

Measles-Specific IgG Antibody Levels and Associated Demographic and Vaccination Factors Among Children in Diyala Governorate, Iraq: A Cross-Sectional Study

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ABSTRACT

Measles is a significant cause of death in children, despite the availability of safe and cost-effective measles vaccines. Monitoring measles-specific IgG antibody levels is essential for evaluating vaccine-induced immunity and identifying factors associated with protective immune responses. This study was aimed to assess of measles IgG antibody levels and identify associated factors affecting measles immunity among children in Diyala Governorate / Iraq. A cross-sectional study was conducted between October 1, 2025, and April 30, 2026. Ninety children aged 1–14 years who had received at least one dose of a measles-containing vaccine were enrolled from primary health care centres in Diyala Governorate. Venous blood samples were collected, and serum anti-measles IgG antibody concentrations were determined using the enzyme-linked immunosorbent assay (ELISA). Demographic characteristics and vaccination history were obtained through a structured questionnaire. Statistical analysis was performed using SPSS version 29, with statistical significance set at $P < 0.05$. Among the 90 enrolled children, 53.3% were males and 46.7% were females. Female children showed significantly higher measles IgG antibody concentrations than males (64.74 ± 58.91 vs. 46.60 ± 46.55 ng/L; $P = 0.006$). No significant differences in measles IgG antibody concentrations were observed according to vaccination status (65.77 ± 73.29 vs. 50.48 ± 41.64 ng/L; $P = 0.682$) or age groups ($P = 0.341$). Furthermore, a weak positive correlation was found between measles IgG antibody concentration and the number of vaccine doses; however, this correlation was not statistically significant ($r = 0.070$, $P = 0.512$). Measles-specific IgG antibody levels were significantly affected by sex, while age and number of vaccine doses showed no statistically significant association with antibody concentrations.

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INTRODUCTION

Measles is an acute, highly contagious viral disease that affects only humans and remains one of the leading causes of vaccine-preventable morbidity and mortality among children worldwide (Hall *et al.*, 2021). The disease is characterized by fever, cough, coryza, conjunctivitis, and a generalized maculopapular rash, and may result in serious complications including pneumonia, encephalitis, blindness, and death, particularly among malnourished children and immunocompromised individuals (Moss & Griffin, 2024; Muñoz-Valle *et al.*, 2026). Measles epidemiology varies throughout the world and is correlated with vaccination rates attained in a certain area. An estimated 2.6 million people died from measles prior to the implementation of mass vaccination campaigns. The World Health Organization (WHO) stated that, despite modern immunization, there were an estimated 107,500 measles fatalities worldwide in 2023, primarily among children under the age of five who were either unvaccinated or undervaccinated (WHO-Measles, 2025). Due to vaccine hesitancy and decreased immunization rates, measles is on the rise in the United States (Lin & Richardson, 2016).

In Iraq, measles remains an important public health challenge. Recurrent outbreaks have been reported during recent years, largely because of fluctuations in vaccination coverage, population displacement, limitations in healthcare services, and interruptions of routine immunization activities. These factors have resulted in the accumulation of susceptible

children and have increased the risk of measles transmission, particularly among under-immunized populations. Recent surveillance reports have demonstrated an increase in measles cases across different Iraqi governorates, highlighting the necessity of strengthening immunization programs and evaluating population immunity to support disease control strategies (Jalal *et al.*, 2025; Jasem *et al.*, 2012). Vaccination is the most effective measure for preventing measles infection and its complications. The live attenuated measles-containing vaccine (MCV) induces long-lasting protective immunity in most recipients, particularly when administered as a two-dose schedule (Di Pietrantonj *et al.*, 2020). However, the timing of the first (MCV1) and second (MCV2) doses varies according to national immunization policies and the epidemiological situation of each country. In regions where measles transmission remains high, the WHO recommends administration of MCV1 at nine months of age followed by MCV2 at 15–18 months, whereas countries with low transmission commonly administer the first dose after 12 months of age and the second dose before school entry. Completion of the two-dose schedule is essential for achieving individual protection, reducing the accumulation of susceptible individuals, and maintaining herd immunity. Accordingly, the WHO recommends vaccination coverage of at least 95% with two doses of measles-containing vaccine to interrupt endemic virus transmission and prevent future outbreaks (Organization, 2019; Wodi, 2021). Following natural infection or successful vaccination, the immune

system produces measles-specific immunoglobulin G (IgG) antibodies that provide long-term humoral immunity. Measurement of serum measles-specific IgG antibodies has become an important tool for evaluating vaccine-induced immune responses (Cheedarla & Hanna, 2019; Galipeau *et al.*, 2020; Patel *et al.*, 2020).

