TUJNAS

Thamar University Journal of Natural & Applied Sciences 11(1) (2026) 1– 7

DOI: https://doi.org/10.59167/131g4523

Original Article

The Impact of Specific Microorganisms Causing the Abortion of a Random Sample of Pregnant Women in Dhamar City, Yemen

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Received: 2 November 2025. Revised: 5 March 2026. Accepted: 15 March 2026. Published: 29 June 2026.

Abstract

This study aimed to determine the prevalence of Cytomegalovirus (CMV), Rubella, *Toxoplasma gondii*, and anti-phospholipid (APL) antibodies among women who have experienced abortion in Dhamar City, Yemen. Additionally, the research sought to identify risk factors associated with seropositivity for these infections and to compare these factors between pregnant women residing in urban and rural areas. The cross-sectional study involved 200 pregnant women, aged 15 to 38 years, who had a history of one or more unexplained recurrent abortions. These participants were recruited from various healthcare facilities, including Dhamar Hospital, local dispensaries, the Reproductive Health Center, private clinics, and diagnostic laboratories. Participants were screened for IgM and IgG antibodies against CMV, Rubella, *Toxoplasma*, and anti-phospholipids using Enzyme-Linked Immunosorbent Assay (ELISA). Demographic, socioeconomic, obstetric, and behavioral data were collected via face-to-face interviews utilizing a pretested questionnaire. The seroprevalence of CMV-specific IgG and IgM among the participants was 92.5% and 7.0%, respectively. Rubella-specific IgG and IgM antibodies were detected in 87.0% and 3.5% of the women, respectively. Furthermore, the prevalence of *Toxoplasma gondii* IgG and IgM was 62.5% and 8.0%, respectively. Seropositivity for anti-phospholipid IgG and IgM were 10.0% and 20.0%, respectively. In conclusion, the presence of IgM antibodies against Rubella, CMV, and *Toxoplasma gondii* correlated with recent or primary infections. Conversely, positive IgG results for these pathogens indicated prior exposure or convalescent infection.

Keywords: Serological Study; Abortion in Pregnant Women; Dhamar; Yemen

1. Introduction

Recurrent spontaneous abortion (miscarriage) is one of the most frequent reproductive complications of early pregnancy. It is clinically defined as three or more consecutive pregnancy losses prior to the 20th week of gestation, occurring before the fetus reaches a viable gestational age [1, 2]. Widely accepted etiologic causes include genetic anomalies, immunologic factors, placental abnormalities, endocrine disorders, nutritional deficiencies, environmental factors, and maternal systemic conditions such as diabetes mellitus and thyroid disease.

Additionally, maternal infections caused by *Toxoplasma gondii*, Cytomegalovirus (CMV), syphilis, rubella, and herpes, alongside the presence of anti-phospholipid (APL) antibodies, are associated with a significantly elevated risk of congenital complications [3]. Contracting these infections during pregnancy can lead to congenital anomalies and abortion, making them a leading cause of perinatal morbidity and mortality, particularly in developing nations [4]. Pathogen transmission can occur prenatally via transplacental passage, or postnatally through contact with infected blood, vaginal secretions, or breast milk (particularly for CMV and Rubella). Clinical evidence of these infections may manifest at birth, during infancy, or even years later [5].

The adverse outcomes produced by these pathogens generally mimic those of abortions, infertility, intrauterine fetal deaths, stillbirths, and congenital malformations. The prevalence of *Toxoplasma gondii*, Rubella, CMV, and APL infections varies significantly by geographic region. However, countries in Southeast Asia and Sub-Saharan Africa consistently report the highest rates of stillbirths associated with these infections [6, 7]. Rubella, *Toxoplasma*, and CMV are common causes of infection across all age groups and are generally asymptomatic; however, primary infection in pregnant women during the first trimester can cause severe fetal congenital malformations and abortion [4]. Because these maternal infections often present without symptoms and clinical diagnoses are inconsistent, it is paramount to identify susceptible women, especially those with acute maternal infections, and to recognize prevalent and recurrent pathogens [7].

