

# The frequency of IgG anti-varicella and anti-rubella antibodies in female students of Shiraz University of Medical Sciences, Iran

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## SUMMARY

**Background:** As infection with rubella and varicella-zoster viruses (VZV) can lead to congenital syndrome and its dangerous complications, assessing immunity to these congenital infections can represent the biological risk assessment related to their exposure in high-risk groups. Therefore, we aimed to evaluate the frequency of IgG anti-varicella/rubella antibodies (Abs) in female students at Shiraz University of Medical Sciences (SUMS), Iran.

**Patients and Methods:** In this study, a total of 434 female students were included. Sera were isolated from blood samples and stored at -20°C for later analysis. A questionnaire form was documented and contained demographic data as well as the history of vaccinations. Enrolled students were divided into recipients of either one or two doses of the measles/rubella (MR) vaccine. Serum samples were analyzed for rubella and VZV IgG Abs using commercial IgG immunoassays.

**Results:** The students were 21.6±4.25 years old on average. Out of the 434 enrolled students, 292 (67.3%) and 287 (66.1%) students were positive for anti-varicella and anti-rubella IgG-Abs, respectively. The frequency of anti-rubella IgG Ab was significantly higher in those who received one dose of MR vaccine ( $P<0.001$ ). In addition, 205 (47.2%) and 59 (13.6%) students were double-positive (anti-varicella/rubella IgG Abs) and double-negative, respectively.

**Conclusion:** Our results indicated that an additional dose of rubella vaccine may be required for those who received two doses of the vaccine. In addition, we recommend the inclusion of the VZV vaccine in Iran's routine vaccination program. Further studies are recommended to verify these results.

**Keywords:** Varicella, rubella, anti-varicella antibody, anti-rubella antibody, vaccine.

## INTRODUCTION

Despite attempts to eradicate preventable diseases such as mumps, measles, rubella, and chickenpox worldwide through vaccines, these

diseases are still a problem with periodic incidence even in developed and industrialized countries [1]. Reports indicate a decrease in antibody (Ab) titers against rubella and varicella-zoster (VZV) viruses in vaccinated populations [2, 3]. There is also evidence that the level of immunity differs significantly among vaccinated individuals [4, 5]. To control these diseases, immunization programs need to be flawlessly administered, immunity status

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must be checked on a regular basis, and geographically sensitive populations must be identified. This is of concern especially for women of child-bearing age, as infection can lead to congenital syndrome and its dangerous complications [6, 7]. Rubella virus is a member of the *Matonaviridae* family and belongs to the Rubivirus genus [8]. Rubella is a self-limiting viral infection that mostly affects youngsters, causing fever and skin rashes in up to 50% of cases [9]. The main concern with rubella is congenital rubella syndrome (CRS) in infants [6, 10]. This complicated syndrome occurs when a non-immune pregnant woman gets the infection, especially in the first few weeks of pregnancy, and the effects on the fetus can potentially lead to hearing impairment, cataracts, glaucoma, microcephaly, mental retardation, cardiac abnormalities, and some other problems [11]. A single dose of rubella vaccine has been shown to achieve a 95% immunization rate in recipients [12]. In a meta-analysis study by Sharghi et al. it was reported that the overall seroprevalence of rubella in women of reproductive age in Iran is 84% [13]. Christenson et al. reported that the vaccinated age group had lower Ab titers than naturally immune age group [14]. Chu et al. reported that almost all persons 16 years old after successful vaccination are found to have rubella Ab mediated by the vaccine [15].

VZV, also known as human herpesvirus 3 (HHV3), is a member of the *Herpesviridae* family which cause varicella (chickenpox). Chickenpox is an acute, highly contagious disease that is often benign and self-limiting in children [16]. Importantly, primary VZV infection during pregnancy has a significant impact on maternal and fetal health [11]. Severe varicella pneumonia can occur during pregnancy, and maternal infection can lead to congenital anomalies as well as severe disseminated infection in the newborn [17, 18]. In addition, in certain cases, VZV can also be considered a nosocomial infection [19]. Therefore, not only health-care workers who are not immune to the virus but also susceptible patients, especially immunocompromised children and adults, are at risk of hospital-acquired varicella infection. According to Mostafavi et al., there are statistically significant differences in the prevalence of VZV antibodies (Abs) between Iranian provinces, ranging from 82.4% in Isfahan to 98.5% in Mazandaran [20]. The varicella vaccine is made of a live attenuated virus. For