Despite the implementation of routine measles vaccination in Iraq, data regarding measles specific IgG antibody levels among children remain limited, therefore this study aimed to assess measles IgG antibody levels and evaluate their association with demographic characteristics and vaccination status among children attending Primary Health Care in Diyala Governorate, Iraq.

MATERIALS AND METHODS

Study Population

This cross-sectional study was conducted between October 1, 2025, and April 30, 2026, at primary health care centers in Diyala Governorate, Iraq. The study included 90 children aged 1–14 years who had received at least one dose of a measles-containing vaccine (MCV). Demographic and vaccination data were collected using a structured questionnaire completed after obtaining written informed consent from the children's parents or legal guardians. The questionnaire included information regarding age, sex, vaccination status, and the number of measles vaccine doses received.

Sample Collection

Five milliliters of venous blood were collected aseptically from each child using sterile disposable syringes after disinfecting the venipuncture site with 70% ethanol. Blood samples were transferred into sterile plain tubes and allowed to clot at room temperature for approximately 30 minutes. The samples were then transported to the laboratory in a cooled container. Serum was separated by centrifugation at 3000–4000 rpm for 5 minutes. The obtained serum was aliquoted into sterile Eppendorf tubes (250 µL per aliquot) and stored at –20°C until laboratory analysis.

Determination of Anti-Measles IgG Antibodies by ELISA

Serum samples were analyzed for anti-measles IgG antibodies using a commercial enzyme-linked immunosorbent assay (ELISA) kit (SunLong Biotech, China) according to the manufacturer's instructions. Briefly, serum samples, standards, and controls were added to the ELISA plate wells pre-coated with measles virus antigen and incubated under the recommended conditions. Following washing steps, enzyme conjugate and substrate solutions

were added sequentially. The reaction was terminated using the stop solution, and the absorbance was measured at 450 nm using an ELISA microplate reader. Antibody concentrations were calculated according to the standard curve supplied with the kit and expressed as ng/L. Samples were interpreted as positive or negative according to the manufacturer's recommended cut-off values.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics software version 29.0 (IBM Corp., Armonk, NY, USA). Data were expressed as mean $\pm$ standard deviation (Mean $\pm$ SD) for continuous variables and as frequency and percentage for categorical variables. Differences between groups were analyzed using Student's t-test for continuous variables and the Chi-square test for categorical variables. A P-value < 0.05 was considered statistically significant.

Ethical Approval

The study was reviewed and approved by Diyala University (IRB Approval No. 26-ASJ-Sci-190, dated 7/7/2026). All participants were fully informed about the objectives and procedures of the study. Participants were also assured that all personal information and collected data would remain strictly confidential and would be used solely for research purposes.

RESULTS AND DISCUSSION

Demographic and Vaccination-status Distribution of the Studied Children

A total of 90 children were included in the study. The demographic and vaccination-status of the are presented in Table (1). The participants were categorized into four age groups. The highest proportion of children belong to the 1–4 years (44.4%, $n=40$), followed by the 5–9 years' age group (28.9%, $n=26$), and children younger than one year (20.0%, $n=18$), and those age 10 years or older (6.7%, $n=6$). Regarding sex distribution, 48 (53.3%) were males and 42 (46.7%) were female, no statistically significant difference between males and female ($p=0.527$).

Regarding measles vaccination status, 15.6% ($n=16$) of children had not received any vaccine dose, 14.4% ($n=13$) had received one dose, 35.6% ($n=32$) had received two doses and 34.3% ($n=31$) had received three doses. A significant difference was observed in the distribution of vaccine doses among participants ($p=0.002$). Furthermore, 70.0% ($n=63$) of children had completed at least two vaccine doses, while 30.0% ($n=27$) had received zero or one dose.

