

Enhancing anti-mumps IgG antibody effectiveness in children aged 5-15 years following MMR vaccination in Diyala province, Iraq

Ansam Dawod Salman^{1*}, Ibtihal Hameed Mohsin¹, Zahraa J. Jameel², Mohammed Kadhom²

¹Department of Biology, College of Sciences, Diyala University, Diyala, Iraq

²Department of Environmental Health, College of Energy and Environmental Science, Alkarkh University of Science, 10081, Baghdad, Iraq

Abstract

Background: The mumps virus is an acute viral infection that primarily affects children and adolescents. Despite the induction of immunity by the MMR vaccine, there has been a resurgence of mumps among vaccinated individuals. This study aims to enhance Mumps virus-specific IgG antibody responses by evaluating different vaccination schedules and durations. An enzyme-linked immunosorbent assay (ELISA) was used to assess the efficacy of mumps IgG antibodies in serum samples collected from 180 individuals (87 males and 93 females). Participants were categorized into three age groups based on their MMR vaccination history. The overall positivity rate of anti-Mumps IgG among vaccinated individuals was 87.222%, with antibody titers ranging from 2.543 to 40.665 NTU/ml and a mean titer of 25.327 NTU/ml. The highest positivity rate (23.566%) was observed in children aged 5-6 years compared to other age groups. Furthermore, individuals who received two doses of the MMR vaccine exhibited a higher positivity rate (83.333%) than those who received a single dose. The study demonstrates that two doses of the MMR vaccine are effective in inducing protective levels of anti-Mumps IgG among vaccinated individuals in Diyala province.

Keywords: Mumps, MMR vaccine, Anti-mumps IgG, Vaccine efficacy, Seroprevalence

1. Introduction

The mumps virus causes mumps, a contagious disease characterized by the swelling of the parotid glands. This condition primarily affects children and is caused by a member of the paramyxovirus family, which contains an RNA genome and a nucleocapsid structure [1]. The mumps virus has a single serotype, and humans are its only natural host [2,35]. Transmission occurs through respiratory droplets, and the disease is prevalent worldwide, with higher incidence rates during the winter season. Approximately 30% of infected children experience subclinical infections, which confer immunity without apparent symptoms [3]. A single infection typically results in strong and lasting immunity, as the mumps virus exhibits limited antigenic diversity [4].

Following natural infection, the immune system produces serum antibodies against several viral proteins, including HN glycoproteins, F glycoproteins, and nucleocapsid proteins (NP) [5]. Antibodies to the NP protein appear earliest (3–7 days after the onset of symptoms) but are short-lived,

usually disappearing within six months. In contrast, antibodies to the HN antigens develop more slowly, emerging around four weeks post-infection, and persist for years. These HN-specific antibodies are strongly associated with long-term immunity [6,7]. Subclinical infections are thought to provide lifelong protection against subsequent mumps infections [5–7].

A cell-mediated immune response subsequently emerges during mumps infection. Interferon activation occurs early in the infection, contributing to the immune defense. In immunized individuals, IgA antibodies released in the nasopharynx exhibit neutralizing efficacy. Passive immunity is transferred from mother to child, which explains why mumps is rarely observed in infants under six months of age [7]. Prevention of mumps relies on the administration of a live, attenuated vaccine, which is highly effective and provides durable protection for at least 10 years with minimal adverse effects [8,37]. The recommended vaccination schedule includes two doses: the first at 15 months of age and a booster between 4 to 6 years, usually administered as part of the combined measles, mumps, and rubella (MMR)

vaccine. However, due to its live-attenuated nature, the vaccine is contraindicated for immunocompromised individuals and pregnant women. Notably, immunoglobulins are no longer considered effective for preventing or treating mumps orchitis.

In the late 1980s, mumps outbreaks were reported among both vaccinated and unvaccinated populations [9–11], leading to the 1989 recommendation for a second dose of the MMR vaccine. Following this recommendation, mumps incidence declined significantly. However, outbreaks reemerged in 2006, with 6,584 cases reported, primarily among college-aged individuals who had received two doses of the vaccine [12,36]. Proposed explanations for these outbreaks include waning immunity after the second dose and differences between the vaccine strain and the circulating wild-type mumps virus genotype responsible for the outbreaks [2,5].

