Chapter 222

Vaccines against COVID-19 available in Brazil

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ABSTRACT
SARS-CoV-2 is a virus that triggered a worldwide disaster after causing deaths in many countries and infecting millions of people causing the disease COVID-19. Several vaccines were developed in record time to contain the pandemic. This study aimed to identify, analyze and compare, through a literature review, the scientific publications on the different vaccines against COVID-19 administered in Brazil. For this, a qualitative literature review was carried out using recently published articles, obtained from the Pubmed, Scielo, Capes, and Lilacs platforms, as well as from the websites of the World Health Organization, Oswaldo Cruz Foundation, and other trustworthy health organizations, seeking relevant information, such as the different types of technologies used for the development of vaccines, composition, efficacy rates, expiration date, storage, doses, administration, adverse effects and contraindications of each manufacturer of vaccines against COVID-19. This study concluded that the four immunizers administered in Brazil: CoronaVac, AstraZeneca, Pfizer, and Janssen, showed reliability, efficacy, and few side effects. With the advance of vaccination, there was a decrease in severe cases and deaths caused by SARS-CoV-2.

Keywords: COVID-19, SARS-CoV-2, Pandemic, Vaccines, Vaccination, Brazil.

1 INTRODUCTION

Acute respiratory syndrome COVID-19 or Coronavirus is a disease caused by the SARS-CoV-2 virus that, to date, has infected around 290 million people and resulted in 5.5 million deaths worldwide. In Brazil alone, there are 22.3 million people infected and more than 619,000 deaths since it emerged at the end of 2019 (OUR WORLD IN DATA, 2021). In January 2020 the World Health Organization (WHO) declared that the outbreak of COVID-19, which emerged in Wuhan - China, triggered a Public Health Emergency of International Importance, generating a pandemic with high transmissibility and rapid lethality on all continents (LANA et al., 2020).

With the disclosure of the genetic sequence of the virus and its high transmissibility, intense research activity was triggered for the rapid development of vaccines against COVID-19, considering that so far there is no antiviral treatment proven effective in the treatment of the disease (SANTOS et al., 2021). The humanitarian and economic impact of the pandemic has driven the use of new vaccine technology platforms to leverage research. With this, the first immunizer approved in the world was that of Pfizer/BioNTech, in early December. According to the WHO, as of February 18, 2021, at least seven different vaccines were being administered worldwide, and more than 200 experimental vaccines are in development. The first dose of the immunizer for COVID-19 occurred in the United Kingdom, still in 2020 (WHO, 2021).

Vaccines aim to produce antibodies to certain diseases in the body, without the patient developing a severe form of the pathology. During the SARS-CoV-2-related pandemic, vaccines have been at the center of discussions. Several movements against immunization have created insecurity in the population, questioning the credibility of the benefits that the vaccine will bring to the body. The spread of fake news accompanied the COVID-19 pandemic, and the wide dissemination of news related to any study (*in vitro*, pre-clinical or clinical) about preventive or treatment options was shared through internet social networks (QUEIROZ and SILVA, 2021).

Currently, there are 1st generation COVID-19 vaccines, with inactivated or attenuated viruses, such as CoronaVac/SinoVac, Bharat Biotech, and Sinopharm; 2nd generation, with the use of viral vectors with recombinant technology, such as AstraZeneca/Oxford, Janssen/Johnson&Johnson and Sputnik V; and the 3rd generation, which are vaccines with nucleic acids DNA and RNA, such as Pfizer/BioNTech and Moderna (ALMEIDA et al., 2021). Four vaccines against the disease have received authorization from the National Health Surveillance Agency (Anvisa) for use in Brazil: CoronaVac, AstraZeneca, Pfizer, and Janssen (ANVISA, 2021).

CoronaVac, a vaccine developed with the Butantan Institute in partnership with the Chinese pharmaceutical company Sinovac, uses inactivated (dead) virus technology, a technique that has been consolidated for years and widely studied. When injected into the body, this virus is not able to cause disease but induces an immune response. CoronaVac's clinical trials in Brazil were conducted exclusively with health professionals, that is, people with high exposure to the virus (INSTITUTO BUTANTAN, 2021). The AstraZeneca vaccine was developed by pharmaceutical company AstraZeneca in partnership with the University of Oxford. In Brazil, it is produced by the Oswaldo Cruz Foundation (FIOCRUZ). It uses the technology called a viral vector, the adenovirus, genetically manipulated to insert the gene of the protein "Spike" (protein "S") of Sars-Cov-2 (GUIMARÃES, 2020).

