

COMPARISON OF THE COVERAGE OF IMMUNIZATION AGAINST MUMPS BEFORE, DURING, AND AFTER THE COVID-19 PANDEMIC

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Abstract. Introduction. Parotitis or mumps is an acute viral infection caused by the Mumps virus. It occurs most often in children and is characterized by an inflammatory process on the parotid glands. The virus is most often transmitted through droplets, direct contact, or indirectly through contaminated objects. Serious complications of this disease are possible, such as meningitis, encephalitis, pancreatitis, oophoritis in women, and orchitis, which in men can be the cause of sterility. Vaccination with the MMR vaccine is one of the most effective ways to fight this disease. After the introduction of the MMR vaccine, the number of people suffering from this viral disease decreased drastically all over the world. This research **aimed** to analyze the coverage of mumps immunization in the period from 2016 to 2023, especially the impact of the COVID-19 pandemic on the vaccination rate during and immediately after the COVID-19 pandemic. **Research Methodology.** Descriptive statistics were applied for the analysis of annual vaccination rates, as well as a comparative analysis before, during, and after COVID-19 for the territory of Šumadija district. Also, data from the Institute for Public Health “Dr. Milan Jovanović Batut” on MMR vaccine coverage were analyzed. **Results and Discussion.** Administration of the vaccine and regular vaccination significantly reduce the rate of morbidity and mortality from this disease. After the introduction of the MMR vaccine as mandatory according to the vaccination calendar, a significant decrease in the incidence of this disease was observed. However, the decline in vaccinations in the years of dealing with a new and unknown infection caused by the Coronavirus has caused concern among epidemiologists about the possibility of a return of sporadic cases and also an epidemic of this disease. A decline in MMR vaccination rates was observed during the COVID-19 pandemic and immediately after it. Evident time differences were observed, especially during COVID-19, as well as immediately after the aforementioned pandemic. There were also regional differences and differences by cities within one district, for example, Šumadija district. Already in 2022, a slight increase was recorded, and in 2023, a further increase in the immunization rate against parotitis was observed in the Šumadija District territory. The reasons for this state of affairs can be attributed to various factors, most notably the overloading of the health system and the closure and reduction of visits to health institutions due to the risk of infection with COVID-19. **Conclusion.** The COVID-19 pandemic affected vaccination coverage with the MMR vaccine in the Šumadija District. Therefore, efforts should be intensified to return the coverage of immunization against mumps with the MMR vaccine to the years before the outbreak of COVID-19 and to successfully implement the vaccination with a result above 95%. In this way, the collective immunity would be increased, and epidemic parotitis would be prevented.

Keywords: mumps, MMR vaccine, immunization coverage, COVID-19, vaccination success

1. INTRODUCTION

Mumps (parotitis) is an acute viral infection of a systemic nature that most often occurs in children and adolescents [1, 2]. The causative agent is myxovirus, an RNA virus, mumps, which has the greatest affinity for seromucous glands, especially the parotid gland [3].

Other salivary glands, the central nervous system, testicles, and, less frequently, the pancreas, thyroid, mammary glands, prostate, kidneys, liver, myocardium, and lacrimal glands are also often affected. The virus is found in saliva, blood, and cerebrospinal fluid.

In one-fifth of those infected, the infection is asymptomatic; in 30–40%, only unilateral or bilateral swelling of the salivary glands occurs, most often the parotid glands, while almost half (40–50%) also exhibit

nonspecific symptoms. The virus is often localised, in 20% of cases, on the soft meninges, causing serous meningitis with headache, stiff neck, and changes in the cerebrospinal fluid. The mildest, often asymptomatic course (in over 30%) occurs among children under two years of age [2].

Complications can manifest in the gonads (orchitis) in men, while in women, infection of the gonads (oophoritis) occurs in 5% of cases. Bilateral orchitis can lead to sterility [4]. Rare complications include pancreatitis, meningitis, encephalitis, thyroiditis, Graves' disease, diabetes mellitus, deafness, and blindness [5]. Serological reactions such as RVK, RIH, and ELISA tests are used to confirm the diagnosis. After the disease has passed, as well as after an inapparent infection, long-lasting and solid immunity remains [6].

The disease occurs in cyclical epidemic waves lasting several years. Such a wave occurred after World War II,

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especially from 1972 onwards, due to intensive urbanisation, and now mainly affects school-age children, unlike earlier years when adults were also affected. Due to its complications, such as sterility in men resulting from previous orchitis [5] and possibly diabetes following past pancreatitis, some countries, especially since 1967, began vaccinating susceptible age groups [7].

In Serbia, 41 patients with this diagnosis were reported in 2015, while in the previous two years, there were slightly more than 60 cases. Mumps in Serbia today is reduced to 1/50 or 1/100 of its previous frequency. During 2009 and 2012, epidemic waves were recorded, with 262 and 584 cases, respectively, which is interpreted, among other factors, as resistance to the MMR vaccine [8].

The implementation of immunisation has led to a significant reduction in incidence. In many European countries that have introduced two doses of the vaccine, the incidence has been reduced by 97% to over 99%, while in countries with a single-dose schedule, the incidence has been reduced by 88–98% [9]. Despite these results, mumps continues to spread epidemically throughout Europe and in other parts of the world [10].