people older than 60 years of age, the zoster vaccine should be used. Except for the 14-fold increase in virus titer, this vaccine is similar to the varicella vaccine. Shingrix is a recombinant zoster vaccine in comparison to Zostavax (a live zoster vaccine). For immunosuppressed patients, it is not recommended to give live virus vaccines. Common side effects of the chickenpox vaccine include sore arms from the shot, fever, and a mild rash where the shot is given. Therefore, in this study, we aimed to assess the frequency of IgG anti-varicella/rubella Abs in Shiraz University of Medical Sciences (SUMS) female students.

## ■ PATIENTS AND METHODS

### *Sample collection*

In this study, the target population was female medical students who were referred to the department of bacteriology and virology at Shiraz medical school from 2016 to 2018. The study was approved by the SUMS Ethics Committee (IR.SUMS.MED.REC.1401.102). After receiving the written informed consent, the questionnaire with the demographic data and the history of the vaccination was recorded. A 5 mL sample of venous blood was drawn from each participant. The sera from the samples were isolated and stored at -20 °C until further analysis.

### *Serological test*

Using commercial IgG immunoassays, serum samples were examined for rubella (Pishtazteb, Tehran, Iran) and VZV (Viricell, Barcelona, Spain) IgG-Abs. Abs were defined as positive or negative based on the manufacturers' methodology. the mean O.D. Cut-off serum in the VZV kit was calculated by the formula: Antibody index = (sample O.D./cut-off serum mean O.D.) × 10, and <9 is negative, 9-11 is equivocal and >11 is positive. Cut-off serum in the rubella kit was calculated by the formula: Cut-off Index (COI) = OD of sample/cut-off value, <0.9 is negative, 0.9-1.1 is equivocal and >1.1 is positive.

### *Statistical analysis*

Pearson's chi-square test and Fisher's exact test were calculated to compare the proportion of anti-rubella and anti-varicella IgG titers between groups (adjusting for sex and age groups). Analysis was performed with SPSS v22 (IBM Corp., Armonk,

NY, USA), and a P-value <0.05 was considered statistically significant.

## ■ RESULTS

A total of 434 female medical students took part in the study. The mean age of the participants was  $21.6 \pm 4.25$  years old, ranging from 18-48. Serological tests showed that 292 (67.3%) and 287 (66.1%) students were positive for anti-varicella IgG Ab and anti-rubella IgG Ab, respectively. In addition, 205 (47.2%) and 59 (13.6%) students were double positive (anti-varicella/rubella IgG Abs) and double negative, respectively. Moreover, 170 (39.2%) students were only positive for anti-varicella IgG Ab or anti-rubella IgG Ab. Enrolled students were divided into two groups based on the 2003 national MR immunization program. The first group consisted of students who received two doses of the MR vaccine as part of Iran's regular immunization program, while the second group consisted of students who received one dose of the MR vaccine (one dose through the national MR immunization program in 2003). Anti-rubella IgG Ab was

significantly higher in those who received one doses of MR vaccine (second group) ( $P < 0.001$ ) (Table 1). Table 2 shows a comparison of age with frequency of anti-rubella IgG Ab in second group who received one dose of vaccine. In the group that received one dose of MR vaccine, the number of positive cases increased significantly with age ( $P = 0.013$ ) (Table 2). We found no statistically significant difference in anti-VZV IgG Ab frequency between the first and second group ( $P = 0.062$ ). Table 3 compares the three age groups of the students in second group with regard to age and the frequency of anti-varicella IgG Ab. There was no significant difference among age groups ( $P = 0.53$ ).

## ■ DISCUSSION

Rubella infection during pregnancy, particularly in the first trimester, can result in miscarriage or delivery of an infant with CRS [21]. Eliminating CRS is one of the most important global goals to improve population health. To achieve this goal, women of childbearing potential should be tested for rubella and, if not immune, vaccinated [21].

**Table 1** - The seroprevalence of anti-rubella IgG Ab between recipients of either 2 or 1 doses of MR vaccine.

MR vaccine dosage	Anti-rubella IgG antibody		P value
	Positive	Negative	
2 doses	85/182 (46.7%)	97/182 (53.3%)	<0.001
1 dose	202/252 (80.15%)	50/252 (19.85%)	

**Table 2** - The frequency of anti-rubella IgG Ab among the recipients of 1 doses of the MR vaccine with different ages.

