

Patent Landscape of COVID-19 Innovations: A Comprehensive Review

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The COVID-19 pandemic gave a stringent upshot on the lives of human. The people are running in race to save themselves and the race is still on. COVID emergency has not only retarded the health of the society but also made it face the economic downfall in a severe manner. The scientists and the data analyst gave their predictions for the additional wave of infection, thus stating COVID appropriate behaviour as the medicine for the time. This health calamity provides an opportunity for cross-sector partnership of technology and science as to keep the battle fight strong, finding new roads leading to fresh solutions in health care and innovations. There is a requirement of asystematic approach for accessing the patent literature that is already available to form a research platform for further advancements. The study serves a general view of the search strategy and approach, categorization of search, database set used, websites, novelty, derivation of innovation, field of work, and the investigational dataset regarding the COVID-19 patent literature under the category of diagnosis, sanitization, personal protection and vaccine development available from December 2019 to June 2021. The patent literature provides us with the knowledge which innovation is filed first for patent and published documents which can be found in the database search, thus deriving the ideologies as a supplementary guidance for the advancement of innovations. Evidently, it can be concluded that our research and report can be helpful in drawing some innovative outlines with industrial applications or some others which require further interpretation with more concern.

Keywords: COVID-19, Patent Databases, Innovation, Pandemic, Patent Search, Patent Analysis

The dawn of 11 March 2020 added a day of crisis for the world by recognizing COVID-19 as a global pandemic by World Health Organization (WHO). At the time of this writing (as of 9 July 2021), over 185,291,530 million confirmed cases and over 4,010,834 million deaths have been recorded across the globe and a total of 3,078,787,056 vaccine doses have been administered as of 7 July 2021.¹ The Coronavirus Disease 2019 (COVID-19) brought the researchers and medical expertise across the world to come together to contribute and save the world from this deadly disease.

The aftermath of the disease not only shivered and shook the medical innovations but also hampered the economy of the world and daily lives of the people.² Looking back into the history of coronavirus, before 2019 the world was aware of only six coronaviruses causing illness in human beings, Human Coronavirus 229E (HCoV-229E), Human Coronavirus OC43 (HCoV-OC43), Human Coronavirus HKU1 (HCoV-HKU1), Human Coronavirus NL63 (HCoV-NL63) Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV), and Middle East Respiratory Syndrome

Coronavirus (MERS-CoV). The reason for the outbreak and severe fatality rate of human lives was because of the seventh discrete coronavirus strain which caused severe respiratory infections leading to fatal pneumonia which emerged in Wuhan, China.³ At this time of extreme crisis, the world looked forward for innovation and creativity. The world definitely witnessed many new innovations at international, national, institutional and individual levels to battle the consequences of COVID-19 pandemic.

In spite of all the problems faced by the world, COVID-19 had spurred a scope for many new innovations and solutions. It has become the need of the hour to quickly accelerate innovation and learning process to overcome the cost that coronavirus has created with health and economy of the countries of the world. To sustain human life, innovation is the need of the day. Based on the survey reports on innovations and activities related to patent during COVID-19 various organizations are adapting their Research and development strategies and innovations.^{3,4} To face this global challenge the Bio-Pharmaceutical companies have come together with full potential and operational policies which are applicable to the identification of specific medical

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needs and an access to diagnostics and therapeutics. Initiation to undergo partnership like “Accelerating COVID-19 therapeutic inventions and vaccines” (ACTIV) shows a collaboration of research and development and clinical activities amongst the industrial, non-profitable government organizations worldwide.^{5,6}

Need of innovative developments have focused on an increased improvement of existing aids and development of bio-medical and pharmaceutical products. The global development community's innovations and strategies to combat the pandemic are not feasible and accessible for many developing nations, both monetarily and politically. Efforts are made to collect data from various clinical institutes to analyse future outbreak, to find out risk factors, therapies and post COVID syndromes.⁷ A Case Study on analysis of patents on Covid-19 for technological Assessment and Future Research was done by Pankaj Musyuni *et al.* in which they analysed the existing patents in the field of coronaviruses and 2019-nCoV and suggested a way forward for the effective contribution in this upcoming research area.⁸

Patent Analytics during Crisis

Intellectual property plays a central role in the global economy which is continuously driven by technological advances. The major role of intellectual property is to provide a motivational frame work in which new innovations can be encouraged to provide with safe move through many hindrances at various stage of inventions to commercial products and services.⁹ Patenting provides publicizing of new technical solutions, innovations and products. The patent offices and the ‘patent industry’ has overall been affected by the COVID-19 emergency. Similarly in the creative industries intellectual property is the one that rewards and facilitates transactions between the author and composers, music, audio-visual producers, performers, broadcasters and distributors like the various electronic distribution platforms or libraries.⁹

In this current pandemic circumstance, to understand the global situation related to Human coronavirus and to inform the policy makers around the world, researchers a systematic characterization of technical knowledge and production is of pivotal interest. Patents are a prominent indicator to characterize the worldwide landscape of innovation, research and technological knowledge production. Patents do provide clear and systematic information

of emerging technology in very detailed hierarchies of technical fields and allocated in geographical time and space.⁹

Given the likelihood of future pandemics of coronavirus infections, patents can be a useful master key and a relevant source of patent information. The global impact of COVID-19 and the challenges we are facing in each wave as of now, research and patent filing is expected to take a speed mirroring the influenza arena. This will incentivize the licencing of innovative IP in return for specialised knowledge or significant biological data. The patent information establishes priority to incentivize and develop technical innovations providing new ideas in technological transformation in an industrial unit and to ensure their patent grant.¹⁰

