The Systematic Research of The Comparison of Moderna Covid-19 Vaccine and Pfizer Covid-19 Vaccine

Qiming Wang*

Department of Chemical Engineering and Analytic Science, The University of Manchester, Manchester, United Kingdom

* Corresponding Author Email: qiming.wang-3@student.manchester.ac.uk

Abstract. The outbreak of the one-of-a-kind coronavirus in March of the year 2020 was designated as a pandemic by the World Health Organization. This article will cover the mechanism of action, mode of administration, adverse effects, and effectiveness of the Pfizer and Moderna created mRNA COVID-19 vaccine, which is licensed for use in the United States, as well as current times. In addition, the evolution of the illness is going to be covered in this article. Pfizer and Moderna, respectively, have created mRNA vaccines that encode the SARS-CoV-2 spike-in protein in order to combat the SARS-CoV-2 outbreak. Since the United States government issued an emergency permission to administer the vaccine there, both those who took part in clinical trials and members of the general public have shown that the vaccine is safe to use. Pfizer and Moderna's SARS-CoV-2 vaccines have been demonstrated to be 95.0% effective in avoiding infections that are regarded as being mild or symptomatic. Because these vaccinations are now the subject of ongoing clinical research, it is essential to have access to medical literature that has been brought up to date. This is especially significant when they are researched in a variety of age groups as well as when new strains of SARS-CoV-2 coronavirus develop. In addition to this, the article presents a succinct review of the future of mRNA vaccines, and it makes the statement that mRNA vaccines will play a significant position in the creation of future human vaccines.

Keywords: Vaccine; COVID-19; SARS-CoV-2; Pfizer; Moderna.

1. Introduction

There are many variants of the SARS-CoV-2 virus, which causes COVID-19. One of these variants is known as the Delta variant (B.1.617.2) [1]. On October 5, 2020, medical professionals in India made the first discovery of the disease. The Delta variety was first identified on the 31st of May 2021, and by the 22nd of November 2021, it had already spread to more than 179 countries throughout the world. [2] The World Health Organization (WHO) issued a study in June 2021 stating that the Delta version is fast becoming the world's most frequent strain of the virus. It is believed that this subtype had a part in the deadly second wave of the pandemic, which started in India in February of 2021. This wave of the epidemic began in India. The World Health Organization (WHO) issued a warning about it in July of 2021, stating that it may potentially have the same effect in Africa and Europe. In addition to this, there was an increase in the number of diseases that were happening each day in the regions of Asia, North America, and Oceania by the end of the month of July [3].

To limit the spread of Covid-19, non-pharmaceutical methods have been adopted, including physical separation, mask usage, teleworking, isolation, and quarantine [4]. However, these behavioural approaches may have unintended implications, such as poor psychological effects, serious depression, and mental health repercussions. The creation of a safe and highly effective vaccination has been the single positive development [5]. The purpose of March 2020, the WHO announced a worldwide pandemic [6].

By the end of October 2021, nine major vaccines will have been licensed and delivered in many nations. Johnson & Johnson, Novavax, Moderna, Oxford-AstraZeneca, Pfizer-BioNTech, Gamaleya, Sinopharm, Sinovac, and Bharat Biotech are the nine companies that produce the vaccine. Figure 1 depicts the primary manufacturing process that goes into the production of SARS-COV-2 vaccines.

In this article, mRNA vaccine will be the specific one that be discussed. In addition, Pfizer mRNA vaccine and Moderna's mRNA vaccine will be the example data used to a representation of the market mRNA vaccine.