Table 1: Demographic and Vaccination-Status Distribution of the Studied Children

Variable	Category	n	%	Statistical test	p value
Age group	<1 year	18	20.0	$\chi^2 = 27.16$, df = 3	<0.001
	1–4 years	40	44.4		
	5–9 years	26	28.9		
	≥ 10 years	6	6.7		
Sex	Male	48	53.3	$\chi^2 = 0.40$, df = 1	0.527
	Female	42	46.7		
Vaccine dose	0 dose	14	15.6	$\chi^2 = 14.44$, df = 3	0.002
	1 dose	13	14.4		
	2 doses	32	35.6		
	3 doses	31	34.4		
Dose completion	0–1 dose	27	30.0	$\chi^2 = 14.40$, df = 1	<0.001
	≥ 2 doses	63	70.0		

Measles IgG Concentration According to Sex

The distribution of measles IgG concentration according to sex is presented in Table (2), females showed higher mean measles IgG concentration compared with males ($64.74 \pm$

58.91 vs 46.60 ± 46.55). There was statistically significant difference ($p=0.006$) in measles IgG concentration between females and males.

Table 2: Sex-Based Variation in Measles Igg Concentration Among the Studied Children

Sex	n	Mean $\pm$ SD	Median (IQR)	Range	p value
Male	48	46.60 ± 46.55	32.95 (28.52–46.12)	7.38–250.90	0.006
Female	42	64.74 ± 58.91	44.12 (34.60–66.68)	6.90–298.89	

Mann-Whitney U test was used because measles IgG concentration was non-normally

Measles IgG Concentration according to Vaccine-dose Completion

The relationship between measles vaccine dose completion and IgG concentration showed in Table (3). Children who

received 0-1 vaccine dose had a mean IgG concentration (65.77 ± 73.29), while those received ≥ 2 doses had mean IgG concentration (50.48 ± 41.64). No differ statistically significant between two group ($p=0.682$).

Table 3: Measles Igg Concentration According to Vaccine-Dose Completion Status

Dose-completion category	n	Mean $\pm$ SD	Median (IQR)	Range	p value
0–1 dose	27	65.77 ± 73.29	32.77 (29.30–62.07)	6.90–298.89	0.682
≥ 2 doses	63	50.48 ± 41.64	38.37 (29.67–52.72)	7.38–225.10	

Measles IgG Concentration according to Age Groups

Table (4) shows the distribution of measles IgG concentration across age group. Children under one years old had the greatest mean IgG concentration (67.30 ± 81.96), followed those between one to four years old (67.30 ± 81.96). Children

between five to nine has lowest mean IgG concentration (49.42 ± 42.99). The concentration of measles IgG concentration did not differ statistically significant between age group ($p=0.341$).

Table 4: Age-Group Differences in Measles Igg Concentration Among the Studied Children

Age group	n	Mean $\pm$ SD	Median (IQR)	Range	p value
<1 year	18	67.30 ± 81.96	32.64 (29.23–63.31)	6.90–298.89	0.341
1–4 years	40	65.30 ± 81.96	36.62 (30.97–51.21)	11.68–215.38	
5–9 years	26	49.42 ± 42.99	38.99 (28.74–49.01)	7.38–225.10	
≥ 10 years	6	51.24 ± 7.40	52.72 (46.22–56.69)	40.61–59.34	

Correlation between Vaccine Dose Number and Measles IgG Concentration

Table (5) shows the relationship between IgG concentration and number of measles vaccination doses. Measles IgG

concentration and number of measles vaccination dosage had weak positive association ($p=0.070$) according to spearman correlation analysis, but this correlation was not statistically significant ($p=0.512$).

Table 5: Correlation Between Vaccine Dose Number and Measles Igg Concentration

Variable 1	Variable 2	Spearman ρ	p value	Interpretation
Vaccine dose number	Measles IgG concentration	0.070	0.512	Weak, non-significant positive correlation

Discussion

Measles is still one of the most contagious vaccine-preventable viral disease despite the national immunization programs being implemented globally. The evaluation of measles-specific IgG antibodies gives insight into both the long-lasting immunity induced by vaccination and predicts the factors that are related to protective immune responses in vaccinated children, yet it is highly preventable through vaccination, with 2 doses of the MMR vaccine providing approximately 97% efficacy in developed countries (Misin *et al.*, 2020). Thus, the current study aimed to evaluate measles IgG antibody levels stratified with respect to demographic characteristics and vaccination status among Iraqi children in Diyala Governorate.

