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Rubella seroprevalence among pregnant women in the region of Rabat, Morocco: a cross-sectional study

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ABSTRACT

Objectives The aim of the present research is to update data on the seroprevalence of rubella and to identify the associated risk factors among pregnant women in the Rabat region of Morocco in order to take immediate action to monitor the virus.

Design A cross-sectional study.

Setting The study was conducted at Ibn Sina University Hospital and at referral healthcare centres in the region of Rabat.

Participants A total of 502 pregnant women (mean age 29.7±6.3 years, range 17–44 years) attending the maternity department during 8 months were selected for serological testing.

Outcome measures A structured questionnaire was used to obtain sociodemographic, reproductive and clinical characteristics after obtaining written informed consent. Venous blood samples were collected to determine rubella-specific IgG antibodies using an automated chemiluminescent microparticle immunoassay (ARCHITECT i1000SR and i2000SR, Abbott Diagnostics).

Results Antirubella IgG antibodies (≥10 IU/mL) were found in 408 (85.9%) pregnant women examined. The rate of susceptibility to rubella virus infection among pregnant women was found to be 14.1%. These protective rates were found to differ significantly between uneducated pregnant women (80.9%) and those with university-level education (95.5%) (p=0.02). Pregnant women in the 17–24, 25–34 and 35–44 years age groups accounted for 92.5%, 85.2% and 82.8%, respectively (p=0.015). Also, IgG seropositivity status was found to differ significantly between multiparous (83.3%) and primiparous (92.5%) pregnant women (p=0.01). None of the other characteristics was significantly associated with rubella infections.

Conclusion Vaccination programmes need to be updated to ensure that campaigns reach their specified goals. Thus, implementing an effective, large-scale screening programme for congenital rubella infection in different regions of Morocco is highly recommended. On the other hand, seronegative pregnant women should be given special preventive care and health education about rubella transmission and congenital rubella syndrome sequelae.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The findings from our local population may not be applicable at the national scale, and local data need to be established in other geographical locations.
⇒ The study used an automated chemiluminescent microparticle immunoassay, which is a particularly sensitive and specific technology used to quantify antirubella IgG.
⇒ The study used a structured questionnaire for a representative sample to gather information on the obstetric history and sociodemographic and clinical characteristics from pregnant women.
⇒ The study lacks information on vaccination history.

INTRODUCTION

Rubella virus (RV) is an important worldwide pathogen that causes a benign illness with uncommon serious complications.[1] It is transmitted mainly through droplets of respiratory secretions or infected body fluids.[2] The primary infection may remain initially asymptomatic, leading to self-limiting, rash-producing disease with low-grade fever and lymphadenopathy.[3] RV spreads through the placenta by haematogenous route from a pregnant woman to the growing fetus, resulting in severe harms of congenital infections.[4] Congenital rubella infections can lead to miscarriage, stillbirth and abortion, as well as a serious disorder known as congenital rubella syndrome (CRS), especially during the first trimester of pregnancy.[5] Clinical manifestations of this syndrome encompass hearing impairment, ophthalmic abnormalities, heart and brain defects, hepatomegaly, and jaundice.[6] The rates of vertical transmission and CRS are the highest, with up to 90% of cases occurring during the first 12 weeks of pregnancy, decreasing to about 25% at the end of the second trimester.[7] However, these complications can be avoided by natural immunisation or by using an effective and safe vaccine, such as a measles/rubella or a measles/mumps/rubella vaccine.[8] The introduction of the rubella vaccine to the national immunisation programme all over the world was recommended by the WHO in 2000 to

