

Seroprevalence of Rubella in a Group of Moroccan Parturients and Physicians' Opinions

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ABSTRACT

Background: Rubella is an acute viral disease generally mild in its clinical manifestations. However, it is most serious for pregnant women due to the high frequency of congenital abnormalities that it causes, known as congenital rubella syndrome. This study aimed to determine rubella seroprevalence among a group of Moroccan parturients and survey physicians' opinions regarding the situation of congenital rubella syndrome in different regions of Morocco.

Methods: We prospectively enrolled 1500 women hospitalized in the Maternity Souissi of Rabat for delivery and 14 pediatricians/neonatologists who were practicing in public and private centers representing different regions of Morocco. Data on rubella serological status were extracted from the medical records of mothers. The physicians involved in this study were visited to answer the survey in person, or they completed the survey by e-mail or phone discussion.

Results: Among enrolled women, and after excluding those who did not bring back evidence of a serological assessment, 222 (17.5%) women performed a rubella serology of which 84.7% were immunized against rubella. The opinion poll of physicians showed an almost absence of reports on congenital rubella syndrome cases. All practitioners surveyed were interested to join the establishment of congenital rubella syndrome reporting system.

Conclusion: To achieve the goals set for congenital rubella syndrome elimination, it is of primary importance to protect women from the childbearing age by vaccination and measures that help avoid any further contact with the virus. There is also a need to expand serological screening to detect and monitor seronegative women. In addition, it is necessary to diagnose and notify new cases of congenital rubella syndrome.

Keywords: Congenital anomalies, Congenital rubella syndrome, Parturient, Rubella, Seroprevalence.

Introduction

Rubella is an acute and generally mild viral disease that is contagious and mainly affects children and young adults (1). A rubella infection, occurring just before conception or early in pregnancy (in the first trimester), can cause a miscarriage or fetal death, as it can cause a range of congenital abnormalities known as congenital rubella syndrome (CRS). Clinical manifestations of CRS include central nervous system malformations (microcephaly and others), microphthalmia, other ocular abnormalities, sensorineural hearing loss, and congenital heart defects (2-4).

Infection with the rubella virus is one of the major causes of birth defects (5). The CRS incidence is higher in developing countries. It is estimated that these values vary within countries between 0.6 and 2.2 per 1000 live births (6). In industrialized countries, the incidence of rubella and CRS cases has decreased significantly from the start of the rubella vaccination.

The vaccine has led to the elimination of rubella and CRS in some European and Pacific countries (7), and it was eradicated in America in 2009 (8). In Canada, the annual incidence of rubella and CRS has decreased after the

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introduction of the immunization program in 1970, and no cases of CRS have been reported since 2000 (9-11). In France, the incidence rate of CRS has decreased simultaneously with a decrease in rubella cases. Therefore, no case of CRS was reported between 2006 and 2008, and only two cases were notified in 2009 (12). The European region is committed to the World Health Organization's (WHO) measles and CRS elimination policy; nevertheless, the elimination target set for 2015 has not been achieved (13).

In 2018, 11,787 cases of rubella and 18 cases of CRS were reported in Africa (14). In Morocco, the epidemiology of rubella and CRS is not very well known, where the incidence of CRS is estimated to be between 0.81 and 1.27 per 1,000 births, thus the annual incidence has been estimated to be between 8.1 and 12.7 cases per 100,000 live births (15,16). The Moroccan national immunization program, which includes the rubella vaccine, aims to achieve 95% vaccination coverage and eradicate a number of diseases, including rubella and CRS (17). In order to prevent rubella and CRS, 2,235,000 young girls and women and approximately 8,500,000 children were vaccinated from 2003 to 2008 in Morocco (18).

We conducted a seroepidemiologic study to assess the level of protective immunity and risk of rubella in Moroccan parturients, as well as an opinion survey among physicians, who are in contact with newborns and infants in different Moroccan regions.

Methods

Study design

This study was conducted in the city of Rabat at the Maternity Souissi, IBN SINA University Hospital Center. Rabat is the capital of Morocco and has a Mediterranean climate. This city is located on the Atlantic coast. The land area is 11,850 ha (118.5 km²), and the total population has been 577,825 inhabitants in 2014.

