella, HTLV and *T. gondii* IgG and IgM antibodies.

Results: The prevalence rates of IgG antibodies found were 95.2% for CMV, 97.0% for Rubella, and 72.3% for *T. gondii*. Furthermore, the prevalence of HTLV-1/2 was 1.2%. IgM antibodies were reactive only for CMV (0.8%) and *T. gondii* (3.7%). Variables independently associated with the detection of anti-*T. gondii* IgG antibodies were white self-reported race/ethnicity (Odds Ratio [OR] 2.26, 95% CI 1.26–4.06, P = 0.006), wage income (OR 0.55, 95% CI 0.35–0.88, P = 0.013), and history of previous pregnancy (OR 1.60, 95% CI 1.02–2.50, P = 0.038).

Conclusions: This study highlights the importance of monitoring for infectious diseases during pregnancy and initiation of early interventions to reduce the burden of fetal losses and other important infant sequelae attributable to congenital infections.

Key words: Cytomegalovirus; Rubella; Human T lymphotropic virus; *Toxoplasma gondii*; pregnant women; public health.

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Introduction

Infectious diseases are the major cause of maternal and fetal morbidity and mortality [1–3]. The increased susceptibility of such population is mainly due to changes in immune function during pregnancy [4–6]. Infections can be transmitted to the neonate vertically through the placenta, perinatally from vaginal secretions and blood and also postnatally, via breast milk and other sources [4]. The clinical manifestations of neonatal diseases vary depending on the infectious agent and gestational age at the time of exposure. The risk of infection is usually inversely related to gestational age at acquisition, with early acquisition sometimes resulting in congenital malformation syndrome [7]. Although some infections are asymptomatic, many have been associated with spontaneous abortion, fetal death, preterm birth, intrauterine growth restriction and a range of other birth defects [1,3,8]. Well documented infectious causes of

these ailments include Cytomegalovirus (CMV), Rubella, and *Toxoplasma gondii*.

CMV infection often occurs during childhood and is one of the most frequently transmitted viruses during pregnancy [9,10]. After primary infection, CMV becomes latent, and can be reactivated in situations that compromise the immune system such as pregnancy. It has been reported that the risk of fetal damage is greater during primary infection, reactivation and reinfection during pregnancy [11–13]. Approximately 30–40% of primary maternal CMV infections result in transmission of virus to the fetus, which can result in symptomatic congenital disease [11–13].

Rubella is an important teratogenic virus and is a common childhood infection. Less severe cases may manifest as mild flu-like symptoms and rash. However, up to 90% of infants born from mothers who had the disease during the first 11 weeks of pregnancy develop Congenital Rubella Syndrome (CRS), presenting growth and mental retardation, cataracts, deafness, congenital organ defects, often affecting the heart [3,14].

Prevalence rates of *Toxoplasma gondii* infection in Brazilian pregnant women are very high in comparison with other parts of the world [15]. Infection with this protozoan parasite can cause severe illness when the organism is contracted congenitally or when it is reactivated in immune-suppressed individuals [15–19]. Approximately 35% of congenital toxoplasmosis is associated with neurological disease including hydrocephalus, microcephaly and mental retardation. Moreover, about 80% have ocular lesions and 40% of children have hearing loss [15].

Human T lymphotropic virus (HTLV-1/2) infection is transmitted during sexual intercourse, blood transfusion, sharing of contaminated needles and from mother to child especially through breastfeeding, although intrauterine and/or at the time of delivery contamination also occur [20,21]. Adult T cell leukemia/lymphoma (ATL), tropical spastic paraparesis or HTLV-1 associated myelopathy (TSP/HAM) and infective dermatitis have been linked to HTLV-1 infection [22,23]. Although several reports of neurological diseases TSP/HAM-like associated with HTLV-2 have been reported in the literature, HTLV-2 has not been definitively associated with any disease [24,25].