The novel coronavirus pandemic in late 2019 sparked a second cycle of growth and a significant boost in patents. Even in “peacetime,” when such viruses do not pose a direct danger, on -going study into emerging infectious diseases is important to being prepared for future outbreaks. Blocking transmission, isolation, respiratory and eye protection, and hand cleanliness are the current emergency management techniques for COVID-19. Many patents have resulted from these approaches. Drug and vaccine development is also a critical task. Treatment and prevention patents attracted the most attention, followed by viral infection diagnostics, disinfection, and medical devices.³ To provide widespread global access to any COVID-19 treatment and preventative methods, a public-facing effort is also required. The WHO has developed a voluntary COVID-19 product pool to gather patent rights, regulatory test data, and other information that may be shared in the development of COVID-19 medicines, vaccines, and diagnostics.¹¹ It is very much necessary to keep a check on database of patents as it provides new avenues to explore and serve as a medium in order to fulfil the gaps in the Covid-19 research and developmental strategies. The main frame of this manuscript depicts an important corner that aims in explanation and discussion of the patents granted by putting the light of concern in the sectors like detection (diagnostics), protective equipment, disinfection and vaccine technologies against all kind of reported strain of Covid-19. This approach of reporting of patents on Covid-19 innovations might be useful to policy makers, researcher’s community and investors round the globe in order to withdraw a solution to overcome this microscopic demon.

Methodology

The databases and web pages were initially examined, searched and reviewed from the websites of the aforementioned scientific publishers, patent offices, or other institutions for this article. The final data reported in tables and figures covering publications in the period between December 2019 and June 2021 were generated using the indicated search strategies and databases.

The patent database that explicitly cite Covid-19, or relevant synonyms, in the title, abstract, and/or claims and that were filed and published during the period of December 2019 and June 2021 were searched for in the following databases and websites:

- (i) Google Patents
- (ii) InPASS
- (iii) WIPO
- (iv) Espacenet EP Full text Search (both available in the EPO website)

The search results were manually reviewed and compared with the results of similar searches within the registers and databases made available by national patent offices (namely in South Korea, USA, India, Italy, United Kingdom, Australia, Israel, Singapore, China, Russia, and Spain) and downloaded in *csv* or *xlsx* format.

After the official announcement of the Covid-19 outbreak, the patent offices started a series of initiatives in order to support applicants and general users of patent system, the payments, the filing formalities and the examination of patent applications, as well as other proceedings usually performed at patent offices, such as the extension (automatic or requested by the applicant) of some deadlines or improvements in internet services that allow perform actions from remote locations.⁶

The World Intellectual Property Organization (WIPO) started providing patent information collected from patent offices worldwide, reports, and specific tools for users at large (investigators, companies, policymakers). As described in the WIPO general webpage about Covid-19, this assistance is intended to support the UN General Assembly Resolution on “*global solidarity to fight Coronavirus Disease 2019 (COVID-19)*”, and its “*Calls for intensified international cooperation to contain, mitigate and defeat the pandemic, including by exchanging information, scientific knowledge and best practices*”.^{6,12}

The patent search has been performed by separating keywords Classification (IPC) codes, the International Patent and the Cooperative Patent Classification (CPC) codes that have been assigned to a large variety of technologies and not only those of a strictly biomedical nature, applicable to Covid-19. The presently available Covid-19 patent literature analysis and different search strategies have prompted the authors to evaluate patent publication by restricting the search, to the main names and acronyms found in the Covid-19 scientific literature. For patent search, the search strategy forms a major part to retrieve the set of documents which further can be analysed as a data set. Keyword search was also essential to find the patent documents. The full names of the seven coronaviruses, abbreviations, or synonyms were used as keywords, the following search queries were used: Topic= “SARSCoV-2” OR “MERS-CoV” OR “SARS-CoV” OR “2019-nCoV” OR “COVID*” OR “CoV-229E” OR “2019 nCoV” OR “CoV-NL63” OR “CoV-OC43” OR “HCoV-229E” OR “CoV-HKU1” OR “HCoV-HKU1” OR “HCoV-OC43” OR “HCoV-NL63” OR “coronavirus*” OR “corona virus” OR “Middle East respiratory syndrome” OR “severe acute respiratory syndrome” OR “MERS” OR “SARS”.⁶

The authors have defined four technological areas on the basis of the categories defined in the literature cited above, the categorization of criteria for searching Covid-19 patent literature in Patentscope and Espacenet, the IPC classification (at the level of group and where available), and by looking at the English titles of the documents in the Early Covid-19 Patent Dataset.⁶

These four technological areas are:

- (i) Diagnostic (means to identify or predict Covid-19 infected subjects);
- (ii) Protection (means to avoid Covid-19 infection by blocking virus contact or propagation mechanically);
- (iii) Sanitization instruments and equipment (means to avoid Covid-19 infection by removing or destroying the virus); and
- (iv) Therapeutic/Vaccine (means to avoid Covid-19 infection by removing or destroying the virus).

This categorization was used to simplify the analysis of subjects that were presenting the early filed and published patent documents and they should not be considered as a definitive status, with patent documents that may unfold

findings relevant or exploitable in more than one domain.