The first part of this study is a cross-sectional descriptive survey, for which the prospective data collection was conducted between July 1, 2019, and October 15, 2019. The second part has been a multicentric study realized in the same period as the first part.

Participants

First part of the study:

Parturients included in the study were all admitted to the Maternity Hospital of Rabat during the study period for delivery.

Second part of the study:

We approached a total of 14 pediatricians and neonatologists practicing in public and private centers from different regions of Morocco to participate in this study.

Data collection

The data collection was carried out using a documentary technique by consulting the medical records of each patient. All data (i.e., age, term of pregnancy, gravidity, parity, history of pregnancy, and serological status) were collected from medical records and entered into an information sheet.

The data collection of the physician opinion poll was performed using a self-administered survey. Some physicians were visited and others received the survey by e-mail or completed it through phone discussion. The data were collected using a questionnaire that was focused on the current status of rubella notification and the situation of the CRS in Moroccan health centers. The questionnaire was composed of five sections: types of congenital pathologies observed by the clinicians, origin of congenital pathologies observed, state of play related to CRS cases, comments, and suggestions.

Statistical analysis

The statistical analysis was performed using SPSS software (version 19).

A descriptive study of quantitative Gaussian distribution variables was performed using mean and standard deviation data. Qualitative variables were expressed using frequencies and percentages and compared using the Chi-square and Fisher tests according to the conditions for the application of each test. A p-value less than 0.05 ($P < 0.05$) was considered statistically significant.

Results

Seroprevalence of rubella

A total of 1500 women were enrolled in this study with a mean age of 29 ± 7 years. Most (58.3%) of the women were in the age range of 19-30 years. Primigravida women represented 41.5% of the study population. Of the 1500 women, 83.8% had no history of pregnancy complications, while 14.2% ($n=213$), 1.2% ($n=18$), 0.5% ($n=7$), and 0.3% ($n=4$) had a history of miscarriages, intrauterine fetal death, neonatal death, and stillbirth, respectively (Table 1).

Out of the whole women, 84.3% have realized

Table 1. Women’s characteristics (N=1500)

| Characteristics | Frequency (%) |
|------------------------------------|---------------|
| Age (Years) | |
| ≤18 | 62 (4.1) |
| 19-30 | 875 (58.3) |
| 31-40 | 511 (34.1) |
| >40 | 52 (3.5) |
| Gravidity | |
| Primigravida | 608 (41.5) |
| Multigravida | 892 (59.5) |
| Parity | |
| Primiparous | 673 (44.9) |
| Multiparous | 827 (55.1) |
| Gestational age | |
| Full-term | 1070 (71.4) |
| Prematurity | 104 (6.9) |
| Postterm | 326 (21.7) |
| History of pregnancy complications | |
| Miscarriages | 213 (14.2) |
| Intrauterine fetal death | 18 (1.2) |
| Neonatal death | 7 (0.5) |
| Stillbirth | 4 (0.3) |

serology for at least one of the following diseases: syphilis, toxoplasmosis, rubella, hepatitis B and C, and human immunodeficiency viruses. Among enrolled women, 222 (17.5%) women performed a rubella serology after excluding those who did not bring back evidence of a serological assessment, of whom 84.7% were immunized against rubella (Figure 1).

Women in the age range of 19-30 years old were most immunized against rubella with a rate of 56%. However, women aged over 30 years were the least immunized against this disease. The statistical analysis did not show a statistically significant difference between age groups and rubella immunity. Among immune women, 53% were multigravida, 53% were primiparous, and 73% had delivered at full term. Most immunized women were multigravida (53%; P=0.028). As for parity, the majority of immunized women were primiparous (53%; P=0.013) (Table 2).