In the current study, most of children had already received more than two doses of Measles Containing vaccine; this is indicating a relatively good vaccination coverage in the whole district areas in Diyala Governorate. Over half of the children had been unvaccinated or vaccinated only once, which is a partial immunity gap that could help to transmit measles during an outbreak. population immunity exceeding 95%, as

recommended by the World Health Organization (WHO). Inadequate vaccination coverage remains one of the principal causes of measles outbreaks, even in countries that have previously achieved elimination (Quach *et al.*, 2025). These findings are consistent with those reported by Kikuta *et al.*, who found that most participants had received two doses of the measles vaccine under the routine immunization program, although a small proportion remained unvaccinated or incompletely vaccinated (Sasaki *et al.*, 2019).

Sex is one of the most established biological factors that impact both innate and adaptive immune systems. Generally, MeV-specific humoral immune responses are higher in females than males. The present study demonstrated that female children exhibited significantly higher measles-specific IgG antibody levels than males. This finding may reflect the well-documented differences in immune responses between the two sexes. Females generally develop stronger humoral and cellular immune responses following vaccination than males, which has been attributed to the immunomodulatory effects of sex hormones, particularly estrogen, in addition to the influence of immune-related genes

located on the X chromosome (Slight-Webb *et al.*, 2023). These biological factors enhance antibody production and contribute to a more robust and persistent immune response after vaccination. The results of the current study are consistent with a study that included 32% females and 68% males (Quach *et al.*, 2025). The significantly higher measles IgG antibody levels observed among females in the present study may be explained by sex-related differences in immune responsiveness (Umlauf *et al.*, 2012). Previous studies have demonstrated that females exhibit stronger measles virus-specific immune responses than males, with significantly higher production of cytokines, including TNF- α , IL-6, and IFN- α , following measles vaccination (Quach *et al.*, 2023; Quach *et al.*, 2026). These immunological differences may contribute to enhanced antibody production and more persistent humoral immunity in females.

Several studies have indicated differences in vaccination-induced IgG antibody levels and the associated immune response between females and males (Feiler *et al.*, 2026; Haralambieva *et al.*, 2014). However, these results are not consistent with the study by Voigt *et al.*, who found no correlation or relationship between biological sex and immunity (humoral or cellular) and measles IgG antibody levels (Voigt *et al.*, 2016).

The current study showed no significant difference in measles-IgG antibody levels between children immunized with 0–1 dose versus ≥ 2 doses of the measles-containing vaccine. Similarly, Sakai *et al.* reported an overall mean measles IgG antibody level above the protective threshold but found that over half of vaccinated individuals had antibody titers below sufficient levels for complete protection, suggesting vaccination dose alone may not be optimal indicator for long-term protective immunity (Sasaki *et al.*, 2019).

The immune responses to both infection and vaccination are heavily influenced by age (Zimmermann & Curtis, 2019). In the current study, no significant relationships were found between age and measles-specific IgG antibody concentrations among the children studied. This finding suggests that vaccine-induced immunity remained relatively stable across the different age groups included in the study. The lack of differences by age could reflect successful implementation of the nationwide measles immunization program, which vaccinates children according to an established schedule with relatively similar immune responses among vaccinated children. Similarly, a large cross-sectional study by Kontio *et al.*, involving highly vaccinated children found that protective measles IgG antibodies were maintained across different pediatric age groups, with no clinically important age-related decline in immunity among fully vaccinated children (Kontio *et al.*, 2016). These findings contradict those of the long-term study by Wang *et al.*, which demonstrated the persistence of long-term humoral immune memory, but with measles antibody concentrations gradually declining with age and the time elapsed since intramuscular vaccination during adolescence (Wang *et al.*, 2023). This discrepancy between this study and several previous reports may be due to differences in study design, age group distribution, vaccination schedules, sample size, and the time interval between vaccination and antibody measurement.