control and reduce CRS and rubella.[9] In Morocco, the introduction of the combined measles-rubella vaccine into the national immunisation programme started in 2003.[10] Since then, this live attenuated viral vaccine has been mandatory for all children aged between 9 and 18 months, according to the national immunisation schedule adopted in Morocco.[11] Thereafter, in 2008, vaccination policy shifted, targeting all children aged 9 months–15 years and girls of childbearing age.[11] Another national immunisation campaign against measles and rubella was carried out in 2013 for those aged 9 months–19 years. Finally, in 2014, it was recommended that a second dose of the measles-rubella vaccine be given to infants 18 months of age. Vaccine boosters are not systematically performed in women post partum.[11] The WHO has reported that this vaccination strategy has allowed a gradual increase in immunisation coverage.[10] Therefore, early screening of pregnant women is an important tool to estimate their level of immunity and determine their rubella serostatus.[12] Serological surveillance data on this virus enable monitoring of progress towards its abolition. In Morocco, studies on the seroepidemiology of these congenital infections in the general Moroccan population are scarce. In fact, information on the seroprevalence of rubella among pregnant women and the burden of CRS remains rare and particularly limited.[13 14] This study aimed to assess the current seroprevalence of antirubella antibodies in order to re-evaluate the level of protective immunity and risks among pregnant women in the region of Rabat. Possible factors associated with RV, such as sociodemographic, biological and clinical characteristics, are also examined. The findings of this research may inform decision-makers in defining the best intervention to prevent rubella and CRS.

MATERIALS AND METHODS

Study area and period

We conducted a cross-sectional study of pregnant women attending the maternity department of Ibn Sina University Hospital and referral healthcare centres in the region of Rabat. Blood samples of pregnant women were collected at the biological sampling unit of the Children's Hospital of Rabat. The blood samples were then sent to the Central Laboratory of Virology at the specialties hospital of Rabat for determination of rubella IgG antibodies as part of the systematic monitoring of pregnancies. During a period of 8 months starting from February until October 2021, 502 pregnant women were recruited for this research.

Sample size

The sample size was determined using data from previous studies in Morocco, while considering a 95% CI and a precision level of 5%. Studies on the seroprevalence of antirubella IgG in Morocco have reported that the overall prevalence among pregnant women in the military teaching hospitals of Rabat and Meknes was, respectively, 90.2% and 88.6% in 2012 and 2017.[13 14] Therefore, a minimum number of 207 pregnant women were selected for enrolment in this study.

Data collection and specimen sampling method

Data were obtained through close monitoring and via a structured questionnaire. The inclusion criteria cover pregnant women in the first two trimesters of pregnancy. This study excluded cases of women suffering from critical illnesses such as immune system-related diseases or unconsciousness. Information regarding the variables analysed included sociodemographic characteristics (age, occupation, educational level, marital status, social level, and current or childhood promiscuity of the pregnant woman) as well as obstetric history (gestational age, parity, gravidity, abortion history, fetal deaths and caesarean section), in addition to ultrasound abnormalities and other clinical symptoms.

Serological testing

Serum samples were analysed to determine the specific IgG antibodies against rubella by using a fully automated random access immunoassay analyser (ARCHITECT i1000SR and i2000SR, Abbott Diagnostics). This system is based on chemiluminescent microparticle immunoassay technology that uses paramagnetic microparticles as a solid phase. The assay allows respectively a quantitative determination and a qualitative detection of rubella IgG antibodies in serum samples. The emitted chemiluminescence signal is amplified and measured as relative light units (RLUs). There is a direct relationship between the concentrations of antirubella IgG in the serum samples and the RLU detected by the Architect System optics. Consequently, the larger the antibody concentrations, the higher the photon counts. In accordance with the manufacturer's instructions, the quantitative rubella IgG results were expressed in international units per millilitre (IU/mL). Serum samples with an antirubella IgG level ≥10 IU/mL were categorised as positive, which suggests protection against RV as a result of past exposure or previous vaccination, while samples with an IgG antibody titre <5 IU/mL were classified as negative, namely susceptible. The results of serum samples were interpreted as equivocal at 5–9.9 IU/mL and were retested; if the results were negative, the sample was then classified as negative. Control kits were tested once every 24 hours each time samples were examined.