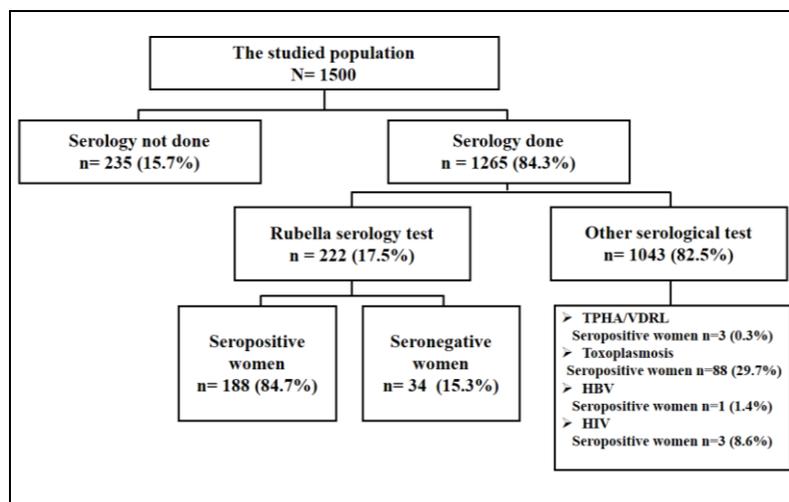


Figure 1. Flowchart of immune status of parturients women
HIV: Human immunodeficiency viruses
HBV: Hepatitis B virus

Table 2. Rubella immune status of women according to age, gravidity, parity, gestational age, and congenital anomalies (N=222)

| Characteristics | Seropositive women | Frequency (%) | Seronegative women | Frequency (%) | P-value |
|-----------------|--------------------|---------------|--------------------|---------------|---------|
| | N=188 | | N=34 | | |
| Age (Years) | | | | | |
| ≤18 | 14 | (7) | 1 | (3) | 0.262 |
| 19-30 | 105 | (56) | 15 | (44) | |
| 31-40 | 62 | (33) | 17 | (50) | |
| >4 | 7 | (4) | 1 | (3) | |
| Gravidity | | | | | |
| Primigravida | 88 | (47) | 9 | (26) | 0.028 |
| Multigravida | 100 | (53) | 25 | (74) | |
| Parity | | | | | |
| Primiparous | 99 | (53) | 10 | (29) | 0.013 |
| Multiparous | 89 | (47) | 24 | (71) | |
| Gestational age | | | | | |
| Full-term | 138 | (73) | 28 | (82) | 0.390 |
| Prematurity | 18 | (10) | 1 | (3) | |
| Post term | 32 | (17) | 5 | (15) | |

Opinion poll of physicians

Healthcare establishments included in our study

A total of 14 physicians, representing both public and private health sectors, replied to the survey whose aim was to achieve a proper assessment of the current situation concerning CRS.

Congenital abnormalities observed by the physicians

Hydrocephalus, congenital heart defect, ophthalmological abnormalities, microcephaly, and deafness were observed in 14 centers during hospitalization and consultation.

Origin of congenital pathologies observed by the physicians

The congenital pathologies observed in the different included hospitals were either of genetic or infectious origin. CRS pathologies are generally diagnosed on clinical presumption; however, six physicians stated that the diagnosis of CRS is also made through laboratory confirmation.

State of play related to CRS cases

- There were no documents or electronic support for recording data of CRS cases in Moroccan health centers except for Moulay Youssef Hospital in Casablanca where data on CRS cases were recorded in registers.
- Concerning the recording of congenital anomalies, registers can be found in all university hospitals and two regional hospitals.
- All physicians confirmed that there were no specialized consultations for CRS cases.
- Five (36%) physicians testified that their centers could potentially be a good site for recruiting CRS cases.
- The majority of physicians asserted that their practicing site could be a sentinel surveillance site for CRS.
- Seven (50%) physicians reported that they explored the immunization history for women at risk of materno-fetal transmission of CRS in their practice through an interrogation or collecting information from the health booklet or the vaccination records and/or from the medical record. Two physicians claimed that they interviewed the affected women about the infection's origin.
- Most physicians are interested to receive saliva sampling kits for rubella testing at the National Institute of Hygiene.
- According to the physicians' testimony, there were two cases of rubella registered at the

provincial hospital center of Midelt, four cases in private pediatric practice at Tinghir, and four suspected cases (three in Tinguir and one in Meknes).

Comments and suggestions from the physicians

- Installation of a technical platform for performing serology testing of rubella.
- Recruitment of specialist physicians (e.g. ophthalmologists) in some sites.
- Organization of a declaration system and specialized medical consultations.
- Immediate postpartum vaccination of seronegative women.
- A good follow-up of pregnancy by performing serological monitoring.
- Improvement of CRS diagnosis in our country.
- Population awareness and training of healthcare workers.

Physicians' opinion poll showed

An almost total absence of reports on CRS cases.

The most common warning signs to suspect CRS cases are congenital anomalies. If present, the cases are referred to pediatrics or neonatology departments.