Due to the absence of a national screening program, there is limited data available regarding the seroprevalence of specific IgM and IgG antibodies to *Toxoplasma gondii*, Rubella, CMV, and anti-phospholipids among pregnant women in Dhamar City. Therefore, this study aimed to evaluate the serological evidence of CMV and Rubella infections during the

first trimester among this demographic. Ultimately, the research seeks to outline the epidemiological and serological landscape of several leading infectious causes of abortion in Dhamar City, Yemen.

2. Materials and Methods

2.1. Study Period and Design

This descriptive, cross-sectional study was conducted over a 14-month period, from September 2019 to October 2020. This duration was specifically selected to ensure the collection of a robust sample size, thereby achieving statistical accuracy and enhancing the overall reliability of the results. The study cohort consisted of 200 women, aged 15 to 38 years, who had been infected by one or more abortion-causing agents. These participants were recruited while attending antenatal clinics in various hospitals and health centers across Dhamar City, Yemen.

2.2. Study Area

The research was carried out in Dhamar City. Geographically, the Dhamar governorate is located between latitudes 43.30 and 44.50, longitudes 14 and 15, and sits at an altitude of 2400 meters above sea level. The mean annual temperature ranges from 20 to 28 °C in the summer, while winter temperatures can drop to between 18 °C and -1 °C during the night and early morning. The relative humidity in the region averages 49% [8].

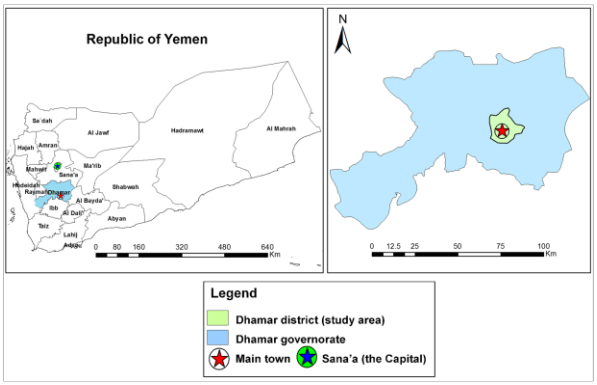

Figure 1: Map showing the location of Dhamar governorate and Dhamar district, Yemen (study area). Reprinted with permission from Abdulelah H. Al-Adhroey *et al.* [8] Copyright 2019 Springer Nature.

2.2 Study Population and Sampling

The study population comprised 200 pregnant women who exhibited infections from one or more targeted pathogens (*Toxoplasma gondii*, Rubella, CMV, and anti-phospholipid antibodies). Participants were between 15 and 38 years old and had a documented history of one or more consecutive, unexplained abortions. Participants were recruited from several facilities, including Dhamar General Hospital, Labanan Hospital, Dar AL-Shifa Hospital, and AL-Hayah Hospital, alongside local dispensaries (Mustawsaf Miahres), medical centers (AL-Amwma and Al-Tafula), and diagnostic laboratories (Al-Dubai Laboratory, New Med Laboratory, and Alpha Laboratory). Obstetric and behavioral data were gathered through face-to-face interviews using a pretested questionnaire.

2.3 Sample Collection

Five milliliters of blood were collected from each participant via venipuncture using sterile disposable syringes. The blood was transferred into a plain tube containing a gel clot activator (without anticoagulant) and allowed to stand for one hour at room temperature to facilitate clot formation. Subsequently, the tubes were centrifuged at 3000 rpm for 10 minutes [9]. The serum was then carefully aspirated using a Pasteur pipette, dispensed into sterile Eppendorf tubes, immediately transported in an ice-box to the laboratory, and stored at -20°C until analysis [9, 10]. Personal patient information was recorded based on standardized questionnaire responses, which captured data on age, region, residence, education status, pregnancy history, and previous abortions [9]. Each sample was labeled with a specific study code corresponding to the participant's questionnaire and informed consent form [10].