Pfizer's immunizer, in partnership with BioNTech, is based on messenger RNA (mRNA) technology. The synthetic messenger RNA gives the instructions to the body for the production of proteins found on the surface of the novel coronavirus, which stimulate the response of the immune system. The interval of application between doses should be done up to twelve weeks (BOURLA, 2020). Developed

by the Janssen laboratory of the Johnson & Johnson group, the Janssen vaccine is given in only one dose. Like the AstraZeneca immunizer, it also uses viral vector technology, based on a specific type of adenovirus that has been genetically modified not to replicate in humans (ALMEIDA et al., 2021).

The idea of conducting a literature review on the vaccines that were developed in a race to combat the pandemic caused by COVID-19 arose from the need to show and clarify to the population how a vaccine is developed, the phases and tests that are carried out to prove its effectiveness, regardless of the technology used in its development. In this sense, the objective of this study was to conduct a bibliographic review of scientific publications on COVID-19 and describe the different types of vaccines available in Brazil, addressing the following factors: types of technologies used for the development of vaccines, composition, efficacy rates, shelf life, storage, doses, administration, adverse effects and contraindications of each manufacturer of vaccines against COVID-19.

2 METHODOLOGY

This is a literature review based on research of scientific articles related to COVID-19, with a broad view on the subject of the pandemic in association with the development of vaccines against the disease in Brazil. The bibliographic research was carried out following guidelines of systematic reviews, with an exploratory qualitative character, gathering information collected from reliable data through published scientific articles described from January 2020 to December 2021 and clarifying the wide range of information about vaccines against COVID-19 using specific keywords based on the prevention of the disease.

To perform the search for articles, three criteria were established: the definition of keywords that deal with the theme proposed in this work, the definition of the languages to be searched, and the selection of journals and portals of academic publication. Because they are considered solid and reliable by the academic community, the search was performed in the following national and foreign databases: Scielo, PubMed, Lilacs (Latin American and Caribbean Literature in Health Sciences), Portal de Periódicos da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (Periódicos CAPES), and Google Acadêmico, in the languages Portuguese, English and Spanish. The keywords used were COVID-19, SARS-CoV-2, pandemic, vaccines, vaccination, and Brazil, in the 3 languages.

After the bibliographic survey and the selection of the articles, the reading and evaluation of the scientific articles were performed. With the reading of the articles, it was noted that some of them were repeated in the different databases and others did not meet the criteria of this study, so the articles were selected for registration and use in the review and excluded those that did not concern the purpose of the work.

3 RESULTS AND DISCUSSIONS

The SARS-CoV-2 virus is a mutation of coronaviruses, they are part of a group of retroviruses that cause respiratory infections. This virus has become the cause of COVID-19 (*coronavirus disease* - 2019). Because the speed of the spread of this disease is much faster than other viruses (transmission by respiratory droplets and direct or indirect contact of infected people), the race for the development of the vaccine against COVID-19 has advanced promisingly, with about 188 vaccines being developed worldwide (SILVA and NOGUEIRA, 2020).

3.1 VACCINE DEVELOPMENT

Vaccines are manufactured using different technologies and compounds, but always idealizing safety and efficacy. Other desirable characteristics include price and capacity to increase production, mode of administration (e.g., orally or injection), number of doses, thermal stability, and the nature and persistence of immune responses (BALLALAI, 2016).

The process of developing a vaccine involves steps carried out in laboratories, such as in *vitro* and preclinical in *vivo*, usually with animal models, aiming at dose and toxicity evaluation in this population. After that, clinical trials occur in humans (SILVA E NOGUEIRA, 2020). To carry out any clinical research involving human beings, the approval of the Research Ethics Committees (CEPs) and the National Research Ethics Commission (Conep) is mandatory. The clinical phase serves to validate the safety and efficacy relationship of the studied drug and also to validate new therapeutic indications (ANVISA, 2021).

There are three phases (I, II, III) within the clinical trial, by which information about the activity, functioning and safety is collected so that the product can be released to the market and be used in patients along with the standard research treatment. The consent of clinical research by ANVISA applies only to clinical research that has the purpose of registration and post-registration of medicines, by requests of companies that will pay for the research, or by their legal representatives (FIOCRUZ, 2021).

