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The safety and effectiveness of COVID-19 vaccines for adolescents

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Abstract. Since the 2019 outbreak of COVID-19, the virus has rapidly spread worldwide, becoming the largest epidemic in recent years. Infection with SARS-CoV-2 can cause symptoms ranging from mild to severe, potentially leading to death, including for patients in intensive care units. Fortunately, scientists and researchers worldwide raced against time, quickly organized, and devoted themselves to vaccine research. After unremitting efforts, they developed a vaccine for COVID-19 at record speed, successfully slowing down and preventing its spread. However, even after more than three years, although significant progress has been made in combating the epidemic, numerous challenges still need to be addressed. One of these problems is the vaccination of young people, which poses a significant challenge. The vaccination of young people is hampered by severe side effects experienced by some individuals and concerns voiced by parents, which makes the process difficult. This paper examines literature and gathers data from sources such as CNKI, Google Scholar, Web of Science, Cochrane Library, and World Health Organization database to analyze the impact of three major COVID-19 vaccines on adolescents. The analysis focuses on vaccination responses and associated effects, aiming to provide references for future epidemic prevention. In addition, the suggestions may increase parents' trust in vaccines, provide them with important information, and help the vaccination of teenagers go more smoothly.

Keywords: Vaccines, Covid-19, Adolescents.

1. Introduction

The COVID-19 pandemic has had a devastating impact on people globally since its first outbreak in December 2019. The virus has affected many people worldwide. During the previous 28-day period (July 17 to August 13 2023), over 1.4 million new COVID-19 cases and over 2300 deaths were reported from six regions of the WHO. Compared to the preceding 28-day period, the cases had increased by 63%, while the deaths had decreased by 56%. As of August 13, 2023, the global number of confirmed COVID-19 cases has exceeded 769 million, and the deaths have amounted to over 6.9 million [1].

Although adolescents are less likely than adults to contract COVID-19, the ongoing development of the adolescent body means that its bodily systems, particularly the immune system, are not as robust as those of adults. Therefore, severe illness can still occur in this group. Children with underlying medical conditions are at an elevated risk for severe illness from COVID-19, and even children without

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underlying medical conditions can experience severe illness.1 Evidence indicates that children with special healthcare needs, such as those with genetic, neurologic, metabolic, or congenital heart conditions, have an increased risk of severe illness from COVID-19. Similar to adults, children with obesity, diabetes, asthma, chronic lung disease, sickle cell disease, or immunosuppression may also be at an increased risk for severe illness resulting from COVID-19 [2, 3]. Additionally, apart from the impact on physical health, the mental health of young individuals during the COVID-19 pandemic is also a grave issue. The outbreak has adversely affected their emotional development and mental well-being. The psychological repercussions of staying at home have been exceedingly harmful to them. Following a COVID-19 infection, occurrences may arise in which the situation significantly impacts daily routines and employment. Thus, it is crucial to "prepare for the rainy day" to ensure protection against viruses.

From the discovery of the first vaccinia vaccine to its subsequent continuous development, vaccines have proven to be an effective measure for resisting, and even eliminating, infectious diseases. Their role in reducing rates of severe illness and mortality, curbing the further spread of disease, and potentially achieving herd immunity cannot be replaced. The outbreak of COVID-19 is a favorable confirmation of these facts. After the outbreak, countries have rapidly organized and developed vaccines for COVID-19. Thanks to the efforts and cooperation of government departments, pharmaceutical companies, and scientific researchers, large-scale vaccination has been achieved in less than two years since the epidemic's outbreak. However, some groups hesitate to receive the vaccine due to the various types available and potential risks [4].

Furthermore, the debate over whether to vaccinate children and teens against COVID-19 has been ongoing since the pandemic began. Various factors contribute to this debate, including physical and psychological conditions, yet parental concerns remain the primary issue. Given the rapid development and widespread availability of COVID-19 vaccines, coupled with reports of severe reactions after vaccination, many parents express apprehension and refuse to vaccinate their children. This section will focus on the classification and safety analysis of COVID-19 vaccines [5]. Objective opinions and data collected by inspection institutes will be utilized to compare vaccine efficacy and suitability for teenagers. The safety and effectiveness of each vaccine type will be comprehensively reviewed to draw a conclusion. The section will conclude with a summary of the findings.