Although serological screening for the presence of or susceptibility to some of these infections is recommended, most women living in developing countries have no or limited access to healthcare services. In this scenario, it is important to investigate the prevalence and risks for pregnant women and their newborns for this at-risk group. Given the nature of the infectious agents mentioned above and the severity of the associated disorders, we aimed to investigate the seroprevalence and risk factors for these ailments in pregnant women from Southern Bahia, Brazil.

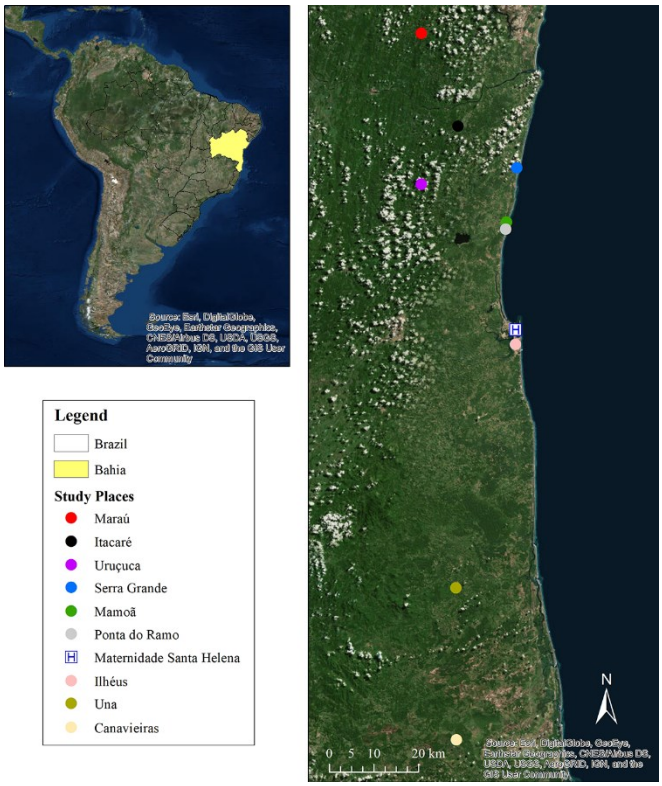
Methodology

Study area

A cross-sectional study was carried out during July 2009–2010 including a population of pregnant mothers who attended the women reference attention center (Maternidade Santa Helena) in Ilhéus city (14°49'33.7"S, 39°02'03.7"W), South region of Bahia State, Brazil (Figure 1). Ilhéus has a total of 176,341 inhabitants distributed in an area of 1.584,693 km^2. The city is located in the Southern mesoregion of Bahia State, covered with Atlantic rainforest, has the most extensive coast of the State, and is characterized by a humid tropical climate [26].

Regarding the healthcare system, Ilhéus has a total of 122 healthcare stations of which 66 are public as part

Figure 1. Overview of South America and Brazil highlighted in yellow (left). On the right, a map of South Bahia State. The pink dot marks in Ilhéus city (the location where this study was performed), and the H marks the women reference attention center (Maternidade Santa Helena). The other colored dots highlights the neighboring cities also attended by Maternidade Santa Helena (Google Earth, 2017).



of Unified Health System (SUS). Two healthcare stations have services relating to emergency care in obstetrics, including Maternidade Santa Helena (Figure 1) [26]. This women reference attention center provides care not only to Ilhéus city but also to other cities in South Bahia State, surrounding the Ilhéus area. The average number of deliveries range from 9 to 12 deliveries per day, reaching up to 380 deliveries per month, and about 90% of births are performed by SUS [26].

Study design

Blood samples were collected from pregnant women between the ages of 13 and 44 years, who voluntarily agreed to participate in the study. Serum samples were sent to the State Central Laboratory of Public Health and subjected to duplicate ELISA testing for the presence of IgM and IgG antibodies against CMV, Rubella, *T. gondii* and HTLV. The HTLV positive samples were confirmed by Western Blot (HTLV BLOT 2.4 – Abbott, Silver Spring, USA) and polymerase chain reaction (PCR).

