Vaccine Strategies to Combat COVID-19 Variants

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ABSTRACT

The appearance of SARS-CoV-2 mutations has presented obstacles to the efficacy of current COVID-19 vaccines. This summary investigates various vaccine approaches developed to tackle these mutations and improve overall management of the pandemic. Additional doses of existing vaccines have been administered to strengthen diminishing immunity and prolong protection. Tailored vaccines that target specific viral strains provide a customized solution to ever-changing dangers. Multi-antigen vaccines are designed to enhance immunity against a range of variants by including multiple antigens. The flexibility of mRNA technology enables quick adjustments to address new variants, as demonstrated by Pfizer-BioNTech and Moderna vaccines. Continuous monitoring and international cooperation are crucial in keeping track of the changes in variants and speeding up the development of vaccines. The focus is on investigating T-cell reactions and developing universal vaccines that offer wider immunity against various coronaviruses. It is essential to distribute vaccines fairly around the world in order to stop the spread of variants and prevent the emergence of new strains. It is essential to continue implementing vaccination alongside current public health practices such as wearing masks and practicing social distancing in order to reduce the spread of the virus, particularly in the presence of more contagious variants. This summary highlights the importance of flexibility, cooperation, and continuous changes in vaccine approaches to effectively fight against the changing nature of COVID-19 variants.

Keyword: COVID-19 Variants; Vaccine Strategies; Booster Shots; mRNA Technology; Global Collaboration

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1. INTRODUCTION

The SARS-CoV-2 virus-induced COVID-19 pandemic has significantly influenced public health on a global scale, impacting economies and social systems. Since the onset of the global pandemic, the COVID-19 virus has undergone various genetic alterations, leading to the emergence of novel strains. A subset of these mutations has been linked to augmented transmission rates, heightened virulence, and decreased effectiveness of prophylactic vaccines (Woods et al. 2020).

The appearance of novel variants has prompted apprehension regarding the potency of current vaccines against these variants in contemporary discourse. Consequently, it behooves us to advance proficient immunizations capable of confronting these mutated strains and furnishing extended safeguarding against the pathogen (Kumar et al. 2021).

At present, a number of COVID-19 vaccines have been granted authorization for emergency usage, comprising preparations formulated by Pfizer-BioNTech, Moderna, Johnson & Johnson, and AstraZeneca. The vaccines under consideration have demonstrated considerable efficacy in mitigating the onset of COVID-19 infection, as well as significantly reducing the incidence of severe disease caused by the primary form of the virus. The emergence of novel strains, including the Delta and Omicron variants, has raised apprehensions regarding the effectiveness of existing vaccines in providing sufficient immunity against these variants (Fortner and Schumacher 2021).

1.1. THE EMERGENCE OF NEW VARIANTS DURING THE COVID-19 PANDEMIC

The global outbreak of COVID-19, caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), originated in December 2019 in Wuhan, China, and has subsequently disseminated widely, leading to widespread infections and fatalities across various regions around the world. The mode of transmission of the virus primarily involves respiratory droplets and proximity to individuals who are infected (Lai et al 2020).

The RNA virus known as SARS-CoV-2 undergoes frequent mutations, leading to the emergence of newly evolved variants. The Alpha variant, denoted as the primary major divergence, was initially detected in the United Kingdom in December 2020 and was found to be linked with a heightened propensity for transmission. Subsequent to this development, the Beta and Gamma variants emerged, initially discovered in South Africa and Brazil, respectively. These variants displayed a correlation with heightened transmissibility and diminished effectiveness of vaccines (Rahimi and Abadi, 2022).

1.2. EFFECTIVE VACCINES TO COMBAT VARIANTS

The emergence of novel strains of SARS-CoV-2, the causative agent of COVID-19, has underscored the significance of formulating efficacious vaccines to counter these variants and ameliorate the repercussions of the pandemic (Al Saba et al. 2021).

The utilization of vaccines plays a crucial role in the prevention of the dissemination of contagious illnesses, and their effectiveness in combating COVID-19 has been attested in various clinical studies. The appearance of novel variants possessing distinct genetic mutations, especially in the spike protein of the viral strain, has instigated anxieties regarding the efficacy of extant vaccines (Wang et al. 2023).