In phase, I small groups of individuals, usually healthy adults, are evaluated to verify safety and determine the type of immune response provoked by the vaccine. In this phase, challenge studies can also be carried out to select the best vaccine projects to proceed to the next phase. In phase II there is the inclusion of a greater number of individuals and the vaccine is already administered to individuals representative of the target population of the vaccine (infants, children, adolescents, adults, elderly or immunocompromised). In this phase, the safety of the vaccine, immunogenicity, dosage, and method of administration are evaluated. Finally, in phase III the vaccine is administered to a large number of individuals, usually thousands of people so that its efficacy and safety are demonstrated, that is, that it can protect individuals with as few adverse reactions as possible (SILVA and NOGUEIRA, 2020).

3.2 CHARACTERISTICS OF VACCINES AGAINST COVID-19 IN BRAZIL

The rapid worldwide contamination of COVID-19 has emphasized the need to develop an effective vaccine to prevent and control the transmission of the disease (PUSHPARAJAH et al., 2021). According to data from the World Health Organization, there are currently more than 200 immunizers in testing phases and 14 vaccines against COVID-19 approved worldwide. In Brazil, the CoronaVac, Pfizer, Janssen, and AstraZeneca vaccines are being administered, which have been approved by Anvisa (National Health Surveillance Agency) to the population over 18 years of age (WHO, 2021).

Table 1 presents characteristics of vaccines authorized in Brazil, such as different types of technologies used for the development of vaccines, composition, efficacy rates, shelf life, storage, doses, administration, adverse effects, and contraindications of each manufacturer of vaccines against COVID-19.

Table 1: National Plan for the Operationalization of Vaccines against COVID-19 approved by the National Health Surveillance Agency (Anvisa). Data was updated in September 2021. Source: WHO, 2021.

	CoronaVac	**AstraZeneca**	**Pfizer**	**Janssen**
Technology	Inactivated Virus	Viral Vector	Messenger RNA	Viral Vector
Composition by dose	0.5 mL contains 600SU of inactivated SARS-CoV-2 virus antigen.	0.5 mL contains 5 × 1010 viral particles (pv) of the replication-deficient chimpanzee recombinant adenovirus vector (ChAdOx1), which expresses the glycoprotein SARS-CoV-2 Spike (S).	0.3 ml contains 30 µg of mRNA encoding SARS-CoV-2 spike protein.	0.5 mL contains Adenovirus type 26 encoding the spike glycoprotein SARS-CoV-2 (Ad26.COV2-S), not less than 8.92 log10 infectious units (Inf. U).
Effectiveness (% protection)	77.96% (for symptomatic cases with outpatient or inpatient care).	73.43% of the general population is among people with comorbidities.	92.6% after the 1st dose and 95.0% after the 2nd dose.	66.9% after 14 days and 66.1% after 28 days. In the prevention of severe cases, the efficacy was 76.7% after 14 days and 85.4% after 28 days.
Shelf life	12 months	6 months	6 months in ultra-low temperature freezer (-80°C to -60°C)	4.5 months
Storage	2 to 8ºC	2 to 8ºC	Can be stored for 5 days between 2 and 8ºC	2 to 8ºC
Doses*	2 separate doses of 0.5 mL each	2 separate doses of 0.5 mL each	2 separate doses of 0.3 mL each	A single dose of 0.5 mL
Interval between doses	2 to 4 weeks	4 to 12 weeks	3 to 12 weeks	Single dose
Administration	Intramuscularly, in the upper arm.	Intramuscularly, in the upper arm.	Intramuscularly, in the upper arm.	Intramuscularly, in the upper arm.
Adverse effects	Mild pain at the site of application. Temporary fatigue and headache.	Mild pain at the site of application. Fever, fatigue, chills, nausea, headache, joint pain, muscle aches.	Mild pain at the site of application. Fatigue, headache, muscle pain, chills, and fever.	Mild pain at the site of application. Headache, feeling very tired, muscle aches, nausea, fever.

Contraindications	Hypersensitivity to the active ingredient or any of the excipients of the vaccine.	Hypersensitivity to the active ingredient or any of the excipients of the vaccine. Patients who have experienced significant venous and/or arterial thrombosis in combination with thrombocytopenia after vaccination with any vaccine for COVID-19. People with a history of capillary leakage syndrome.	Hypersensitivity to the active ingredient or any of the excipients of the vaccine.	Hypersensitivity to the active ingredient or any of the excipients of the vaccine. People with a history of capillary leakage syndrome.