All volunteers completed a structured questionnaire to obtain demographic data (age, self-reported race/ethnicity, monthly income, educational level, and marital status) and practices considered risk factors (alcohol consumption whilst pregnant, smoking, tattoos/piercings, intravenous drug use, and history of pregnancies). Other risk factors specifically related to *T. gondii* such as contact with dogs and cats, raw meat and non-treated water consumption, land manipulation and miscarriage were also evaluated. These data were converted to variables and tested for correlation to the presence or absence of outcomes for each pathogen evaluated.

Statistical analysis

To identify risk factors associated with each pathogen, a bivariate analysis was carried out using Chi-square and Fisher's exact tests with a significance level of 5% using EPI-INFO software version 7.2 (www.cdc.gov/epiinfo). All variables with $p \leq 0.2$ on bivariate analysis were subjected to collinearity analysis determined by the Spearman's rank correlation test according to BioEstat 5.0. Subsequently, multivariate logistic regression analysis was performed using EPI-INFO.

Ethical considerations

Ethical clearance was obtained from the Ethics Committee on Human Research of Universidade Estadual de Santa Cruz under protocol number 194/2008. Prior to data collection, the objectives of the study were explained to all study participants. Informed written consent was obtained from all study participants. In the case of minors (age < 18 years old), consent was provided by the parents or legal guardians.

Results

A total of 726 pregnant women were enrolled in this survey. Most women attended Maternidade Santa Helena are from Ilhéus city (77%) however, other participants are from neighboring cities such as Canavieiras, Itacaré, Maraú, Serra Grande, Una, and Uruçuca were also included (Figure 1). The prevalence of specific antibodies against CMV, Rubella, HTLV, and *Toxoplasma gondii* are presented in Table 1. Rubella had the highest IgG seroprevalence (97.0%), followed by anti-CMV IgG (95.2%) and anti-*T. gondii* IgG (72,3%). Furthermore, the seroprevalence for HTLV-1/2 was similar to that observed in the general Brazilian population. In contrast, a low seroprevalence rate of IgM antibodies was observed for *T. gondii* (3.7%) and CMV (0.8%), when compared to the general population.

Table 2 summarizes demographic characteristics of study population. Approximately 20% of pregnant women were teenagers (with a lower limit of 13 years old; n = 3). The self-reported race/ethnicity of pregnant women enrolled was diverse, with brown predominating (53.9%), and the majority living on minimum wage (61%). Most women had medium/high levels of education, and analphabetism was observed only in five. Marital status was stratified into two groups: married or living with a spouse (83.7%), and single/divorced/widowed (15.4%). Self-reported

Table 1. Prevalence rates of IgG and IgM antibodies for Cytomegalovirus (CMV), Rubella, Human T lymphotropic virus (HTLV) and *Toxoplasma gondii* in pregnant women from Southern Bahia State, Brazil.

Pathogen	N of screened women	IgG (%)	CI 95%	IgM (%)	CI 95%
CMV	589	561 (95.2)	93.1 – 96.8	5 (0.8)	0.3 – 2.1
Rubella	508	493 (97.0)	95.1 – 98.3	0	
HTLV-1/2	511	6 (1.2)	0.5 – 2.7	Not tested	
T. gondii	463	335 (72.3)	68.2 – 76.5	17 (3.7)	2.2 – 5.9

race/ethnicity and income wage were significantly associated with the presence of anti-*T. gondii* IgG antibodies (Table 2).

Behavioral characteristics reported by few women include the presence of tattoos/piercings (23.1%), alcohol consumption whilst pregnant (13.1%), smoking (5.9%), previous blood transfusion (4.5%), and intravenous drug use (0.6%), and most had reported a history of previous pregnancy (53.3%). These variables had no correlation with CMV, HTLV-1/2 and Rubella seropositivity. However, more than one pregnancy was associated to the presence of IgG anti-*T. gondii* (p = 0.015) (Table 3).