Cases of CRS are often suspected in the pediatrics and neonatology departments.

Discussion

Although rubella is usually a mild infection, it is very severe in women during the first trimester of pregnancy. Its severity is represented in the occurrence of birth defects in most cases. The risk of viral transmission is estimated to be 90% during the first 10 weeks of pregnancy, 54% between the thirteenth and fourteenth weeks of pregnancy, and 25% at the end of the second trimester. The risk of fetal malformation becomes rare or non-existent after the 20th week of pregnancy (19, 20).

After the establishment of vaccination programs in industrialized countries, the incidence of rubella and CRS has considerably decreased (21). Rubella vaccine is usually given as the combined measles, mumps, and rubella vaccine (22). The coverage of the vaccine varies from one country to another; therefore, the virus remains circulating in many countries and cases of CRS are still always reported (23). In Africa, rubella is badly monitored, resulting in limited information about this disease. Among the developing countries, only 28% have included rubella in their immunization program including

Morocco, Tunisia, Libya, and Egypt (4,15,24).

In Morocco, rubella is not a notifiable disease and the studies carried out remain very limited (25). In 2003, Morocco introduced the rubella vaccine in the public sector, and before this date vaccination was only carried out in the private sector (26,27). The vaccination program does not take into consideration women of childbearing age and there is no legislation requiring rubella screening in pregnant women (16). It is necessary to determine the rubella antibody status of pregnant women early in pregnancy to raise awareness among women at risk and vaccinate them in the postpartum period (28, 29). According to global health experts, the primary purpose of rubella vaccination is to prevent CRS (28).

In our study, among the women who performed a rubella serology test, 84.7% were seropositive and 15.3% were not immunized. Our results are similar to those carried out by Zahir et al. (16), among pregnant women in Agadir, Marrakech, and Ouarzazate, whose seropositivity was 84.7%. National serological studies carried out between 2002 and 2015 reported comparable seropositivity ranging from 83.4% to 90.2% among pregnant women. According to Caidi et al. (27), 83.4% of the women were immunized, 90.2% were immunized according to Belefquih et al. (26), and 88.6% were immunized according to Sbity et al. (30). The risk of infection in Moroccan women of childbearing age is not neglected and consequently, the risk of CRS still exists. The seropositivity of rubella was 85.5% in 2000 and 81.1% between 2007 and 2008 as per the study carried out by Chaabouni et al. in Tunisia (31).

In view of our results, it might be important to sensitize and educate seronegative women about hygiene measures to reduce the risk of exposure to the virus, while encouraging members of unimmunized families to get vaccinated (32). In April 2012, the Measles and Rubella Initiative launched a new Global Measles and Rubella Strategic Plan that covered the period between 2012 and 2020. Morocco is part of the countries that have adopted this strategy which had as one of its expectations the achievement of regional measles, CRS, and rubella eradication goals by the end of 2015 (33).

To achieve the CRS eradication goal in our country, it is important to know the current epidemiological situation of rubella and CRS and to implement a national reporting system for CRS cases. The reporting system must be distributed at the national level to ensure data collection and real-time monitoring of CRS cases as well as

measuring seroprevalence of infection. It is necessary to conduct surveys with physicians to determine the current state of play before proposing and establishing such reporting system.

A survey of physicians showed that there were no specialized consultations for CRS cases. The data on CRS cases were recorded in only one Moroccan health center. Moreover, there was no electronic medical record support to document CRS cases. Since 1976, the surveillance of rubella infections in pregnant women and newborns has been conducted in France to evaluate the vaccination policy and preventive measures taken against rubella (34).

The surveillance of CRS cases requires a broad screening system for suspected cases in infants and young children, as well as a thorough clinical examination and laboratory tests for each case. It also requires the establishment of a national reporting system to collect data systematically and continuously concerning those cases to set up public health measures and prevent the occurrence of new cases.

Conclusion

To achieve CRS elimination goals, it is of primary importance to protect women of childbearing age both by vaccination and measures that help avoid any further contact with the virus. There is also a need to expand serological screening to detect and monitor seronegative women.

The establishment of a national reporting system for CRS is of great importance. It will allow us to know the epidemiology of the disease in order to control the situation at the national level, identify the transmission of the disease, and prevent its deadly and disabling consequences in our country.