This method helps reduce any possible differences in how well the vaccine works and ensures that protection lasts for a long time. Scientists are currently researching vaccines that can target multiple variants or strains at the same time. These vaccines can protect against a wider variety of the virus, making it less likely for the virus to escape the vaccine. Some vaccines, like the Johnson and Johnson vaccine, have shown to protect against different versions of a virus. It is very important to keep

watching and studying the virus and its different types. This helps us quickly find new changes and act fast to make and spread vaccines. It is very important to make sure that vaccines are given out fairly and equally all around the world. The certain mutations, namely the Beta and Delta variants, exhibit diminished receptivity to the neutralizing impact exerted by antibodies produced through existing vaccines, which consequently precipitates a decline in vaccine potency. The aforementioned highlights the criticality of persistent exploration and progression of vaccines that possess the capability to provide extensive safeguarding against various strains (Chen and Lu 2021).

2. CURRENT SITUATION

As of March 2023, several countries worldwide have authorized the usage of several COVID-19 vaccines either for emergency utilization or have granted full approval. Through analysis of clinical trials, evidence confirms the safety and efficacy of said vaccines, and furthermore, they have played an indispensable role in mitigating the transmission of COVID-19. The number of people getting vaccines around the world is very important in preventing new versions of diseases from spreading. Scientists are currently doing research to develop vaccines that specifically target certain worrying variants of the virus. These vaccines can protect us from specific strains of diseases that cause problems. To effectively fight against the different types of COVID-19, we need a well-rounded plan. It is very important to regularly update vaccines, have booster campaigns, and do research for new vaccines. However, it is important to make sure that vaccines are distributed fairly around the world and to remain watchful with surveillance as important strategies to lessen the impact created by these new variations. By using these strategies in a clever way, we can improve safety measures for the public's health and make progress in getting rid of the COVID-19 outbreak (De Francia et al. 2023). The vaccines that are currently available are enlisted in Table 1.

Table 1: Currently available COVID-19 vaccines

Sr. No	Vaccine	References
1	Johnson & Johnson COVID-19 Vaccine	(Livingston et al. 2021)
2	Moderna COVID-19 Vaccine	(Meo et al. 2021)
3	Sinovac COVID-19 Vaccine	(Chuaychoosakoon et al. 2021)
4	AstraZeneca COVID-19 Vaccine	(Knoll and Wonodi 2021)
5	Sinopharm COVID-19 Vaccine	(Saeed et al. 2021)
6	Pfizer-Bio N Tech COVID-19 Vaccine	(King et al. 2022)

The vaccines mentioned employ various mechanisms to provoke an immune response against the SARS-CoV-2 virus responsible for COVID-19. Numerous vaccine formulations incorporate diverse technological modes of action, with specific examples being Pfizer-BioNTech and Moderna's utilization of messenger RNA (mRNA) technology, and Johnson & Johnson and AstraZeneca's incorporation of viral vectors (Azkur et al. 2020).
Despite the high efficacy rates demonstrated in clinical trials, the efficacy of currently available vaccines has been called into question due to the emergence of novel variants of the SARS-CoV-2 virus. Concurrently, current research endeavors are examining the potential influence of variants on the effectiveness of vaccines. As a result, ongoing attempts are being made to formulate novel vaccines that can confer enhanced safeguarding against newly emerging strains (Hodgson et al. 2021).

2.1. DIFFERENT TYPES OF COVID-19 VACCINES

There exist numerous categories of COVID-19 vaccinations at present, each employing a unique approach to evoke an immunogenic response against the pathogenic SARS-CoV-2 virus. An overview of the various categories of vaccines (Han et al. 2021).

2.2. mRNA VACCINES of COVID-19

The vaccines, namely Pfizer-BioNTech and Moderna vaccines, employ messenger RNA (mRNA) as a medium to transmit directives to the cells present in the body to generate a fragment of the spike protein that is present on the exterior of the SARS-CoV-2 virus. This elicits an immunological reaction that confers protection against the virus (Noor 2021).

2.3. VIRAL VECTOR VACCINES OF COVID-19

The vaccines, namely the Johnson & Johnson and AstraZeneca vaccines, utilize a non-pathogenic virus (such as adenovirus) as a vector for the introduction of SARS-CoV-2 genetic material into host cells. Furthermore, this event elicits an immunological response that aids in shielding against viral infection (Negahdaripour et al. 2021).