2.4 Laboratory Analysis

Samples were analyzed to detect the presence of specific IgG and IgM antibodies against CMV, Rubella, *Toxoplasma*, and APL. The ELISA technique was utilized in strict accordance with the manufacturer's instructions to determine both positive and negative results. ELISA was selected due to its high sensitivity for detecting specific immunoglobulin markers. A test value greater than 1.5 was classified as a positive sample, whereas a value less than 1.0 was considered negative. Values falling between 1.0 and 1.5 were deemed equivocal. All serological screenings were conducted at Al-Dubai Labs, Alfa Labs, and New Med Lab in Dhamar City using the cobas 411 analyzer (Roche Diagnostics, Mannheim, Germany) [10].

2.5 Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS version 22.0, Chicago, IL). Results were presented using descriptive statistics, relying on frequencies and percentages to determine the statistical significance of the distribution of CMV, Rubella, *Toxoplasma*, and APL infections. Additional variables, including age, geographic region, residence, education status, pregnancy timelines, and abortion history, were also factored into the analysis.

3 Results

This study aimed to determine the epidemiological and serological prevalence of several infectious agents causing abortions among pregnant women in Dhamar City, Yemen. The findings are detailed in the subsequent sections, tables, and figures.

3.1 Places of Sample Collection

A total of 200 samples were collected from various hospitals, dispensaries, and laboratories. The highest proportion of samples was obtained from Lebanon Hospital, contributing 58 samples (29.0%), while the lowest number was collected from Al-Amwma and Al-Tafula, with 9 samples (4.5%). Additional samples were sourced as follows: Al-Dubai Labs provided 42 samples (21.0%), Al-Hayyah Hospital contributed 21 (10.5%), and Dhamar Hospital Dispensary and Alpha Labs each supplied 18 samples (9.0%). Furthermore, Mustawsaf Mihras accounted for 13 samples (6.5%), New Med Lab for 11 (5.5%), and Dar Al-Shifa Hospital for 10 (5.0%). These can be summarized as shown in Table 1.

Table 1. Number and percentage of samples collected from Any Hospital and Clinical in Dhamar.

Place of the collected samples	No.	%
Lebanon Hospital	58	29.0
Al-Dubai Labs	42	21.0
Al-Hayyah Hospital	21	10.5
Alpha Labs	18	9.0
Dhamar Hospital Dispensary	18	9.0
Mustawsaf Mihras	13	6.5
New Med Lab	11	5.5
Dar Al-Shifa Hospital	10	5.0
Al-Amwma and Al-tafula	9	4.5
Total	**200**	**100.0**

3.2 Distribution of Pregnant Women According to Causative IgG and IgM Antibodies:

Among the 200 participants, all exhibited infections by one or more of the targeted agents associated with abortions (*Toxoplasma gondii*, Rubella, CMV, and anti-phospholipid antibodies). The results revealed that positive IgM antibody tests for APL were the most frequent (20.0%), followed by *Toxoplasma gondii* (7.5%) and CMV (7.0%). Rubella demonstrated the lowest IgM seropositivity at 3.5%. Conversely, for IgG antibodies, CMV showed the highest prevalence (92.5%), followed by Rubella (87.0%) and *Toxoplasma gondii* (62.5%), while APL had the lowest IgG positivity rate at 10.0%. These results were presented in Figure 2 and Tables 2 and 3.

Table 2. Showing seroprevalence of CMV IgM and IgG and Rubella IgM and IgG in pregnant women.

Tests	CMV IgM		CMV IgG		Rubella IgM		Rubella IgG	
Result	No.	%	No.	%	No.	%	No.	%
Positive	14	7.0	185	92.5	7	3.5	174	87.0
Negative	186	93.0	15	7.5	139	96.5	26	13.0
Total	**200**	**100**	**200**	**100**	**200**	**100**	**200**	**100**

Table 3. Showing seroprevalence of *Toxoplasma* IgM and IgG and Anti-phospholipid IgM and IgG in pregnant women.