Previously established risk factors specific to *T. gondii* seropositivity are shown in Table 4. However, none of these factors were significantly associated with anti-*T. gondii* IgG or IgM antibodies in this study. Other variables that showed a significant difference between those with positive and negative serology were analyzed using the multivariate logistic regression model. Variables independently associated with the presence of IgG antibodies anti-*T. gondii* ($p < 0.05$) were self-reported race/ethnicity, history of previous pregnancy, and income (Table 5). Women who reported white self-reported race/ethnicity were 2.2 times more likely to possess anti-*T. gondii* IgG antibodies compared to other races (OR = 2.2; 95% CI = 1.26 – 4.06). Furthermore women who had a history of more than one pregnancy were 1.6 times more likely to possess anti-*T. gondii* IgG antibodies compared to those who reported their first pregnancy (OR = 1.6; 95% CI = 1.06 – 2.43). On the other hand, those pregnant women with an income > 1 minimum wage were less likely to possess anti-*T. gondii* IgG compared to those with an income < 1 minimum wage (OR = 0.55; 95% CI = 0.34 – 0.88).

Table 2. Analysis of demographic characteristics for 796 pregnant women attended at reference attention service from Southern Bahia State, Brazil, 2009-2010, according to the seropositivity for Rubella, Cytomegalovirus (CMV), Human T lymphotropic virus (HTLV) and *Toxoplasma gondii* IgG antibodies.

Demographics	Rubella (n tested women = 508)†			CMV (n tested women = 589)†			HTLV (n of tested women = 511)†			*T. gondii* (n of tested women = 463)†		
	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value
Age (years)												
≤ 18	97 (19,1)	5 (0,9)	0.163	109 (18.5)	5 (0.8)	0.534	1 (0.2)	105 (20.5)	0.637	57 (12.3)	29 (6.2)	0.102
> 19	396 (78,0)	10 (1,9)		452 (76.7)	23 (3.9)		5 (0.9)	400 (78.3)		276 (59.6)	98 (21.1)	
Self-reported race/ethnicity												
White	72 (14,2)	1 (0,2)	0.924	83 (14.1)	2 (0.4)	0.547	0	78 (15.2)	0.860	33 (7.1)	28 (6.0)	**0.015**
Black	124 (24,4)	4 (0,8)		138 (23.4)	10 (1.6)		2 (0.4)	123 (24.1)		87 (18.8)	29 (6.2)	
Brown	283 (55,7)	8 (1,6)		321 (54.5)	16 (2.7)		4 (0.8)	288 (56.3)		202 (43.6)	69 (14.9)	
Yellow	3 (0,6)	0		4 (0.8)	0		0	3 (0.6)		2 (0.4)	0	
Native	8 (1,6)	0		10 (1.6)	0		0	6 (1.2)		5 (1.1)	1 (0.2)	
Income‡												
≤ minimum wage	287 (56,5)	9 (1,7)	0.272	329 (55.8)	18 (3.0)	0.560	4 (0.8)	312 (61.0)	0.545	212 (45.8)	68 (14.7)	**0.004***
> minimum wage	134 (23,8)	2 (0,4)		152 (25.8)	8 (1.3)		1 (0.2)	312 (61.0)		75 (16.2)	46 (9.9)	
Educational level┼												
Have never gone to school	3 (0,6)	1 (0,2)	0.433	11 (1.8)	1 (0.1)	0.282	0	3 (0.6)	0.08	4 (0.8)	1 (0.2)	0.106
Elementary school or less	234 (46,1)	5 (0,9)		266 (45.1)	11 (1.8)		5 (0.9)	230 (45.0)		154 (33.2)	51 (11.0)	
High school or more	249 (49,0)	7 (1,4)		284 (48.2)	6 (2.7)		1 (0.2)	261 (51.1)		170 (36.7)	75 (16.2)	
Marital status												
Married	70 (13,8)	1 (0,2)	0.434	480 (81.5)	24 (4.1)	0.223	0	77 (15.1)	0.370	60 (12.9)	21 (4.5)	0.396
Single/divorced/widow	423 (83,3)	10 (2,0)	0.434	80 (13.6)	2 (0.3)	0.223	6 (1.2)	426 (83.4)	0.370	270 (58.3)	106 (22.9)	

† Counts might not equal to sample size due to missing data; ‡ Minimum income value in Brazilian currency in 2009–2010 = R$ 510,00 (US$ 1,00 = R$ 1,81 approximately); ┼ Elementary school or less (≤8 years of study), High school or more (>8 years of study); * Odds Ratio: 1.91 (95% Confidence Interval: 1.17–3.02).

