A Recent Achievement in the Discovery and Development of Vaccines and Therapeutic Agents in the Race for COVID-19 Protection and Treatment

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Abstract
Currently, the coronavirus disease 2019 (COVID-19) is a big challenge to the healthcare systems in the world. Several researchers in the world have immediately carried out clinical investigations for the discovery of vaccines and drugs. Different studies have shown that antiviral measures including small bioactive compounds targeting multifaceted molecular communications take in COVID-19 infection. The drug development archived in this review emphasizes mainly on drugs that are effective for the Management of MERS-CoV, SARS-CoV, and other RNA viruses. The investigation of therapeutic agents for COVID-19 includes anti-inflammatory agents, antibodies, and nucleic acid-based treatments targeting virus gene expression as well as different sorts of vaccines. Numerous patents revealed techniques of these biologics with the potential for treating and preventing coronavirus infections, which may apply to COVID-19. Phase 3 clinical trials such as Sputnik V, AZD1222, mRNA-1273, BNT162b2, Ad5-nCoV, Anti-COVID antibodies, Kevzara; Actemra, Jakafi; Baricitinib, and some others were undergoing in the race for Covid-19 treatment. However, there’s still a lack of a review on vaccines and drugs for COVID-19 management. Therefore, this review summarizes different studies that are ongoing in the race for Covid-19 protection and treatment.

Keywords
coronavirus, antiviral drugs, vaccines

Received September 4, 2020. Accepted for publication March 23, 2020.

Background
Coronavirus is a single-stranded RNA virus caused by severe acute respiratory syndrome coronavirus 2.¹ Coronavirus can be classified into four groups such as delta, gamma, beta, and alpha. The coronavirus group comprises SARS-CoV-2, MERS-CoV, and SARS-CoV. Both middle East respiratory syndrome and severe acute respiratory syndrome viruses affects the LRS leading to viral pneumonia and as well it affects the CNS, heart, GIT, liver, and kidney led to multiple organ damage. Similarly, SARS-CoV-2 can attack different body parts such as liver, CNS, kidney, GIT, lung, and heart.², ³ Recent findings revealed that severe acute respiratory syndrome 2 is more infectious than severe acute respiratory syndrome.⁴ COVID-19 have been reported to cause different sign and symptoms such as respiratory distress, pneumonia, fever, cough, and death.⁵, ⁶ COVID-19, being a pandemic infectious disease, could be a genuine risk to human wellbeing.⁷-⁹

According to the most recent data, up to September 21, 2020, the number of confirmed cases in the world reached 31,240,347, of which 965,071 were dead and 22,835,563 were recovered.

Based on the genome sequence, several types of research have been done on existing agents as well as on new biological molecules in the race for COVID-19 protection and treatment.¹⁰ Supportive care and reducing symptoms are the most commonly used modalities in the management of COVID-19.¹¹ Agents in the clinical trial can act by numerous possible

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mechanisms of actions such as targeting vital enzymes (helicase, proteases, and other viral proteins), targeting host cell proteins (protease, endocytosis proteins, S1 RBD, siRNA, neutralizing antibodies, antiviral peptide targeting, anti-sense RNA, and receptors), and targeting several molecules which are attached to the virus.10,12,13

Table 1 summarizes different targets, indications, and possible mechanisms of actions of therapeutic agents for COVID-19 protection and treatment. The current review offers a solid rational base for the continuing discovery of vaccines and drugs in the race for Covid-19 treatment.

Remdesivir

Remdesivir is a prodrug with a broad-spectrum antiviral effect against RNA viruses and its structure is similar to adenosine. A recent study has revealed that remdesivir is a potential agent for the treatment of COVID-19.25 Remdesivir produces its effect by inhibiting the RNA polymerase and integrating it into nascent viral RNA. This leads to two important outcomes such as termination of the viral RNA chain and subsequently inhibits the viral genome replication. The previous finding revealed that remdesivir was not effective for the treatment of Ebola. However, it provides the safety of remdesivir in humans, which permitted the remdesivir clinical trial in the treatment and protection of COVID-19 without delay.26 According to in vivo study in mice, treatment of MERS-CoV infected mice with remdesivir revealed a reduction in lung viral load, recover lung function, and reduce lung tissue damage.15 Likewise, both in vitro and in vivo studies showed a promising effect of remdesivir in the management of MERS-CoV and SARS-CoV.27 Currently, remdesivir showed significant antiviral activity against SARS-CoV-2 in the in-vitro model.16