Patient and public involvement

Patients neither were involved in the development of the research questions or the outcome measures, nor were involved in developing plans for design or implementation of the study. Patients were not asked to provide input on the conduct of the research or the interpretation and writing of the results. Information about pregnant women was obtained by the first investigator, while the outcome measures were obtained by the other researchers. There are no plans to disseminate the study results to relevant patient community.

Ethical issues

The purpose, risks and benefits of this study were explained to all pregnant women and each of them provided a formal written consent. Code numbers were used for confidentiality of data.

Statistical analysis

All generated data were collected by Microsoft Office Excel V.2007 and exported to SPSS V.18, and data were summarised by descriptive statistics. Pearson's χ^2 test or Fisher's exact test was performed to assess the association between rubella serological status and sociodemographic, obstetrical and clinical characteristics. The statistical comparisons were run between positive and negative Ig G results while equivocal results were excluded. Variables with a p value equal to or less than 0.05 obtained in the bivariate analysis were selected for binary logistic regression analysis. Statistically significant variables in the univariable logistic regression analysis were included as adjusted variables for multiple logistic regression analysis, according to two models, to determine the variables independently associated with the presence of antibodies. Model 1 included age, educational level and parity, and model 2 included age and parity. The use of adjusted ORs with 95% CIs allows the estimation of the strength of the association. Statistical significance was set at a p value <0.05.

RESULTS

Out of 646 participants enrolled during the study period, a total of 502 pregnant women had a second-trimester serum samples available for testing. The mean maternal age was 29.7 years (range 17–44 years, SD 6.3), with a median of 29.5 (25–34). Women in the 17–24 and 25–34 years age groups accounted for 23.1% and 52.4%, respectively. Approximately two-thirds of these pregnant women were urban residents (65.9%). The proportions with irregular and low income were, respectively, 88.6% and 66.9%. Of the participants who had taken part in the study, 361 had a primary or secondary education and 19% had no formal education (table 1).

Antirubella IgG antibodies were found in 408 (85.9%) of the 502 pregnant women examined. According to the present study, the rest of the women who were screened (67, 14.1%) were found to be susceptible to rubella (IgG-negative). The highest percentage of women with IgG titres (51.6%) was recorded in the tranche of 21–100 IU. The protective rates of pregnant women in the 17–24, 25–34 and 35–44 years age group were 92.5%, 85.2% and 82.8%, respectively (table 1). The median titre of anti-rubella IgG was higher among women aged 25–34 years old, with 36.7 (16.8–81.4) UI/mL, but the titres were not significantly higher than that of the other groups, although it could be observed that the rate of anti-rubella IgG decreases with the increasing of age. It was seen in the bivariate analysis that there is a significant difference in protective rates among the age group of 25–34 (85.2%) and the other age groups of 17–24 and 35–44, with proportions of 92.5% and 82.8%, respectively (p=0.015). Seroprevalence was found to differ significantly by educational level (p=0.02), which was lower among uneducated women (80.9%) and higher among women with secondary education (90%) and university degrees (95.5%). There were no statistically significant correlations between protective rate, place of residence, professional activity and social level.

The participants had a mean term of 20.5±4.3 weeks of amenorrhoea (extremes 2–26)'. Gravidity ranged from 1 to 7, while parity ranged from 1 to 5. Of the pregnant women, 90% were in their second trimester and 71% had at least one previous live birth (table 2). The average number of children was 1.3±1 (range 0–5), and 25% of women had at least one spontaneous abortion. The seropositivity rate of antirubella IgG was lower among women who were multiparous (83.3%) and primigravida (92.8%). In the bivariate analysis, parity and gestation were found to be significantly associated with IgG seropositivity status (table 2). On the other hand, there were no statistically significant relations between protective rates and abortion history, previous caesarean section and embryo-fetopathy antecedent. Regarding the type of gynaecological assistance, 44.4% of the participants reported to have been assisted by a gynaecologist, whereas 83.2% stated that they had not undergone ultrasound checks. In this study, we have found that 84% of the IgG-positive pregnant women had fever, 72.2% had lymphadenopathy, 83% had erythema, 83.5% had joint pain and 86.3% had runny nose. However, these symptoms, including fever, lymphadenopathy, articular signs, cutaneous signs or respiratory signs, did not show an association with rubella seroprevalence by bivariate analysis (table 3).