Some possible causes of the re-emergence of epidemics include insufficient collective immunity in environments that facilitate the easy spread of disease (such as schools and colleges), improper storage of vaccines and breaks in the cold chain, primary immunisation failure (inadequate immune response) or secondary failure (loss of post-vaccination immunity), and reinfection with heterologous virus strains.

Protection against this disease is provided by vaccination in the second year of life and revaccination at the age of 12, through subcutaneous administration of a combined, live, attenuated vaccine against measles, mumps, and rubella (MMR vaccine) [11, 12]. The modern, currently used live vaccine with attenuated pathogens was licensed in the USA in 1967. Before that, since 1948, an inactivated vaccine was available, but it provided only short-term protection. The mumps vaccine is no longer administered separately in many developed countries, but only in combination, either as MMR or MMRV [13].

Most countries have included this immunisation in their vaccination schedules, combined with the measles and rubella vaccine as the MMR vaccine. In Serbia, the mumps vaccine has been given since 1986 as a combination with measles (MM). The MMR vaccine has been used since 1993, and in 1996, revaccination with the trivalent MMR vaccine was introduced, which has been administered before starting school since 2006. In our country, three MMR vaccines are mainly used: Trimovax, Priorix, and M-M-R-VaxPRO [14].

ProQuad is a combined quadrivalent vaccine used for immunisation against mumps, measles, rubella, and varicella viruses [15, 16, 17]. Passive prophylaxis for exposed individuals is achieved by administering hyperimmune mumps immunoglobulin.

Many developed countries are close to eliminating mumps. However, in a third of countries, virus transmission continues unhindered due to the absence of vaccination. The epidemiological and clinical

characteristics of mumps, together with the availability of a vaccine of satisfactory quality, provide grounds to consider the theoretical possibility of global eradication of this infection [18, 19].

The main **aim** of this paper is to analyse and compare the coverage of mandatory vaccination against parotitis, specifically the MMR vaccine, in the Šumadija District. The focus is on assessing changes in immunisation across three periods: before the onset of the COVID-19 pandemic (2016–2018), during the COVID-19 pandemic (2019–2021), and after the pandemic (2022–2023).

2. METHODOLOGY OF THE STUDY

The descriptive method was used in this research. The analysis is based on data from annual immunisation reports for the territory of the Šumadija District, prepared by the Kragujevac Institute for Public Health, as well as official statistics published by the Institute for Public Health of Serbia “Dr. Milan Jovanović Batut” [20]. The research compared pertussis immunisation coverage across three periods: before the pandemic (2016–2018), during the COVID-19 pandemic (2019–2021), and after the pandemic (2022–2023). Standard statistical procedures within the SPSS software package version 23.0 (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA) were used for data processing. The level of statistical significance was set at $p < 0.05$. The results are presented graphically to clearly identify trends and differences in vaccination coverage during the observed time intervals.

3. RESULTS AND DISCUSSION

In 2016, in the Šumadija District, municipality of Arandelovac, 284 out of 400 children planned for mumps vaccination with the MMR vaccine in their second year of life were vaccinated, representing 71.0%. In the municipality of Batočina, 79 out of 84 were vaccinated, which is 94.0%. In the municipality of Knić, 70 out of 75 were vaccinated, resulting in immunisation coverage of 93.0%. In the municipality of Kragujevac, 1,672 out of 1,750 were vaccinated, which is 95.0%. In the municipality of Lapovo, all 58 planned children were vaccinated, which is 100.0%. In the municipality of Rača, 72 out of 100 were vaccinated, which is 72.0%. In the municipality of Topola, all 152 planned children were vaccinated, which is 100.0%.

According to the statistically processed data, a total of 2,387 out of 2,619 planned children in the Šumadija District received the first dose of the MMR vaccine, administered in the second year of life. This is 91.0% in percentage terms. Given that the immunisation coverage for 2016 in the territory of the Šumadija District is 91.0% and is less than 95.0%, it is interpreted that the immunisation was carried out satisfactorily.

According to the vaccination calendar applied in the Republic of Serbia, revaccination with the MMR vaccine is carried out in the seventh year of life, before entering the first grade of primary school. Through

revaccination, in the territory of the Šumadija District, in the municipality of Aranđelovac, out of the planned 426 children, 426 were revaccinated, which is the maximum percentage, i.e., 100.0%. In the municipality of Batočina, out of the planned 76, 73 were revaccinated, which is 96.0%. In the municipality of Knić, out of the planned 90, 90 were revaccinated, which is 100.0%. In the municipality of Kragujevac, out of the planned 1,700, 1,646 were revaccinated, which is 97.0%. In the municipality of Lapovo, out of the planned 60, 46 were revaccinated, which is 77.0%. In the municipality of Rača, out of the planned 92, 88 were revaccinated, which is 96.0%. In the municipality of Topola, out of the planned 182, 177 were revaccinated, which is 97.0%.