Tests	*Toxoplasma* IgM		*Toxoplasma* IgG		Anti-phospholipid IgM		Anti-phospholipid IgG	
Result	No.	%	No.	%	No.	%	No.	%
Positive	15	7.5	125	62.5	40	20.0	20	10.0
Negative	185	92.5	75	37.5	160	80.0	180	90.0
Total	**200**	**100**	**200**	**100**	**200**	**100**	**200**	**100**

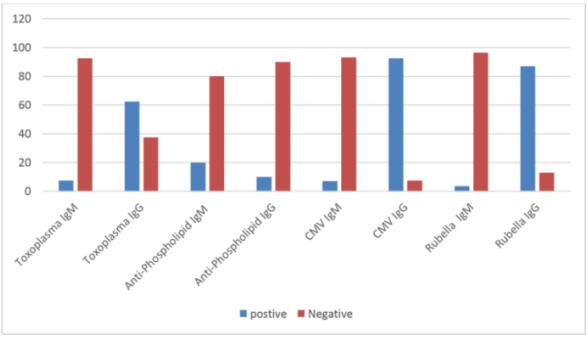

Figure 2: Epidemiology of pregnant women according to the type of IgG and IgM Antibodies.

3.3 Distribution by Geographic Location

The majority of the pregnant women resided in the rural districts of Dhamar City, accounting for 106 participants (53.0%), compared to 94 participants (47.0%) from urban areas. In the rural district, the highest IgM prevalence was observed for APL (23.6%), while the lowest was for Rubella (3.8%). Similarly, in urban areas, APL showed the highest IgM positivity (15.9%), whereas Rubella and *Toxoplasma* tied for the lowest at 3.2%. Regarding IgG antibodies, CMV was the most prevalent in both rural (93.4%) and urban (91.4%) districts. APL showed the lowest IgG prevalence in both regions, at 11.4% and 8.5%, respectively. These results were shown in Tables 4 and 5.

3.4 Times of the Abortion

When analyzing the number of abortions relative to IgM positivity, the highest percentage occurred among women with a single abortion (40.5%), followed by those with two (32.5%), and those with more than two (27.0%). For women with a single abortion, APL IgM was the most prevalent (27.1%), and Rubella was the least prevalent (1.2%). Among those with two abortions, APL again had the highest IgM ratio (23.1%), with Rubella being the lowest (4.6%). For women experiencing more than two abortions, *Toxoplasma* showed the highest IgM prevalence (7.4%), while CMV and Rubella both presented at 5.5%, as shown in Tables 6 and 7.

In terms of IgG seropositivity, women with a single abortion showed the highest rates for CMV and Rubella (90.2%), and the lowest for APL (14.8%). For those with two abortions, CMV IgG was highest (92.3%), and APL was lowest (7.7%). This trend continued for women with more than two abortions, where CMV IgG prevalence was 96.3% and APL was 5.6%, as shown in Tables 6 and 7.

3.5 Relationship Between Education and Abortion

Educational status significantly impacted the observed trends, with educated women representing 64.5% of the cases compared to 35.5% for uneducated women. Among educated women, the highest IgM positivity was for APL (18.6%), and the lowest was for Rubella (3.2%).

Table 4. Showing seroprevalence of CMV IgM and IgG and Rubella IgM and IgG in pregnant women according to location.

Tests	Total	CMV IgM				CMV IgG				Rubella IgM				Rubella IgG			
		+		–		+		–		+		–		+		–	
		No.	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Urban	94	4	4.3	90	95.7	86	91.4	8	8.5	3	3.2	91	96.8	84	89.6	10	10.6
Rural	106	10	9.4	96	90.6	99	93.4	7	6.6	4	3.8	102	96.2	90	85.0	16	15.0

+ = Positive – = Negative

Table 5. Showing seroprevalence of *Toxoplasma* IgM and IgG and anti-phospholipid IgM and IgG in pregnant women according to location.

Test	Total	*Toxoplasma* IgM				*Toxoplasma* IgG				Anti-phospholipid IgM				Anti-phospholipid IgG			
		+		–		+		–		+		–		+		–	
		No.	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Urban	94	3	3.2	91	96.8	70	74.4	24	25.5	15	15.9	79	84.0	8	8.5	86	91.5
Rural	106	12	11.3	94	88.7	55	51.8	51	48.1	25	23.6	81	76.4	12	11.3	94	88.7

+ = Positive – = Negative

Table 6. Showing seroprevalence of CMV IgM and IgG and Rubella IgM and IgG in pregnant women according to enumerated abortions.