Taking promiscuity into account, the majority of the IgG-positive pregnant women (314, 84.8%) had more than one child living in the same house (p=0.107). Furthermore, 332 (87%) of the IgG-positive pregnant women had frequent exposure to children with erythema (p=0.24).

In addition, 84.3% lived with more than three people per room and 93% lived with more than four people per room during their childhood, but the relationship with housing conditions in childhood currently did not show any significant correlations (table 4).

Univariate analysis showed that rubella seropositivity was associated with age 35–44 years (OR 0.3 (95% CI 0.1 to 0.9), p=0.03) among pregnant women compared with those aged 17–24. As can be observed, the odds of being immune to rubella decreased in pregnant women aged 35–44 years compared with those aged 17–24 years.

As can be seen, pregnant participants with university degrees were four times more likely to have a positive IgG (OR 4.7 (95% CI 1.04 to 21.61), p=0.043) than uneducated ones. Parity was significantly associated with rubella infection in the univariate analyses. None of these investigated sociodemographic obstetrical factors was associated with rubella in multivariate analyses.

Table 1 Distribution of rubella IgG antibodies among pregnant women by sociodemographic characteristics

Variables	Descriptive data n (%) tested	Rubella seroprevalence IgG-negative, n (%)	Rubella seroprevalence IgG-positive, n (%)	Rubella seroprevalence χ^2 test	Univariable logistic regression OR (95% CI)	Univariable logistic regression P value	Multivariable logistic regression AOR (95% CI)	Multivariable logistic regression P value
Age group (years)								
Mean±SD=29.7±6.3								
Minimum–maximum=17–44								
Median (IQR)=29.5 (25–34)								
17–24	116 (23.1)	8 (7.5)	98 (92.5)		0.4 (0.2 to 1)	0.065	0.6 (0.2 to 1.4)	0.285
25–34	263 (52.4)	37 (14.8)	213 (85.2)	0.015	0.3 (0.1 to 0.9)	0.034	0.6 (0.2 to 1.7)	0.405
35–44	120 (23.9)	20 (17.2)	96 (82.8)					
Place of residence								
Urban	331 (65.9)	42 (13.5)	270 (86.5)		0.9 (0.5 to 1.6)	0.743		
Suburban	141 (28.1)	20 (15)	113 (85)	0.76	0.7 (0.2 to 2.1)	0.6		
Rural	30 (6)	5 (16.7)	25 (83.3)					
Treating physician								
General doctor	276 (55)	31 (12)	227 (88)	0.19	0.6 (0.4 to 1.1)	0.15		
Specialist	226 (45)	36 (16.6)	181 (83.4)					
Educational level								
Unschooled	96 (19)	18 (19.1)	76 (80.9)					
Primary	172 (34)	29 (18.2)	130 (81.8)	0.02	1.0 (0.5 to 2.0)	0.881	0.9 (0.4 to 1.9)	0.939
Secondary	189 (38)	18 (10.1)	160 (89.9)		2.0 (0.9 to 4.1)	0.056	1.7 (0.7 to 3.6)	0.168
University	45 (9)	2 (4.5)	42 (95.5)		4.7 (1.0 to 21.6)	0.043	3.7 (0.7 to 17.6)	0.094
Professional activity								
Regular income	55 (11)	6 (11.3)	47 (88.7)					
Irregular income	445 (88.6)	61 (14.5)	359 (85.5)	0.76				
None	2 (0.4)	0 (0)	2 (100)					
Social level								
Low	336 (66.9)	48 (15.1)	270 (84.9)					
Mid	163 (32.5)	19 (12.3)	135 (87.7)	0.67				
High	3 (0.6)	0 (0)	3 (100)					
Marital status								
Married	501 (99.8)	67 (14.1)	407 (85.9)	1				
Single	1 (0.2)	0 (0)	1 (100)					

AOR: OR adjusted by multiple logistic regression analysis of the variables age, educational level and parity.
AOR, adjusted OR.