Favipiravir

Favipiravir is antiviral that inhibits the RNA polymerase (RNA-dependent) through bear a resemblance in structure to the guanine which is an endogenous compound.28 Thus, favipiravir is capable of reducing viral replication through competitive inhibition. Favipiravir is an approved drug for the treatment of influenza. However, there are no enough clinical studies that support the use of favipiravir for the management of severe acute respiratory syndrome virus 2. Though, patients have been conscripted to assess the effectiveness of interferon-α and favipiravir combination based on the predictable synergistic activities in immune augmentation and viral inhibition. Certainly, favipiravir was the first accepted medication for the treatment of COVID-19 in china, since favipiravir showed promising effects against COVID-19 with minimal side effects.29

### Table 1. Existing Drugs in the Race for Covid-19 Treatment.

| Name of drug candidates | Target | Possible mechanism of action for COVID-19 infection | Disease indication | Ref |
|-------------------------|--------|---------------------------------------------------|-------------------|-----|
| Baricitinib             | JAK-kinase | A JAK inhibitor | Used for the treatment of rheumatoid arthritis | 14 |
| Lopinavir/Darunavir     | 3CLpro/PLpro (Viral proteases) | Protease inhibitors | For HIV infection | 15, 16 |
| Favipiravir             | RdRp | A purine nucleoside (alternate substrate) | Used for the treatment of influenza | 17, 18 |
| Remdesivir              | RNA dependent RNA polymerase, and Nascent viral RNA | Block viral nucleotide synthesis | Used for the management of Ebola virus infection | 15, 17 |
| Ribavirin               | | | Hepatitis C, viral hemorrhagic fevers and RSV infection, Ebola virus, Hepatitis C, and Marburg virus | 17, 19, 20 |
| Galidesivir             | | | Ebola virus, Marburg virus, and hepatitis C, | 20 |
| Salt form of galidesivir (BCX-4430) | | | | |
| Arbidol                 | S protein/ ACE2d | Interrupt binding of viral envelope protein to the host cells and avert viral entry to the target cells | Influenza | 10, 21 |
| Nitazoxanide            | IMP₂/β₁ heterodimer | Dissociate the preformed IMP₂/β₁ heterodimer | Anti-parasitic use | 22 |
| Ivermectin              | IMP₂/β₁ heterodimer | | | |
| Toremifene              | Disturbs proteins related to HCoV, (EIF3F, HNRNPA1, NPM1, EIF3E, EIF3I, and RPL19,) | Averts fusion b/w the viral and endosomal membrane | For the management of advanced breast cancer | 23, 24 |
Ivermectin

Ivermectin is anthelmintic which was approved by the FDA, which also has an antiviral activity for both dengue virus and human immunodeficiency virus. Its antiviral activity is through blockage of IMPα/β1 heterodimer, which is accountable for the nuclear transport of viral protein cargos.25 Targeting the viral nuclear transport process might be a possible treatment modality for RNA viruses including COVID-19, since the viral nuclear transport process plays a significant role in the embarrassment of the host’s antiviral response and enhancing the viral replication cycle.22 In vivo investigation (infection with SARS-CoV-2) has confirmed the antiviral effect of Ivermectin by reducing the viral RNA up to 5,000-fold.29,30

Lopinavir/Ritonavir, Ribavirin, Oseltamivir

Medications that are effective against different RNA viruses are being candidates for the management of SARS-CoV-2. As far as this, the most familiar medications tried in patients infected with SARS-CoV-2 are IFN, lopinavir/ritonavir, ribavirin, and some others.31 These antivirals, irrespective of their antiviral effect reported in vitro model, the clinical activity wasn’t unswerving.27 Similar finding showed that ribavirin didn’t prolong the survival of patients infected with COVID-19 infection.32 However, the coformulation of lopinavir, ritonavir, and ribavirin showed a promising effect in patients infected with COVID-19 infection.33 Previous studies revealed that lopinavir and ritonavir are capable of inhibiting the 3CL1pro protease of COVID-19 viral infection.33,34 Moreover, numerous in vivo and invitro studies revealed the effectiveness of these antivirals for the treatment of MERS and SARS viruses.16,35 Recently, the coformulation of Lopinavir/ritonavir was tested in patients infected with COVID-19 infection, though, it exhibited a slight advantage for improving the clinical outcome of patients infected with COVID-19.35,36