2. Review and Discussion

mRNA Vaccines

Unlike traditional vaccines, mRNA vaccines are a new type of vaccine. They had not been used on a large scale before the COVID-19 outbreak. These vaccines act on immune cells by producing specific antibodies against the SARS-CoV-2 spike protein. The antibodies induce immune responses and stimulate differentiation of T and B memory cells [6]. In this outbreak, Pfizer/BioNTech first researched and developed an mRNA vaccine, which passed review and was put into production and use. As the fastest vaccine allowed to be injected among teenagers in the United States, we passed several experiments and data to analyze the vaccine situation.

Regarding the Pfizer vaccine, the BNT162b2 Covid-19 vaccine, Dr. Robert W. Frenck conducted a multinational, placebo-controlled, observer-blinded study on the use of the vaccine in people under 16 years of age. The entire process was randomized 1:1 so that participants received 2 injections of 30 μg BNT162b2 or placebo, and the data obtained in the adolescents were compared with those of adults who received injections. There are more than 2,000 samples, and the conclusion is quite convincing [7].

Based on his experiments, we can conclude that the vaccine is generally relatively safe. All the adolescents who were injected have mild to moderate pain at the injection site, headache, fatigue, etc., and no serious adverse events are related to the vaccine. Side effects of the first injection in the adolescent group analyzed were mainly mild headache and fatigue, and a small number of severe headaches occurred. However, the overall proportion was lower than that of the first injection in adults, and about 20% of the second injection adolescents had fever, as did 17% of the adult group. Of all the teens who participated in the test, about 6% had adverse events, but later analysis showed that only about

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3% were vaccinated, and the rest were experimenters who were injected with placebos. Among the experimenters who were actually vaccinated, it was found through testing that the immune response of the adolescents was significantly higher than that of the adult group one month after the second dose, and the efficacy basically reached 100%. [7] According to the experiment of Doc. Stephen J. Thomas, the immune efficacy of BNT162b2 mRNA Covid-19 vaccine was tracked 6 months after vaccination, and the conclusion was that the vaccine efficacy against Covid-19 was 91.3% (95% confidence interval [CI], 89.0 to 93.2). Although the efficacy of the vaccine has declined, and various factors such as different countries and regions, different races, ages, and genders will have different degrees of impact, this level of immune efficacy has good safety. It is effective in preventing Covid-19 effect [8]. Another issue of great concern to parents is that many adolescents show symptoms similar to myocarditis after vaccination, which is a major factor of concern to them. Some teenagers will have symptoms similar to myocarditis after the second injection, but the rate of life-threatening reaction has also increased after the second injection, which proves that the second injection may cause side effects to a greater extent. However, after a booster dose, such symptoms are significantly reduced, so parents and teens should be informed before injection [3, 9].

In short, there is a high probability that adolescents will have certain side effects when they are vaccinated with the Pfizer vaccine, but most people's reactions are mild to moderate, which will not affect normal life. Moreover, the continuous immune effect of the Pfizer vaccine is effective and can basically be avoided. Reinfection with the virus. With follow-up research, it is possible to improve the vaccine, reduce the degree of side effects, and minimize or avoid severe reactions. So, the Pfizer vaccine is not too bad for teenagers.

3. Inactivated Vaccine

When new pathogens, such as SARS-CoV, emerge, rapid and simple development of vaccines is urgently needed due to the lack of understanding of the pathogenesis. The classical approach of using cell culture-based inactivated virus is likely the fastest and easiest development method for CoV vaccines, as there is a wealth of experience with many inactivated vaccines for other viral diseases. Moreover, the inactive vaccine can preserve the normal conformation of the S protein, leading to an effective induction of a certain level of immune response and antibody production [10].

Here, we use the example of the inactivated COVID-19 vaccine CoronaVac produced by Beijing Kexing Company to examine basic information about the vaccine among adolescent vaccinators based on experimental data. Based on experiments by Bihua Han MSc et al.. Hundreds of underage volunteers were recruited and divided into three groups. They were then injected with aluminum hydroxide, 1.5 μ g vaccine, and 3.0 μ g vaccine, respectively, and observed for 28 days. Two groups were later administered doses post-vaccination. About 27% of genuine vaccine recipients reported experiencing at least one adverse reaction within 28 days. Most reactions were mild or moderate, while less than 1% were severe. Additionally, the majority of adverse reactions emerged within 7 days post-vaccination and were resolved within 48 hours. The experiment mainly showed adverse reactions such as pain at the injection site and fever. In addition, it was observed that adolescents aged 12-17 have a higher probability of experiencing adverse reactions compared to those aged 3-5. Finally, after a follow-up period, it was determined that the immune response was favorable. It was concluded that both doses of CoronaVac, 1.5 μ g and 3.0 μ g, were safe and well-tolerated for children and adolescents aged 3-17. The dose of 3.0 μ g induced higher immune responses in all age groups compared to the 1.5 μ g dose. However, when compared to the data of the adult group, children exhibit a stronger immune response. This suggests that they may also be more susceptible to immune overreaction than adults, making it a viable option to lower the vaccination dosage accordingly [11, 12].