DISCUSSION

The elimination of congenital rubella and CRS prevention are a growing concern for public health worldwide. They both require screening for rubella among pregnant women and rubella vaccination of the general population.[8] For these reasons, many countries carried out serosurveys among pregnant women to determine the seroprevalence of RV infection. In the present study, the overall seroprevalence of rubella IgG among the recruited samples was 85.9%, indicating past exposure to infection with the development of protective immunity or vaccination. However, 14.1% of the pregnant women are at risk of rubella infection, and their unborn babies may be vulnerable to CRS. Similar findings have been reported from other countries, such as Beijing in China (83%), Alberta in Canada (84%) and Zakho in Iraq (83%).[15–17] Also, the 14% seronegativity in the present study is consistent with the pooled average of 11% seronegativity that has been reported in a meta-analysis of 19 African studies among pregnant women.[18] Nonetheless, the seropositivity rate of IgG antibody to RV in the studied pregnant women was lower than those found in previous studies in

Table 2 Distribution of rubella IgG antibodies in relation to the reproductive history of pregnant women

Variables	Descriptive data n (%) tested	Rubella seroprevalence			Univariable logistic regression		Multivariable logistic regression	
		IgG-negative, n (%)	IgG-positive, n (%)	χ^2 test	OR (95% CI)	P value	AOR (95% CI)	P value
Gestational age (days)								
Mean±SD=143.5±29.8								
Minimum–maximum=12–189								
Median (IQR)=147 (126–168)								
First trimester	50 (10)	4 (8.2)	45 (91.8)	0.28	0.5 (0.1 to 1.5)	0.236		
Second trimester	452 (90)	63 (14.4)	363 (85.6)					
Age group (years)								
17–24	116 (23.1)	8 (7.5)	98 (92.5)					
25–34	263 (52.4)	37 (14.8)	213 (85.2)	0.015	0.4 (0.2 to 1)	0.065	0.6 (0.2 to 1.4)	0.254
35–44	120 (23.9)	20 (17.2)	96 (82.8)		0.3 (0.1 to 0.9)	0.034	0.5 (0.2 to 1.3)	0.202
Parity								
Primiparous	145 (29)	10 (7.5)	124 (92.5)	0.01				
Multiparous	357 (71)	57 (16.7)	284 (83.3)		2.4 (1.2 to 4.9)	0.013	2 (0.9 to 4.2)	0.07
Gestation								
1	94 (19)	6 (7.2)	77 (92.8)					
2–3	296 (59)	39 (13.8)	244 (86.2)	0.04	0.4 (0.2 to 1.2)	0.129		
>3	112 (22)	22 (20.2)	87 (79.8)		0.3 (0.1 to 0.8)	0.021		
History of abortion								
None	377 (75)	47 (13.2)	308 (86.8)	0.36				
≥1	125 (25)	20 (16.7)	100 (83.3)		0.7 (0.4 to 1.4)	0.422		
Caesarean antecedent								
None	417 (83)	52 (13.2)	343 (86.8)					
Once	68 (14)	13 (20)	52 (80)	0.48	0.5 (0.2 to 1.1)	0.12		
≥2	17 (3)	2 (15.4)	13 (85)		0.9 (0.2 to 4.3)	0.948		
Embryo-fetopathy antecedent								
Yes	30 (6)	5 (17.2)	24 (82.8)	0.58	0.7 (0.2 to 2.0)	0.577		
No	472 (94)	62 (13.9)	384 (86.1)					
Ultrasound abnormalities								
Not done	114 (22.7)	18 (16.8)	89 (83.2)	0.58				

AOR: OR adjusted by multiple logistic regression analysis of the variables age and parity.
AOR, adjusted OR.

