

## **Specificity of Immunity in Children Living in the South Aral Sea Region After Vaccination with Different Pneumococcal Vaccines**

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**Abstract:** Two types of pneumococcal vaccines for children are registered in Uzbekistan: Prevenar-13 (Pfizer, USA), which contains capsular polysaccharides of thirteen pneumococcal serotypes conjugated with genetically engineered diphtheria toxoid, and 10-valent conjugate vaccine Pnevmosil (India). Until 2020, children were vaccinated with the 13-valent vaccine Prevenar-13, after 2020 - Pnevmosil-10. We conducted a study to assess the humoral immune response (IgG) to 15 pneumococcal CPS in ELISA in children with pneumonia, as well as in relatively healthy children. Analysis of the same sera showed a higher level of IgG in the post-vaccination period to the Prevenar-13 vaccine to a greater extent than to the 10-valent vaccine (1.3-2 times).

**Keywords:** pneumococcus, capsule polysaccharides, children, specific antibodies against capsule polysaccharides, vaccines.

**Introduction.** One of the leading causes of morbidity and mortality among children under the age of 3 years is pneumococcus [1, 10, 13, 14].

In conclusion, the introduction of planned vaccination against pneumococcal infection in Russia has led to a 35% reduction in mortality from community-acquired pneumonia in children and a decrease in the incidence of acute otitis media. However, children with altered immune status or frequent bronchopulmonary diseases may experience a decrease in specific antibodies to many CPS included in the vaccines in the case of invasive disease [3, 5, 6, 9, 15, 16, 17, 18].

Polysaccharides cause an immune response by a T-independent mechanism, therefore, they stimulate the formation of antibodies in children older than a year, and for serotypes 6A, 14, 19F and 23A, a high titer is not formed until the age of 5 years. After vaccination, specific IgM and IgG antibodies are formed. The peak of IgG is reached only by 70-100 days after vaccination and persists for about five years, slowly decreasing and returning to the level before immunization. Various studies have determined protective titers of 0.05 to 0.4  $\mu$ g/mL 6-8 weeks' post-vaccination, this may need to be done later [2, 11, 12].

Some individuals may have a reduced immune response to certain serotypes of pneumococcus included in the vaccine, which could be related to genetic factors and the HLA system. Maternal antibodies provide a certain level of antibodies to pneumococcal polysaccharides at birth, but this decreases after 2 months. When the first dose of vaccine is administered at around 1 year of age, a high immune response is observed against certain strains, while others elicit a moderate or low titer of antibodies. When the first dose of vaccine is administered at around 1 year of age, a high immune response is observed against strains 3, 4, 8, 9N, a moderate level of antibodies against 1, 2, 7F, 18C, 19F, 25, and a low titer against 12, 14, 23, 6A, 6B.

The vaccination schedule in Uzbekistan follows a planned approach, with vaccinations given at 2 and 3 months of age with a minimum interval of 4 weeks, and a booster dose at 12 months.

This suggests that a significant proportion of the serotypes causing pneumonia in Uzbekistan are covered by both the PCV-13 and PCV-10 vaccines. However, the PCV-13 vaccine provides coverage for a greater number of serotypes compared to the PCV-10 vaccine. In the pre-vaccination era, serotypes 1, 3, 5, 6A, 14, and 19 were commonly identified in patients with pneumonia in Uzbekistan, with the 6A/B serogroup being the most frequently identified. When comparing the serotypes included in the PCV-13 vaccine with those isolated from patients, there was overlap in 78.3% of cases. Similarly, there was overlap with serotypes included in the PCV-10 vaccine in 62.7% of cases. This suggests that vaccination has the potential to reduce pneumonia-related morbidity and mortality in children in Uzbekistan. [4].

When studying the serotype landscape of pneumococcus 2-3 years after the introduction of the Prevenar-13 vaccination, we identified only the group serotype 6A/B/C/D, the remaining serotypes were not detected [8]. Identification of serogroup 6A/B/C/D can be attributed to the features of the pneumococcal landscape in our country. The disappearance of the most common pneumococcal serotypes after vaccination indicated the effectiveness of vaccination.