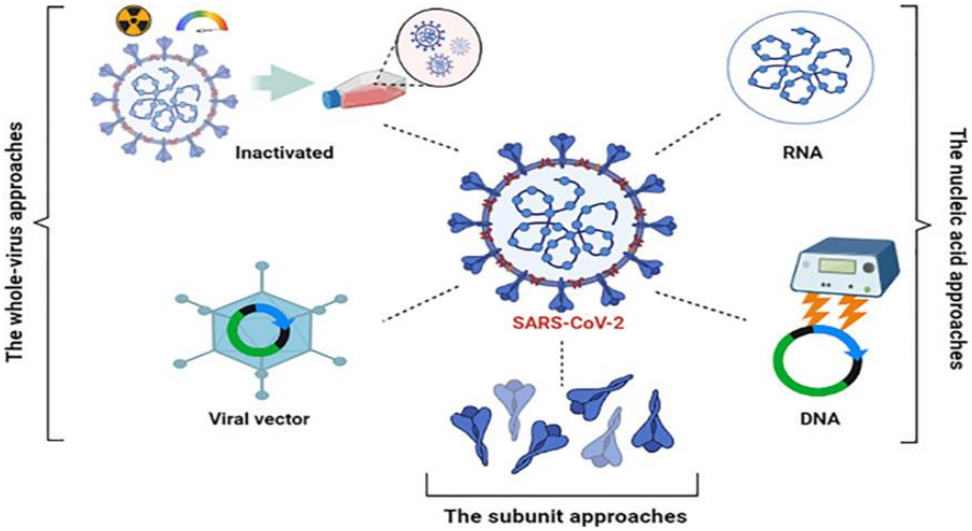

Figure 1. Type of vaccine in the market description (Reproduced from [7])

For the creation of Covid19 vaccines, major vaccine technology platforms are used. Inactivated strains of severe acute pulmonary disease coronavirus 2 (SARS-CoV-2) are used in the production of inactivated vaccines against Covid-19. Viral vector Covid19 vaccines use adenoviruses containing the target virus' genetic material. Vaccines designed to protect against Covid19 are made up of RNA that encodes the target antigen as well as LNP. Electroporation is the most common method for administering vaccines that protect against Covid19. These vaccines include a DNA plasmid that encodes the target antigen. Purified SARSCoV2 antigens are included in the subunit Covid19 vaccines. These antigens stimulate the immune system and are purified.

Pioneering research carried out between 1947 and 1961 uncovered the role of messenger RNA (mRNA) as a transitional link between genes and the proteins they code for [8]. Research conducted on the structural and functional properties of mRNA led to the creation of a technique known as in vitro transcriptional (IVT) mRNA. This approach involves the production of mRNA in a laboratory at the end of the 1980s. Since the initial animal proof-of-concept experiments were carried out in the year 1990, researchers have investigated a broad variety of alternative methods in an effort to enhance the instability and immunogenicity of IVT mRNAs [9].

2. Comparative analysis of the Pfizer and Moderna vaccines' modes of action

The Pfizer and Moderna vaccines both work in a way that is functionally similar to one another and are hence interchangeable. A nucleoside-modified type of messenger RNA (mRNA) that expresses the SARS-CoV-2 spike glycoprotein is included in the vaccine. This mRNA is delivered to the body in the form of lipid nanoparticles so that it can enter the cells of the host in a more efficient manner. The vaccine is intended to protect against SARS-CoV-2. [10] In order to achieve the current work, it is necessary to synthesize and briefly express a translated protein product once the LNP-mRNA treatment has been carried out. This will allow the task to be completed successfully. The strand of mRNA is recognized by the ribosomes of the host cell once it has traversed the cellular membranes and been released from the LNP into the cytoplasm. It undergoes translation in the standard fashion, which is the process that takes place anytime RNA is turned into proteins. This results in the creation of a protein product. Despite the fact that presently available vaccination formulations do not replicate, research is still being conducted on a second class of mRNA vaccines. These mRNA strands, which have been given the moniker of self-replicating, also express the viral replication machinery, which allows for an extended generation of the mRNA [11]. In spite of the