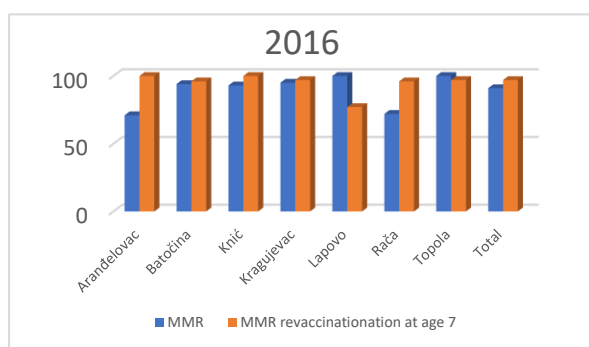


Figure 1. Graphic representation of immunization against mumps on the territory of the Šumadija District in the period of 01.01.2016 - 31.12.2016.

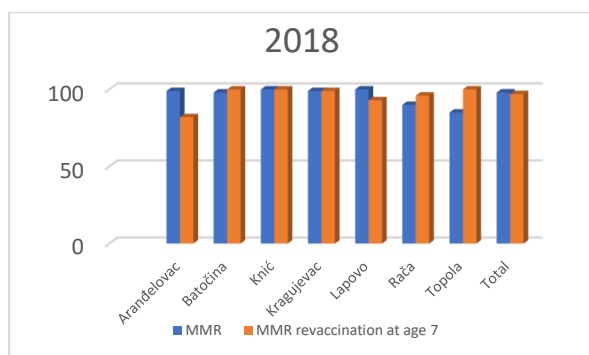


Figure 2. Graphic representation of immunization against mumps on the territory of the Šumadija District in the period of 01.01.2018 - 31.12.2018.

Thanks to the successful implementation of the immunisation plan and programme against measles, rubella, and mumps, there has been a significant decrease in the number of people suffering from these diseases, as well as a reduction in the occurrence of possible complications that could lead to an increased mortality rate. Summarising the results of this clinical study, we concluded that every child should be vaccinated with all the vaccines included in the mandatory immunisation programme in Serbia. In this way, a high level of collective immunity would be achieved, preventing the incidence and epidemic occurrence of vaccine-preventable diseases. This would also result in a significant reduction in the negative effects that certain infectious diseases have on public

health, and ensure the elimination, eradication, and control of these infectious diseases.

During 2018, 77 children were scheduled to receive the MMR vaccine in the municipality of Knić, in the territory of the Šumadija District, which is administered in the second year of life. All 77 children were vaccinated, meaning that every child was fully vaccinated against mumps with the first dose of the MMR vaccine. In percentage terms, this is 100.0%, so maximum immunisation coverage was achieved. The same results were observed in the municipality of Lapovo, where all 49 planned children were vaccinated, also amounting to 100.0%.

In the municipality of Aranđelovac, out of the planned 389 children, 385 were vaccinated with the MMR vaccine in their second year of life, which is 99.0%. In the municipality of Kragujevac, 1,780 children were planned for vaccination with the MMR vaccine, and 1,770 were vaccinated, which is 99.0%. In the municipality of Batočina, out of the planned 68 children for vaccination with the MMR vaccine, 67 were vaccinated, which is 98.0%.

The lowest vaccination rate in the territory of the Šumadija District during 2018, with the first dose of the MMR vaccine, was observed in the municipality of Topola, where out of 167 planned for vaccination, 143 were vaccinated, which is 85.0%. In the municipality of Rača, satisfactory immunisation coverage was also not achieved, as out of 70 planned for vaccination, 63 children were vaccinated, which is 90.0%. For the 2018 calendar year in the territory of the Šumadija District, immunisation coverage was greater than 95%, so it is considered that immunisation against mumps with the MMR vaccine in the second year of life was successfully implemented.

It is noted that the implemented revaccination with the MMR vaccine in the seventh year of life in the territory of the Šumadija District was 97%, as out of the total planned 2,541, the number of revaccinated was 2,457. Thus, it is concluded that revaccination with the second dose of the MMR vaccine in the seventh year of life was also successfully implemented in the 2018 calendar year.

In the municipality of Aranđelovac, 329 out of the planned 400 were revaccinated, which is 82.0%. In the municipality of Lapovo, 50 out of the planned 54 were revaccinated, which is 93.0%. In the municipality of Rača, 96 out of the planned 100 were revaccinated, which is 96.0%. In the municipality of Kragujevac, 1,665 out of the planned 1,670 were revaccinated, which is 99.0%. In the municipality of Batočina, all 78 of the planned 78 were revaccinated, which is 100.0%. In the municipality of Knić, all 77 of the planned 77 were revaccinated, which is 100.0%. In the municipality of Topola, all 162 of the planned 162 were revaccinated, which is 100.0%.

During the calendar year 2018 in the municipality of Aranđelovac, 241 received the first dose, 34 received the second dose, and 46 received both the first and second doses, out of a total of 321 planned for vaccination and revaccination. In the municipality of Knić, 3 received the first dose, out of a total of 3. In the municipality of Kragujevac, 109 received the first dose, and 30 were

revaccinated, for a total of 139. In the municipality of Lapovo, 1 person was revaccinated, out of a total of 1. According to statistical data, a total of 353 received the first dose, 65 were revaccinated, and 46 received both the first and second doses at once. There were 463 children in total.