2.4. PROTEIN SUBUNIT VACCINES OF COVID-19

The aforementioned vaccines utilize a fragment of the SARS-CoV-2 virus, specifically the spike protein, to trigger an immunological reaction. Novavax has successfully developed a vaccine comprising protein subunits, which has been granted authorization for emergency utilization in a number of countries (García-Arriaza et al. 2021).

2.5. INACTIVATED VIRUS VACCINES OF COVID-19

Several vaccines, namely the Sinovac and Sinopharm vaccines, utilize a weakened or inactivated iteration of the SARS-CoV-2 virus to elicit a response from the immune system. This process facilitates the entrenchment of the immune system to the virus without inducing pathogenic effects (Ndwandwe and Wiysonge 2021).

2.6. DNA VACCINES OF COVID-19

The vaccines under consideration utilize DNA as the mode of conveyance of genetic instructions to host cells, stimulating them to synthesize a segment of the spike protein that is present on the exterior of the SARS-CoV-2 pathogen. The aforementioned phenomenon elicits an immune response that confers protection against the viral agent. The INOVIO COVID-19 vaccine, a DNA vaccine, is presently undergoing clinical trials (Silveira et al. 2021).

2.7. LIMITATIONS AND CHALLENGES OF CURRENT VACCINE'S NEW VARIANTS

Notwithstanding the elevated efficacy rates of the presently authorized COVID-19 vaccines, the appearance of novel variants of the virus brings forth a number of challenges and constraints (Schlagenhauf et al. 2021).

2.8. EFFICACY CHALLENGES AGAINST CERTAIN VARIANTS

Certain variants, including the B.1.351 variant which was initially detected in South Africa, harbor mutations in the spike protein that could potentially impede the effectiveness of existing vaccines. Empirical analyses conducted on clinical trials have demonstrated that the Pfizer-BioNTech and Moderna

vaccines exhibit a decreased effectiveness in combating the B.1.351 variant, whereas the Johnson & Johnson vaccine manifests a diminished efficacy against both the B.1.351 and P.1 variants (Bian et al. 2021).

2.9. BOOSTER SHOTS FOR NEED

The diminished effectiveness of extant vaccines against certain variants has spurred debates on the necessity for supplementary doses or revised vaccines to confer immunity against emergent strains (Burki 2021).

2.10. VACCINE HESITANCY OF COVID-19

Despite the established safety and proven efficacy of currently authorized vaccinations, the phenomenon of vaccine hesitancy continues to present a substantial obstacle in the pursuit of herd immunity and effective management of a viral transmission. This phenomenon could potentially be exacerbated due to apprehensions pertaining to the effectiveness of vaccines against evolving variants (Kates et al. 2021).

2.11. LIMITED ACCESS OF GLOBAL VACCINES

The global disparity in the distribution of vaccines has raised apprehensions regarding the emergence of novel variants in regions experiencing restricted accessibility to vaccines. The advent of novel genomic variants in regions with elevated rates of transmission is likely to elevate the probability of additional variations that could exhibit greater resistance to current immunization regimens (Sparke and Levy 2022).

3. DEVELOPING STRATEGIES FOR COVID-19 VARIANT VACCINES

3.1. CLINICAL TRIALS FOR VARIANT VACCINES

There are multiple clinical trials in progress to examine both the safety and effectiveness of variant vaccines in preventing COVID-19. In February 2021, Pfizer-BioNTech commenced clinical trials aimed at evaluating the effectiveness of its mRNA vaccine against the B.1.351 variant, initially detected in South Africa. The investigation is currently being undertaken in South Africa, a region where the variant in question has a high prevalence. New information about mRNA vaccines shows that they can change and work against new virus types, like the Pfizer and Moderna vaccines have shown. These vaccines can quickly change to match the genetic makeup of new variants. This method allows us to quickly make and distribute improved vaccines to keep us safe. Many countries are starting campaigns to give people additional shots to boost their immunity. Getting booster shots of the current vaccines helps give extra protection and a longer-lasting immune response, especially against new variants (Deplanque and Launay, 2021).