Tests	Total	CMV IgM				CMV IgG				Rubella IgM				Rubella IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Once	81	6	7.4	75	92.6	73	90.2	8	9.8	1	1.2	80	98.8	73	90.2	8	9.8
Twice	65	5	7.7	60	92.3	60	92.3	5	7.7	3	4.6	62	95.4	59	90.7	8	12.3
More than	54	3	5.5	51	94.4	52	96.3	2	3.8	3	5.5	51	94.4	44	81.5	10	18.5
Total	**200**	**14**		**186**		**185**		**15**		**7**		**193**		**174**		**26**	

+ = Positive – = Negative

For uneducated women, APL IgM was also the highest (22.5%), while Rubella was the lowest (4.2%). A possible explanation is that educated women may possess greater awareness regarding their reproductive health, leading them to seek clinical care more frequently. For IgG antibodies, CMV was the most prevalent among both educated (91.5%) and uneducated (94.0%) women. APL showed the lowest IgG prevalence in both groups, at 10.0% and 9.8%, respectively. These results were tabulated as shown in Tables 8 and 9.

3.6 Relationship Between Age and Abortion

The results indicated that pregnant women aged 21–26 years experienced the highest rate of abortions (41.0%), followed by the 27–32 age group (33.0%) and the 15–20 age group (18.0%). The lowest incidence (8.0%) was recorded among women aged 33–38 years (Table 10).

Across all age groups, APL showed the highest IgM seroprevalence: 13.8% for ages 15–20; 22.0% for ages 21–26; 21.2% for ages 27–32; and 18.7% for ages 33–38. Rubella generally exhibited the lowest IgM rates across these cohorts (Tables 10 and 11). Regarding IgG tests, CMV consistently demonstrated the highest seropositivity across all age categories, peaking at 95.5% in the 27–32 age group. Conversely, APL showed the lowest IgG prevalence across all age brackets (Tables 10 and 11).

Table 7. Showing seroprevalence of *Toxoplasma* IgM and IgG and Anti-phospholipid IgM and IgG in pregnant women according to enumerated abortions.

Test	Total	*Toxoplasma* IgM				*Toxoplasma* IgG				Anti-phospholipid IgM				Anti-phospholipid IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Once	81	6	7.4	75	92.6	57	70.4	24	29.6	22	27.1	59	72.9	12	14.8	69	85.1
Twice	65	5	7.7	60	92.3	37	57.0	28	43.0	15	23.1	50	76.9	5	7.7	60	92.3
More than	54	4	7.4	50	92.6	31	57.4	23	42.6	3	5.6	51	94.4	3	5.6	51	94.4
Total	**200**	**15**		**185**		**125**		**75**		**40**		**160**		**20**		**180**	

+ = Positive – = Negative

Table 8. Showing seroprevalence of CMV IgM and IgG and Rubella IgM and IgG in pregnant women according to education.

Test	Total	CMV IgM				CMV IgG				Rubella IgM				Rubella IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Educated	129	7	5.4	122	94.6	118	91.5	11	8.5	4	3.2	125	96.8	116	90.0	13	10.0
Uneducated	71	7	9.8	64	90.2	67	94.0	4	5.6	3	4.2	68	95.7	58	81.7	13	18.3
Total	**200**	**14**		**186**		**185**		**15**		**7**		**193**		**174**		**26**	

+ = Positive – = Negative

Table 9. Showing seroprevalence of *Toxoplasma* IgM and IgG and Anti-phospholipid IgM and IgG in pregnant women according to education.

Test	Total	*Toxoplasma* IgM				*Toxoplasma* IgG				Anti-phospholipid IgM				Anti-phospholipid IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
Educated	129	9	7.0	120	93.0	74	57.4	55	42.6	24	18.6	105	81.4	13	10.0	116	90.0
Uneducated	71	6	8.4	65	91.6	51	71.8	20	28.2	16	22.5	55	77.5	7	9.8	64	90.1
Total	**200**	**15**		**185**		**125**		**75**		**40**		**160**		**20**		**180**	

+ = Positive – = Negative

Table 10. Showing seroprevalence of CMV IgM and IgG and Rubella IgM and IgG in pregnant women according to age group.