From 1 January to 31.12.2018, the highest MMR vaccination coverage was achieved in Knić and Lapovo (100%), while revaccination was carried out with maximum success in Batočina, Knić, and Topola (100%). At the level of the Šumadija District, 2,554 out of the planned 2,600 children received the first dose of the MMR vaccine, representing 98.0%. For revaccination, 2,457 out of a total of 2,541 planned children received the second dose of the MMR vaccine in their seventh year of life. This immunisation coverage is also considered successful, as it is 97%, exceeding the 95% threshold for successful immunisation.

In the pre-vaccination period, the incidence rate of mumps in Vojvodina ranged from 300 to 700 per 100,000, with a peak incidence of 846.7 per 100,000 recorded in 1988, two years after the introduction of immunisation, when an epidemic occurred with over 17,000 registered cases. Intensive population screening, combined with high immunisation coverage, led to a drastic reduction in incidence. Although the incidence of mumps remained low during the vaccination period, localised epidemics were recorded in which vaccinated individuals also became ill. The largest epidemic in the post-vaccination period occurred in 2012 [21].

The epidemic began among students in Novi Sad and spread to the wider area of Vojvodina. The highest number of cases was recorded in the South Bačka District. The epidemic primarily affected adolescents. However, fully immunised individuals also became ill during the epidemic. Of the 57 patients with valid health documentation on their vaccination status, 40 (70%) had received two doses of the mumps vaccine. Despite the epidemic, the registered mumps incidence rate of 18.6 per 100,000 in Vojvodina in 2012 was incomparably lower than the values from the pre-vaccination period [22].

The antibody level is lower than that achieved through natural immunity. For satisfactory population immunity, vaccination coverage of over 90% of children is necessary. In addition to coverage, proper preparation of the vaccine, including maintaining the cold chain during storage, is also important for a successful vaccination programme.

The best way to prevent this disease is through regular, legally prescribed vaccination with the MMR combined live attenuated vaccine, which protects against mumps, rubella, and measles. Before the introduction of the MMR vaccine, this mild viral disease often occurred in small or large epidemics, mainly in kindergartens and schools. Successful protection is as important as it is challenging [23].

Successful immunisation of children was achieved with the combined vaccine against mumps, measles, and rubella. In Serbia, mandatory vaccination of children aged 12 to 24 months with the combined measles-mumps vaccine began in 1981.

In the territory of the Šumadija District, during the period from 01.01. to 31.12.2019, in the municipality of Arandelovac, 370 out of 389 planned residents were vaccinated, representing 95.00%. In the municipality of Batočina, 81 out of 84 planned residents were vaccinated, which is 96.00%. In the municipality of Knić, 89 out of 91 planned residents were vaccinated, which is 98.00%. In the municipality of Kragujevac, 1,651 out of 1,730 planned residents were vaccinated, which is 95.00%. In the municipality of Lapovo, 41 out of 49 planned residents were vaccinated, which is 83.00%. In the municipality of Rača, 62 out of 65 planned residents were vaccinated, which is 95.00%. In the municipality of Topola, 139 out of 153 planned residents were vaccinated, which is 91.00%. This indicates that in the municipalities of Topola and Lapovo, immunisation was not successfully implemented.

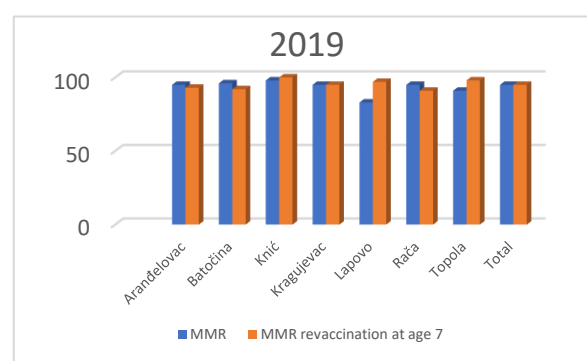


Figure 3. Graphic representation of immunization against mumps on the territory of the Šumadija District in the period of 01.01.2019 - 31.12.2019.

During 2019, immunisation with the first dose of the vaccine in the second year of life in the Šumadija District was successfully implemented, as the immunisation coverage was 95.0%, with a total of 2,433 out of 2,561 planned children vaccinated.

Based on these data, the highest vaccination rate was in the municipality of Knić at 98.00%, followed by Batočina at 96.00%, and Arandelovac, Kragujevac, and Rača at 95.00%. The lowest percentage of vaccinated people was recorded in the municipality of Lapovo, where 83.00% were vaccinated, and in the municipality of Topola, where 91.00% were vaccinated. In the territory of the Šumadija District in 2019, the vaccination rate was 95.00%.

Revaccination of children in their seventh year was also assessed. In the municipality of Arandelovac, out of 421 planned, 392 were revaccinated, representing 93.00%. In the municipality of Batočina, out of 100 planned, 92 were revaccinated, or 92.00%, indicating that revaccination in 2019 was not fully successful in this municipality, but was satisfactory. In the municipality of Knić, all 94 planned children were revaccinated, achieving 100.00%. In the municipality of Kragujevac, 1,597 out of 1,675 planned were revaccinated, which is 95.00%. In the municipality of Lapovo, 61 out of 63 planned were revaccinated, or 97.00%. In the municipality of Rača, 100 out of 110 planned were revaccinated, or 91.00%. In the

municipality of Topola, 155 out of 158 planned were revaccinated, or 98.00%.