Research conducted in China revealed that following administration of oseltamivir did not show improvement in the viral disease (SARS-CoV-2).5 Recently, oseltamivir alone and in together with other antiviral medications have been investigated in treating SARS-CoV-2.37

Selective Estrogen Receptor Modulators

Gene expression of estrogen receptor exhibited a significant effect in hindering the viral replication.38 Among the possible mechanism for inhibition of viral replication, the non-classical pathways linked with estrogen receptors take the key role.38 Selective estrogen receptor modulators hinder viral replication at various steps including post-viral entry and fusion. The antiviral action of selective estrogen receptor modulators is possible in the time off detectable estrogen receptor gene expression.39 Toremifene is NSERM, in vitro findings revealed it’s antiviral effect against Ebola, SARS-CoV, and MERS-CoV viruses.39,40 Toremifene can hinder the viral replications through averts the fusion between the endosomal membrane and the viral (disrupting the virus membrane glycoprotein).41 Toremifene highly affects numerous main host proteins linked with HCoV, for instance, EIF3I, RPL19, EIF3F, NPM1, EIF3E, and HNRNPA1.23,24 Equin is an estrogenic steroid that can aver the entry of HIV and the Ebola virus.39 Currently, both equin and toremifene are on investigation for the management of SARS-CoV-2.42

Emodin is an anthraquinone derivative obtained from the root extract of R. tanguticum. Emodin has shown antiviral activity through inhibition of SARS-CoV-associated 3a protein,43 and blocked the communication between ACE2 and SARS-CoV spike protein.44 Thus, a combination of emodin and toremifene could be a potential therapeutic approach for the management of SARS-CoV-2.42

Angiotensin Receptor Blockers

Angiotensin receptor blockers play a significant role in the management of viral infection, including SARS-CoV.45 Angiotensin-converting enzyme2 receptor is considered as an essential target for the treatment of COVID-19. Angiotensin receptor blockers and angiotensin-converting enzyme inhibitors have shown a negative effect on people infected with SARS-CoV-2.49,50 It is considered that SARS-CoV and SARS-CoV-2 bind to human cells by communicating with angiotensin-converting enzyme-2 receptors.51 In vivo studies have shown that long-lasting management with ACE-2 type 1 receptor antagonists such as olmesartan, losartan, and losartan enables renal and cardiac ACE-2 receptors gene expression.52 However, following the entry of SARS-CoV into respiratory epithelial cells inhibits the effect of ACE-2 receptors thereby increases the levels of angiotensin 2. This leading to severe lung impairment.53 Though, Treatment with Angiotensin receptor blocker and angiotensin-converting enzyme inhibitors may be crucial for the survival of a patient infected with COVID-19 through attenuating the cardiac stress and reduce profibrotic and vaso-constriction activity of angiotensin 2 in alveolar capillaries.54

Angiotensin-Converting Enzyme 2 Receptor

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Immunosuppressant or Antineoplastic Agents

According to previous findings, rapamycin complex 1 plays a significant role in regulating the replications of different
viruses such as coronavirus, Andes orthohantavirus, and some others. The recent finding revealed that sirolimus decreases the MERS-CoV infection by more than sixty percent. Furthermore, the use of sirolimus significantly improves the disease progressions in patients with acute respiratory failure and H1N1 pneumonia. mercaptopurine, an antimetabolite, antineoplastic agent that impedes DNA and RNA synthesis; acts as a false metabolite and is incorporated into DNA and RNA, ultimately constraining their synthesis; specifically for the S phase of the cell cycle. In the previous study, mercaptopurine plays a significant role in interferon stimulation and viral maturation by targeting papain-like protease. Hence, mercaptopurine exhibited a selective inhibitor of SARS-CoV and MERS-CoV. In addition, mercaptopurine can target selected host proteins such as NCL, PABPC1, NPM1, and JUN.

Ant-inflammatory Agents

A previous study has revealed the significant role of inflammatory pathways in viral infections. Recently, melatonin is being a potential agent in the treatment of viral infections. Oxidative stress is usually increased secondary to viral infections through immune-inflammatory damage, and lead to impairments in multiple organs. As melatonin exhibited a significant antioxidant activity, it can recover the immune system, eradicate the viral infection and finally, lengthen the survival time of the patients. Eplerenone is a selective aldosterone blocker (potassium-sparing diuretic) that possesses comparable anti-inflammatory activity with melatonin through suppressing fibrosis and hindering mast-cell-derived proteases. In vivo study has revealed the antiviral activity of eplerenone in encephalomyocarditis virus-infected mice.