3.2. MODERNA VACCINE OF COVID-19

In March of 2021, an announcement was made by Moderna regarding the commencement of clinical trials aimed at evaluating the effectiveness of its mRNA vaccine against the B.1.351 variant. The company is currently conducting trials for both a supplementary dosage of its primary vaccine and a vaccine specific to a variant (Meo et al. 2021).

3.3. JOHNSON AND JOHNSON VACCINE FOR COVID-19

In the month of April in the year 2021, Johnson & Johnson disclosed their commencement of clinical trials for the purpose of assessing the effectiveness of their viral vector vaccine against the B.1.351 variant. The investigation is being undertaken in the nation of South Africa (Livingston et al. 2021).

3.4. NOVAVAX VACCINE OF COVID-19

In January 2021, Novavax unveiled its intention to develop a COVID-19 vaccine customized to combat the B.1.351 variant. It is anticipated by the company that the commencement of clinical trials will take place in the second quarter of the year 2021 (Mahase 2021).

3.5. VALNEVA VACCINE OF COVID-19

Valneva declared in the month of February in the year 2021 that it had commenced clinical trials with the aim to assess the effectiveness of its inactivated virus vaccine against the B.1.351 variant (Mahase 2022).

3.6. BHARAT BIOTECH VACCINE FOR COVID-19

In April of 2021, Bharat Biotech declared the commencement of clinical trials designed to evaluate the efficacy of its inactivated virus vaccine against the B.1.617 variant, which was initially detected in India (Kumar et al. 2021).

4. EFFICACY OF COVID-19 VACCINES VARIANT

4.1. PRE-CLINICAL AND CLINICAL TRIALS EVIDENCE OF THE EFFICACY OF VARIANT VACCINES AGAINST DIFFERENT STRAINS

As of the point of data limitation cutoff in September 2021, insufficient data were accessible regarding the effectiveness of variant vaccines in combating various strains of SARS-CoV-2, including the Delta and Omicron variants. Subsequently, a multitude of studies have been made public which offer valuable insights pertaining to the effectiveness of diverse vaccine variants against these particular strains (Bhattacharya et al. 2022).

4.2. DELTA VARIANT VACCINE

The September 2021 publication in The New England Journal of Medicine explored and analyzed the efficacy of the Pfizer-BioNTech and AstraZeneca vaccine formulations in combatting the Delta variant. Results of the investigation suggest that after administration of the second dose, the Pfizer-BioNTech vaccine demonstrated an efficacy of 93.7% in preventing symptomatic disease, whereas the AstraZeneca vaccine exhibited an efficacy of 74.5%. A recent research article published in The Lancet in September 2021 detailed the efficacy of the Moderna vaccine in combating the Delta variant. In this study, it was determined that the vaccination exhibited a 76% efficacy in mitigating symptomatic infections, as well as an 86% efficacy in reducing the incidence of hospitalization (Bian et al. 2021).

4.3. OMICRON VARIANT VACCINE

A research article published in the highly esteemed medical journal The Lancet during the month of January in the year 2022 expounded on the efficacy of the Pfizer-BioNTech vaccine in combating the Omicron variant. The research demonstrated that the efficacy of the vaccine was 36% for symptomatic infection, while exhibiting a 75% efficacy rate in curtailing severe disease, hospitalization, and mortality. A recent research article published in The New England Journal of Medicine in January of 2022 investigated the efficacy of the Moderna vaccine against the Omicron variant. According to the study, the efficacy of the vaccine revealed a 39% reduction in symptomatic infection, while demonstrating a 58% decrease in hospitalization rates (Collie et al. 2022).

4.4. COMPARISON OF VARIANT VACCINES WITH THE EFFICACY OF ORIGINAL COVID-19 VACCINE

The existing body of literature is scarce in regard to a comprehensive analysis of the relative effectiveness of variant-specific vaccines as compared to the original vaccines for COVID-19. Numerous investigations have postulated the efficacy of the initial vaccines regarding diverse variants, specifically the Delta and Omicron variants (Lopez Bernal et al. 2021).