Table 3. Analysis of risk factors for 796 pregnant women attended at reference attention service from Southern Bahia State, Brazil, 2009–2010, according to the seropositivity for Rubella, Cytomegalovirus (CMV), Human T lymphotropic virus (HTLV) and *Toxoplasma gondii* IgG antibodies.

Demographics	Rubella (n tested women = 508)†			CMV (n tested women = 589)†			HTLV (n of tested women = 511)†			*T. gondii* (n of tested women = 463)†		
	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value	Positive n (%)	Negative n (%)	p value
Alcohol use												
Yes	72 (14.1)	2 (0.4)	0.589	80 (13.6)	4 (0.7)	0.586	1 (0.2)	61 (11.9)	0.544	43 (9.3)	13 (2.8)	0.262
No	421 (82.8)	11 (2.1)		480 (81.5)	24 (4.0)		5 (0.9)	440 (86.1)		288 (62.2)	114 (24.6)	
Smoking												
Yes	31 (6.1)	0	0.435	33 (5.6)	1 (0.1)	0.508	2 (0.4)	34 (6.6)	0.061	18 (3.9)	3 (0.6)	0.119
No	462 (90.9)	13 (2.5)		527 (89.4)	27 (4.6)		4 (0.8)	467 (91.4)		313 (67.6)	124 (26.8)	
Blood transfusion history												
Yes	22 (4.3)	0	0.556	25 (4.2)	2 (0.3)	0373	1 (0.2)	22 (4.3)	0.244	11 (2.3)	7 (1.5)	0.205
No	470 (92.5)	13 (2.5)		534 (90.6)	26 (4.4)		5 (0.9)	478 (93.5)		320 (69.1)	120 (25.9)	
Tattoo and/or piercing												
Yes	117 (23.0)	1 (0.2)	0.153	132 (22.4)	4 (0.7)	0.183	2 (0.4)	116 (22.7)	0.425	73 (15.7)	31 (6.7)	0.336
No	376 (76.0)	12 (2.3)		428 (72.6)	24 (4.0)		4 (0.8)	385 (75.3)		258 (55.7)	96 (20.7)	
Intravenous drug use												
Yes	2 (0.4)	0	0.948	4 (0.7)	0	0.820	0	2 (0.4)	0.976	1 (0.2)	0	1.000
No	487 (95.8)	13 (2.5)		551 (93.5)	28 (4.7)		6 (1.2)	493 (96.4)		326 (70.4)	125 (27.0)	
Pregnancies history												
1st	265 (52.1)	8 (1.6)	0.395	251 (42.6)	14 (2.3)	0.364	5 (0.9)	263 (51.4)	0.138	182 (39.3)	55 (11.9)	**0.015***
> 1	228 (44.9)	5 (0.9)		309 (52.4)	14 (2.3)		1 (0.2)	237 (43.8)		148 (31.9)	72 (15.5)	

† Counts might not equal to sample size due to missing data; * Odds Ratio = 1.61 (95% Confidence Interval = 1.06–2.43).

Table 4. Analysis of specific risk factors for *Toxoplasma gondii* for 352† pregnant women attended at reference attention service from Ilheus, Southern of Bahia State, Brazil, 2009–2010, according to the seropositivity for IgG antibodies.