Sirolimus plus Dactinomycin

Sirolimus is an immunosuppressive agent that constrains the T-lymphocytes proliferation and activation secondary to cytokine and antigenic stimulation and hinders antibody production. Agents that can inhibit rapamycin complex 1 are capable of inhibiting virion release and gene expressions. Dactinomycin is an antineoplastic that binds to the guanine portion of DNA intercalating between guanine and cytosine base pairs inhibiting DNA and RNA synthesis and protein synthesis. According to a recent finding, the growth of feline enteric CoV is significantly inhibited by dactinomycin. Studies revealed that both dactinomycin and sirolimus synergistically target HCoV-associated host protein subnetwork through a different mechanism such as by inhibiting the mammalian target of rapamycin, DNA topoisomerase 2-alpha, and DNA topoisomerase 2-beta.

Teicoplanin

Recently, Teicoplanin showed significant activity against SARS-CoV in the in vitro model. Teicoplanin has been effective against numerous virus types including SARS-CoV, MERS-CoV, flavivirus, HIV, Ebola, Ebolavirus, and influenza virus. Teicoplanin inhibits the virus replication cycle and the release of viral RNA by acting on the early step of the viral life cycle (constraining the low pH cleavage of the viral spike protein). This activity indicates the target sequence that serves as a cleavage site for cathepsin L is conserved among SARS-CoV spike protein. 1.66 µM was the IC50 value of teicoplanin that was required to inhibit fifty percent of the virus in the in vitro model, which was lesser than the concentration reached in human serum (8.78 µM). Thus, teicoplanin could be used as a potential therapeutic agent for the management of COVID-19.

Azithromycin

Azithromycin is a macrolide that disrupts RNA-dependent protein synthesis and blocks transpeptidation by binding to 50 s ribosomal subunit and used to treat different bacterial infections such as bacterial conjunctivitis, community-acquired pneumonia, infective endocarditis, mild to moderate respiratory infection, skin and soft tissue infections, bacterial exacerbation of COPD, urethritis, trachomatis, and some others. Furthermore, azithromycin also effective against different viruses such as Ebola and Zika viruses in the in vitro model. Recently, several clinical trials are ongoing to show the effect of azithromycin against COVID-19.

Dexamethasone

Dexamethasone is a steroid that regulates protein synthesis and depresses the migration of reverses capillary permeability, leukocytes, lysosomal stabilization, and fibroblasts at the cellular level to control and avoid inflammation. A study conducted in UK showed that dexamethasone is effectively decreased deaths by 1/3 in patients infected with COVID-19. Similarly, a study conducted in hospitalized patients revealed that the mortality rate of COVID-19 infected hospitalized patients was significantly (p<0.001) varied reliant on respiratory support. Dexamethasone showed a reduction in deaths by 1/3 in patients getting invasive mechanical ventilation (p<0.001, 29.00% vs. 40.70%), by 1/5 in patients getting oxygen without invasive mechanical ventilation (p=0.002, 21.50% vs. 25.00%). However, dexamethasone didn’t decrease mortality in patients not getting respiratory support (p=0.14, 17.00% vs. 13.20%).

Current Clinical Trials advance in the Race for Covid-19 Protection and Treatment