Age (years old)	Anti-rubella IgG antibody		P value
	Positive	Negative	
21-25	99/135 (73.34%)	36/135 (26.66%)	0.013
26-30	84/96 (87.5%)	12/96 (12.5%)	
30-48	19/21 (90.5%)	2/21 (9.5%)	

**Table 3** - The frequency of anti-varicella IgG Ab among 3 age subgroups of students in group B.

Age (years old)	Anti-varicella IgG antibody		P value
	Positive	Negative	
21-25	96/135 (71.11%)	39/135 (28.89%)	0.53
26-30	66/96 (68.75%)	30/96 (31.25%)	
30-48	17/21 (80.95%)	4/21 (19.05%)	

Takahashi strain vaccine was integrated into Iran's regular immunization program [22]. Our results showed that female students who received only one dose of MR vaccine were significantly more seropositive to rubella compared to recipients of two doses of vaccine (80.15% vs. 46.7%). It seems that the reason why there are more positive cases in female students who have received one dose is their age and the possibility of more exposure to the virus and infection. In a cross-sectional study by Rahmani et al. 97.3% of medical students at SUMS who had a positive MR vaccination in December 2003 were positive for IgG against rubella [23]. Similarly, our results showed that immunity was 87.5% in students who received one dose of the vaccine in December 2003. It was reported that the seroprevalence of IgG against rubella in mothers was 79.6% three years after the introduction of rubella vaccination in Vietnam [24]. Thayyil et al. also found that the prevalence of rubella-specific IgG Ab in unvaccinated 13-15 year old girls (in the rural area of Mavoor Panchayath, Kozhikode District, Kerala, India) due to natural infection was 68.3% [25]. Frau et al. reported a 97.3% seropositivity for rubella in Italian female school workers [26]. In another study, the rate of immunized women over the 8-year study period in Korean women of childbearing age (aged 15-49 years) ranged from 90.3% to 92.2% [27]. Shahapur et al. also reported that anti-rubella IgG Ab were present in 39.2% of pregnant and 20.86% of non-pregnant women [28]. In a meta-analysis study, Azami et al. reported that the overall immunity rate for rubella in pregnant Iranian women before and after the national vaccination program was 88.6% and 91.5%, respectively [29]. Another meta-analysis reported that 84% of Iranian women of childbearing age had a seroprevalence of rubella. The lowest prevalence rate of anti-rubella IgG was in Jahrom (54%), the highest prevalence in Zahedan, Arak and Rasht (100% each). Subgroup analysis showed that the prevalence rate of anti-rubella IgG increased from 78% in 1989 to 99% in 2012 [13]. Occupational exposure (for doctors, nurses, and teachers) is a factor that increases the likelihood of rubella infection. Torre et al. reported that out of 1106 healthcare workers in a teaching hospital in Rome, 73 (6.6%) were susceptible to rubella [30]. In our study, 46.7% and 80.15% of the female medical students who received two and one doses of the MR vaccine were seropositive. This implies that the majority of re-

cipients of the two doses of the vaccine are still susceptible and at potential risk of contracting rubella infection. In our study, a statistically significant difference was found between age and seroprevalence for rubella in each group. In a study, three years after the introduction of rubella vaccination in Vietnam, the seronegativity in mothers under 35 years old was significantly low [24].

Chickenpox is another contagious disease for which protective levels of Ab against VZV are important, particularly during pregnancy, and require vaccination in susceptible women of childbearing potential [31]. In our study, 292 (67.3%) female students were positive for anti-varicella IgG Ab. There was no statistically significant difference in the frequency of anti-varicella IgG Ab between the two age groups. In a similar study, Majidy et al. reported that 71.2% of women were susceptible to VZV infection before marriage [32]. They also reported that immunity to VZV increased as the person aged [32]. Immunity to VZV infections, such as rubella, is critical for healthcare workers to prevent and control nosocomial infections. According to Torre et al., 3.2% of medical staff at a teaching hospital in Rome were susceptible to chickenpox [30]. In a cross-sectional study, Pourakbari et al. reported that 65.3% of individuals aged 10 to 25 years were seropositive for VZV [33]. In addition, Ziyaeyan and colleagues found that VZV-IgG were positive in 66.3% of 1- to 70-year-old individuals from Shiraz, southwestern region of Iran [34]. In the western region of our country, Kermanshah, 84.5% of healthcare workers and medical students were seropositive [35]. In a general tertiary hospital in Tehran, 71% of medical staff had VZV seropositivity [36]. Our findings and other studies showed a proportion of precipitants are susceptible to the VZV infection. Ghaffari Hoseini et al. suggested that the best strategy to reduce the risk of the disease is to vaccinate seronegative persons [37].