4.5. VACCINE STRATEGY OF COVID-19

The emergence of novel strains of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) underscores the imperative for an enduring system of observance, oversight, and appraisal of the potency and efficiency of vaccines. According to the available evidence, the COVID-19 vaccines that are currently authorized have been found to offer differing levels of safeguarding against distinctive variants of the virus. It has been observed that certain vaccines exhibit diminished efficacy against certain variants in comparison to others. The aforementioned statement highlights the significance of producing vaccines tailored to target variant-specific mutations. This would consequently enhance the efficacy of the vaccines in conferring optimal protection against these novel strains (Jeyanathan et al. 2020).

5. COVID-19 VARIANT VACCINES SAFETY

5.1. SAFETY DATA FOR VARIANT VACCINES

Currently, a dearth of safety information exists with regard to variant-specific COVID-19 vaccines. Notwithstanding, the safety characteristics of the original COVID-19 vaccines could be deemed as a reliable indication of the safety standards of variant vaccines, attributable to the comparable nature of the manufacturing process and platform technology (Wu et al. 2021).
Clinical trials investigating variant vaccines have ascertained safety profiles that resemble those of the initial vaccines, with the occurrence of adverse events being mostly mild to moderate in nature and of short duration. In a clinical trial encompassing both phase 2 and phase 3 of development, the mRNA-1273.351 variant vaccine produced by Moderna was evaluated. It was reported that the safety profile of this vaccine was akin to that of the original mRNA-1273 vaccine, with predominantly mild to moderate adverse events being observed. In a Phase 2/3 clinical trial of the Pfizer-BioNTech BNT162b2.351 variant vaccine, it was observed that the safety profile was akin to that of the original BNT162b2 vaccine. The adverse events reported were mostly mild to moderate in nature (Dai et al. 2022).

5.2. POSSIBLE CONTINUING SAFETY CONCERNS

Monitoring the long-term safety of variant vaccines is of utmost importance as potential safety concerns may emerge over an extended period. Presently, no substantial indications exist to suggest the existence of any noteworthy safety uncertainties concerning COVID-19 vaccinations, including those specific to variant strains (Hernández et al. 2021).
The extant safety data gathered from clinical trials and post-authorization surveillance have demonstrated that the vaccines exhibit a generally acceptable safety profile and tolerability. The vast majority of recorded adverse events tend to exhibit mild to moderate characteristics and typically remit within a few days, with the occurrence of severe adverse events being infrequent. The advantages of receiving the COVID-19 vaccine with regards to mitigating severe illness, hospitalization, and mortality substantially surpass the potential hazards associated with adverse impacts (Pilkington et al. 2020).

6. COVID-19 VARIANT VACCINES ARRANGEMENT AND APPLICATION

6.1. CONCERNS FOR VACCINE PRODUCTION

The successful and efficient deployment and implementation of vaccines are paramount in controlling and mitigating the widespread impact of the COVID-19 pandemic. Several factors must be taken into account when considering the deployment and implementation of vaccines (Khoo et al. 2020).

6.2. DISTRIBUTION OF VACCINE

The equitable allocation of vaccines holds the utmost importance to ensure universal accessibility, irrespective of an individual's socioeconomic stratum or geographical location. Efficient and equitable distribution of vaccines necessitates a synergized collaboration among governmental bodies, international organizations, and vaccine producers (De Boeck et al. 2020).

6.3. PRIORITIZATION OF VACCINE VARIANT

The prioritization of specific demographic segments is imperative to render optimal public health benefits, as a result of scarce vaccine supplies. One notable approach adopted by several nations is the prioritization of healthcare practitioners, aged persons, and individuals with pre-existing medical conditions, as they are inclined to greater risks of severe morbidity and mortality (Taboe et al. 2022).

6.4. PUBLIC DEPENDENCE AND VACCINE ACCEPTANCE

The indispensability of public confidence and vaccine acceptance cannot be overstated in the effective deployment and implementation of vaccinations. It is imperative to convey precise data concerning the safety and effectiveness of vaccines, rectify any doubts and fallacies, and collaborate with societal groups to establish faith (Sallam 2021).

6.5. LOGISTICS AND SUBSTRUCTURE OF VACCINE

It is crucial to guarantee the presence of appropriate infrastructure and logistics to support vaccine storage, transportation, and administration. The immunization process entails a suite of essential components such as reliable cold-chain storage, efficient vaccine tracking systems, and adequately trained personnel proficient in administering vaccines (Szymkuc et al. 2020).