Regarding revaccination, the highest percentage of vaccinated children in their seventh year was recorded in the municipalities of Knić, Lapovo, and Kragujevac, with rates of 100.00%, 97%, and 95% respectively. The lowest percentage was in the municipality of Rača, at 91.00%. Across the entire Šumadija District, out of 2,612 children planned for revaccination, 2,491 were revaccinated, representing 95.0%.

Missed years – in the municipality of Arandjelovac, 82 children were revaccinated. In the municipality of Kragujevac, 17 children received the first dose, 11 were revaccinated, totalling 28. Additionally, 17 children received the first dose, and 89 were revaccinated, totalling 110.

During the period from 01.01 to 31.12.2019, the most successful vaccination was achieved in Knić, where revaccination was also carried out with maximum success. At the level of the Šumadija District, 2,433 out of the planned 2,561 children were vaccinated with the MMR vaccine, which is 95.0%. The same percentage (95%) of children were revaccinated with the second dose of the MMR vaccine in their seventh year.

The MMR (measles, mumps, rubella) vaccine, specifically MMR-II, is a combined, trivalent, live attenuated vaccine used for immunisation against mumps, measles, and rubella. This vaccine is a live attenuated viral vaccine used to induce immunity against measles, mumps, and rubella. In our country, the MMR vaccine is administered in two doses: at 12 to 15 months of age and before enrolment in the first year of primary school [24].

Experts generally assess the MMR vaccine as “highly immunogenic” (providing a high degree of protection) and “generally well tolerated”. For these reasons, the World Health Organization advocates its use, stating that it is “safe and effective”, and experts are outraged by false rumours about its alleged harmfulness.

The Federal Immunisation Regulations specify general contraindications: acute illness, febrile conditions, and hypersensitivity (prophylaxis) to vaccine components. There are two additional contraindications for live virus vaccines: immunodeficiency (due to malignant diseases, antimetabolite therapy, high doses of corticosteroids, alkylating agents, or radiation) and pregnancy. There are no specific contraindications. Therefore, immunisation is the best form of prevention for these diseases [25].

In the Šumadija District, from 01.01.2021 to 31.12.2021, in the municipality of Arandjelovac, 379 out of the planned 388 were vaccinated, which is 97.00%. In the municipality of Batočina, out of the planned 80, 76 were vaccinated, which is 95.00%. In the municipality of Knić, out of the planned 89, 86 were vaccinated, which is 96.00%. In the municipality of Kragujevac, out of the planned 1,760, 1,480 were vaccinated, which is 84.00%. This indicates that immunisation was not successfully implemented in this municipality. In the municipality of Lapovo, all 47 planned individuals were vaccinated, which is 100.00%, indicating successful immunisation in this municipality.

In the municipality of Rača, out of the planned 70, 62 were vaccinated, which is 89.00%. In the municipality of Topola, out of the planned 127, 115 were vaccinated, which is 90.00%.

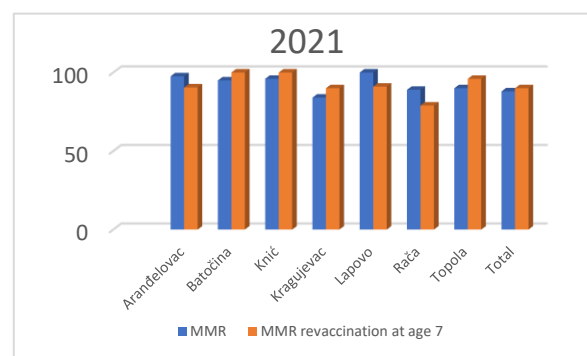


Figure 4. Graphic representation of immunization against mumps in the Šumadija District in the period of 01.01.2021 - 31.12.2021.

Taking into account the total number of those planned for vaccination with the MMR vaccine in the second year of life (2,561), compared to the number vaccinated (2,245), in the territory of the Šumadija District for 2021, the percentage vaccinated is 88.00%. The highest number of vaccinated children was in the municipality of Lapovo, where the percentage was 100.00%. The lowest number was in the municipality of Kragujevac, where the percentage was 84.00%.

Based on statistical data on the revaccination of children in the seventh year, in the municipality of Arandjelovac, out of the planned 400, 362 were revaccinated, which is 90.00%. In the municipality of Batočina, all 81 planned children were revaccinated, achieving 100.00%. In the municipality of Knić, out of the planned 79, the same number of children were revaccinated, which is 100.00%. In the municipality of Kragujevac, out of the planned 1,770, 1,588 were revaccinated, which is 90.00%. In the municipality of Lapovo, out of the planned 58, 53 were revaccinated, which is 91.00%. In the municipality of Rača, out of the planned 80, 63 were revaccinated, which is 79.00%. This means that immunisation was not successfully implemented in this municipality. In the municipality of Topola, out of 128 planned, 123 were revaccinated, which is 96.00%.

In total, 2,349 were revaccinated in the Šumadija District, out of 2,596 planned, which is 90.00%. The largest number of revaccinated people was in the municipalities of Batočina and Knić, where the percentage of revaccinated people was 100.00%. The smallest number of revaccinated people was in the municipality of Rača, where the percentage was 79.00%.