fact that the current vaccine formulations cannot be replicated, this study is still being carried out. The S2-P antigen is a kind of antigen that is distinguished by the fact that it is specially encoded by the mRNA. A glycoprotein that is unique to SARS-CoV-2 and a transmembrane anchor are both components of this structure. The antigen is then either exported outside of the cell or localized to the cell membrane, both of which are locations where it has the potential to activate humoral and cellular immune responses. In the former case, the antigen is exported outside of the cell. In the latter case, it is localized to the cell membrane. Antigen-presenting cells are known to phagocytose antigens prior to maturing and traveling to lymph nodes. Once there, they offer antigen fragments on their surfaces to T lymphocytes that are growing in the lymph nodes. Because of this, CD8 T cells are able to generate a rapid immune response, which in turn leads to the production of humoral immunity that is able to ward against subsequent infections brought on by the same pathogen. It is possible for B cells to get activated in one of two ways: either directly, via the detection of antigens at the B cell receptor (BCR), or indirectly, with the aid of CD4 T cells. B cells are capable of producing antibodies that are specific to antigens after they have been activated. It is possible that in the not-too-distant future, these antibodies will be able to detect the antigen that is genuinely present on the true pathogen and promptly trigger an immune response before the pathogen can proliferate and cause an illness. This would be a significant advance. When a person who has gotten an mRNA vaccine against a virus is later exposed to that virus, the antibodies in that person's body may promptly recognize, bind to, and kill the virus before it can cause major sickness. This may happen before the infection can cause serious illness. This humoral protection is the foundation of the immunity that vaccination bestows for a lifetime [12]. Figure 2, which may be seen over on this page, provides a more comprehensive illustration of the intracellular process. In addition, the effectiveness of a treatment may be determined by measuring the patient's antibody responses to S2-P after receiving the treatment. This may be accomplished in a number of different ways. To put it more simply, the purpose of the vaccine is to stimulate an immunological response to the spike protein in the body's B and T cells in order to protect the individual against the disease. The evidence that was made public indicates that the vaccination was efficacious in eliciting antibody responses against full-length S2-P as well as the RBD. The researchers came to this conclusion after examining the data [13].

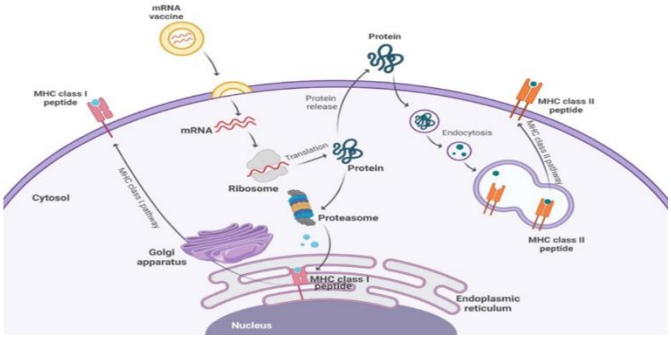

Figure 2. Immunity mechanisms mediated by mRNA vaccines description (Reproduced from [14])

MRNA that contains the genetic instructions for viral proteins is imported into the cell, where it is read by the ribosomes and converted into protein. The proteasome is responsible for the breakdown of the resultant proteins into peptides, and the Golgi apparatus is the organelle that is in charge of transporting the peptides outside the cell. Complexes are provided as the form in which the remaining components of the intracellular structure are displayed. In addition, immune cells could be able to take in extracellular proteins, which the endosomes of those cells would then disassemble further into smaller and smaller pieces.

3. Efficacy of Pfizer vaccine (BNT162b2) at clinical phase

Nearly 37,000 people who had no signs of a current or a previous infection with Covid-19 yet nevertheless tested positive for the virus, 8 were seen in vaccinated participants (at a minimum of