The seroprevalence of VZV in medical students from other countries has led to mixed results. In Germany and Switzerland, which include the VZV vaccine in routine vaccination programs, 96.9% and 97% of medical students, respectively, had protective levels of VZV Ab [38, 39]. Although VZV infections are worldwide, regional and geographic differences in VZV seroprevalence have previously been explained [40]. Primary varicella infection is more common in preschool children

and younger children in temperate regions where varicella vaccination has not been administered, while this infection is less common in tropical climates [41]. In our study, we found no statistically significant difference between age and seroprevalence for varicella in each group. In this regard, there was no significant difference in age and VZV IgG seroprevalence among students at Babol University of Medical Sciences [42]. Nevertheless, Fahimzad et al. found a direct relationship between IgG titer and age [43]. In addition, a significant difference between age and frequency of VZV-IgG was reported among healthcare workers and medical students in Italy [44].

## CONCLUSION

Our results indicated that the national MR immunization program had a significant impact on the frequency of anti-rubella IgG Ab and that it might be necessary to detect susceptible person to rubella virus and receive the rubella vaccine. In the case of VZV, we propose to include VZV vaccine in Iran's routine vaccination program since about 40% of female students were susceptible to VZV infection. Further studies are needed to verify these results.

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## Author contributions

AH.A., SMA.H., and J.S. designed the study. AH.A., F.N., F.D., Z.K., S.M. performed most of the experiments. AH.A. and SMA.H. analyzed the data. AH.A. collected the study data. SMAH wrote the manuscript. J.S., GR.D., V.S. and K.K. reviewed the manuscript. J.S. supervised the study. All authors read and approved the final manuscript. Seyed Mohammad Ali and Amir Hossein Alipour contributed equally to this work and designated as co-first author

## Conflict of interest

The authors declare that they have no competing interests.

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## REFERENCES

- [1] Prevention ECfD, Control. Monthly measles and rubella monitoring report. ECDC Stockholm, Sweden; 2019.
- [2] Crooke SN, Riggenbach MM, Ovs yannikova IG, et al. Durability of humoral immune responses to rubella following MMR vaccination. *Vaccine*. 2020; 38 (51): 8185-8193.
- [3] Bianchi FP, Tafuri S, Larocca AMV, Germinario CA, Stefanizzi P. Long-term persistence of antibodies against varicella in fully immunized healthcare workers: an Italian retrospective cohort study. *BMC Infect Dis*. 2021; 21 (1): 1-7.
- [4] Haralambieva IH, Ovsyannikova IG, Pankratz VS, Kennedy RB, Jacobson RM, Poland GA. The genetic basis for interindividual immune response variation to measles vaccine: new understanding and new vaccine approaches. *Expert Rev Vaccines*. 2013; 12 (1): 57-70.
- [5] Fischinger S, Boudreau CM, Butler AL, Streeck H, Alter G. Sex differences in vaccine-induced humoral immunity. *Semin Immunopathol*. 2019; 41 (2): 239-249.
- [6] Toizumi M, Vo HM, Dang DA, Moriuchi H, Yoshida L-M. Clinical manifestations of congenital rubella syndrome: A review of our experience in Vietnam. *Vaccine*. 2019; 37 (1): 202-209.
- [7] Sophie B, Philippe L. Management of varicella in neonates and infants. *BMJ Paediatr Open*. 2019; 3 (1): e000433.
- [8] Lefkowitz EJ, Dempsey DM, Hendrickson RC, Orton RJ, Siddell SG, Smith DB. Virus taxonomy: the database of the International Committee on Taxonomy of Viruses (ICTV). *Nucleic Acids Res*. 2018; 46 (D1): D708-D17.
- [9] Winter AK, Moss WJ. Rubella. *The Lancet*. 2022; 399 (10332): 1336-1346.
- [10] Mawson AR, Croft AM. Rubella virus infection, the congenital rubella syndrome, and the link to autism. *Int J Environ Res Public Health*. 2019; 16 (19): 3543.
- [11] Lamont RF, Sobel JD, Carrington D, et al. Varicella-zoster virus (chickenpox) infection in pregnancy. *BJOG*. 2011; 118 (10): 1155-1562.
- [12] Gershon AA. 154 - Rubella Virus (German Measles). Mandell, Douglas, and Bennett's Principles and Practice of Infectious Diseases (Eighth Edition). Philadelphia: W.B. Saunders; 2015; 1875-80.e2.
- [13] Sharghi M, Heidari Z, Cascio A, et al. Seroprevalence of Rubella among Women of Reproductive Age in Iran: A Prisma-Based Systematic Review and Meta-Analysis. *Ann Clin Lab Sci*. 2021; 51 (6): 852-860.
- [14] Christenson B, Böttiger M. Long-term follow-up study of rubella antibodies in naturally immune and vaccinated young adults. *Vaccine*. 1994; 12 (1): 41-45.
- [15] Chu SY, Bernier RH, Stewart JA, et al. Rubella antibody persistence after immunization: sixteen-year follow-up in the Hawaiian Islands. *JAMA*. 1988; 259 (21): 3133-6.