Conclusion

This study achieved the highest measles specific IgG antibody levels among the vaccinated children belonged to Diyala Governorate and no significant correlations with age or number of vaccine doses received but a higher

concentration in females was observed when compared with males. These findings support the role of demographic and biologic factors in differences seen in vaccine-induced humoral immunity and reinforce the importance of continued ongoing assessment of post-vaccination immune responses. Serological surveillance of measles-specific IgG antibodies is advisable to detect waning immunity in children and for evidence-based immunization strategies, including investigation of booster vaccination in at-risk populations.

REFERENCES

- Cheedarla, N., & Hanna, L. E. (2019). Functional and protective role of neutralizing antibodies (NAbs) against viral infections. In *Recent developments in applied microbiology and biochemistry* (pp. 83-93). DOI: <https://doi.org/10.1016/B978-0-12-816328-3.00007-6>
- Di Pietrantonj, C., Rivetti, A., Marchione, P., Debalini, M. G., & Demicheli, V. (2020). Vaccines for measles, mumps, rubella, and varicella in children. *Cochrane Database of Systematic Reviews*(4). doi: <https://doi.org/10.1002/14651858.cd004407.pub5>
- Feiler, M. O., Salerno, M., Pei, X., & Colicino, E. (2026). Racial and ethnic differences in the association between pediatric phthalate exposures and antibody response to vaccination from NHANES 2015-2016. *Environmental Research*, 305, 124973. DOI: <https://doi.org/10.1016/j.envres.2026.124973>
- Galipeau, Y., Greig, M., Liu, G., Driedger, M., & Langlois, M.-A. (2020). Humoral responses and serological assays in SARS-CoV-2 infections. *Frontiers in immunology*, 11, 610688. DOI: <https://doi.org/10.3389/fimmu.2020.610688>
- Hall, E., Control, C. f. D., & Prevention. (2021). *Epidemiology and prevention of vaccine-preventable diseases*. US Department of Health and Human Services, Centers for Disease Control. DOI: <https://stacks.cdc.gov/view/cdc/252997>
- Haralambieva, I. H., Salk, H. M., Lambert, N. D., Ovsyannikova, I. G., Kennedy, R. B., Warner, N. D., Pankratz, V. S., & Poland, G. A. (2014). Associations between race, sex and immune response variations to rubella vaccination in two independent cohorts. *Vaccine*, 32(17), 1946-1953. DOI: <https://doi.org/10.1016/j.vaccine.2014.01.090>
- Jalal, M. A., Halboot, K. M., Lami, S. A., Kumar, E. A., Al-Delphi, M. H. K., Lami, F., & Taher, T. M. J. (2025). Epidemiological trends and clinical characteristics of measles in Iraq (2023–2024): a retrospective cross-sectional study. *BMC infectious diseases*, 25(1), 487. DOI: <https://doi.org/10.1186/s12879-025-10904-8>
- Jasem, J., Marof, K., Nawar, A., & Islam, K. M. (2012). Epidemiological analysis of measles and evaluation of measles surveillance system performance in Iraq, 2005–2010. *International Journal of Infectious Diseases*, 16(3), e166-e171. DOI: <https://doi.org/10.1016/j.ijid.2011.11.00>
- Kontio, M., Palmu, A. A., Syrjänen, R. K., Lahdenkari, M., Ruokokoski, E., Davidkin, I., Vaarala, O., & Melin, M. (2016). Similar antibody levels in 3-year-old children vaccinated against measles, mumps, and rubella at the age of

12 months or 18 months. *The Journal of infectious diseases*, 213(12), 2005-2013.

Lin, L.-T., & Richardson, C. D. (2016). The host cell receptors for measles virus and their interaction with the viral hemagglutinin (H) protein. *Viruses*, 8(9), 250.

Misin, A., Antonello, R. M., Di Bella, S., Campisciano, G., Zanotta, N., Giacobbe, D. R., Comar, M., & Luzzati, R. (2020). Measles: an overview of a re-emerging disease in children and immunocompromised patients. *Microorganisms*, 8(2), 276.

Moss, W. J., & Griffin, D. E. (2024). What's going on with measles? *Journal of virology*, 98(8), e00758-00724.