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Conflicts of interest

The authors declare that they have no conflicts of interest to report.

References

1. Best JM. Rubella. *Semin Fetal Neonatal Med.* 2007;

- 12(3):182- 92.
2. Woolf SH, Battista RN, Anderson GM, Logan AG, Wang E. Assessing the clinical effectiveness of preventive maneuvers: Analytic principles and systematic methods in reviewing evidence and developing clinical practice recommendations A report by the Canadian task force on the periodic health examination. *J Clin Epidemiol.* 1990; 43(9):891- 905.
 3. Duszak RS. Congenital rubella syndrome—major review. *Optometry.* 2009; 80(1):36- 43.
 4. Caidi H, Abernathy ES, Benjouad A, Smit S, Bwogi J, Nanyunja M, et al. Phylogenetic analysis of rubella viruses found in Morocco, Uganda, Cote d'Ivoire and South Africa from 2001 to 2007. *J Clin Virol.* 2008; 42(1):86- 90.
 5. Kassa ZY, Hussien S, Asnake S. Sero-prevalence of rubella among pregnant women in Sub-Saharan Africa: a meta-analysis. *Hum Vaccines Immunother.* 2020; 16(10):2472- 8.
 6. Cutts FT, Robertson SE, Diaz-Ortega JL, Samuel R. Control of rubella and congenital rubella syndrome (CRS) in developing countries, Part 1: Burden of disease from CRS. *Bull World Health Organ.* 1997; 75(1):55-68.
 7. WHO. Roadmap to elimination standard measles and rubella surveillance = Feuille de route pour une surveillance de la rougeole et de la rubéole. Available at : <https://apps.who.int/iris/handle/10665/254754>.
 8. Andrus JK, de Quadros CA, Solórzano CC, Periago MR, Henderson DA. Measles and rubella eradication in the Americas. *Vaccine.* 2011; 29(4):91-6.
 9. Gilbert NL, Rotondo J, Shapiro J, Sherrard L, Fraser WD, Ward BJ. Seroprevalence of rubella antibodies and determinants of susceptibility to rubella in a cohort of pregnant women in Canada, 2008-2011. *Vaccine.* 2017; 35(23):3050- 5.
 10. Dontigny L, Arsenault MY, Martel MJ, Biringer A, Cormier J, Delaney M, et al. Rubéole au cours de la grossesse. *J Obstet Gynaecol Can.* 2008; 30(2):159- 66.
 11. Public Health Agency of Canada. Surveillance of Rubella [Internet]. Government of Canada. 2016 [cited 2021 Sep 13]. Available from : <https://www.canada.ca/en/public-health/services/diseases/rubella/surveillance-rubella.html>
 12. Adamo G, Sturabotti G, D'andrea E, Baccolini V, Romano F, Iannazzo S, et al. The end of measles and congenital rubella: an achievable dream. *Ann Ig.* 2017; 29(1):1- 26.
 13. Béraud G, Abrams S, Beutels P, Dervaux B, Hens N. Resurgence risk for measles, mumps and rubella in France in 2018 and 2020. *Euro Surveill.* 2018; 23(25):1-11.
 14. Grant GB, Desai S, Dumolard L, Kretsinger K, Reef SE. Progress toward rubella and congenital rubella syndrome control and elimination—Worldwide, 2000–2018. *Morb Mortal Wkly Rep.* 2019; 68(39):855-59.
 15. Bloom S, Rguig A, Berraho A, Zniber L, Bouazzaoui N, Zaghoul K, et al. Congenital rubella syndrome burden in Morocco: a rapid retrospective assessment. *Lancet.* 2005; 365(9454):135- 41.
 16. Zahir H, Arsalane L, Elghouat G, Mouhib H, Elkamouni Y, Zouhair S. Seroprevalence of rubella in pregnant women in Southern Morocco. *Pan Afr Med J.* 2020; 35(1):1-3.
 17. Direction de la Population. Programme National d'Immunsation, Aspects pratiques de la vaccination Manuel de formation [Internet]. 2013 [cited 2021 Oct 22]. Available from: https://www.sante.gov.ma/Documents/Manuel_PNI_29juin2013_VersionImprime_SIPAMA.pdf
 18. Service de la Protection de la Santé de l'Enfant / Division de la Santé Maternelle et Infantile / Direction de la Population. PROGRAMME NATIONAL D'IMMUNISATION. 2012 [Internet]. Available from : <https://fr.slideshare.net/MehdiRazzok/programme-national-dimmunsation>
 19. Miller E, Cradock-Watson JE, Pollock TM. Consequences of confirmed maternal rubella at successive stages of pregnancy. *Lancet.* 1982; 320(8302):781- 4.
 20. Banatvala JE, Brown DW. Rubella. *Lancet.* 2004; 363(9415):1127- 37.
 21. Robertson SE, Featherstone DA, Gacic-Dobo M, Hersh BS. Rubella and congenital rubella syndrome: global update. *Rev Panam Salud Publica.* 2003; 14:306- 15.
 22. Mangtani P, Evans SJ, Lange B, Oberle D, Smith J, Drechsel-Baeuerle U, et al. Safety profile of rubella vaccine administered to pregnant women: A systematic review of pregnancy related adverse events following immunisation, including congenital rubella syndrome and congenital rubella infection in the foetus or infant. *Vaccine.* 2020; 38(5):963- 78.
 23. Robertson SE, Featherstone DA, Gacic-Dobo M, Hersh BS. Rubella and congenital rubella syndrome: global update. *Rev Panam Salud Publica.* 2003; 14(5):306- 15.
 24. Karakoc GB, Altintas DU, Kilinc B, Karabay A, Mungan NO, Yilmaz M, et al. Seroprevalence of rubella in school girls and pregnant women. *Eur J Epidemiol.* 2003; 18(1):81- 4.
 25. Bulletin officiel n° 2853 du 5/07/1967 (5 juillet 1967). Décret royal n° 554-65 du 17 rebia I 1387 (26 juin 1967) portant loi rendant obligatoire la déclaration de certaines maladies et prescrivant des mesures prophylactiques propres à enrayer ces maladies. [Internet]. [cited 2019 Oct 20]. Available at : https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKewiN6_Lap4X6AhUIGP0HHVeKAb4QFnoECAYQAQ&url=https%3A%2F%2Fwww.ilo.org%2Fwcmssp5%2Fgroups%2Fpublic%2F---ed_protect%2F---protrav%2F---ilo_aids%2Fdocuments%2Flegaldocument%2Fwcmss_127078.pdf&usq=A0vVaw21ThfKiwl9_tleYbsFgcHQ
 26. Bo Belefquih B, Kasouati J, Doblali T, Touil N, Tagajdid MR, Kabbaj H, et al. Rubella seroprevalence in pregnant women at the military teaching hospital, Rabat, Morocco. *Int J Gynecol Obstet.* 2013; 120(2):191- 2.