seven days following the administration of the second dose of vaccination) and above 160 were observed in placebo recipients, indicating an anti-infective effectiveness of 94.6% [15]. Although this was not the major objective of the research, the observed vaccination effectiveness of 52.0% was noteworthy. This implies that the BNT162b2 vaccine offers early protection against infection 12 days after the first vaccination. This 52.0% effectiveness was based on the incidence between the first and second administration periods in 39 BNT162b2 vaccine-treated patients and 82 placebo-treated patients [14]. Nearly 50,000 people from across the world took part in Pfizer's phase III trial, and on November 18, 2020, the results of a satisfactory effectiveness study led to the Food and Drug Administration (FDA) awarding an expanded use authorization (EUA) for immunisation in the USA. The research examined the occurrence of the illness between the second vaccines. The study looked at those who had never had the virus before as well as those who remained infection-free 7 and 14 days after receiving the second vaccination. The statistics showed that the vaccine had a success rate of 95.0% in averting infections seven days following the delivery of the second dose of immunisation. This success rate is essential for the FDA to acquire EEA clearance for this vaccine in the USA. Pfizer announced the findings of a phase 1/2/3 research on March 31, 2021. The study included more than 2,000 adolescents ranging in age from 12 to 15, all of whom were immunised with BNT162b2. [15]. The vaccine achieved a remarkable 100% survival rate in adolescents. In teenagers, the vaccination had a strong efficacy of 100%.

4. Evaluation of the effectiveness of the Pfizer vaccine against the B.1.617.2 strain

The vaccine efficacy is the common question that every government focus. How is the efficacy of the Pfizer against B.1617.2 strain? In October 2020, India reported its first case of the B.1.617.2 Delta variant. Due to the discovery of two mutations in the RBD, this mutant was designated as a "double mutant." According to the findings of the research, these modifications boost the ability to connect to the ACE2 receptor, which leads to an increase in transmission ability. The significance of these mutations on the present immunization is still being examined; however, tests in various countries have revealed that the vaccine is less effective against the B.1.617.2 variation, which is a variety of concern according to the World Health Organization. It was claimed that the B.1.617.2 immunization was efficacious in Qatar at 64.2% 14 days following the first injection and at 53.5% 14 days after the second injection, preventing severity rate and death. [16]. The effectiveness of the B.1.617.2 variation in avoiding asymptomatic infection in the UK was 33.5% after the first dosage and 59.8% after the second [17]. In the USA, further investigation of the B.1.617.2 variation was conducted. After receiving two Pfizer vaccination, protection against symptomatic illness was initially 88.0% in the first month, then subsequently reduced to 47.0% after five months. In the first month after immunization, 75.0% of moderate to severe infections were prevented. The vaccination was 93.0% effective across all age groups in avoiding hospitalizations. These findings raise the issue of whether the steady loss in effectiveness is attributable to a diminishing antibody response over time or to changes in the B.1.617.2 variation that allow immune evasion. A sample assessment of infected individuals in Israel revealed a significant incidence of the Delta strain, with a curative effect of 39.0% for asymptomatic infection, 40.5% for symptomatic illness, nearly 90% for severity rate. 91.4% of important instances were effective [18]. Table 1 displays the effectiveness values for symptomatic B.1.617.2 infections as well as severe or fatal infections that need hospitalization. According to the table below, the efficacy against symptomatic infection is quite low except in the United Kingdom. However, the vaccine shows great efficacy fatal infection which means almost every infected people have mild symptoms.

Table 1. The effectiveness of the Pfizer-BioNTech vaccine against the feared variant: Delta B.1.617.2

Variant	Country	effectiveness against infections exhibiting symptoms	effectiveness against infections that are severe or deadly
B.1.617.2	Israel	40.5%	91.4%
B.1.617.2	Qatar	53.5%	89.7%
B.1.617.2	United Kingdom	75.0%	93.0%
B.1.617.2	United States	40.5%	91.4%