Rabat and Central Morocco, which were 90% and 88.6%, respectively.[13 14] Furthermore, the rubella seroprevalence found in other studies was high, with a 95% seroprevalence among pregnant women in Finland and the Netherlands[19] and a measured seroprevalence of 90% among pregnant women in Ontario.[20] These comparisons should be carefully taken into consideration since these studies have been conducted for decades and in various areas and laboratory tests. The tests used to determine the Ig G antibodies titres and their cut-off values were probably different from what we have used.[21]

According to the WHO, a susceptibility rate of 10% among adult women could result in outbreaks of CRS.[5] It should be noted that the estimated yearly incidence rate of CRS in Morocco is 8.1–12.7 per 100 000 live births.[22] Therefore, attention must be paid to the susceptible group of women in this study in order to reduce this medium risk of CRS in future pregnancies. In addition, the observed rates of past exposure in the current study and other reports in different African countries were generally high, which indicates a continuous transmission of an endemic RV in the region. As a result, most

Table 3 Distribution of rubella IgG antibodies in relation to the clinical information of pregnant women

Variables	Descriptive data n (%) tested	Rubella seroprevalence			Univariable logistic regression	
		IgG-negative, n (%)	IgG-positive, n (%)	χ^2 test	OR (95% CI)	P value
Fever						
Yes	83 (17)	13 (16.3)	67 (83.8)	0.59	0.7 (0.4 to 1.532)	0.486
No	418 (83)	54 (13.7)	340 (86.3)			
Lymphadenopathy						
Yes	20 (4)	5 (27.8)	13 (72.2)	0.15	0.3 (0.1 to 1.1)	0.089
No	482 (96)	62 (13.6)	395 (86.4)			
Hepatic signs						
Yes	9 (1.8)	0 (0)	7 (100)	0.60		
No	493 (98.2)	67 (14.3)	401 (85.7)			
Digestive signs						
Yes	165 (33)	28 (18.1)	127 (81.9)	0.09	0.6 (0.3 to 1.0)	0.101
No	337 (67.1)	39 (12.2)	281 (87.8)			
Articular signs						
Yes	105 (21)	16 (16.5)	81 (83.5)	0.51	0.8 (0.4 to 1.5)	0.555
No	397 (79.1)	51 (13.5)	327 (86.5)			
Cutaneous signs						
Yes	56 (11)	9 (17)	44 (83)	0.53	0.7 (0.3 to 1.6)	0.477
No	445 (89)	58 (13.8)	363 (86.2)			
Cardiac signs						
Yes	124 (24.7)	14 (11.9)	104 (88.1)	0.54	1.3 (0.7 to 2.6)	0.337
No	378 (75.3)	53 (14.8)	304 (85.2)			
Respiratory signs						
Yes	141 (28)	20 (15.3)	112 (85)	0.7	0.9 (0.5 to 1.6)	0.752
No	361 (82)	47 (13.7)	296 (86.3)			

women become infected before reaching their childbearing age.[23] On the other hand, the fact that 14.1% of these studied women were seronegative may be due to an incomplete antibody response or a decline in antibodies over time. In Morocco, rubella is not a notifiable disease. Even though an effective vaccine against this infection has existed since 2003 in Morocco, RV has not been eradicated. In accordance with the WHO recommendations, efforts should be put into accomplishing supplemental immunisation activity and regular periodic follow-up at the national level.[5] Selective vaccination of adolescent girls and women of childbearing age susceptible to rubella or vaccination in the postpartum period should be implemented to prevent the spread of rubella and to reduce the risk of CRS. Of the 71% women who have undergone pregnancy, 16.7% are still susceptible to rubella despite recommendations for vaccination after delivery. There is a low compliance with vaccination among these multiparous pregnant women and this may be due to irregular follow-ups during their pregnancy and therefore to insufficient awareness. Although they are still unconvinced of the benefits of vaccination, vaccine awareness campaigns, especially among unvaccinated multiparous women, remain necessary to achieving the goal of eliminating RV. The WHO recommends that every multiparous seronegative pregnant woman should be vaccinated post partum before discharge from hospital in order to reach 100% seroprevalence; however, this has not yet been done in Morocco.[14] In addition, 8% of primiparous women remain seronegative because there is no premarital rubella serodiagnosis, knowing that interpretation of serology becomes more complicated if done during pregnancy. The WHO recommends that such women must be vaccinated after delivery before leaving the hospital to achieve 100% seroprevalence.[5] Besides, this reflects adults' non-compliance with the national immunisation plan and the barriers that prevent the adoption of rubella vaccines. Indeed, these pregnant women are still poorly informed about vaccination against rubella in the postpartum period and about CRS. A major barrier is the lack of an effective communication strategy to address vaccine hesitancy among these pregnant women to increase their adherence to the vaccination programme. The health system sector should improve awareness and knowledge