In the Šumadija District, in the territory of Kragujevac, 17 were vaccinated with the first dose, 21 were revaccinated with the second dose, and 38 were vaccinated with both the first and second doses, for a total of 38. In the municipality of Topola, 15 children were vaccinated with the first dose, and 15 with both the first and second doses, making a total of 15. The total number of children for the missed years was 53.

Elimination of an infectious disease is achieved when there is not a single case of the disease in an area, and practice has shown that this is possible if at least 95% of the population in each administrative unit of a territory has received two doses of the vaccine.

The MMR vaccine has quickly become one of the greatest fears among parents. Concern about whether a child will become autistic after vaccination has spread so widely that the percentage of vaccinated children in 2016 fell to a minimum of 81%, which is insufficient for herd immunity. This was largely due to the anti-vaccination movement, which uses social networks to publish numerous supposedly expert papers directly linking the MMR vaccine to autism. The most controversial issues are its “suspicious composition and origin”, as well as its “mercury content”.

In the absence of solid scientific evidence about the true causes of the increasing number of autistic children worldwide, and because autism is most often clinically manifested and recognised in the second year of life – the age at which the MMR vaccine is intended to be administered – these two factors are often falsely linked in a cause-and-effect relationship. After comprehensive studies involving millions of children from various parts of the world, using scientific methods, the possibility of a link between the MMR vaccine and autism has been definitively ruled out. It cannot be claimed that MMR causes autism, given that this condition is five times more common in boys than in girls, while MMR vaccination is administered equally to both sexes [26, 27, 28, 29].

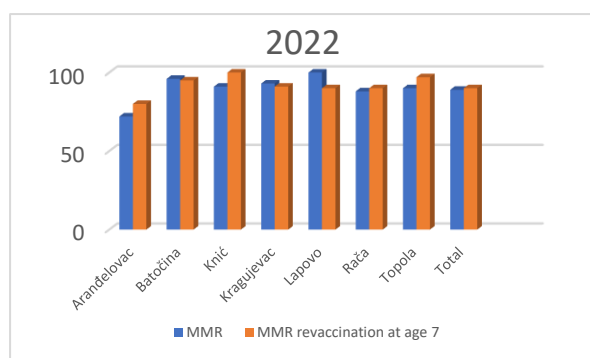


Figure 5. Graphic representation of immunization against mumps on the territory of the Šumadija District in the period of 01.01.2022 - 31.12.2022.

In the territory of the Šumadija District, from 01.01.2022 to 31.12.2022, in the municipality of Aranđelovac, 385 children were planned for MMR vaccination in their second year, and 276 were vaccinated, which is 72.00%. This indicates that immunisation was not successfully carried out in this municipality. In the municipality of Batočina, out of 74 planned, 71 were vaccinated, which is 96.00%. In the municipality of Knić, vaccination coverage was 91.00%, with 67 out of 73 planned individuals vaccinated. In the municipality of Kragujevac, out of 1,570 planned, 1,456 were vaccinated, which is 93.00%. In the municipality of Lapovo, all 61 planned children were vaccinated, which is 100.00%. In the municipality of Rača, out of 65 planned, 57 were vaccinated, which is 88.00%. In this

municipality as well, the percentage of individuals immunised with the MMR vaccine is low (less than 95%), so immunisation is considered unsuccessful. In the municipality of Topola, out of 140 planned, 126 were vaccinated, which is 90.00%.

Considering the total number planned for MMR vaccination in the second year of life (2368), compared to the number vaccinated (2114), in the territory of the Šumadija District for 2022, the vaccination rate is 89.00%. The highest number of vaccinated individuals was in the municipality of Lapovo, where the vaccination rate was 100.00%. The lowest number was in the municipality of Aranđelovac, where the vaccination rate was 72.00%.

In Aranđelovac, 370 individuals were planned for MMR revaccination in the seventh year, and 298 were revaccinated, which is 80.00%, indicating that immunisation was not successfully implemented in this municipality. In Batočina, out of 84 planned, 80 were revaccinated, which is 95.00%. In Knić, all 81 planned individuals were revaccinated, which is 100.00%. In Kragujevac, out of 1780 planned, 1627 were revaccinated, which is 91.00%. In Lapovo, out of 53 planned, 48 were revaccinated, which is 90.00%. In the municipality of Rača, 90 out of the planned 100 individuals were revaccinated, representing 90.00%. In the municipality of Topola, 141 out of the planned 145 were revaccinated, which is 97.00%.

A total of 2,365 individuals were revaccinated in the Šumadija District, out of the planned 2,613, amounting to 90.00%. The highest number of revaccinated individuals was in the municipality of Knić, where the revaccination rate was 100.00%. The lowest number was in the municipality of Aranđelovac, where the revaccination rate was 80.00%.

Healthcare workers need to raise awareness of the need for mandatory vaccination and revaccination against infectious diseases to achieve collective immunity. It is known that every unvaccinated person poses a risk for the occurrence of the disease. Educating people about infectious diseases and their transmission is extremely important. Given this, it is important to emphasise that the causative agent of epidemic parotitis is a virus with a marked affinity for the salivary glands and the central nervous system. Although mumps is generally mild and harmless, complications – such as atypical localisation (meningitis, orchitis, pancreatitis, diabetes, etc.)—have been recorded increasingly often in recent times, creating a need for its control. This can only be achieved through the systematic immunisation of children at the earliest possible age. The disease most often affects children aged five to seven years.