Risk factors	N (%)	IgG positives (%)*	IgG negatives (%)**	Odds Ratio (CI95%)	P value
Contact with cats					
Yes	83 (23.6)	64 (77.1)	19 (22.9)	1.42 (0.80–2.53)	0.22
No	269 (76.4)	189 (70.2)	80 (29.8)		
Contact with dogs					
Yes	153 (43.4)	108 (70.6)	45 (29.4)	0.89 (0.56–1.42)	0.63
No	199 (56.6)	145 (72.8)	4 (27.2)		
Raw meat consumption					
Yes	24 (6.8)	14 (58.3)	10 (41.7)	0.52 (0.22–1.21)	0.20
No	328 (93.2)	239 (72.8)	89 (27.2)		
Non-treated water consumption					
Yes	61 (17.3)	48 (78.7)	13 (21.3)	1.56 (0.80–3.03)	0.21
No	289 (82.7)	203 (70.2)	86 (29.8)		
Land manipulation					
Yes	98 (27.8)	68 (69.4)	30 (30.6)	0.84 (0.50–1.42)	0.51
No	254 (78.2)	185 (72.8)	69 (27.2)		
Miscarriage history					
Yes	89 (25.3)	64 (71.9)	25 (28.1)	1.00 (0.58–1.71)	1.00
No	263 (74.7)	189 (71.8)	74 (28.2)		
Total	**352 (100.0)**	**253 (71.9)**	**99 (28.1)**		

† Counts were not equal to 463 sample size due to missing data; * Percent frequencies are shown by column; ** Percent frequencies are shown by row.

Table 5. Multivariate logistic regression for 796 pregnant women attended at reference attention service from Southern Bahia State, Brazil, 2009-2010, according to the seropositivity for *Toxoplasma gondii* IgG antibodies.

Variables	Odds Ratio	CI 95%		P value
White self-reported race/ethnicity				
Yes / No	2.2603	1.2577	4.0622	0.006
Wage				
> minimum / ≤ minimum	0.5542	0.3470	0.8852	0.013
Pregnancies history				
1st / > 1	1.6031	1.0242	2.5091	0.038

Discussion

Infectious diseases are a common cause of morbidity and mortality in developing countries. Poverty, low education, lack of basic infrastructure, certain lifestyles and environmental conditions are known risk factors for a high incidence of infectious diseases among specific groups such as pregnant women [1,3,8,27–29]. In fact, most obstetrical and neonatal populations in Brazil have limited access to healthcare assistance and diagnostic examinations in the public health system, and so the prevalence of important infectious diseases is frequently underestimated. Screening and early diagnosis of these infections in high-risk pregnant women will facilitate the early detection and appropriate management of these infections.

CMV is a widespread and very well known cause of congenital disorders in vertically infected children [10–12,30]. The overall seroprevalence of anti-CMV IgG antibodies was very high in this study (95.2%) when compared to other studies conducted in Mato Grosso do Sul State (82% [31]) and in Sergipe State (76.6% [32]). Serra et al [33] analyzed 4620 pregnant women from several Brazilian regions and found a global IgG seroprevalence of 84%, although in Bahia State the prevalence rate was 78.1%. Regarding anti-CMV IgM antibodies, we found 0.8% seropositivity in pregnant women, which is also considered high. Although these results indicate a low seroprevalence, they suggest a recent or active CMV infection, with a great risks of vertical transmission. The presence of CMV infection can cause serious outcomes for the fetus, especially in the first trimester of pregnancy, while most infected women are asymptomatic. Hence, the developing baby could be at risk of vertical transmission and potentially resulting in a number of pathologies including growth retardation, microcephaly, chorioretinitis and hepatosplenomegaly [9–12,30]. However, the IgM seroprevalence reported here may not be a true reflection of the number of active infections because IgM antibodies can only be detected 1-3 months after the primary infection [9–13]. Although previous studies have reported correlations between a high prevalence of anti-CMV antibodies and social characteristics such as poverty, low education, and certain behaviours, there was no statistical association between serology and these variables in this study.

Rubella is an exanthematous illness that occurs worldwide with a seasonal distribution. This virus can act as a teratogen, inducing Congenital Rubella Syndrome (CRS) especially when transmitted from mother to fetus in the first trimester of pregnancy [3,14]. The seroprevalence of IgG antibodies found here (Table 1) shows concordance with previous studies performed in Brazil [31,32,34,35] which demonstrated seroprevalence rates of 87.9%, 95%, 71.6% and 83.9%, respectively. In fact, the high levels of IgG antibodies detected are associated to the success of vaccination campaigns in women of fertile age. Although no IgM positive cases were found in this study, approximately 3% of pregnant women in this study were considered susceptible to infection (n = 15), which increases the risk of CRS in the subsequent pregnancies. Furthermore, it is possible that the immunization coverage is not complete in the studied region, so the prenatal screening is important to encourage vaccination postpartum in these specific cases.