Finally, it is concluded that inactivated vaccines exhibit exceptional immune efficacy in adolescents, while the frequency of adverse reactions, such as pain and fever at the injection site, remains relatively high, albeit primarily mild to moderate. These symptoms usually surface within 7 days of vaccination and subside relatively quickly. Since the timing of such adverse reactions is roughly controllable, this

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vaccine benefits those who cannot take extended breaks. Vaccinations should be considered if school attendance needs to be maintained for the child.

4. Vector Virus Vaccine

Like mRNA vaccines, viral vector vaccines are a very new technology. Although they have been used in the field of gene therapy for a long time, there are still many aspects to be explored in terms of vaccines. Its advantages are mainly reflected in cost and resistance; that is, the cost of making the vaccine is low, and the vaccine is easy to maintain and is not easy to fail, but the safety and stability of the carrier virus also need to be actively considered. Some viruses may cause other problems, which also makes this kind of vaccine not suitable for use as a vaccine. Vaccines that can be widely administered, so they are not used as a reference in this article [13].

Overall, three vaccines are currently available and have demonstrated significant immune efficacy in adults. However, this article concentrates on comparing mRNA and inactivated virus vaccines for adolescents. While other vaccine types await further research, we present a final analysis of the data for these two vaccines. In contrast, the mRNA vaccine (BNT162b2) induced significantly higher levels of binding and neutralizing antibodies compared to the inactivated vaccine (CoronaVac) [14]. This suggests that the immune response generated by the mRNA vaccine is superior. Adverse reactions were also analyzed, with mRNA vaccines resulting in mostly mild-to-moderate fatigue and headache, while inactivated vaccines mainly caused mild-to-moderate fever and pain at the injection site. Technical terms are explained in their first usage wherever considered necessary. On the other hand, the likelihood of adverse reactions from mRNA vaccines is comparatively low and the timeline is relatively short and randomized, whereas the timing of inactivated vaccines is more definite, and the recovery is faster despite a higher likelihood of adverse reactions. Additionally, severe adverse reactions caused by mRNA vaccines occur slightly more frequently than those caused by inactivated vaccines. Of course, the incidence of adverse reactions for both vaccines is rare, but the mRNA vaccine can lead to symptoms akin to myocarditis. This is a noteworthy aspect that merits attention. Thus, in the long-term, parents can evaluate their children to a certain extent. If you are active, enjoy sports, possess optimal bodily functions, or have ample leisure time, you may opt for the mRNA vaccine due to its superior immune response. However, be aware that its side effects can be more severe and may disrupt your everyday life. And if you are busy with your studies and cannot take many days off, you may opt for the inactivated vaccine, which has relatively tolerable adverse reactions and minimal impact. If participants desire a greater immune effect, they may opt for an enhancer injection, etc.

According to the conclusion of a heterologous inoculation experiment, the immune effectiveness and duration of protection for those inoculated with heterologous vaccines are higher compared to those inoculated with homologous vaccines. Additionally, the former group shows high immunity to different variants. Therefore, if conditions permit, choosing to receive heterologous vaccines may be an option [14, 15].

5. Conclusion

Based on the analysis of several vaccines mentioned above, this paper has reached conclusions that support the vaccination of young individuals. However, this analysis is limited to common vaccines available on the market and does not cover all existing vaccines. Therefore, more research is needed to find and summarize effective vaccination methods. Nonetheless, the conclusions of this study have instilled a greater level of confidence in COVID-19 vaccination among parents. Finally, the research of the revised article focuses on children and adolescents aged 3-17, as there is currently no available data or vaccination status for those under the age of 3. Long-term experiments are required, and in-depth research and evaluation will be conducted simultaneously, with additional data gradually supplemented and improved. The aim is to ultimately address the COVID-19 vaccination problem comprehensively.

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