In the patent classification criteria, the chosen IPC Group considered to be providing a level of information granularity sufficient to identify main technological features. Within the Diagnostic Technologies, IPC Groups C12Q1, G01N33 and C12R1 (identifying processes and assays for investigating, measuring or testing or analysing materials, using microorganisms, enzymes, nucleic acids etc.) are largely prevalent, where patent applications may combine two or more Subgroups among these IPC Groups.⁶

The IPC Group, C12N15 (referring to genetic engineering and related products such as plasmids), may be used to define both Diagnostic and Therapeutic Technologies, which indeed are strongly associated with specific A61P Groups which is associated with anti-infectives or disorders of the respiratory system and to a generally wider range of IPC groups given the frequent association of IPC Groups under A61K, A61P, and various C07. Under Therapeutic Technologies, a large variety of IPC Groups under A61K are present with the expected prevalence of A61K31 (medicinal preparations containing organic active ingredients, often associated with reformulation of drugs for medical uses, as in drug repurposing) and A61K39 (broadly explaining medicinal preparations containing antigens or antibodies, including vaccines).⁶ The vaccines were divided into ten categories to determine the vaccine technology employed. The vaccine candidates developed were based on a variety of approaches, including recombinant protein-based vaccines (protein subunit vaccines, virus-like particles (VLP)), viral vector vaccines conventional whole virus vaccines (live attenuated or inactivated vaccines), and nucleic acid vaccines (DNA- and mRNA-based vaccines).¹³

The analysis further shows that Protection Technologies are mostly associated with IPC Groups under A41D (which includes a series of outerwear, protective garments and accessories, in particular for medical personnel and uses) and A62B (which includes a series of life-saving devices and products such as those analogous to respiratory apparatus, helmets and filters for breathing-protection purposes). Patent documents listed under Protection Technologies may share the IPC Groups G16H50 (referring to Information and Communication

Technologies for medical diagnosis or other medical uses) or A61L (referring to sterilization, disinfection, or purification methods for human safety and health).⁶

Patent documents filed under Cleaning Technologies share a comparable distribution in a number of different IPC Groups (somehow between the distributions observed for Diagnostic and Therapeutic Technologies). The present specific IPC Groups related to preparations, chemical compounds, methods or apparatus for disinfecting, sterilizing Materials are (A61L2, A01P1 A61L101) or air-conditioning and ventilation (under F24F Subclasses).⁶

The present report shows patents deposited from December 2019 to June 2021. As by various reading and research of patent files, patents related to animals were deleted and only the patent files related to human coronavirus were included for the study. Keeping in view the present time, the pending patent applications were also included in the study, as to keep picture of latest progress in patent activities intact in the era of fast pace of developments. Patents are the propagation and a medium of give and take of information, even if they are not granted. Hence the pending patent applications are very useful for the examination and research, along with the published ones.

The search for patents falling under the category ‘Diagnostic technologies’ was carried out using code (C12Q1) of the International Patent Classification (IPC). Using the keyword ‘COVID-19’, GRANT, and priority date of 1-12-2019. A total of 217 patents were identified for preliminary evaluation from the database, out of which 70 were excluded due to the fact that full text was unavailable. Also, after reading the title and abstract, 73 patents were excluded from being outside the focus of our review. Finally, 74 patents were selected for our analysis under this category. In case of patents falling under ‘Protection equipment technology’ IPC code (G16H50) was used following the keywords, ‘COVID-19’, ‘GRANT’ and priority date of 01-12-2019 to 31-05-2021. A total of 137 patents were identified out of which 81 patents were selected for the analysis. Under the category of ‘Disinfection and Cleaning technologies’ a total of 353 patents were identified out of which 164 were reviewed using the IPC code ‘A61L’ and the keyword ‘GRANT’ with priority date of 01-12-2019 to 31-05-2021 for the current study.

Analysis of Patents Related to Diagnostic Technologies for Covid-19 Strains

In this subset of patent scan report, it was observed among the total patents granted/published, the majority of patents filed for diagnostic technologies were from China and India contributing (42% and (39%) respectively. Contribution from USA (4%), South Korea (4%), Russia (10%) and Australia (1%) (Fig. 1). It was observed that the majority of patents registered between the period of December 2019 to May 2021 were based on ELISA, RT-PCR and isothermal amplification methods. These methods focused on developing low-cost tests that reduced false-positive and false negative results. It was analysed that some of the patents that were identified were based on PCR methods similar to the earlier patents. One of the inventions revealed the use of fluorescent RT-PCR methods and a hydrolysis probe for the rapid detection of SARS-CoV-2.^{14,15} Other COVID-19 detection patents employed a primer pair for identifying viral RNA of the novel coronavirus using quantitative fluorescence PCR.^{14,16}

Another study was patented using a digital PCR micro-drop kit which amplified the ORF 1ab and N genes to detect SARS-CoV-2.¹⁷ Isothermal amplification method was also patented for the detection of COVID-19 virus. A set of primers was developed by Song Min-Seok and Baek Yoon-hee from nucleocapsid genes which could detect the virus by the method of isothermal amplification within 90 minutes.¹⁸ Wan *et al.* invented a rapid kit for detecting the Covid-19 virus using the Loop mediated isothermal amplification (LAMP) method. The search also revealed patents for Peptide-based magnetic chemiluminescence enzyme immunoassay with high

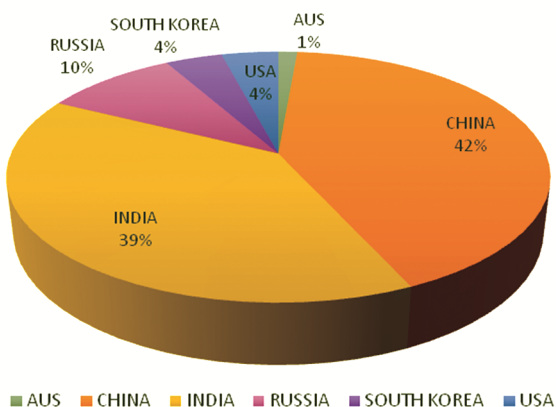


Fig. 1 — Percentage of patents describing Diagnostic Technologies across the globe

specificity.^{19,20} This method can be used in combination with rRT-PCR, having 71.4% and 57.2% of rate positivity for IgG and IgM. The diagnostic accuracy of COVID-19 may be enhanced by combining this immunoassay with real time RT-PCR.²¹⁻²⁴ ELISA method is widely used due to its easy execution, practicality and low cost with the countries developing its own technologies by purifying the local antigens for better test results.²⁵⁻²⁷ CRISPR-based methodologies, viscoelastic testing, biosensors for COVID-19, lateral flow immunoassay and viscoelastic testing are some of the promising methodologies which can be conceived as alternatives to the usual methods as shown in Table 1.^{14,28-33}