2. Materials and Methods

2-1 Study group

The present investigation was conducted in Diyala province between January 1, 2024, and February 15, 2025. A total of 180 participants were enrolled in the study. The mean age of participants was 30.0 ± 17.5 years, with an age range of 3 to 69 years.

The majority of participants were female (51.666%), compared to males (48.333%). All individuals included in the study had received the MMR vaccine.

2-2 Diagnostics of mumps IgG antibodies using ELISA test

The analysis was conducted using a commercially available kit (Nova Tec, Germany). Reactive results were indicated by an absorbance value of 11 NTU or higher, while an absorbance value below 9 NTU defined non-reactive results.

2-3 Quantitative analysis

The data analysis was conducted using the SPSS-25 statistical software (Statistical Tool for the Social Sciences—version 25).

3. Results

The current study included 180 participants. The mean age was 11.546 years, with a range of 5 to 15 years. The majority of participants were female (51.666%), compared to males (48.333%). Of the participants, 83.333% received two doses of the MMR vaccine, while 16.777% received a single dose, as shown in Table 1.

Table 1. Characterization of the study group

Variables	No. (%)
Age groups	
5-6 years	36 (20 %)
7-8 years	28 (15.555%)
9-10 years	29 (16.111 %)
11-12 years	57 (31.666 %)
13-14 years	12 (6.666 %)
= 15 years	18 (10 %)
Total	180 (100%)
Mean age (Range): 11.546 (5-15) years	
Gender	
Male	87 (48.333 %)
Female	93 (51.666 %)
Total	180 (100%)
Vaccination status	
Single dose of MMR vaccine	30 (16.777)
Two doses of MMR vaccine	150 (83.333%)
Total	180 (100%)

3-1 Anti-Mump IgG positivity rate and titer

Table 2 revealed that among the 180 vaccinated individuals who received the MMR vaccine, 157 (87.222%) tested positive for anti-Mumps IgG. According to WHO criteria, individuals were considered protected if their serum contained anti-Mumps IgG levels > 11 NTU/ml. The anti-Mumps IgG titers among the participants ranged from 2.543 to 40.665 NTU/ml.

Table 2. Anti-Mumps IgG positivity rate and titer

Category	Anti-Mumps IgG Positivity Rate		Anti- Mumps IgG Positivity Titer	
	Positive No. (%)	Negative No. (%)	Range	Mean
Subjects with positive anti-Mumps IgG (> 11 NTU/ml)	157 (87.222%)	23 (12.777%)	2.543 – 40.665 NTU/ml	25.327 NTU/ml

3-2 Anti-Mump IgG positivity rate according to variables

The results in Table 3 showed that the highest positivity rate (23.566%) was observed among individuals aged 5-6 years. The anti-Mumps IgG positivity rate was 36.496% among males and 54.14% among females. Additionally, the lowest positivity rate (8.917%) was found among individuals who received a single vaccine dose, while a significantly higher positivity rate (93.63%) was observed among those who received two doses of the vaccine.

Table 3. Prevalence of anti-mumps IgG positive based on variables

Age groups	Total No.	Positive anti- Mumps IgG	
		No.	%
5-6 years	36	37	23.566
7-8 years	28	28	17.834
9-10 years	29	49	31.21
11-12 years	57	31	19.745
13-14 years	12	8	5.095
= 15 years	18	4	2.547
Total	180	157	100
Gender	Total No.	Positive anti- Mumps IgG	
		No.	%
Male	87	73	36.496
Female	93	85	54.14
Total	180	157	100
Vaccine doses administered	Total No.	Positive anti- Mumps IgG	
		No.	%
Single dose of MMR vaccine	30	14	8.917
Two doses of MMR vaccine	150	147	93.63
Total	180	157	100

Discussion

Mumps is a disease that primarily affects children but can also occur in adolescents and young adults, often leading to more severe complications. In the absence of immunization, mumps remains endemic. Measles, mumps, and rubella (MMR) are highly contagious viral diseases that can be effectively prevented through vaccination [14]. This study found that the overall anti-Mumps IgG positivity rate among vaccinated children in Diyala province was 87.222%.