Seroprevalence studies have shown that 50% of children aged four to six and 90% of those aged 14–15 are seropositive. In temperate climates, the disease is seasonal, with the highest incidence during winter and spring. General measures, as with other droplet infections, are the same and ineffective. Specific measures include active protection – vaccination – as well as passive protection in cases of more severe forms of the disease.

According to the Federal Immunisation Regulations, this vaccination is administered in the

second year of life, that is, after 12 months of age, up to 14 years. The mumps monovaccine may also be given to older children and adolescents according to epidemiological indications, up to 15 years of age.

The combined live vaccine against measles, mumps, and rubella, known as the MMR vaccine, is produced by most manufacturers worldwide from the same virus strains. In the USA and Western countries, including Biocine-Sclavo (Italy), this combined vaccine is made from attenuated strains: for measles, the Schwarz strain; for mumps, the URABE Am9 strain; and for rubella, the Wistar RA27/3 strain. The duration of immunity in vaccinated individuals is about 10 years.

According to WHO data, in 1996, 74 (39%) member countries had introduced the mumps vaccine into their national immunisation programmes, with more than half using a single-dose regimen. By the end of 2004, 109 (57%) countries had introduced this vaccine, and by the end of 2010, 117 (61%) countries were implementing immunisation, with the majority (110 countries) using a two-dose schedule. Immunisation is still not implemented, mainly in poorer countries in Africa and Southeast Asia, which have other health priorities [30].

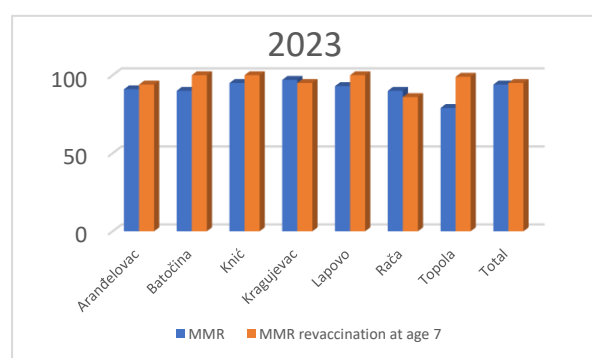


Figure 6. Graphic representation of immunization against mumps on the territory of the Šumadija District in the period of 01.01.2023 - 31.12.2023.

After the COVID-19 pandemic, overall MMR vaccination coverage in the second year of life in 2023 was 94%, with revaccination at 95%. The lowest primary coverage was in Topola (79%), while Kragujevac maintained the highest value at 97%. Revaccination was lowest in Rača (86%) and highest in Batočina, Lapovo, and Knić (100%). In 2023, following the pandemic, recovery is evident: overall primary coverage reached 94%, and revaccination 95%. These results are close to the recommended minimum coverage of 95%, which the World Health Organization (WHO) defines as necessary to establish herd immunity and prevent epidemic outbreaks of mumps. The largest number of vaccinated and revaccinated children was expected in Kragujevac, the largest municipality in the district, which recorded 97% coverage in the second year and 95% in the seventh year, indicating a stable and reliable immunisation system.

By municipality, certain differences in coverage are evident. These may result from population migration or insufficient control of missed years. In contrast, Batočina, Knić, and Lapovo achieved 100%

revaccination coverage, indicating well-organised primary health care activities and consistent monitoring of children in the target age groups.

When analysing the number of children from missed years who were subsequently vaccinated, a total of 158 children were covered: 101 received the first dose, 56 received the second dose, and one child received both doses. This data is particularly important, as it helps reduce the number of susceptible individuals and the risk of mumps in the community. However, the number of missed children indicates that there is room for improvement, especially in the timely calling and monitoring of unvaccinated children.

Overall, the Šumadija District achieved high levels of immunisation coverage against measles, mumps, and rubella in 2023, indicating the efficiency of the implementation of the Compulsory Immunisation Programme. However, to fully meet the WHO goal of measles elimination, it is necessary to continuously improve the surveillance system, conduct targeted outreach in municipalities with lower coverage, and continue to educate parents and health workers about the importance of vaccination.

Barriers during the pandemic, such as temporary clinic closures, reallocation of teams to COVID-19, and delays in scheduling and calling, may have led to delays in first appointments and missed booster shots in preschool children [31, 32, 33]. In addition, loss of confidence in vaccines likely contributed to delays in parents' decision-making about MMR vaccination even after restrictions were lifted. These stated hypotheses are consistent with other international research on the impact of the pandemic on routine immunisation and changes in attitudes towards vaccines.

Interpretation of our data suggests that backlogs occurred during 2020–2021 and were only partially compensated for in 2022–2023. The differences observed between individual municipalities probably reflect variations in the availability of appointments, the intensity of active recall, and differences in the interpretation of possible risks. Although vaccine availability was satisfactory and stable, factors such as timing, working hours, overloading of paediatric teams, and information barriers (including various vaccine announcements on social media) probably had a greater effect on MMR vaccination than on vaccines administered at an earlier age.