In comparison to previous studies, the prevalence rate of HTLV-1/2 infection reported here (1.2%) is important [36–39]. Even though the prevalence in the city of Salvador is about 1.8% in the general population, others studies conducted with pregnant women showed a prevalence of between 0.84% and 0.88% in Salvador [40,41], and 0.98% in Cruz das Almas [42]. Vertical transmission is an important route of HTLV infection and children vertically infected can develop disorders such as infective dermatitis, ATL or HAM/TSP [43,44]. Moreover, the virus can also be transmitted during the breastfeeding process. Hence, the detection of HTLV infection through prenatal or neonatal screening would be a public health surveillance practice so that preventative measures could be introduced to reduce vertical transmission (e.g. avoidance of breastfeeding among mothers who are HTLV carriers).

The seroprevalence of *T. gondii* in the Brazilian population, in general, is considered variable but also is

one of the highest in the world [15]. The seroprevalence of anti-*T. gondii* IgG antibodies in the pregnant population studied here was higher compared to other epidemiological studies [15,45–48]. Conversely, the seroprevalence of IgM antibodies found here was similar to that observed in the other States of Brazil, such as Paraná (1.2%) and Minas Gerais (3.6%) [45, 47], although IgM can remain elevated for years, and a positive result does not always implicate a recently acquired infection, while a rise in IgM titer is evidence of acute infection [7].

Well established risk factors for *T. gondii* infection were not statistically relevant in this study (Table 5). Indeed, a number pregnancies > 1 ($p = 0.038$) were associated with a higher prevalence of infection due to the natural immunosuppression that occurs during pregnancy, as reported previously in Brazil [45, 49–51]. Also, income ($p = 0.013$) and ethnicity ($p = 0.006$) were related to a greater risk of anti-*T. gondii* IgG seropositivity. The positive correlation between social and economic variables with the risk of toxoplasmosis has also been reported in previous studies [16].

Serological screening for vertically transmissible pathgens such as CMV, Rubella, HTLV, and *T. gondii* is important to prevent birth defects and other negative neonatal outcomes. The results of this study emphasize the importance of follow-up for pregnant women that are seropositive for the pathogens investigated in this study. Although pregnant mothers may not have any suggestive signs or symptoms, we highlight the importance of Pre- and Neonatal programs that facilitate detection and management of these diseases to improve outcomes for neonates by reducing or eliminating the associated sequelae. Furthermore, our findings are a useful guide for perinatologists, public health specialists and health policy makers and will facilitate the development of improved prevention and control strategies in the future.

Conclusions

The results of this study emphasize the importance of monitoring the incidence to assess the risk of infectious diseases in pregnancy at all population levels, especially in groups of higher risk who depend on the public health system in the developing world. These data also support the need for improving regulations in the public health system in order to implement effective preventive programs that will reduce the risk of vertically acquired infections.

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Author's contribution

Conception or design of the work: SRG and LJM; Data and samples collection: GBC, MCO, and MRSR; Data analysis and interpretation: GBC, MCO, SRG, GRA, MT, MRSR, SMBS, and LJM; Drafting the article: GBC and MCO; Critical revision of the article: GBC, MCO, SRG, GRA, MT, MRSR, SMBS, and LJM; Final approval of the version to be published: GBC, MCO, SRG, GRA, MT, MRSR, SMBS, and LJM.

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Corresponding author

Galileu Barbosa Costa, PhD
Departmento de Microbiologia, Universidade Federal de Minas Gerais, Av. Presidente Antonio Carlos, 6627, Belo Horizonte, Brazil, 31270301.
Phone: +553134092747
Fax: +553134092733
Email: galileuk1@gmail.com

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