All vaccinated individuals in the study exhibited protective levels of anti-Mumps IgG (> 11 NTU/ml in their sera), with antibody titers ranging from 2.543 to 40.665 NTU/ml. These findings are consistent with a previous study conducted in Mosul, which reported a 68% anti-Mumps IgG positivity rate among individuals of varying ages and sexes [15].

The present results are consistent with findings from other studies [16–20]. Additionally, the protective rate observed in this investigation aligns with the global range of MMR vaccine efficacy, as supported by similar findings reported in other studies [16,18,20]. These results strongly affirm the consensus on the effectiveness of the MMR vaccine in protecting against mumps.

The results of the current study found the highest anti-Mumps IgG positivity rate among children aged 5-6 years (23.566%). These findings are consistent with those reported by another Iraqi study [21] and align with results from other studies worldwide [17,19,22]. This highlights the need for further research in Diyala province and across Iraq to support evidence-based implementation of vaccination and control programs. Serological assessment of anti-Mumps IgG levels should be conducted to determine the need for mumps vaccination, particularly to reduce the risk of severe illness and complications in high-risk adult populations. Variations between the current results and those of other studies may be attributed to differences in age groups (adults vs. children), the sensitivity of ELISA kits, study populations, and factors such as seasonality, geography, and climatic conditions.

The findings in Table 3 align with other research indicating no gender disparities in the protective rate among MMR-vaccinated children [17,21,22]. The present study found that 8.917% of individuals who received a single vaccine dose were protected, compared to 93.63% of those who received two doses of the MMR vaccine. These results are consistent with previous studies [23,24] and are supported by similar findings in other research [16,18–20]. Additionally, several studies have emphasized the importance of a booster dose of the MMR vaccine, particularly for adult populations [19,25].

To reduce the occurrence of mumps and prevent its

spread, herd immunity must exceed 75%–86% [24]. Recently, the World Health Organization has emphasized achieving herd immunity through MMR vaccination coverage of more than 95% [9,25,26]. The mechanism by which the mumps vaccine influences humoral immunity remains poorly understood. Waning immunity over time is considered a significant factor contributing to mumps reinfection [26–28]. Susceptibility to mumps virus infection may also be influenced by the quality (avidity) of anti-mumps IgG. Approximately six months after an acute infection, mumps antibody avidity matures from low to high [29,30]. However, vaccine-induced IgG avidity is generally lower compared to that generated by wild-type mumps virus infection [31–34]. Enhancing the safety and effectiveness of the MMR vaccine among adults and adolescents, stratified by age and gender, is crucial. Further studies in Diyala province are needed to comprehensively evaluate the protective effects of the MMR vaccine in these populations.

Conclusions and Recommendations

The results of the present investigation demonstrate that the administration of the MMR vaccine to children is effective, generating protective levels of anti-Mumps IgG after two doses in Diyala province. Two doses of the vaccine produce the highest protective anti-Mumps IgG titers, particularly in vaccines aged 15 years, regardless of the regularity of the vaccination schedule. The peak rate of anti-Mumps IgG protection occurs 5–6 years after the final vaccine dose, with gender having minimal or no influence on the generation of protective antibodies. However, the average anti-Mumps IgG titers decline as the interval since the last vaccine dose increases. The highest mean anti-Mumps IgG titers were observed following the administration of two vaccine doses, irrespective of the children's age at the time of testing.

Based on these findings, the following recommendations are proposed:

Vaccination against the mumps virus should be implemented consistently, regardless of the regularity of the vaccination schedule.

Children who do not achieve protective levels of anti-Mumps IgG should promptly receive an additional

booster dose of the MMR vaccine.

Molecular investigations are necessary to assess the potential presence of mumps virus mutants, as circulating mutants may compromise vaccine efficacy.

Similar studies should be conducted in other regions of Diyala province to comprehensively evaluate the MMR vaccination program.

A broader, province-wide study is recommended to examine the MMR vaccination program's impact on reducing mumps infection incidence.

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Ethics statement

This work was approved via the higher committee at Diyala University with the number 1549 on 14/1/2025.

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Conflict of interest

There is no known conflict associated with this work.

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