*It is recommended to administer an additional booster dose throughout the population following the vaccination schedule.

3.2.1 Viral Vaccine – Inactivated Virus – Coronavac

The CoronaVac vaccine, from the Chinese laboratory Sinovac, uses the classic platform of inactivated virus, with cell culture of the virus in cells with subsequent inactivation. The virus is replicated and later killed, so it is not able to multiply in the body, but it can trigger the production of antibodies and produce an immune response. It has a high safety profile due to the technology used in manufacturing, it is one of the most studied worldwide. In Brazil, it established a partnership with the government of the State of São Paulo, through the Butantan Institute, and was tested on health professionals from 12 Brazilian centers (LIMA et al., 2021).

Approved on January 19, 2021, by ANVISA for emergency use in Brazil (ANVISA, 2021), the CoronaVac vaccine showed results in seroconversion studies, higher than 92% in participants who took both doses of the vaccine in the interval of 14 days, and more than 97% in participants who took both doses of the vaccine in the interval of 28 days. The effectiveness of this vaccine has been proven in a plan containing 2 doses 2 to 4 weeks apart. In symptomatic cases of COVID-19 that required outpatient or inpatient care, efficacy was 77.96% (Chart 01). In these studies, there were no severe cases in the vaccinated subjects, against 7 severe cases in the placebo group (WHO, 2021).

Contraindications are hypersensitivity to the active ingredient or any of the excipients of the vaccine. Adverse reactions were observed from the phase 3 clinical study in adults up to seven days after administration of the second dose of the vaccine in less than 5% of the vaccinated population. More common were headaches, tiredness, and pain at the site of the application of the vaccine. Common effects (between 1% and 10% of patients), motion sickness, diarrhea, muscle pain, chills, loss of appetite, cough, joint pain, itching, runny nose, nasal congestion, redness, swelling, itching at the site of application of the vaccine. Unusual effects (between 0.1% and 1% of patients) vomiting, fever, redness, allergic reaction, sore throat, pain when swallowing, sneezing, muscle weakness, dizziness, abdominal pain, drowsiness, malaise, pain in the extremities, vertigo, shortness of breath, swelling and hematoma at the site of application of the vaccine (INSTITUTO BUTANTAN, 2021).

Concerning storage, licensed viral vector vaccines are stored at approximately 2–8°C or low freezing temperatures (−80 to −55°C) with a shelf life of more than one year, as is the case with CoronaVac. What determines the stability of the vaccine are the particular characteristics of each recombinant virus. Some viruses are more sensitive to thermal degradation, another important factor is exposure to freeze-thaw cycles and free radical oxidation. Therefore, managing optimal storage conditions for virus-based vaccine distribution is crucial to maintaining its effectiveness (PUSHPARAJAH et al., 2021).

10 months after the start of vaccination in Brazil, a study published by the Center for Disease Control and Prevention of Canton Province (Guangdong) showed that total immunization, with two doses of the CoronaVac vaccine, prevents the development of severe cases of COVID-19 caused by the delta variant of SARS-CoV-2 and has an efficacy of 69.5% against the onset of pneumonia, one of the most serious consequences of COVID-19 (CAO et al., 2021).

3.2.2 Recombinant Vaccine – Adenovirus – Astrazeneca

Non-replicating adenoviruses have been the main viral vectors used in development platforms for COVID-19 vaccines, it is believed that these vaccines confer greater safety than their viral counterparts, since they are human (Ad5 and Ad26) or apes (ChAd chimpanzees). The ChAdOx1 nCoV-19 vaccine was developed at the University of Oxford in England in partnership with drugmaker AstraZeneca. In Brazil, the AstraZeneca vaccine is being developed in partnership with the Oswaldo Cruz Foundation (FIOCRUZ). It uses as a viral vector a non-replicating chimpanzee adenovirus that expresses the SARS-CoV-2 protein S. After the application of two doses, this vaccine induces a strong immune response, including cellular immunity, presenting a production of neutralizing antibodies detected between 91 and 100% of patients (LIMA et al., 2021).