There is an urgent necessity to develop an effective therapy for severe COVID-19 treatment that improves mortality. Mostly, vaccines and drugs are required years of testing and investigation before attainment in the health facilities, nevertheless, researchers are trying to develop effective and safe therapeutic agents for coronavirus protection and treatment. Several companies are testing about 89 preclinical vaccines in animals and 36 clinical trials vaccines on humans. Development and
| Company                                                                 | Name of vaccine and drug                  | Type     | Descriptions                                                                                                                                                                                                 | Progress |
|------------------------------------------------------------------------|-------------------------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Moscow's Gamaleya institute,                                          | Gam-COVID-Vac (Sputnik V)                 | Vaccine  | Gam-COVID-Vac is an adenoviral-based vaccine that displays the SARS-CoV-2 glycoprotein S molecule on its surface. Upon vaccination, the individual will generate an immune response against the glycoprotein S molecule and thus will have endogenous antibodies that will protect them from infection with SARS-CoV-2. | Phase 3  |
| University of Oxford, AstraZeneca, Bill and Melinda Gates Foundation,  | AZD1222 (ChAdOx1 nCoV-19)                | vaccine  | AZD1222 (formerly ChAdOx1 nCoV-19) is an attenuated adenovirus that displays the SARS-CoV-2 spike protein on its surface. Since the virus is attenuated, it is safe to inject it into humans. Upon vaccination, the individual will generate an immune response against the spike protein and thus will have endogenous antibodies that will protect them from infection with SARS-CoV-2. | Phase 3  |
| Moderna Inc.                                                           | mRNA-1273                                 | Vaccine  | Moderna’s mRNA-1273 uses messenger RNA to prompt the body to make a key protein.                                                                                                                                                                                                 | Phase 3  |
| BioNTech SE, Pfizer Inc., Shanghai Fosun Pharmaceutical Group Co.,     | BNT162b2                                  | Vaccine  | BioNTech’s BNT162 program is a messenger RNA vaccine platform that the German company is developing with Pfizer. The Ad5-nCov vaccine is generated by incorporating a full-length SARS-CoV-2 spike protein into a replication-defective Adenovirus Type 5 vector. It is then injected intramuscularly into patients and antibodies will be generated against the SARS-CoV-2 spike protein. | Phase 3  |
| CanSino Biologics Inc.                                                 | Ad5-nCoV                                  | Vaccine  |                                                                                                                                                                                                                                                                       | Phase 3  |
| Sinovac Biotech Ltd                                                    | CoronaVac                                 | Vaccine  | The vaccine uses an inactivated virus, which can help the body develop antibodies to the pathogen without risking infection. Inactive viral vaccines are created by propagating viruses in cell culture (such as in Vero cells) followed by inactivation using a chemical reagent (such as beta-propiolactone). Upon vaccination, this allows the body to generate a diverse immune response against numerous viral antigens while having no threat of actually being infected because the virus is inactive. | Phase 3  |
| Wuhan Institute of Biological Products, Sinopharm, China National     | Unnamed Inactive Vaccine                  | Vaccine  |                                                                                                                                                                                                                                                                       | Phase 3  |
| Biotec Group Company Limited, G42 Healthcare company, Abu Dhabi Health |                                                          |          |                                                                                                                                                                                                                                                                       |          |
| Services Company                                                        |                                                          |          |                                                                                                                                                                                                                                                                       |          |
| Gilead Sciences Inc.                                                   | Remdesivir                                 | Antiviral | Remdesivir targets genetic material named RNA and is intended to stop SARS-CoV-2 from replicating.                                                                                                                                                                      | Authorized |
| AstraZeneca Plc, Eli Lilly & Co., Regeneron Pharmaceuticals Inc.,      | Anti-Covid Antibodies                     | Antiviral | Antibodies revealed by drug makers can copycat an immune-system response to the virus.                                                                                                                                                                               | Phase 3  |
| GlaxoSmithKline Plc, Vir Biotechnology Inc., and others                |                                                          |          |                                                                                                                                                                                                                                                                       |          |
| hejiang Hisun Pharmaceutical Co.                                       | Favipiravir                                | Antiviral | Favipiravir is a flu drug that targets viral RNA to halt the spread of the virus.                                                                                                                                                                                      | Authorized |