Ever since emergence of Sars-CoV-2, so many countries around the world have indeed been caught by several major and minor variant waves of Covid-19 including Alpha (B.1.1.7), Delta (B.1.617.2), and the Omicron (B.1.1.529) variants which have infected patients over the last two years. Multiple regions throughout the world have seen a rise in the Omicron variation, according to dynamic tracking of variant frequencies. As a result, it's crucial to monitor the increasing prevalence of varied Covid-19 variants in different regions of the world. So far, the most common way for tracking the occurrence of these variations has been to sequence them, but this technique is slow and expensive³⁴. Some of the most widely used COVID-19 diagnostic methods, including real-time fluorescence quantitative PCR (RT-qPCR), computed tomography, and next-generation sequencing, have a variety of advantages, especially for early diagnosis and screening. In addition, using technologies such as dPCR, ELISA, fluorescence immunochromatography assay, and the microfluidic detection chip method, researchers from all over the world have developed other rapid detection methods with high sensitivity, ease of use, cost-effectiveness, or the ability to perform multiplex analysis.³⁵ The patent analysis of detection technologies related to detection of delta and omicron strain of COVID 19 was done and it was found that several other diagnostic procedures are constantly evolving in addition to the widely utilised real-time reverse-transcription polymerase chain reaction (RT-PCR) detection techniques.³⁶ It was analysed that some of the patents that were identified were based on genome sequencing and phylogenetic analysis, which were utilised to detect mutations in SARS-CoV-2, which was beneficial in understanding the function of point mutations in SARS-CoV-2 transmissibility and

Table 1— Patents describing the innovations in the area of diagnostic technologies (World data)

S.No.	Title	Publication No.	Country	Summary/Invention
1.	Novel coronavirus nucleic acid rapid hybridization capture immunofluorescence detection kit and preparation method thereof	CN111471796B	China	A novel coronavirus nucleic acid rapid hybridization capture immunofluorescence detection kit.
2	Primer group and kit for detecting novel coronavirus COVID-19	CN112501359B	China	Usage of primer group, consisting of more than one or more primer pairs for detection of SARS-2 virus.
3	A COVID-19 Nucleic Acid detection kit for novel coronavirus and use method thereof.	CN111118228B	China	Detection kit by using the first primer pair and a first probe corresponding to CoV-N, and a second primer pair and a second probe corresponding to Cov-ORF1 ab.
4	Novel coronavirus COVID-19 nucleic acid detection method and kit	CN111304366B	China	Detection kit by obtaining an amplification product using primer pair P after RTPCR and mixing with the premixed solution, lastly detecting the reaction product using test paper by observing detection lines
5	Rapid detection kit for SARS-CoV-2 dry powder L AMP	CN111154922B	China	It discloses the usage of dry powder L AMP with specific primer use in the kit and detection by the colour development indicator resulting positive or negative colour development difference have obvious negative and positive colour development difference.
6	Novel coronavirus (COVID-19) IGGIGM antibody detection kit	CN212483597U	China	Detection based on the IgG and IgM antibody comprising aluminium foil bag and detection card.
7	Assays for the detection of SARS-CoV-2	US10815539B1	USA	Detection discloses the methods for assaying for the presence of SARS-CoV-2 in a sample, using oligonucleotides, reagents and kits useful in assays.
8	Primer, probe and kit for detecting novel coronavirus	CN111197112B	China	The invention reveals a detection kit by using less template amount with high sensitivity.
9	CRISPR nucleic acid detection kit for detecting novel coronavirus (2019-nCoV)	CN111270012B	China	Covid-19 virus detection kit based on CRISPR nucleic acid.
10	Novel coronavirus neutralizing antibody detection kit	CN112098660B	China	Disclosure of detection method by neutralizing antibody detection kit comprising HEK293-hACE2 cells, PE labelled novel coronavirus spike glycoprotein S1, a novel coronavirus neutralizing antibody positive standard, a negative control antibody sample and a flow detection buffer.

The other patents related to Diagnostic technologies are provided in supplementary file

toxicity. Xi Hui *et al.* suggested that multisensor technology may also be utilised to identify numerous variations of SARS-CoV-2 at the same time by enabling a rapid, effective, and accurate point-of-care testing (POCT) for genotyping mutations.³⁷ Hamill V *et al.* developed a real-time RT-PCR (RT-qPCR) for the detection of SARS-CoV-2 that covers virtually all strains and allows for the distinction of highly transmissible Delta mutant strains.³⁸ Another study was done by Leng Q. & Mixson A. Jin which they established two sensitive and specific qPCR techniques for identifying the Omicron. By recognising the Omicron L981F mutation, one approach can discover particular point mutations. This approach may easily be modified to detect other developing variants with distinct point mutations. The

second approach involves creating a primer that is specific for the area of the Omicron variation where a deletion and an insertion have occurred (210-217 amino acids in the spike protein region).¹ Using CRISPR-Cas12a-based assay Liang Y, developed a rapid detection and tracking of Omicron variant of SARS-CoV-2 by designing allele-specific CRISPR RNAs (crRNAs) targeting the signature mutations in the spike protein of omicron variant.³⁹ Another study was patented (CN113774169) which claimed to develop a nucleic acid detection method for Delta variant strains. Specific primers and probes were designed which targeted at delta variant protein coding genes T19R, L452R, T478K and P681R mutation sites, and also included a one-step RT-PCR reaction solution.⁴⁰ One of the inventions