Muñoz-Valle, J. F., Macedo-Ojeda, G., Turrubiates-Hernández, F. J., Hernández-Bello, J., García-Arellano, S., Hernández-Ramírez, C. O., Baños-Hernández, C. J., Coronado-Carrillo, P. M., Lona-Reyes, J. C., & Viera-Segura, O. (2026). Decreasing Antibody Titers and the Slow Decay of Measles Immunity in Mexico's Current Epidemiological Landscape. *Vaccines*, 14(3), 234.

Organization, W. H. (2019). *Strategic plan for measles and rubella elimination in WHO South-East Asia Region: 2020–2024*. World Health Organization. Regional Office for South-East Asia.

Patel, M. K., Goodson, J. L., Alexander Jr, J. P., Kretsinger, K., Sodha, S. V., Steulet, C., Gacic-Dobo, M., Rota, P. A., McFarland, J., & Menning, L. (2020). Progress toward regional measles elimination—worldwide, 2000–2019. *MMWR. Morbidity and Mortality Weekly Report*, 69.

Quach, H. Q., Chen, J., Monroe, J. M., Ratishvili, T., Warner, N. D., Grill, D. E., Haralambieva, I. H., Ovsyannikova, I. G., Poland, G. A., & Kennedy, R. B. (2023). The influence of sex, body mass index, and age on cellular and humoral immune responses against measles after a third dose of measles-mumps-rubella vaccine. *The Journal of infectious diseases*, 227(1), 141-150.

Quach, H. Q., Jones, S. P., Joseph, I., Powell, A. J., Ovsyannikova, I. G., Warner, N. D., Grill, D. E., Johnson, J. B., Sasi, R. V., & Ajithakumari, A. M. (2025). Low Measles

Seropositivity in Vaccinated Children. *JAMA Network Open*, 8(8), e2529409.

Quach, H. Q., Ratishvili, T., Haralambieva, I. H., Ovsyannikova, I. G., Poland, G. A., & Kennedy, R. B. (2026). Sex-based differences in mumps immunity after a third dose of measles-mumps-rubella vaccine. *Vaccine*, 79, 128480.

Sasaki, H., Fukunaga, T., Asano, A., Suzuki, Y., Nakanishi, Y., Kondo, J., Ishikawa, H., & Shibata, N. (2019). A survey of vaccine-induced measles IgG antibody titer to verify temporal changes in response to measles vaccination in young adults. *Vaccines*, 7(3), 118.

Slight-Webb, S., Thomas, K., Smith, M., Wagner, C. A., Macwana, S., Bylinska, A., Donato, M., Dvorak, M., Chang, S. E., & Kuo, A. (2023). Ancestry-based differences in the immune phenotype are associated with lupus activity. *JCI insight*, 8(16), e169584.

Umlauf, B. J., Haralambieva, I. H., Ovsyannikova, I. G., Kennedy, R. B., Pankratz, V. S., Jacobson, R. M., & Poland, G. A. (2012). Associations between demographic variables and multiple measles-specific innate and cell-mediated immune responses after measles vaccination. *Viral immunology*, 25(1), 29-36.

Voigt, E. A., Ovsyannikova, I. G., Haralambieva, I. H., Kennedy, R. B., Larrabee, B. R., Schaid, D. J., & Poland, G. A. (2016). Genetically defined race, but not sex, is associated with higher humoral and cellular immune responses to measles vaccination. *Vaccine*, 34(41), 4913-4919.

Wang, Q., Wang, W., Winter, A. K., Zhan, Z., Ajelli, M., Trentini, F., Wang, L., Li, F., Yang, J., & Xiang, X. (2023). Long-term measles antibody profiles following different vaccine schedules in China, a longitudinal study. *Nature communications*, 14(1), 1746.

Wodi, A. P. (2021). Advisory Committee on Immunization Practices recommended immunization schedule for children and adolescents aged 18 years or younger—United States, 2021. *MMWR. Morbidity and Mortality Weekly Report*, 70.

Zimmermann, P., & Curtis, N. (2019). Factors that influence the immune response to vaccination. *Clinical microbiology reviews*, 32(2), <https://doi.org/10.1128/cmr.00084-00018>