27. Caidi H, Bloom S, Azilmaat M, Benjouad A, Reef S, El Aouad R. Rubella seroprevalence among women aged 15-39 years in Morocco. *East Mediterr Health J*. 2009; 15(3):526- 31.
28. Martínez-Quintana E, Castillo-Solórzano C, Torner N, Rodríguez-González F. Congenital rubella syndrome: a matter of concern. *Rev Panam Salud Pública*. 2015; 37(3):179- 86.
29. Boucoiran I, Castillo E. No 368 - La rubéole durant la grossesse. *J Obstet Gynaecol Can*. 2018; 40(12):1657- 68.
30. Sbiti M, Lahmadi K, Louzi L. Rubella immune status in pregnant women in central Morocco. *JSM Microbiol*. 2017; 5(2):1041.
31. Chaabouni M, Messadi F, Fki L, Hammami A, Karray H. Rubella seroprevalence in Tunisian childbearing women two years after vaccination program introduction. *Pathol Biol (Paris)*. 2012; 60(3):170- 3.
32. White SJ, Boldt KL, Holditch SJ, Poland GA, Jacobson RM. Measles, mumps, and rubella. *Clin Obstet Gynecol*. 2012; 55(2):1-10.
33. WHO. Global measles and rubella strategic plan: 2012–2020. 2022. Available at : <http://apps.who.int/iris/bitstream/10665/44855/1/9789241503396%5Feng.pdf>
34. Cerase V, Rebière I. La rubéole chez la femme enceinte et le nouveau-né en France en 1996. *J de Pédiatrie et de Pueric*. 1998; 11(7):435–9.