- [16] Leonid I, Evelyn L. Primary varicella in an immunocompetent adult. *J Clin Aesthet Dermatol.* 2009; 2 (8): 36.
- [17] Gardella C, Brown ZA. Managing varicella zoster infection in pregnancy. *Clevel Clin J Med.* 2007; 74 (4): 290.
- [18] Lamont RF, Sobel JD, Carrington D, et al. Varicella-zoster virus (chickenpox) infection in pregnancy. *Int J Obstet Gynaecol.* 2011; 118 (10): 1155-1162.
- [19] Yang J, Liu J, Xing F, et al. Nosocomial transmission of chickenpox and varicella zoster virus seroprevalence rate amongst healthcare workers in a teaching hospital in China. *BMC Infect Dis.* 2019; 19 (1): 1-7.
- [20] Mostafavi SN, Hoseini SG, Kelishadi R, et al. Seroprevalence of varicella zoster infection at provincial level in Iranian adolescents: The CASPIAN-III study. *Arch Pediatr Infect Dis.* 2017; 5 (4).
- [21] Zimmerman LA, Knapp JK, Antoni S, Grant GB, Reef SE. Progress toward rubella and congenital rubella syndrome control and elimination-worldwide, 2012-2020. *MMWR Morb Mortal Wkly Rep.* 2022; 71 (6): 196.
- [22] Shafayi A, Mohammadi A. A Review on Rubella Vaccine: Iran (1975-2019). *Arch Razi Inst.* 2021; 76 (2): 167-92.
- [23] Rahmani N, Moattari A, Pirbonyeh N, Keshavarzi V, Nezhad GSM. Immunity to Measles, Rubella, and Hepatitis B Viruses among students of Shiraz University of Medical Sciences, Iran: A cross-sectional study. *Zahedan J Res Med Sci.* 2019; 21 (3).
- [24] Toizumi M, Tanaka S, Moriuchi M, Nguyen H-AT, Takegata M, Iwasaki C, et al. Rubella seroprevalence among mothers and incidence of congenital rubella three years after rubella vaccine introduction in Vietnam. *Hum Vaccines Immunother.* 2021; 17 (9): 3156-3161.
- [25] Thayyil J, Kuniyil V, Moorkoth AP, Rao B, Selvam P. Prevalence of rubella-specific IgG antibodies in unimmunized young female population. *Fam Med Prim Care Rev.* 2016; 5 (3): 658.
- [26] Frau N, Meloni F, Fostinelli J, et al. Seroepidemiology of Measles, Mumps, Rubella and Varicella in Italian Female School Workers: A Cross-Sectional Study. *Vaccines.* 2021; 9 (10): 1191.
- [27] Choi R, Oh Y, Oh Y, Kim SH, Lee SG, Lee EH. Recent trends in seroprevalence of rubella in Korean women of childbearing age: a cross-sectional study. *BMJ open.* 2020; 10 (1): e030873.
- [28] Shahapur PR, Kandi V. Seroprevalence of Rubella virus-specific antibodies in women and the diagnostic efficacy of enzyme-linked immunoassay and rapid immunochromatographic tests. *Cureus.* 2020 12 (3).
- [29] Azami M, Jaafari Z, Soleymani A, Badfar G, Abbasalizadeh S. Rubella immunity in pregnant Iranian women: a systematic review and meta-analysis. *Int J Fertil Steril.* 2019; 13 (3): 169.
- [30] La Torre G, Marte M, Imeshtari V, et al. Susceptibility towards Chickenpox, Measles and Rubella among Healthcare Workers at a Teaching Hospital in Rome. *Vaccines.* 2022; 10 (10): 1573.