Another measure of the immune response is the seroconversion rate. The WHO Expert Working Group defined the seroconversion rate as an immunological correlate of efficacy, i.e. the proportion of individuals with the level of type-specific antibodies of the IgG class at a concentration above 0.35 µg/ml of vaccination [11, 12].

This statement suggests that the effectiveness of the PCV vaccine can be influenced by various factors, including the number and timing of vaccine doses, the interval between doses, the region where the individual lives, and whether they receive simultaneous DTP immunization. The duration of mass vaccination campaigns can also impact the level of immunity provided by the vaccine.

**Materials and methods.** To evaluate the immune response to pneumococcus, researchers examined the blood of children who had received either Prevenar-13 or a 10-valent vaccine. The study focused on children hospitalized with community-acquired pneumonia, with 11 having received Prevenar-13 before 2020 and 15 having received the 10-valent vaccine Pneumosil from India. As a control group, blood sera of 12 children without pneumonia (children who were in the hospital for various surgical conditions (dislocation of the forearm, nasal trauma, calculous cholecystitis, etc.) were studied.

For the analysis of sera, the method of solid-phase ELISA was used. Collapsible plates for ELISA, produced by " Greiner " (Germany). For sorption of plates, a portion of each of the CPS preparations (1, 3, 4, 5, 6 B, 7 F, 9 N, 9 V, 14, 15 B, 18 C, 19 A, 19 F and 23 F) was dissolved in phosphate- saline buffer solution (PBS) with pH = 7.2-7.4 to a concentration of 5 µg / ml. The volume of CPS solution introduced into the well is 100 µl. Duration of sorption was 2 hours at 37 °C and 16-18 hours at 8-10°C. 30 minutes at a temperature of 18-20 °C. After being freed from the solution, working solutions of the analyzed sera were added to the wells in duplicate. The working dilution of sera was 1:200. A pool of sera from 100 clinically healthy people in the same dilution was used as a negative control. The reaction of sera with immunosorbent (antigen on polystyrene) lasted 1 hour at 18-20° C. Then the contents of the wells were shaken out, the wells were washed with saline containing 4% tween-20. 100 µl of working dilution of CG (peroxidase - labeled monoclonal antibodies diagnostic against human IgG, produced by POLYGNOST LLC, St. Petersburg), diluted in PBS with BSA to a ratio of 1:4000, was added to each well and incubated for 30 minutes at 18-20 °C After washing the wells of the plates from unbound CG, 100 µl of a substrate mixture containing TMB was added and after 10 minutes the reaction was stopped by adding 50 µl of 2M HCL. Optical density was determined at 450 nm. The results are presented in terms of OD, ΔOP and c.u., which are calculated by the formula:

$$\frac{OD_{\text{ah}}}{OD_{\text{K-}} + 0,25} \times 100.$$

N for adult clinically healthy people - (OP  $\kappa$  + 0.25) or up to 100 c.u.

**Results and Discussion.** We have analyzed the immunological efficacy of immunization after routine vaccination with the pneumococcal vaccine Prevenar-13 (Pfizer, USA) and the 10-valent pneumococcal conjugate vaccine Pneumosil. To assess the immunological efficacy, we determined specific anti- SPP IgG antibodies to Streptococcus capsular polysaccharides pneumoniae by ELISA in immunized children no earlier than 2 months after the last vaccine administration. There were 11 children who received Prevenar - 13, and 15 children who received the 10-valent vaccine. As a control group, sera of children who did not receive vaccination against pneumococcus (12 children) were studied.

When analyzing the sera of children with CAP (n=11) vaccinated with a 13-valent vaccine (Table 1), it was found that the level of specific antibodies to individual CPS in them is in a wide range of values - from 35 c.u. e. to CPS Pn-9 N up to 101 cu e. to KPS Pn- 23 F.