6.6. POST-VACCINATION INVESTIGATION

The establishment of post-vaccination surveillance systems is deemed crucial in monitoring the safety and efficacy of vaccines throughout an extended period. The aforementioned systems possess the capability to discern and pinpoint any unfavorable events that might transpire subsequent to immunization and aid in disseminating vital information that leads to the implementation of required adjustments in vaccination policies (Bamouh et al. 2021).

6.7. GLOBAL COOPERATION FOR THE PRODUCTION OF VARIANT VACCINES

The creation and implementation of diverse vaccines mandate international collaboration and synchronization to establish impartial availability of vaccines and avert transboundary transmission of the virus. The World Health Organization has underscored the importance of a well-coordinated worldwide initiative in response to the COVID-19 outbreak, with a focus on the creation and dissemination of vaccines, as well as the exchange of information and resources among nations (Bajaj et al. 2022).

A critical aspect of promoting worldwide collaboration in the advancement of alternate vaccines is the dissemination of knowledge and technology across nations. Possible academic rewrite: Collaboration among stakeholders in the biomedical industry may encompass diverse activities, ranging from disclosing data derived from clinical trials and exchanging knowledge on manufacturing technology, to furnishing funding resources to facilitate the research and development of alternate vaccines. The World Health Organization (WHO) has established the COVID-19 Technology Access Pool (C-TAP) with the aim of promoting equitable access to intellectual property and technology associated with COVID-19 vaccines and treatments (Pilkington et al. 2022).

6.8. FUTURE GUIDELINESFOR RESEARCH IN THE FIELD OF COVID-19 VARIANT VACCINES

Potential avenues for further investigation and continuing endeavors within the sphere of COVID-19 variant immunizations encompass (Jain et al. 2021).

6.9. PRODUCTION OF MULTIVALENT VACCINES

There is ongoing development of multivalent vaccines aimed at affording protection against various variants of SARS-CoV-2. Recent studies indicate that these vaccines possess the potential to confer wider immunity and exhibit enhanced efficacy against newly emerged variants (Humpierre et al. 2020).

6.10. PLATFORMS FOR VACCINE DELIVERY

Scientists are presently investigating novel avenues for vaccine administration, such as the utilization of self-amplifying RNA vaccines, in order to enhance the potency and longevity of vaccination procedures, specifically in relation to variant strains (Lee at al. 2022).

6.11. ASSESSMENT OF BOOSTER DOSES

Ongoing studies are being conducted to assess the safety and effectiveness of administering booster doses of COVID-19 vaccines, with a particular focus on those designed to target variants of concern (Achrekar et al. 2022).

6.12. OBSERVING OF VACCINE EFFICIENCY

Ongoing studies are being conducted to assess the safety and effectiveness of administering booster doses of COVID-19 vaccines, with a particular focus on those designed to target variants of concern (Walsh et al. 2023).

6.13. ASSOCIATION AMONG INVESTORS

The imperative for the effective development and global dissemination of variant vaccines demands a collaborative effort among a diverse array of stakeholders, including governments, industry, and international organizations (Adil et al. 2022).

7. CONCLUSION

An overview of COVID-19 vaccine status viral variants and variant vaccine development was discussed. New COVID-19 variants concern vaccine effectiveness. Available vaccines vary in type: mRNA, viral vector, and protein subunit. Despite their demonstrated effectiveness and safety, COVID-19 vaccines may be limited when faced with new variants. Advances in vaccine development have led to new technologies. Clinical trials assess vaccine efficacy and safety against Delta and Omicron variants. Deployment involves disseminating, prioritizing, establishing trust, and gaining widespread acceptance. Variant vaccine development requires global collaboration. Research guides strategy. COVID-19 pandemic control requires effective vaccines. New variants and fair vaccine distribution require more research and global cooperation. New SARS-CoV-2 strains emphasize COVID-19 vaccine research. Variant vaccines must stop the pandemic and prevent future outbreaks. Adaptable methods are needed to improve vaccines and manage variants.Genomic sequencing and surveillance are essential for identifying new COVID-19 variants and monitoring vaccine efficacy. Variant vaccines' effectiveness affects distribution, prioritization, and acceptance. Age, occupation, and health determine health priorities. Acceptance mitigates viruses. COVID-19 emphasizes vaccine research and public health policies to prevent outbreaks.

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