(CN113846184) revealed the use of primers for rapidly detecting delta variant strain of SARS-CoV-2. The primer composition of the kit has high sensitivity and specificity and is not restricted by annealing temperature in the employing process thus simultaneous detection of numerous targets is simple to achieve.⁴¹ Another nucleic acid detection kit was developed by Jiang X *et al.* (CN113981140) for the detection of novel coronavirus delta mutant strain having high specificity and accuracy in detection which was based on the amplification of the target region by taking an ORF1ab gene region and S gene.⁴² A set of primer probes were designed which targeted 6 mutation sites of the Omicron mutant strains using a bidirectional ARMS PCR technology thus improving the detection accuracy of the mutant strain by nearly 100% (CN114085928).⁴³ A kit was developed by carrying out combined detection on the three target genes of new crown ORF1ab and S, N of the omicron mutant strain which covered the specific mutation site of the variant (CN114107574).⁴⁴ Another patent developed by Govekar S *et al.* (IN202141060399) which revealed the use of primer and probes in which the DNA labelled probes were capable of binding to Omicron variant of SARS-CoV-2 by qRT-PCR method.⁴⁵ Tan A & Guo Y developed a kit for detecting and typing SARS-CoV-2 mutant strains which was based on fluorescence probe melting curve method thus detecting four different characteristic functional variant sites on the S gene with the oncojon variant strain in a single tube reaction system.⁴⁶ For detecting different new coronavirus mutant strains, a multiplex PCR based technology detection kit was developed in which the S protein mutation sites and conserved sequences of new coronaviruses were determined and accordingly designing multiple amplification of primers followed by single-tube multiple PCR amplification (CN114107572).⁴⁷ An AI based smart system was developed by Pande S D *et al.* (202211006016) for the early detection of omicron and COVID -19 symptoms. The system comprised of an AI sensor unit, a temperature, oxygen and pulse rate sensor for detecting omicron infected individual.⁴⁸

Analysis of Patents Related to Protective Equipment and Related Technologies

Now in the present state, innovations are more dependent on infection prevention and healthcare PPE (Personal Protective Equipment). To prevent infection a safe sustainable and reusable strategy must be the

key aspect of developing PPE in future. The study reveals that most of patents are based on protection technologies which included protective masks, gloves and face shields. It was analysed that the innovations related to personal protective equipment included protective guard with a microphone, capable of reducing the diffusion of droplets. A face imaging module was developed to ensure that the customers entering the fuel stations are wearing masks. Innovations also included a smart hand glove for monitoring body temperature, blood oxygen and pulse rate. A Smart COVID Scanner: Portable and Affordable Scanner was developed to Detect COVID-19 Virus. For infection control, a wearable laser distance indicator was designed and patented. For capturing and destroying pathogenic viruses like COVID -19, a contactless a smart UV-C disinfectant box Phipps indoor air filter (PIAF) was found in the search analysis. To reduce the transmission of respiratory infection masks are considered to be the most applicable PPE.^{49,50} To decrease the spread of Covid-19, different varieties of masks came into existence like, medical masks, N95 masks, and homemade masks, which could be made of four-layer kitchen paper and one-layer cloth.^{51,52} Medical masks should be prioritized for the health care workers and surgical masks can be used in case there is no risk of aerosol transmission.⁵³ Under the category of protection technologies and gears, a total of 81 patents were selected out of which 27% of patents were filed from Japan, from China (18%), India (17%), Australia (16%), USA (10%), South Korea and Russia both contributing (6% each) out of total the granted/published patents that were published during the time of Covid-19 (Fig. 2 & Table 2).

Analysis of Patents Related to Cleaning and Disinfection Technologies

In the patents describing cleaning technology, out of 164 total selected patents (Table 3), South Korea emerged as the top contributor with 47%, Australia (13%), India (10%), China (11%) and USA (12%), Russia (5%) and Germany contributed (1%) against the total patents granted (Fig. 3). The patents categorized under cleaning and disinfection technologies reveals different types of sanitization devices which are commonly UV based, disinfection tunnels, drones and more.⁵⁴ The patent analysis report also portrays innovations like an apparatus to inactivate airborne pathogens on the surface of objects. Disinfection technologies developed moving

tunnel sanitizer for the purpose of decontamination. An air supply system was installed in building elevators to provide continuous purification and filtration of exterior air for the improved safety of elevator passengers. Other disinfection innovations were units for thermal sanitization, Ultraviolet type C LED based mop, far-UVC lamp light, UV robots, quartz tube germicidal lamp, walk through sanitization tunnels, Personal sanitation enclosure

(PSE), Sensor operated sanitization device, ultrasonic fogging sterilization centre and many others.⁵⁵

Worldwide Status of Vaccine Development

As of 23 June 2021 the Covid-19 - living NMA initiative collected 268 RCTs (randomised control trial) and 111 non-randomised studies of vaccines from the ICTRP (The International Clinical Trials Registry Platform) and 180 of these trials are recruiting patients.⁵⁶ Since the outbreak of the COVID-19 pandemic, there has been a global race to produce vaccinations to combat the virus. According to a review of vaccine development data from the World Health Organization, more than 40 nations and regions were working on COVID-19 vaccines by the end of February 2021, with at least half of these countries having one or more vaccines in clinical trials.⁵⁷ A total of 288 COVID-19 vaccine candidates had been created by the end of June 2021, with 104 in clinical trials and 184 in preclinical investigations.