The AstraZeneca vaccine was approved by ANVISA in March 2021 to be administered to the Brazilian population (ANVISA, 2021). Efficacy has been proven in a plan containing 2 doses 12 weeks apart. Seroconversion studies have shown results in 98% of subjects within 28 days of the first dose and greater than 99% in 28 days after the second dose. Individuals who had comorbidities had a vaccine efficacy of 73.43%, similar to the efficacy of the AstraZeneca vaccine observed in the general population (WHO, 2021). As in viral vector vaccines, the storage of recombinant vaccines should be carried out at temperatures of 2–8 ° C or low freezing temperatures (−80 to −55 ° C), however, the shelf life is shorter, around 6 months (Table 01) (PUSHPARAJAH et al., 2021).

According to the package leaflet of the vaccine produced by FioCruz/AstraZeneca, most of the side effects presented in patients during the clinical studies were mild or moderate and showed improvement within a few days. Very common effects: tenderness, pain, the feeling of warmth, redness, itching, swelling or bruising at the application site, tiredness, fatigue, chills, and fever, as well as nausea or nausea, headaches, muscle, and joint pain. Common effects: nausea and vomiting, lump formation at the site of application of the vaccine, high fever, sore throat, runny nose, and cough. Unusual effects: feeling dizzy,

decreased appetite, abdominal pain, enlarged lymph nodes, excessive sweating, itching, and rashes on the skin (FIOCRUZ, 2021).

Contraindications are hypersensitivity to the active ingredient or any of the excipients of the vaccine, patients who have experienced significant venous and/or arterial thrombosis in combination with thrombocytopenia after vaccination with any vaccine for COVID-19, and people with a history of capillary leakage syndrome. The European Medicines Agency (EMA) looked at 62 cases of cerebral venous sinus thrombosis (CVST), which are clots in the sinuses that drain blood from the brain, and 24 cases of splanchnic vein thrombosis or clotting in the abdomen. The European health body concluded that the vaccine caused an unusual combination of blood clots in dozens of people with low platelet counts (EMA, 2021).

Published in October 2021, the study conducted by 20 researchers from Brazil the United States, and Spain, showed the effectiveness of the two doses of the AstraZeneca vaccine, produced in Brazil by Fiocruz, against the Gama variant in people over 60 years. Based on São Paulo, the research reveals that the second dose increases by about 30% the protection against death, about the application of the first, reaching an effectiveness of 93.6%. This study reinforces to health authorities the need to seek out absentee elderly and complete their vaccination schedule (HITCHINGS et al., 2021).

3.2.3 Genetic Vaccine – Rna Messenger – Pfizer

Messenger RNA (mRNA) vaccines have demonstrated an acceptable safety profile and excellent cellular and humoral immune responses. Because they consist of synthetic products, they have the advantage of being produced on a larger scale, however, they have the disadvantage of products that require preservation in freezing. The vaccine produced by the Pfizer laboratory, in partnership with the mRNA-based biotechnology company BioNTech, demonstrated an optimal response in inducing humoral and cellular immunity, producing neutralizing antibodies 2.8 times higher when compared to convalescent human sera of COVID-19 (LIMA et al., 2021).

Studies have shown the high vaccine effectiveness of the Pfizer vaccine when compared to the other 3 vaccines authorized for administration in Brazil. The approval of the ANVISA took place in January 2021 (ANVISA, 2021). Efficacy has been proven in a plan containing 2 doses 4 weeks apart. Efficiency in frontline health workers was 80% after the first dose and 90% after the second against SARS-CoV-2 infection. Seniors over the age of 70 had a reduced risk of hospitalization of about 80% and a risk of death from COVID-19 of 85%. In the general population, the Pfizer vaccine showed 97% efficacy against symptomatic cases, need for hospitalization, or death from the disease (WHO, 2021). RNA products are very sensitive to temperature and should always be kept at extremely low temperatures (−80 °C) during storage and distribution. Although short-term storage is possible, in a refrigerator (2–8°C), RNA will eventually deteriorate in days (Table 01) (PUSHPARAJAH et al., 2021).