The researchers found that the average lower limit for most CPS (capsular polysaccharides) was between 30 and 40 cu. units, while the upper limit was around 60-100 cu. units. When calculating the average level of antibodies, they discovered that for the majority of CPS, it was around 40-50 cu. units. This difference was statistically significant ( $p < 0.05$ ).

**Table - 1. Immunological efficacy of vaccination against pneumococcal infection in children**

	The level of specific antibodies in children with CAP (c.u.)	
	Prevenar-13	Pneumosil
Pn1	67.4±22.6	40.6±8.3 <sup>^</sup>
PN 3	41.3±6.4	33.2±3.8* <sup>^</sup>
PN 4	44.2±6.4	42.2±4.2
Pn 5	53.9±10.9	46.7±5.3*
Pn 6A	41.4±7.9	33.2±3.0 <sup>^</sup>
Pn 6B	41.7±5.8	40.2±4.1
Pn 7F	38.8±6.7*	42.4±7.2
Pn 9N	35.1±4.5	37.1±5.6
Pn 9V	47.0±6.9	49.9±7.9
Pn 14	53.4±9.4	49.4±6.9* <sup>^</sup>
Pn 15B	44.8±6.9*	36.3±4.3* <sup>^</sup>
Pn 18C	63.0±26.3*	30.5±2.6* <sup>^</sup>
Pn 19A	50.1±6.6	62.7±17.8*
Pn 19F	59.1±14.8	42.1±3.9* <sup>^</sup>
Pn 23F	101.0±29.3*	54.1±11.9 <sup>^</sup>

Note: (\*-  $P < 0.05$ ); <sup>^</sup> - reliability of data in relation to the group of vaccinated children until 2020 (<sup>^</sup>-  $P < 0.05$ ).

At the same time, for the KPS Pn-23 F was more than 100 cu. units, which is associated with the presence of individuals with a high level of antibodies (AT) to it. The conducted studies showed that in all children of the control group (11 children) a diagnostically significant level of IgG to one or several CPS was determined. When analyzing the sera of children vaccinated with a 10-valent vaccine, it was found that the level of specific antibodies to individual CPS was in a lower range of values (30-40 units) than that of vaccinated Prevenar-13.

It was found that after vaccination with Prevenar -13, the level of IgG to CPS Pn-1, Pn-18C most often increased and the level of antibodies to Pn-23 (2 times) increased significantly, which probably indicates a higher immunogenicity of these CPS in Prevenar -13. The weakest was the increase in the level of antibodies to CPS PN-3, 4, 6A, 6B, 7 F, 9 N, 9 V, 14, 15 B. Children vaccinated with 10 - valent vaccine had levels of antibodies to 70% CPS (Pn 1, 3, 4, 6 A, 6B, 7 F, 9 N, 9 V, 14, 15 B) significantly lower than those vaccinated with Prevenar-13. It should be noted that in those vaccinated with the 10-valent vaccine, the levels of antibodies to only two CPS (Pn 19 A and 7 F) significantly increased.

When analyzing sera (n=12) of the control group of children without pneumonia, the following results were obtained (Table 2).

**Table - 2. Level of IgG to individual S.pneumoniae capsular polysaccharides and vaccines Prevenar-13 and Pneumosil in vaccinated and unvaccinated children (c.u.)**

	Control group	Main group	
		Prevenar 13	Pneumosil
Pn1	53.2±9.7	67.4±22.6	40.6±8.3^
PN 3	54.9±13.9	41.3±6.4	33.2±3.8*^
PN 4	56.4±16.5	44.2±6.4	42.2±4.2
Pn 5	60.5±16.3	53.9±10.9	46.7±5.3*
Pn 6A	41.8±8.6	41.4±7.9	33.2±3.0^
Pn 6B	46.9±11.4	41.7±5.8	40.2±4.1
Pn 7F	41.7±10.1	38.8±6.7*	42.4±7.2
Pn 9N	43.7±10.1	35.1±4.5	37.1±5.6
Pn 9V	49.8±12.6	47.0±6.9	49.9±7.9
Pn 14	58.5±10.4	53.4±9.4	49.4±6.9*^
Pn 15B	63.1±8.4	44.8±6.9*	36.3±4.3*^
Pn 18C	45.8±10.9	63.0±26.3*	30.5±2.6*^
Pn 19A	55.6±14.7	50.1±6.6	62.7±17.8*
Pn 19F	61.9±18.7	59.1±14.8	42.1±3.9*^
Pn 23F	55.9±11.8	101.0±29.3*	54.1±11.9^