5. Adverse effect of the Pfizer vaccine

In order to capture any potential delayed side effects, the findings of the phase III study's evaluation of the drug's safety were assessed within 14 weeks following the second dosage. After taking the second injection of the vaccine, the individual tolerability of the medication, as characterized by local and immediate responses, as well as systemic adverse effects are outlined in Table 2. Participants reported pain ranging from moderate to severe at the site of injection more often than any other local reaction, and it lasted for as long as one week. Patients who were younger were more likely to report pain at the injection site than patients who were older (almost 80% after each dosage). Patients who were older were less likely to experience discomfort at the injection site. Patients who were older were less likely to report experiencing soreness at the injection site (which occurred in about 70% of cases after each dosage). The frequency of systemic reactions was significantly higher at the second and second doses, and it was more prominent in participles who are younger than some patients who are elder. Additionally, the frequency of systemic responses increased with age. Headaches were recorded by nearly 40.0% of older patients, while fatigue was noted by above 50.0% of patients, and 11.0% of patients reported having fever. Headaches were reported by 52.0% of younger patients, nearly 60.0% of younger patients felt exhaustion, and 16.0% of younger patients experienced fever. 4 It is important to highlight that weariness and headache were also often mentioned by individuals who had received the placebo (23% and 24%, respectively) [15, 19].

Table 2. Tolerability and systemic side effects in vaccination recipients after a second injection manufactured by Pfizer

Individuals between 18 and 55 Tolerability	Mild to moderate	Severe (symptoms prevent daily activity)	Individuals over 55 Tolerability	Mild to moderate	Severe (symptoms prevent daily activity)
Injection Site Discomfort	76.6%	1.2%	Injection Site Discomfort	65.7%	0.5%
Erythema	5.4%	0.5%	Erythema	6.8%	0.5%
Fever	30.2%	1.2%	Fever	21.5%	0.3%
Fatigue	54.8%	4.6%	Fatigue	47.7%	2.8%
Headache	48.5%	3.2%	Headache	38.4%	0.5%
Myalgia	37.3%	2.2%	Myalgia	27.8%	1.0%
Swelling Systemic Reactions	5.9%	0.3%	Swelling Systemic Reactions	7.3%	0.2%
Vomiting	1.7%	0.2%	Vomiting	0.6%	0.1%

6. Efficacy of Moderna vaccine (mRNA-1273) at clinical phase

After receiving two injections, the Moderna had a success rate of 94.1% in preventing COVID-19 symptoms in those who received the treatment. Those who were older than 65 years old had a vaccination efficiency that was slightly lower than the average of 86.4% seen throughout the whole population. There was found to be no noticeable difference, in terms of its efficiency, between the various racial and ethnic groups that were studied. For the COVE Phase 3 experiment, participants were selected from populations who had a high number of risk factors for COVID-19 infection. Over 30,000 people took part in the study that was being conducted. In comparison, 11 persons in the control group were diagnosed with signs of the sickness, whereas 185 people in the vaccination group were impacted by the condition. [20] The outcomes of this research indicated that the vaccination was effective 94.1% of the time. Serious adverse effects occurred at rates that were comparable between the immunization group and the control group. However, these adverse events were very uncommon. When the findings from all of the COVE studies were considered together, they showed that COVID-19 is effective in treating adults.

7. Evaluation of the effectiveness of the Moderna vaccine on the B.1.617.2 strain

According to a piece of research that was published, In the case of Delta strains, the quantity of neutralising resistance found in the serum of patients who got two injections of the vaccine was 6.8 times more than the amount found in patients who received just one injection. At the end of the experiment, each and every subject who had been vaccinated had successfully suppressed the Delta strain [21]. An examination of the efficacy of the Moderna vaccination against the B.1.617.2 variation was carried out and the findings were presented in a paper that was generated by the Clinical Health System at the Mayo Clinic. The study, which was conducted between January and July of 2021, found that the number of people infected with the B.1.617.2 variation in the area served by the Mayo Clinic increased by a factor of seven over that time period. According to the findings of the study, which were not evaluated by an independent panel of experts, the Moderna vaccine was effective against the Delta variant 76.0 percent of the time. The vaccine's efficacy in reducing hospitalization and death maintained between 90.0% and 95.0% across all relevant studies, despite the fact that its effectiveness against acquired infections had diminished [22].