Adverse reactions in clinical studies reported in the Pfizer vaccine package insert, most common (occur in 10% of patients using this immunizer) were pain and swelling at the injection site, tiredness, headache, diarrhea, muscle pain, joint pain, chills, and fever. Common reactions (occur between 1% and 10% of patients using this drug) were redness at the injection site, nausea, and vomiting. Unusual reactions (occur between 0.1% and 1% of patients using this drug) were enlarged lymph nodes, hypersensitivity reactions, rash (skin lesion), pruritus, urticaria, angioedema, decreased appetite, pain in the limbs, insomnia, lethargy, hyperhidrosis, night sweat, asthenia, feeling unwell and itching at the injection site. Rare reactions (occur between 0.01% and 0.1% of patients using this drug) such as acute facial paralysis, myocarditis (inflammation of the heart muscle), and pericarditis (inflammation of the outer lining of the heart) have occurred in some people who have received the vaccine. In most of these people, symptoms began within a few days of receiving the second dose of the vaccine (PFIZER, 2021).

3.2.4 Recombinant Vaccine – Adenovirus – Janssen

Like the AstraZeneca vaccine, the Janssen vaccine also uses recombinants-to-adenovirus technology for its production (LIMA et al., 2021). Janssen's COVID-19 (recombinant) vaccine is composed of a recombinant, non-replicating human adenovirus type 26 vector encoding a full-length spike glycoprotein (S) SARSCoV-2 in a stabilized conformation. It stimulates both neutralizing and other specific functional antibodies with cellular immune responses directed against the S antigen, contributing to protection against COVID-19 (JANSSEN, 2021).

Its approval by ANVISA took place in April 2021 (ANVISA, 2021). Efficacy has been proven in a single-dose plan. The studies showed efficacy rates of 66.9% after 14 days and 66.1% after 28 days. In the elderly population, the efficacy reached 100% after 14 days. In the prevention of severe cases, the efficacy was 76.7% after 14 days and 85.4% after 28 days of the application of the immunizer. It was found that none of the immunized patients required hospitalization, showing even greater effectiveness in preventing severe cases (WHO, 2021). The Janssen vaccine is initially stored and frozen by the manufacturer and then shipped between 2 °C and 8 °C. After being thawed, do not refreeze (Table 01) (PUSHPARAJAH et al., 2021).

According to the Janssen vaccine leaflet, the main contraindications are hypersensitivity to the active ingredient or any of the excipients of the vaccine. Most adverse reactions occurred within 2 days of vaccination. Very common effects: pain at the site of application of the vaccine, headache, muscle aches, nausea, and fatigue. Common effects: redness and swelling at the site of application of the vaccine, chills, joint pain, cough, and fever. The unusual effects were: skin irritation, muscle weakness, pain in the upper and lower limbs, weakness and indisposition, sneezing, sore throat, tremors, and excessive sweating (JANSSEN, 2021).

The immunization done with the Janssen vaccine occurs with only one dose, as it was verified to obtain sufficient efficacy for emergency use in the current pandemic (JANSSEN, 2021). However, recently.

the Ministry of Health released a technical note directing the 4 million Brazilians who took the single dose of Janssen to take a booster dose of the same immunizer. The guidance is based on scientific studies that show a significant increase in immunity after the application of one more dose of the vaccine, especially with a longer interval of 2 to 6 months, which provided up to 94% protection against COVID-19 (BRAZIL, 2021).

3.3 VACCINATION AGAINST COVID-19 IN ADOLESCENTS AND CHILDREN

The asymptomatic form of Covid-19 is more common among children and adolescents, who have a better prognosis when infected but are not immune. They transmit, can become seriously ill, and even die as a result of the disease. Nearly half of Brazilian children and adolescents killed by COVID-19 in 2020 were as young as 2 years old; one-third of deaths up to 18 years of age occurred among children under 1 year of age and 9% among babies under 28 days of age (FIOCRUZ, 2021).

Following the confirmation of clinical trials of the Pfizer vaccine in adolescents, in May 2021, the United States and Canada were the first countries to approve the Pfizer vaccine for adolescents over the age of 12. In Brazil, ANVISA's approval for the application of the Pfizer vaccine in adolescents aged 12 to 17 years occurred in June 2021 (ANVISA, 2021), however, the Ministry of Health allowed vaccination only in October of the same year (BRASIL, 2021).