Note: \* - reliability of data in relation to the control group (\* - P <0.05); ^ - reliability of data in relation to the group of vaccinated children until 2020 (^- P<0.05).

In the control group of children (who did not receive vaccination) for Pn 1, the average level of AT was 53.2 c.u. (p < 0.05) (Table 2). However, the average values for CPS Pn-3, Pn-14, Pn-7 F, Pn-5, Pn-15B and Pn-19F in unvaccinated children were 1.3-1.5 times higher. For other CPS (Pn-6A, Pn-6 B, Pn-9 N, Pn-4, Pn-9 V) the difference was not significant. In addition to those described, an analysis was made of the frequency of increasing the level of antibodies to each CPS in the post-vaccination period.

Researchers conducted a study on children who were hospitalized with community-acquired pneumonia and had received either Prevenar-13 or the 10-valent vaccine. They analyzed the immune response by examining the blood samples of these children. The study found that the average lower limit for most capsular polysaccharides (CPS) was between 30 and 40 cu. units, while the upper limit was around 60-100 cu. units. The average level of antibodies for most CPS was around 40-50 cu. units, which was statistically significant compared to other groups. The study also observed that unvaccinated children in this group had higher lower limits of antibody levels for most CPS, indicating repeated exposure to pneumococcal infection. The Prevenar-13 vaccine did not show an increase in antibodies to CPS Pn-9N, which could be due to the absence of this polysaccharide in the vaccine.

Thus, the analysis of the same sera showed a higher level of IgG in the post-vaccination period to the Prevenar-13 vaccine to a greater extent than to the 10-valent vaccine (1.3-2 times).

**Conclusion.** In the study of blood sera using enzyme immunoassay, which is based on 15 immunosorbents containing CPS of serogroups / serotypes of pneumococcus (1, 3, 4, 5, 6 B, 7 F, 9 N, 9 V, 14, 15 B, 18 C, 19 A, 19 F and 23 F) showed that the highest level of IgG to 15 CPS pneumococcus in the pre-vaccination period was demonstrated by the sera of children in the control group. The second place in terms of the level of antibodies to CPS pneumococcus was occupied by the sera of children who received Prevenar -13, and the third place was taken by the blood sera of children vaccinated with the 10-valent vaccine (Table). In vaccinated Prevenar -13, the highest level of antibodies was observed to CPS 23 F (more than 100 c.u.), the lowest to CPS serotypes absent in the 13-valent vaccine (9 N, 15B). As noted above, children who received the

10-valent vaccine had significantly lower levels of antibodies than in the previous group. This can be explained by the greater effectiveness of the 13-valent vaccine.

However, high levels of antibodies were found for some serotypes (19A, 23F). Children in the control group showed a high level of specific antibodies, this fact can be explained by the absence of diseases in them that lead to an immunodeficiency state and, as a result, a good immune response. The study concludes that some individuals may have had previous pneumococcal infections or their immune response may have been activated by another agent. The low level of antibodies to some of the vaccines used suggests that a certain portion of individuals may not be fully protected from pneumococcal infection in an unfavorable epidemic situation.

In conclusion, while vaccination with commercial pneumococcal vaccines generally protects most vaccinated children, those with altered immune status or frequent bronchopulmonary diseases may experience a decrease in specific antibodies to many CPS included in the vaccines in the case of invasive disease

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