Table 4 Distribution of rubella IgG antibodies in relation to the entourage of pregnant women, their housing conditions and consequences of promiscuity

Variables	Descriptive data n (%) tested	Rubella seroprevalence			Univariable logistic regression	
		IgG-negative, n (%)	IgG-positive, n (%)	χ^2 test	OR (95% CI)	P value
Number of children living in the same house						
0	114 (22.7)	9 (8.7)	94 (91.3)			
≥1	388 (77.3)	58 (15.2)	314 (84.8)	0.1	0.5 (0.2 to 1.1)	0.098
Child in the same house with erythema						
Yes	95 (19)	50 (13.1)	332 (86.9)	0.24	0.7 (0.3 to 1.3)	0.263
No	407 (81)	17 (18.3)	76 (81.7)			
Housing condition: sibling during childhood ≥5						
Yes	295 (58.8)	41 (14.5)	242 (85.5)	0.79	0.9 (0.5 to 1.5)	0.723
No	207 (41.2)	26 (13.5)	166 (86.5)			
More than four people/room during childhood						
Yes	209 (41.6)	23 (11.6)	175 (88.4)	0.22	1.4 (0.8 to 2.5)	0.178
No	293 (58.4)	44 (15.9)	233 (84.1)			
More than three people/room currently						
Yes	207 (41.2)	31 (15.7)	166 (84.3)	0.07	0.7 (0.4 to 1.3)	0.394
No	295 (58.8)	36 (12.6)	242 (87.4)			
≥4 room at home currently						
Yes	44 (8.8)	3 (7.1)	39 (92.9)	0.24	2.1 (0.6 to 7.3)	0.202
No	458 (91.2)	64 (14.8)	369 (85.2)			

about the risk of rubella and CRS among these pregnant women, especially before conception, or during or after their first pregnancy. Vaccination awareness campaigns, especially among non-immunised multiparous and primiparous women, remain crucial but are not carried out by health authorities. On the other hand, despite the implementation of supplementary vaccinations in 2008 and 2013 for girls aged 15–24 years old and for both genders aged 9 months–19 years old, the country still records relatively high seronegativity according to this study and other studies when compared with the RV eradication objective of the Ministry of Public Health.[13 14] Consequently, health authorities must continue their efforts to achieve sufficient immunisation coverage by mass vaccination of women of childbearing age and school-age girls, as well as routine vaccination of children against measles and rubella. Furthermore, rubella-sensitive populations should have easy access to the site where vaccination services are provided and available.

Several factors may influence the seroprevalence of rubella among and within countries.[5] This study showed that the immunity rate among pregnant women decreased significantly and progressively with increasing age. This fact points out that these older Moroccan women present potentially increased risk factors. Future studies should be focused on rubella IgG seroprevalence in older age groups to assess the appropriate age for a catch-up campaign. On the other side, other seroepidemiological worldwide studies revealed that the seropositivity among pregnant women increased with age.[15 24] Along with this, matching results were recorded in studies conducted in India and Burkina Faso.[25 26] Moreover, in Morocco, there was a change in the immunisation programme with regard to the dosage of rubella. Indeed, prior to 2003, RV 'vaccine' was mainly administered as a single dose. Since then, the number of doses has increased from one to two. As a result, the efficiency of the two doses is 'better' than one even if the difference is slight. In addition, antibody levels may decline over time after vaccination and after natural infection, as noted in the literature, by a minimal annual decay of 2.9%.[21] However, younger pregnant women may access healthcare differently compared with older pregnant women depending on the year of vaccination and therefore they may have different preconception or prenatal health behaviours.[27]