8. Adverse effect of Moderna vaccine

Monitoring for both local and systemic side effects has been used in the evaluation of the Moderna vaccine's efficacy and safety. This has allowed for an assessment of the vaccine's effectiveness and safety. It is vital to monitor the health of the vaccinated individual, to study the patient for tens of days to collect precise information on adverse responses, and to question the vaccinated individual about side effects seven days after vaccination and again 28 days after they manifest. Inquire further if the vaccine recipient has quit immunization owing to adverse effects. Discomfort, erythema, edema, and an expansion of the lymph nodes are all examples of local adverse reactions. Systemic side effects have been shown in the table 3. According to the results of the clinical study, participants who were given mRNA had a significantly higher risk of experiencing local adverse effects at the injection site compared to those who were given a placebo [20]. Also, the incidence of systemic adverse side effects was significantly higher in the group that received mRNA following injections 1 and 2 as compared to the group that received the placebo. Following administration of the second injection of the mRNA immunization, 50% of the sample had moderate to severe systemic side effects. Fever, arthralgia, and myalgia were some of the symptoms that accompanied this condition. On the other hand, these systemic side effects were completely gone by the second day after receiving the vaccination.

Table 3. Tolerability and systemic side effects in vaccination recipients after a second injection manufactured by Moderna [23]

Individuals between 18 and 64 Tolerability	mild to moderate precipitation	Severe	Individuals over 64 Tolerability	mild to moderate precipitation	Severe
Injection Site Discomfort	90.1%	4.6%	Injection Site Discomfort	83.4%	2.7%
Erythema	9.0%	2.0%	Erythema	7.4%	2.1%
Fever	17.4%	1.6%	Fever	10.2%	0.5%
Fatigue	67.6%	10.6%	Fatigue	58.4%	6.9%
Headache	62.8%	5.0%	Headache	46.4%	3.0%
Myalgia	37.3%	2.2%	Myalgia	27.8%	1.0%
Nausea	21.3%	<0.1%	Nausea	11.8%	0.3%
Swelling Systemic Reactions	12.6%	1.7%	Swelling Systemic Reactions	10.8%	1.9%
Vomiting	1.7%	0.2%	Vomiting	0.6%	0.1%

9. Advantage and disadvantage of mRNA vaccine

The mRNA vaccine shows promise as a safer, more manageable, and more efficient alternative to vaccines based on pathogen-based viruses. mRNA vaccines provide the major safety benefit of a non-integrated method of action. This means that all activity is contained to the cytoplasmic lysis, and genome disruption and off-target consequences are not as big of a worry with these vaccines as they are with DNA-based vaccinations. Gene expression, in vivo viability, cell absorption, and bioreactor production of mRNA molecules are all rather straightforward processes. Cells containing antigens, also known as CPAs, have been shown to be capable of demonstrating mRNA protein products to a degree that is comparable to that of immunisation achieved through the use of more traditional methods [24]. These tests have been conducted in both clinical and laboratory settings.

Utilizing a plasmid that already contains the isolated target gene as a template for the mRNA strand during the production process of mRNA vaccines results in a significant simplification of the process. Because of this, the process should not provide too many challenges. A high level of security can be maintained throughout the production process as a result of the procedure's scalability and the absence of potentially harmful live virus or strictly controlled cell cultures. These two elements contribute to the fact that the achievable degree of security is substantial. This is possible to accomplish because of the following reasons: In addition, the high degree of safety may be accomplished despite the fact that the technique can be quickly altered. This is a significant advantage. The further procedures that need to be followed in order to make the final product are to encapsulate the nanoparticles and then purify them after they have been encapsulated. However, in order to carry out the final treatment, it is vital to have a reliable cold chain in place. For vaccines manufactured by Pfizer and BioNTech, this temperature range is equivalent to around -70 degrees Celsius. Even while it is considerably easier to create and store naked mRNA than it is other kinds of vaccine components, this has a significant impact on the logistics of shipping and storing these vaccinations in countries that are classified as developing or tropical. As a result, there has been an increased reliance on inactivated formulations in these regions. However, the technology is still in its infancy, and the introduction of mRNA vaccines into these regions won't be possible until improved heat-resistant formulations developed by businesses such as CureVac are proven to be safe and effective in clinical tests. Until that time, the introduction of mRNA vaccines into these regions won't be possible. The formulation of Moderna is not impacted by the temperatures used in commercial refrigeration; nonetheless,