As of September 2021, Pfizer conducted studies with children ages 5 to 11 to evaluate the efficacy and safety of the immunizer against COVID-19. The efficacy and safety for this age group was 90.7% against COVID-19. Thus, Pfizer has requested authorization to vaccinate children aged 5 to 11 years worldwide (PFIZER/BIONTECH, 2021). As with teenagers, other countries such as the United States, Canada, and Europe are already vaccinating children in the 5- to 11-year-old age group against COVID-19. In Brazil, ANVISA's approval for the application of the Pfizer vaccine in children of this age group occurred in December 2021 (ANVISA, 2021), however, so far the Ministry of Health has not allowed vaccination (BRASIL, 2021). Recent studies released by the Centers for Disease Control and Prevention (CDC) evaluated reports and survey responses from 43,000 children ages 5 to 11 who received the Pfizer-BioNTech vaccine and concluded that serious problems are extremely rare in this age group (CDC, 2021).

3.4 VACCINATION PLAN AGAINST COVID-19 IN BRAZIL

Brazil began implementing COVID-19 vaccination on January 17, 2021, almost a month after its neighbors in Latin America, which caused strong social and congressional pressure on ANVISA and the Ministry of Health. Despite the delay, as soon as the first vaccine was authorized, Brazil quickly caught up with other countries (FONSECA et al., 2021).

According to Our World In Data (2021), as of December 2021, 143 million people are fully vaccinated, with the two doses of COVID-19 vaccines, corresponding to 67.4% of the Brazilian population. The data also show that 77.8% of the population with at least one dose of the vaccine and 12.4% of the

population with the booster dose (OUR WORLD IN DATA, 2021). To date, 40.9% of the doses administered are from the Fiocruz laboratory (AstraZeneca), 29.7% are from the Sinovac Butantan laboratory (Coronavac), 27.6% from the BioNTech/Pfizer laboratory and 1.8% from the Janssen laboratory. , in the course of the campaign, depending on the epidemiological scenario at the time and strategy, the sending of doses occurred unequally, with states and municipalities having greater availability of one immunizer than the other (BRASIL, 2021).

Through studies and research, it is possible to affirm that vaccination against COVID-19, regardless of the immunizer used, contributed to a reduction in the number of severe cases, hospitalizations, and deaths caused by the disease (WHO, 2021). Currently, COVID-19 deaths in Brazil involve in most cases, unvaccinated people. All vaccines against COVID-19 in application in the country have had their effectiveness confirmed in clinical trials with minimal side effects (BRAZIL, 2021).

Another relevant study showed the importance of vaccination in people who have already had COVID-19. Researchers revealed that the four COVID-19 vaccines administered in Brazil offer a high degree of additional protection against symptomatic infection and severe forms of the disease in people who have already contracted Sars-CoV-2. From the national database on notification, hospitalization, and vaccination, the researchers used a negative test design to verify the effectiveness of Coronavac, AstraZeneca, Janssen, and Pfizer in previously infected people and showed the effectiveness of 39% to 65% to prevent symptomatic forms of the disease. In the case of initial infection, the effectiveness against symptomatic reinfection 14 days after the full vaccination schedule is 63.7% for Pfizer, 53.4% for AstraZeneca, and 37.5% for CoronaVac, compared to people infected with the coronavirus and unvaccinated. These data evidence the importance and reliability of vaccination against COVID-19 (CERQUEIRA-SILVA et al., 2021).

4 CONCLUSIONS

The COVID-19 pandemic has devastated the world and, consequently, Brazil, bringing numerous losses and compromising several sectors. In this context, it is worth mentioning the need to disseminate grounded and scientific information resulting from research and reliable sources to describe the importance of vaccination in combating the pandemic, bringing clarification on the effectiveness and side effects of vaccines available in the country. Through this literature review, it was possible to identify that the vaccines approved in Brazil demonstrated efficacy to decrease severe cases and deaths caused by SARS-CoV-2.

Understanding the pathogenesis of the Coronavirus was instrumental in the development of vaccines against COVID-19. Having a general knowledge of the pathology of the virus, including the infected target organs and the route of transmission, facilitates the development of vaccines to interfere with viral spread and prevent serious infections and death. Therefore, new studies should continue to happen for cases of new variants of SARS-CoV-2, and so that it is possible to manage new outbreaks that may arise, from this or other new viruses.

The four immunizers administered in Brazil: CoronaVac, AstraZeneca, Pfizer, and Janssen, showed reliability, efficacy, and few side effects. With the advance of vaccination, there has been a drop in the overall average of COVID-19 deaths in the country. The number of hospitalizations and deaths, slowed in recent months, especially in the group of the elderly, these data reflected the results of the vaccination plan that was put in place in February 2021 evidencing the importance of vaccination.

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