Test	Total	CMV IgM				CMV IgG				Rubella IgM				Rubella IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
15-20	36	3	8.3	33	91.6	34	94.4	2	5.6	2	5.6	34	94.4	30	83.3	6	16.6
21-26	82	5	6.1	77	93.9	73	89.0	9	10.9	2	2.4	80	97.5	71	86.5	11	13.4
27-32	66	5	7.5	61	92.5	63	95.5	3	4.5	3	4.5	63	95.4	60	90.9	6	9.1
33-38	16	1	6.3	15	93.7	15	93.7	1	6.2	0	0	16	100	13	81.2	3	27.2
Total	**200**	**14**		**186**		**185**		**15**		**7**		**193**		**174**		**26**	

+ = Positive – = Negative

Table 11. Showing seroprevalence of Toxoplasma IgM and IgG and anti-phospholipid IgM and IgG in pregnant women according to age group.

Tests	Total	*Toxoplasma* IgM				*Toxoplasma* IgG				Anti-phospholipid IgM				Anti-phospholipid IgG			
		+		–		+		–		+		–		+		–	
		No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
15-20	36	2	5.6	34	94.4	22	61.1	14	38.8	5	13.8	31	86.1	5	13.8	31	86.1
21-26	82	8	9.7	74	90.2	51	62.2	31	37.8	18	22.0	64	78.0	8	9.7	74	90.2
27-32	66	4	6.0	62	94.0	41	62.1	25	37.8	14	21.2	52	78.7	6	9.1	60	90.9
33-38	16	1	6.3	15	93.7	11	68.7	5	31.2	3	18.7	13	81.3	1	6.2	15	93.7
Total	**200**	**15**		**185**		**125**		**75**		**40**		**160**		**20**		**80**	

+ = Positive **– = Negative**

4. Discussion

During pregnancy, the maternal immune system undergoes significant adaptations to tolerate the developing fetus; however, this natural immunosuppression, particularly during the first trimester, increases the mother's susceptibility to various infections [11]. Exposure to pathogens such as Rubella, CMV, and other viruses can further compromise immune defenses. Consequently, the weakened immune system struggles to protect the fetus, significantly elevating the risk of abortion [12].

In this study, comparisons of positive IgM antibodies among the targeted pathogens revealed that APL was the most frequent, followed by *Toxoplasma gondii* and CMV, with Rubella showing the lowest recent infection rate. For IgG antibodies, CMV was the most prevalent, followed by Rubella and *Toxoplasma gondii*, while APL was the least common. These findings align with reports from other regions globally, including other areas of Yemen and neighboring countries [13]. Although the CMV IgG prevalence in the present study was slightly lower than rates reported in some developed nations, it is consistent with previous findings in Hodeidah City, Yemen (98.7%) [14], as well as in Iraq (98.3%) [15], Turkey (97.2%) (Uysal *et al.*, 2012) [16], Qatar (96.5%) [17], Bahrain (100%) [18], Tunisia (96.3%) [19], Palestine (99.6%) [20], Egypt (100%) [21], Sudan (97.5%) [22], Nigeria (93.2%) [23], and Ethiopia (88.5%) [24].

Our results are also in agreement with Tamer *et al.* [25], who investigated the seroprevalence of these agents in western Turkey, finding similar trends in IgG and IgM distributions. Furthermore, Aynioglu *et al.* [4] reported comparable findings among pregnant women in northwestern Turkey. Additionally, our observation that *Toxoplasma gondii* IgG positivity (62.5%) significantly outpaced IgM positivity (7.5%) mirrors findings from Hadi *et al.* [26] in Qadisiyah province, Iraq, where IgG and IgM rates were 44% and 4%, respectively. Similar seroepidemiological patterns have been documented in Sana'a [27] and Taiz [28], Yemen, as well as in western Sudan [29]. Consistent findings were also reported by Hajipour *et al.* [30] in their cross-sectional assessment of TORCH infections.