(continued)
| Company                                                                 | Name of vaccine and drug | Type      | Descriptions                                                                                                                                                                                                 | Progress |
|------------------------------------------------------------------------|---------------------------|-----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Regeneron Pharmaceuticals Inc. and Sanofi                              | Kevzara; Actemra          | DMARD     | These drugs are used for the treatment of rheumatoid arthritis by targeting a pathway known as interleukin-6 or IL-6. These drugs could support patients with Covid-19 from respiratory distress. | Phase 3  |
| Incyte Corp., Novartis AG; Eli Lilly & Co.                            | Jakafi; Baricitinib       | JAK inhibitors | JAK inhibitors that target inflammation and block cellular proliferation. Baricitinib, advertised by the brand-name Olumiant.                                                                                      | Phase 3  |
| Inovio Pharmaceuticals Inc.                                            | NO-4800                   | Vaccine   | Novio’s experimental vaccine used DNA to trigger the immune system of the patients.                                                                                                                        | Phase 2  |
| Novavax Inc.                                                           | NVX-CoV2373               | Vaccine   | Novavax’s vaccine comprises copied spike proteins.                                                                                                                                                           | Phase 2  |
| Johnson & Johnson                                                     | Multiple unnamed candidates | Vaccine | J&J is employed on an unnamed adenovirus-based vaccine along with 2 backups.                                                                                                                                 | Phase 2  |
| Arcturus Therapeutics Holdings Inc., Duke-NUS                          | LUNAR-COV19               | Vaccine   | Duke-NUS and Arcturus are emerging a single-dose messenger RNA vaccine.                                                                                                                                      | Phase 2  |
| Merck & Co.                                                            | V591, V590                | Vaccine   | Merck’s 2 vaccine candidates employ prevailing technology behind a measles virus vector platform.                                                                                                          | Phase 1  |
| Sichuan Clover Biopharmaceuticals Inc.                                | CB-2019                   | Vaccine   | Produces proteins similar to the virus’s spike protein in mammalian cell culture and vaccinates them into muscles to activate an immune response.                                                           | Phase 1  |
| AstraZeneca Plc                                                        | AZD7442                   | Antiviral | AstraZeneca’s antibody cocktail comprises of 2 antibodies.                                                                                                                                                 | Phase 1  |
discovery of safe and effective therapy for severe COVID-19 treatment and protection require investment and commitment. Table 2 provides a summary of current clinical trials advance in the race for COVID-19.

**Traditional Herbal Medicines**

The use of traditional medicines for the management of infectious disease has increased because of several reasons including the participation of different concerning bodies in the production and investigations of herbal-based medicines. Recently, several studies were conducted in elucidating the medicinal values of herbal medicines for the management of COVID-19. Previously, plant-derived herbal medicines have been employed for the management of different outbreaks including H1N1 influenza and SARS. Currently, several countries such as South Korea and China have agreed on guidelines on the use of traditional medicine for the management of COVID-19. In China, eighty-five percent of COVID-19 infected patients were received traditional medicine. A recent study showed that traditional medicines are supposed to competitively targets angiotensin-converting enzyme2 receptor similar to SARS-CoV-2 and SARS-CoV. This revealed the possibilities of traditional medicine for the management of SARS-CoV-2. Among the commonly used plant-based traditional medicine in China: *Atractylodis Rhizoma, Saposhnikoviae divaricata, Astragalus membranaceus, Cytomium fortunei J. Sm, Glycyrrhiza uralensis, Lonicerae Japonicae Flos, Radix platycodonis, Fructus forsythia, Agastache rugosa, and Rhizoma Atractylodis Macrocephalae* are used for the management of COVID-19. Besides, Re Du Ning and Shen Fu Injection are herbal-based traditional medicine that possessed significant immunosuppressive activity and thus they can reduce the level of different type of cytokines such as IL-6, IL-1β, IL-8, TNF-α, IL-10, and some other cytokines, leading to the prevention of acute lung injury and lung inflammation.

**Conclusion and Recommendation**

Investigators are searching for a safe and effective vaccine and therapeutics agents for the management of the fatal COVID-19 infection. As is evident from this review, different drugs are an efficient therapeutic option intervention against COVID-19. The drug-repurposing trial summarized in the present review mainly concentrated on agents presently identified to be effective against RNA viruses such as influenza, SARS-CoV, Ebola, MERS-CoV, and HCV as well as Ivermectin, Anti-inflammatory, and Anticancer medications. The possible effect of biologics for management of COVID-19 is auspicious and comprises numerous options including vectored antibodies, nucleic acid-based therapies targeting virus gene expression, bioengineered, cytokines, and several kinds of vaccines and existing drugs.

In the present review, studies on the discovery of vaccines and drugs in the race for COVID-19 treatment were summarized. Most of these agents were previously approved and used for the prevention and treatment of various diseases other than COVID-19 infection. These agents could be classified into wide groups, those based on immunotherapy approaches and those that target the virus replication cycle. On the other hand, therapeutic agents and vaccines that may explicitly target SARS-CoV-2 are also being investigated. The information provided in the present review offers a strong intellectual base for the ongoing discovery of vaccines and drugs in the race for Covid-19 treatment. Further researches are needed to investigate the transmission dynamics, replication, and pathogenesis in humans. This could support the researchers to develop and assess potential therapeutic strategies against Covid-19 infection.

**Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

**Funding**

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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