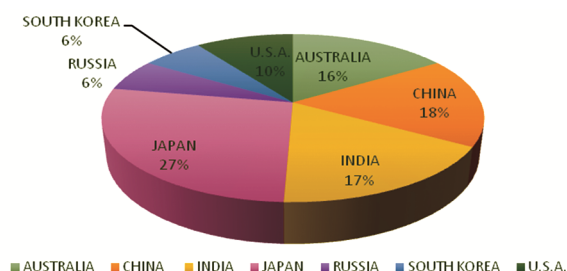


Fig. 2 —Percentage of patents describing Protection Technologies across the globe

Table 2 — Patents describing the innovations in Protection Equipment and Technology (World data)

S.No	Title	Publication No.	Country	Abstract
1.	Protective guard and protective mask and microphone with protective guard	JP6865943B1	Japan	Development of a protective mask using the protective guard, and a microphone assisted face shield capable of reducing the diffusion of droplets.
2	Face shield	JP3231759U	Japan	Face shield which protects the eyes from incoming light and thus prevent facial expression
3	Special ventilation loop connecting device for breathing machine	CN212547875U	China	The utility model relates to a dedicated loop connection device of ventilating of breathing machine.
4	Protective type spray collecting mask	CN212036133U	China	The utility model discloses a protective type spray collecting mask, which comprises a mask body and fixing bands connected to the left side and the right side of the mask body with opening for oral and nasal parts assisted with spray chamber.
5	Multifunctional medicine core and mask	CN210432886U	China	The utility model discloses a multi-functional medicine core and gauze mask, multi-functional medicine core contains one deck, two-layer or three-layer and contains the medicine layer.
6	Plant medicine atomizing gauze mask	CN211960994U	China	The utility model provides a plant medicine atomizing gauze mask, include: the mask comprises a mask body, an aerosol atomizer is arranged on the inner side of the mask body and the air inlet is communicated with an air passage of the aerosol atomizer having a pack filled with plant extract.
7	Simple bedside negative pressure isolation device	CN210494450U	China	The utility model discloses a simple and easy bedside negative pressure isolating device, it contains: the protective cover shell comprises a transparent side wall and a transparent top surface, with 3-D framework of a protective layer.
8	Closed face screen for detecting swab of nose and throat	CN211961031U	China	The utility model relates to a closed face screen for nasopharynx and larynx swab detection.
9	Disposable Hygienic Glove	RU201685U1	Russia	The utility model refers to disposable PPE used for hands when travelling in public transport.
10	Non-contact sanitizer dispenser glove	US10842899B1	USA	The invention relates to a sanitizer dispensing glove and a method of sanitizing an object using the glove.

The other patents related to Protection equipment and technology are provided in supplementary file

Table 3 — Patents describing the innovations in Cleaning and Disinfection Technology (World data)

S. No.	Title	Publication no.	Country	Summary/invention
1	Sterilization apparatus having monitor for Covid- 19 diffusion protection	KR-102193257-B1	South Korea	A disinfection apparatus equipped with a monitor for preventing the spread of Corona 19.
2	Posterior sampling device and method for respiratory infectious diseases	CN-111388024-B	China	The invention relates to a sampling device and a sampling method for respiratory infectious diseases, which comprises an operation platform and a support frame arranged on the upper part of the operation platform.
3	Hand dryer providing sterilizing effect	KR-102178392-B1	South Korea	A Sterilization device
4	Apparatus which can spraying chlorine dioxide aqueous solution in indoor space	KR-102235110-B1	South Korea	The present invention relates to a chlorine dioxide water supply device capable of automatically spraying an aqueous solution of chlorine dioxide.
5	Anti-virus door visor system	KR-102239410-B1	South Korea	An anti-virus door visor system using an ultraviolet lamp.
6	SARS-CoV-2 combination air purifier and decontamination and bioburden reduction system for surgical masks/respirators.	US-10905790-B1	USA	The present invention relates to an air purifier having an ultraviolet wave chamber which is accessible from the exterior designed for the placement of masks/respirators in need of decontamination.
7	Apparatus for inactivation of airborne pathogens and pathogens on the surface of an object	US-10994034-B1	USA	An apparatus for the inactivation of airborne pathogens and pathogens on the surface of an object comprising both of an activated carbon filter and a catalyst to convert the oxidant into oxygen.
8	Airborne microbial capture sterilizer	KR-102210378-B1	South Korea	An apparatus for collecting and sterilizing microorganisms in the air.
9	Individual and mobile biological protection devices by irradiating flowing air with ultraviolet radiation	RU-2729292-C1	Russia	A device for inactivation of pathogenic microorganisms in the air stream, made in the form of a flow chamber containing a means of air intake and forced pumping of air, an exhaust funnel
10	TOV 770 - An innovative ethyl alcohol, chlorite, hydrogen peroxide, tea tree oil extract (<i>Melaleuca alternifolia</i>) based anti-SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) viral surface sanitizer	AU-2020100545-A4	Australia	An innovative ethyl alcohol, chlorite, hydrogen peroxide, tea tree oil extract (<i>Melaleuca alternifolia</i>) based anti- SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2) viral surface sanitize

The other patents related to Cleaning and disinfection technologies are provided in supplementary file

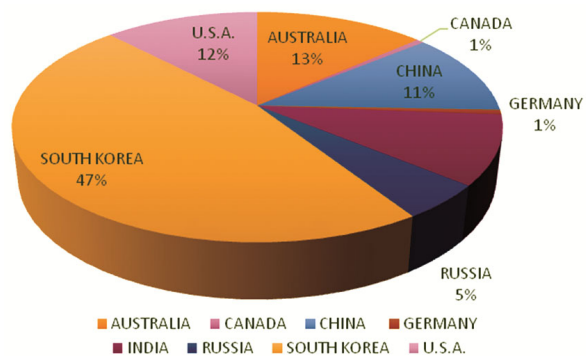


Fig. 3— Percentage of patents describing Cleaning Technologies across the globe

The vaccine candidates developed were based on a variety of approaches, including recombinant protein-based vaccines [protein subunit vaccines, virus-like particles (VLP)], viral vector vaccines, conventional whole virus vaccines (live attenuated or inactivated vaccines), and nucleic acid vaccines (DNA- and

mRNA-based vaccines). Table 4 and Figure 4 illustrates the distribution of different COVID-19 vaccine candidates across various platforms.