- [31] De Moira AP, Edmunds W, Breuer J. The cost-effectiveness of antenatal varicella screening with post-partum vaccination of susceptibles. *Vaccine.* 2006; 24 (9): 1298-1307.
- [32] Majidy P, Khodabandehloo M, Azadi N-A. Seroprevalence of varicella zoster virus antibody among young women before marriage in Sanandaj, Iran. *Iran J Microbiol.* 2016; 8 (2): 147.
- [33] Pourakbari B, Shahbaznezhad L, Parvaneh N, et al. Seroepidemiology of Varicella Zoster Virus among children, adolescents and medical students in a referral children medical center, Tehran, Iran. *Iran J Microbiol.* 2012; 4 (3) 1: 36.
- [34] Ziyaeyan M, Abdolvahab A, Jamalidoust MM, Pourabbas B. Seroepidemiology of Varicella Zoster Virus Infection among 1-70 year individuals in Iran. *Iran Red Crescent Med J.* 2010; 12.
- [35] Farshchi A, Niayesh A. Seroprevalence of Varicella antibodies in healthcare workers in Imam Reza Hospital of Kermanshah-Iran. *J Pharma& Health Sci.* 2012; 1: 37-40.
- [36] Talebi-Taher M, Noori M, Shamshiri A-R, Barati M. Varicella Zoster antibodies among health care workers in a university hospital, Teheran, Iran. *Int J Occup Med Environ Health.* 2010; 23 (1): 27-32.
- [37] Hoseini SG, Kelishadi R, Kasaieian A, Ataei B, Yaran M, Motlagh ME, et al. Seroprevalence and risk factors of Varicella Zoster Infection in Iranian Adolescents: A Multilevel Analysis; The CASPIAN-III Study. *PlosOne.* 2016; 11(6): e0158398.
- [38] Wicker S, Rabenau HF, Gottschalk R, Doerr HW, Allwinn R. Seroprevalence of vaccine preventable and blood transmissible viral infections (measles, mumps, rubella, polio, HBV, HCV and HIV) in medical students. *Med Microbiol Immunol.* 2007; 196: 145-150.
- [39] Baer G, Bonhoeffer J, Schaad UB, Heining U. Seroprevalence and immunization history of selected vaccine preventable diseases in medical students. *Vaccine.* 2005; 23 (16): 2016-2020.
- [40] Tseng H, Tan H, Chang C, et al. A seroepidemiology study of varicella among children aged 0-12 years in Taiwan. *Southeast Asian J Trop Med Public Health.* 2005; 36 (5): 1201.
- [41] Hambleton S, Gershon AA. Preventing varicella-zoster disease. *Clin Microbiol Rev.* 2005; 18 (1): 70-80.
- [42] Rasti Ghamsari F, Sadeghi F, Moradi M, et al. Seroprevalence of Varicella-Zoster Virus IgG among students of Babol University of Medical Sciences: importance of vaccine strategy for women of reproductive age (2016-2017). *Iran J Microbiol.* 2018; 12 (5): 357-362.
- [43] Fahimzad A, Nouri M, Shiva F, Shamshiri AR, Gholinejad Z, Karimi A. The seroprevalence of Varicella Zoster Virus in a healthy population from Tehran, Iran. *Arch Pediatr Infect Dis.* 2018; 6 (1).
- [44] Balbi O, Baldi S, Rizza S, Pietroiusti A, Perrone S, Coppeta L. Seroprevalence survey for Varicella among healthcare workers and medical students in Italy. *Hum Vaccin Immunother.* 2021; 17 (2): 372-376.