distribution was originally delayed since the manufacturing plant did not have adequate capacity. Depending on the manufacturer, the cost of a single dose of an mRNA vaccination might vary anywhere from $20 to $40 at the present time. This is a much higher price compared to those of formulations that are more traditionally used, which may be obtained for anywhere from $2 to $10 for each individual dosage [25]. On the other hand, many governments throughout the world are currently helping to subsidize this cost, and it is anticipated that this cost will decrease as manufacturing capacity increases.

10. Conclusion

This article contains a review and overview of the existing data on the effectiveness, mechanism of action, administration technique, and safety of the two vaccines that are now being used in the globe. Both of these vaccinations are in widespread use. Both Pfizer and Moderna's early clinical investigations have shown an efficacy of around 95% in avoiding infection. This is a major resemblance between the two companies' findings. Both companies provide two independent dosages of mRNA vaccine, each with its own unique mode of action and delivery, in order to stimulate an immune response. More research has to be done on the efficacy of both vaccines against variants, especially novel variants such as Omicron, since this may provide light on why more doses are required. Both vaccinations are extremely effective for reducing severity rate and mortality, which are the two primary objectives of vaccination. It is impossible to overstate how quickly pharmaceutical companies responded to the COVID-19 epidemic. As the distribution of the vaccine becomes more widespread across the world, it appears that humanity will finally emerge victorious in its fight against the virus that has been responsible for the deaths of almost millions of people. Because it could provide light on the need of giving higher doses, the growing variety requires special care. This focus must be directed to it. The prevention of hospitalization and death, which is the basic goal of immunization, is achieved with a high degree of effectiveness by both vaccinations. The pandemic caused by COVID-19 has accelerated the development of technology for the delivery of mRNA vaccines. A new generation of vaccines has gradually been gaining greater public awareness as a means of preventing and treating a range of infectious diseases. This is because vaccinations are effective in both preventing and treating infectious diseases. At this time, the COVID-19 mRNA vaccine is very necessary in order to put a stop to the ongoing pandemic. mRNA vaccinations, in contrast to traditional vaccinations, have the potential to change the design of the antigen and even combine the sequences of a large number of different variants in order to take into account any new mutated genes in the virions. This is done in order to prevent the vaccine from becoming ineffective. Platforms based on mRNA technology will, in the not-too-distant future, make it feasible to treat, manage, and prevent infectious illnesses in addition to other disorders. mRNA vaccine has a rapid production cycle, does not need cell culture, and is highly immunogenic. Because of the need for very low temperatures, transporting and storing mRNA vaccines might be more difficult. As a result, further research and development work has to be done to perfect the stability of mRNA vaccines. In addition, distribution of mRNA has progressed from its initial form to LNP-based delivery since its inception. It is anticipated that in the future, mRNA delivery will include the use of innovative polymer materials, which are now the focus of growing research. Current mRNA vaccines provide a high level of protection and safety, but it will not be possible to determine whether or not they are effective over the long term until more clinical studies are carried out. It is important not to discount how quickly pharmaceutical companies responded to the COVID-19 pandemic. In light of the current expansion of the vaccine's dissemination around the globe, the fight against a virus that has been responsible for the deaths of almost one million people appears to eventually benefit humankind. Emerging variants in particular need to be the subject of more research since this might provide information on the need to provide additional dosages. The prevention of hospitalization and death is the single most important goal of immunization, and there is a high degree of confidence that all three doses can accomplish this target. It is important not to undervalue the speed with which

pharmaceutical companies responded to the COVID-19 epidemic. The battle against the virus that has been responsible for the deaths of almost millions of people appears to be turning in favor of humanity in the long run.

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