Protein-based vaccines are the most common type of COVID-19 vaccine candidate, accounting for 32% of all COVID-19 vaccine candidates in development, with 104 in clinical trials and 184 in preclinical research. Non-replicating viral vectors, mRNA, DNA, replicating viral vectors, and inactivated vaccines account for 15%, 16%, 10%, 2%, and 15% of all vaccinations, respectively. The vaccines that are in the most advanced clinical trial stage, Phase 4 (post market) research in the countries like United States, China, the United Kingdom, and Germany. India is the only country where a COVID-19 vaccine with live attenuation is being produced. Table 5 provides the details about vaccine development.⁵⁷ The majority of the vaccines are based on protein subunit maybe because they are thought to be safer than whole-

Table 4 — Vaccine candidates in clinical phase

Platform		Candidate vaccines (no. and %)
RNA	RNA	17 16%
PS	Protein subunit	33 32%
VVnr + APC	VVnr + Antigen Presenting Cell	1 1%
DNA	DNA	10 10%
VLP	Virus Like Particle	5 5%
VVnr	Viral Vector (non-replicating)	16 15%
VVr	Viral Vector (replicating)	2 2%
VVr + APC	VVr + Antigen Presenting Cell	2 2%
IV	Inactivated Virus	16 15%
LAV	Live Attenuated Virus	2 2%
		104

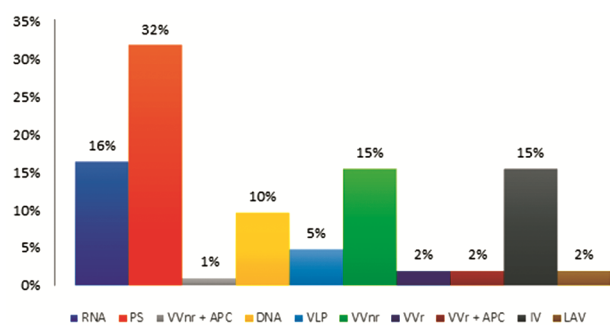


Fig. 4 — Percentage of different vaccine candidates in clinical stage

pathogen immunization methods. In addition to the advantages of specificity and safety, employing peptides as immunogens reduces vaccine production costs and lead times. The viral vector vaccines are also majorly being produced as they are simple to make and affordable.^{3,58-60} Vaccines that have received regulatory approval or authorization are Covaxin (Inactivated) by Bharat Biotech, BNT162b2 (RNA) by Pfizer/BioNTech, mRNA-1273 (RNA) by Moderna, EpiVacCorona (Protein Subunit) by FBRI, Ad5-nCoV (Viral Vector) by CanSino, Ad26.COV2.S (Viral Vector) by Janssen (Johnson & Johnson), Covishield (Viral Vector) by Serum Institute of India, BBIBP-CorV (Inactivated) by Sinopharm (Beijing), Sputnik V (Viral Vector) by Gamaleya, Inactivated (Vero Cells) by Sinopharm (Wuhan), CoronaVac (Inactivated) by Sinovac, AZD1222 (Viral Vector) by Oxford/AstraZeneca, CoviVac (Inactivated) by Chumakov Federal Scientific Centre for Research and Development of Immune and Biological Products as shown in (Table 5).⁶¹⁻⁸⁵ Pfizer-mRNA BioNTech's

vaccine and Moderna's mRNA vaccine were the first two authorised mRNA vaccine.⁸⁶ It's a novel approach to vaccine development, and no such vaccine has ever been approved for use against an infectious disease. Despite this, mRNA vaccines may suffer supply-chain issues. We require vaccines that are simple to design and manufacture, as well as vaccines that are cost-effective and safe.^{3,87}

Why Patents in Vaccines are so Debatable?

The COVID-19 rampant has rekindled a long-running dispute about how to strike the right balance between private gain and global health. Many experts and campaigners believe that intellectual property (IP) restrictions set by the World Trade Organization (WTO) impede impoverished countries' access to crucial medicines, others argue that the IP rules are necessary to motivate drugmakers.⁸⁸ In record time, biopharmaceutical companies have created safe and effective COVID-19 vaccinations, bringing hope in the face of a catastrophic pandemic. While these vaccines have saved many lives, there has been much debate about worldwide vaccine access, particularly between developed and underdeveloped countries. While a range of factors contribute to these inequities, intellectual property (IP) rights have received a lot of attention.^{89,90} The global struggle against the severe acute respiratory syndrome coronavirus 2 (SARS-Cov-2) has been viewed as a global battle in which no country, particularly low-income ones, can be left behind. With the emergence of new strains, this factor may actually enhance the virus's unchecked reproduction. The waiver of patent rights for COVID-19 vaccines is one possible approach to limit this problem. India and South Africa have asked the World Trade Organization (WTO) to permit all nations to choose not to grant or impose patent protection and other property rights (IP) attributed to COVID-19 prescription medications, vaccines, diagnostics, and other technologies for the duration of the pandemic, until worldwide herd immunity is attained. The US administration indicated its willingness to liberalise intellectual property for COVID-19 vaccinations on 5 May 2021.⁹¹⁻⁹³ Although this is an intriguing topic, its viability is exceptionally difficult and complicated. As a result, there are differing viewpoints among academics and clinicians about the true utility of patent liberalisation.⁹³⁻⁹⁷ Among their objections, they contend that relaxing patents would do little to stimulate mass development of COVID-19 vaccines. They claim that even if third