Infections by *Toxoplasma gondii* are primarily linked to the environmental distribution of oocysts shed by cats, which can persist for extended periods under normal conditions [31]. Waterborne transmission via contaminated sources is a well-documented global issue [32]. The consumption of bottled water and improvements in the quality of tap water [33] could reduce oocyst ingestion. Regional variations in seroprevalence may stem from differences in meat consumption, cooking practices, and the underlying *Toxoplasma* burden in local livestock [8].

Viruses like CMV have evolved sophisticated mechanisms to evade the host's immune system, such as capturing host genes encoding cytokines, because these viral proteins have cellular counterparts [34], or down-regulating MHC class I and II synthesis. Additionally, some express secreted proteins that suppress inflammatory responses, such as murine IL-10 [35] and ebvIL-10 [10]. When comparing CMV and Rubella in our cohort, CMV consistently demonstrated higher rates of both IgM and IgG seropositivity. This predominance of CMV is a recognized pattern, supported by studies in Ghana [10], western Turkey [25], Ethiopia [36], Iraq , and among Syrian refugees [37]. Similar distributions were reported in Hodeidah [14] and Iran [38].

Demographically, a higher proportion of cases originated from rural districts (53.0%) compared to urban areas (47.0%). This trend is supported by Alghalibi *et al.* [14], as well as research in China [39] and Tanzania [40]. This geographic disparity may be influenced by varying social backgrounds, living environments, education levels, access to healthcare [39], alongside a greater lack of reproductive health information and differing cultural factors in rural settings [41-43].

The abortion frequencies observed here align with findings from Iraq [44] and other regional studies in Yemen [45], as well as China [39], confirming that multiple factors are associated with the acquisition of CMV [29].

Notably, education appeared to play a critical role; educated women represented a larger portion of our study sample (64.5%), likely due to higher health literacy and more frequent interaction with wider social environments [46]. This agrees with prior research in Yemen [27], though it contrasts with findings from China [39]. Studies in Taiz [28] and other international cohorts [10, 47] further highlight these disparities. Uneducated women may not visit clinics as regularly, meaning educated pregnant women are represented at a higher average in our data compared to uneducated women [48]. Educated women may also be more proactive in using protection, preventing infection transmission [49].

Finally, age distribution analysis revealed that women aged 21–26 years were the most affected (41.0%), a finding consistent with findings from Sana'a [45] and Hodeidah [14]. Similar age trends were recorded in Iran [38] and Ghana [10]. This peak in abortion rates among young women may be associated with hormonal fluctuations, particularly involving progesterone and estrogen, alongside specific immune factors present during pregnancy [46].

5. Conclusions

CMV emerged as the predominant causative agent among the IgG-seropositive pregnant women in Dhamar City. Overall, recent infections (indicated by positive IgM) were most frequently associated with APL, followed by *Toxoplasma gondii* and CMV, while Rubella showed the lowest incidence. Conversely, prior exposure or chronic infection (indicated by positive IgG) was highest for CMV, followed by Rubella and *Toxoplasma gondii*, with APL being the least common. The highest burden of these infections was observed among pregnant women aged 21 to 26 years. The significant differences between IgM and IgG seropositivity rates highlight varying levels of past and recent exposures among the participants. Based on these findings, we strongly recommend further investigation into the spread of these infectious agents to prevent stillbirths and abortions. Enhancing patient awareness regarding the critical importance of regular antenatal clinical visits, especially during the first trimester, is essential. Furthermore, evidence-based recommendations, such as administering the Rubella vaccine to women of childbearing age, should be actively promoted, alongside continued research into maternal infectious diseases.

Ethical Approval

Ethical approval was obtained from Thamar University, Faculty of Applied Sciences, Biology Department, No. 1, 25-01-2020. Ethical approval has been granted to the hospitals.

Data Availability

The datasets used and analyzed during the current study are available from the corresponding author upon reasonable request.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare no conflicts of interest.

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