The decline in immunisation coverage is sufficient to allow the possibility of the spread of contagious droplet infections again, especially among preschool children. Certain activities that should be carried out are very important, all of which are intended to compensate for missed opportunities during the COVID-19 pandemic. The primary health service, together with the paediatrician, paediatric nurse, and other team members, should play a major role in this. Maintaining coverage of more than 95% for both doses of MMR vaccination remains not only a goal, but also a necessary condition to prevent the spread of possible mumps epidemics.

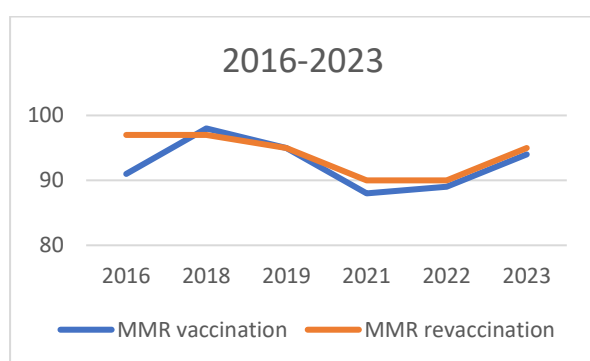


Figure 7. Graphic representation of immunization against mumps (MMR vaccine) in the Šumadija District in the period of 2016 – 2023.

From 1 January to 31 December 2016, the most successful MMR vaccination was achieved in Lapovo and Topola, while revaccination was carried out with maximum success in Aranđelovac and Knić. At the level of the Šumadija District, 2,387 individuals were vaccinated with the MMR vaccine out of the planned 2,619, representing 91.0%.

From 1 January to 31 December 2018, the most successful MMR vaccination was achieved in Knić and Lapovo, while revaccination was successfully carried out in Batočina, Knić, and Topola. At the level of the Šumadija District, 2,554 individuals were vaccinated with the MMR vaccine out of the planned 2,600, which is 98.0%.

From 1 January to 31 December 2019, the most successful vaccination was achieved in Knić, while revaccination was also carried out with maximum success in Knić. At the level of the Šumadija District, 2,433 out of the planned 2,561 were vaccinated with the MMR vaccine, which is 95.0%.

From 1 January to 31 December 2020, the most successful vaccination was achieved in Lapovo, while revaccination was most successfully carried out in Batočina, Knić, and Rača. At the level of the Šumadija District, 2,676 out of the planned 2,758 were vaccinated with the MMR vaccine, which is 97.0%.

From 01.01 to 31.12.2021, the most successful vaccination was conducted in Lapovo, while revaccination was most successful in Batočina and Knić. In the Šumadija District, 2,245 out of the planned 2,561 individuals were vaccinated with the MMR vaccine, representing 88.0%.

From 01.01 to 31.12.2022, the most successful vaccination was again conducted in Lapovo, while revaccination was most successful in Knić. In the Šumadija District, 2,114 out of the planned 2,368 individuals were vaccinated, which is 89.0%.

After the COVID-19 pandemic, the total number of vaccinated individuals in 2021 was 1% lower than in 2022, indicating that the pandemic itself affected immunisation against mumps. Further comparison of statistical results shows that in 2019, 95.0% of people were vaccinated in the Šumadija District, while after the pandemic, in 2022, the number of vaccinated individuals in this district was 89.0%. This shows that, when comparing these two years, the percentage of

vaccinated individuals decreased by 6%. Additionally, by reviewing other data related to different vaccinations, it can be concluded that immunisation for other infectious diseases also decreased significantly during the COVID-19 pandemic.

Analysis of data by year and municipality clearly shows differences in MMR vaccination and booster coverage before, during, and immediately after the COVID-19 pandemic.

Key recommendations include assessing and monitoring immunisation coverage, organising targeted catch-up campaigns with priority for groups that missed the first or second dose of the MMR vaccine, and strengthening primary health care to educate parents, prevent vaccine misinformation, and ensure continued immunisation during future health crises. These measures are necessary to prevent a decline in herd immunity, which could lead to larger outbreaks and more severe complications of the disease itself [34, 35, 36, 37].

4. CONCLUSION

This paper analyses the importance of vaccination as the most effective way to prevent and protect against mumps. It is important to emphasise that vaccination is crucial for protecting the entire population, especially vulnerable groups such as children. Our findings confirm that MMR vaccination coverage in the Kragujevac territory and its surroundings underwent a significant change in the period preceding, during, and following the COVID-19 pandemic. In the pre-pandemic period, coverage was stable and close to programme goals. In 2021, we recorded a decline related to restrictions on the work of primary health care, staff reorganisation, and the prioritisation of care for patients suffering from COVID-19. In addition, the significant impact of delayed preventive examinations and reduced mobility of parents can be observed. After the easing of measures, there was a partial recovery in coverage, but it was insufficient to reach pre-pandemic levels in all groups. This pattern is consistent with the global trend of stagnant recovery in routine immunisation. The COVID-19 pandemic adversely affected children's routine immunisation, as evidenced by a decline in pertussis vaccination coverage. These findings indicate that reorganisation of the health system, difficult access to health services, and restricted population movement during the pandemic contributed to decreased immunisation coverage.

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