Table 5 – World wide data of COVID-19 vaccine development				
S. No.	Vaccine brand name/other names	Developer/originator, country name	Active substance	Publication no.
1	COVID-19 Vaccine Janssen/ Ad26COVS1 JNJ-78436735	Janssen Pharmaceuticals (J&J), Belgium	adenovirus type 26 encoding the SARS-CoV-2 spike glycoprotein (Ad26.COVS1)	WO2021/064688 ^{61,62}
2	Sputnik V/ Gam-COVID-Vac	Gamaleya Research Institute, Russia	Combined vector vaccine for the prevention of coronavirus infection caused by the SARS-CoV-2 virus	WO 2021/002776 WO 2021/076010, WO 2021/076009, RU2744444C1, RU2744442C1 ⁶³⁻⁶⁶
3	CVnCoV ^{67,68}	CureVac AG, Germany	Messenger RNA (mRNA), 5'-capped, encoding a full-length codon optimised pre-fusion stabilized conformation variant (K986P and V987P) of the SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2	
4	Covaxin(R)/ BBV152 ⁶⁹⁻⁷²	Bharat Biotech, Indian Council of Medical Research, India.	Whole Virion Inactivated Corona Virus Vaccine	
5	Vaxzevria/ AZD1222 ChAdOx1 nCoV-19	AstraZeneca and Oxford University, UK	ChAdOx1-SARS-COV-2	WO 2020/043869 ⁷³⁻⁷⁵
6	CoronaVac/ Sinovac COVID-19 vaccine ⁷⁶	Sinovac, China	SARS-CoV-2 Vaccine (Vero Cell), Inactivated [CoronaVac]	
7	SARS-CoV-2 Vaccine (Vero cell) Inactivated ^{77,78}	Sinopharm / Beijing Institute of Biological Products Co-Ltd, China	SARS-CoV-2 Vaccine (Vero Cell), Inactivated (InCoV)	CN 111569058 A
8	Comirnaty/ BNT162b2 ⁷⁹⁻⁸¹	Pfizer and BioNTech, Europe, USA	Single-stranded, 5'-capped messenger RNA produced using a cell-free in vitro transcription from the corresponding DNA templates, encoding the viral spike (S) protein of SARS-CoV-2	
9	Covovax/ NVX-CoV2373 ^{82,83}	Novavax CZ AS, USA	NVX-CoV2373/Covovax [Recombinant nanoparticle prefusion spike protein formulated with MatrixM™ adjuvant]	
10	COVID-19 Vaccine Moderna/ mRNA-1273	Moderna, USA	CX-024414 (single-stranded, 5'-capped messenger RNA (mRNA) produced using a cell-free in vitro transcription from the corresponding DNA templates, encoding the viral spike (S) protein of SARS-CoV-2)	US20200282046 ⁸⁴⁻⁸⁵

parties were not bound by patents, they would still be unable to manufacture vaccines in large quantities due to a lack of crucial technical knowledge. This predicament not only puts global access to COVID-19 vaccinations in jeopardy, but it also highlights a disturbing inconsistency at the core of the patent system. The patent holders of biopharmaceutical sector who own the legal protection to COVID-19 vaccines have reportedly disclosed their technologies. However, these same patentees assert that without carefully held implicit knowledge and trade secrets, third parties will be unable to manufacture these patented vaccinations.⁹⁰ From a practical perspective, the expulsion of patent protections would restrict the economic models for the credible producers of

COVID-19 vaccines. Among prospective initiatives to promote the waiver of patent protections it is plausible to also include the donation of vaccines from the high-income countries, the reduction of the costs of the production lines, the shortening of the period of patent protections, and a series of preferential patent exclusions to countries that produce a substantial portion of the worldwide vaccines. As a result, further financial investments and supportive technology transfer to low- and middle-income nations may be required (LMICs). In reality, countries like India, who manufacture a significant proportion of the world's vaccines, could play a key role in ensuring that low-income countries' populations get access to COVID-19 vaccines.⁹³

Conclusion

Undoubtedly, the Covid-19 pandemic is something very devastating emergency that has distressed the generation in every corner of their life. The Covid-19 crisis has garnered much attention for immediate action of invention and novelty as to protect the lives from the deadly virus which is in the mode of high mutation and transmission. In this patent search analysis, we have focused on the major categories of the present time, the importance of the patent in the innovation system can be well conversed. Innovations in humanitarian and developmental responses to the pandemic have inclined the focus on increased improvements on existing aid approaches as well as on new biomedical and pharmaceutical product developments. This patent search was focused on diagnostic, protection, surface treatment and vaccine developments done to sustain the setbacks faced during this pandemic. The insight of this study reflects patent analytics in innovation at the time of crisis and to motivate innovators for further innovations and development. Focusing on the international legal dimension, this pandemic gave the research sector and the policy makers a brief idea on the importance of protecting their ownership on the product, technique or the idea been developed, as patent is not a stand-alone innovation system.⁹⁸ IP system helps to achieve a balance between the competing innovations. Thus, IPRs are pivotal, knowledge-sharing, fostering trust, and collaboration between individuals and organisations. As the world is battling against the different strains of Covid-19 emergency, low-cost inventions are at demand as to meet the public call-in pandemic as well as in the economic crisis, before the pandemic patent filing was not in tendency but as by the passage of time and emergence of new virus variant urge the health practitioner, research sector and the scientist to provide the society a better escape plan. Protective equipment, sterilizing equipment, diagnostic innovations and vaccine development have fostered the hopes of human race to be intact in the competition of innovations by preserving their ideas aiming at leveraging access to technologies rather securing financial advantages. The present report could be helpful in taking the research and innovation facet onto a different level of vision and mission by the support of the patented technologies all-round the globe in a view to fulfil the fissures for the areas needed to be explored on the other side.

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