In the current study, illiteracy, middle educational level and parity appear as risk factors for increased susceptibility to rubella infection, perhaps through contact with contagious secretions from their own children and with the poor hygiene practised by these women.[28] This could also be attributed to the increased probability of acquiring rubella infection during the early school years.[29] The secondary education group, accounting for 160 (89.9%), had the highest seropositivity rate for IgG. This result could be related to lack of awareness about RV among this group. The association between lower educational

attainment and increased rubella susceptibility may also suggest socioeconomic inequalities in rubella vaccine uptake. This possibility is consistent with inequalities observed in the general uptake of childhood vaccine in Canada.[30] However, more research is needed to determine the underlying causes of these inequalities and to measure the relative contributions of vaccine hesitancy and systemic barriers. In contrast, no statistically significant difference in rubella IgG positivity was found in relation to professional activity, marital status and social level. In a recent study, similar findings were recorded in southern Ethiopia[23] and in other studies in Nigeria[31] and Burkina Faso.[26] At the time of data collection, there was no significant association between the presence or absence of clinical signs and rubella IgG positivity. This may be due to the non-specificity of clinical manifestations. In effect, clinical diagnosis of rubella is unreliable.[32]

Regarding the distribution of rubella exposure by age in the univariate analysis, it was revealed that the youngest age group (17–24 years) had better immunity compared with the oldest age group. The 17–24 years age group probably benefited from mass vaccination campaigns in 2003, but this was not the case for the older age group. The odds of seropositivity were calculated by multivariate analysis to assess the predictors of rubella susceptibility while controlling age group, parity and educational level. It was found that none of these variables was significantly associated with rubella infection. The association between rubella immunity, age and multiparity could be confusing since age and multiparity act in the same direction (confounding variables).

The current study has some limitations which need to be taken into consideration. Because of limited resources, it was difficult to use advanced laboratory techniques such as RT-PCR (Retrotranscriptase Polymerase Chain Reaction) for the diagnosis of congenital rubella in all laboratories. As an important limitation of this study, there is also a lack of confirmed history of rubella vaccination. In addition, our results concern the region of Rabat and its surrounded areas. Knowing that Moroccan population is mainly distributed in urban areas with a population of 19.969 million and in rural areas with 16.861 million, these results cannot be extended to other regions of Morocco, especially to people living in rural or remote areas where access to healthcare is more difficult. Further studies need to be done in several clinics with larger sample sizes to determine the seroprevalence of rubella in Moroccan communities. This study, however, might serve as basic data for the study area as there is a paucity of information on rubella among pregnant women in the country.

CONCLUSION

The rate of rubella immunity among pregnant women in the region of Rabat is high (85.9%), where nearly 14.1% of pregnant women were non-immune, which in our study represent the group susceptible to rubella. This suggests a continuous transmission of an endemic RV even with good vaccination coverage. However, vaccination programmes need to be evaluated to ensure that an intervention reaches its specified goals. In the current study, there is a need to catch up with a vaccine regimen that targets seronegative women to reinforce routine immunisation coverage in combination with supplementary immunisation of adolescent girls. Of multiparous pregnant women, 17% were susceptible to rubella infection, suggesting that compliance to the postpartum vaccination recommendations among these women should have a positive impact. As 17.2% among older women were found to be susceptible, this age group should be considered in future studies to design additional strategies for vaccination. Risk factors associated with rubella seropositivity found in this study may be useful for the optimal design of preventive measures against rubella and its sequelae.

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Patient consent for publication Obtained.

Ethics approval This study involves human participants and was approved by the Ethics Committee for Biomedical Research of the Faculty of Medicine and Pharmacy, Rabat, Morocco (file number: 64-21). Participants gave informed consent to participate in the study before taking part.

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