

Review Article

# Challenges of Inventors in Balancing Public Interest, Enterprise Profits, Commercial Competitions and Knowledge Sharing with Respect to The Technology Development in The Biomedical Sector During the Pandemic: A Study Through Patent Filing Trends

Rajkrishna Rajan, J.S. Gopika

IP Cell, Biomedical Technology Wing, Sree Chitra Tirunal Institute for Medical Sciences and Technology, Poojappura, Thiruvananthapuram 695012, India

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The world grapples with the pandemic coronavirus. A new mutation of coronavirus is popping up from independent parts of the world. People affected with coronavirus undergo lenient to acute respiratory problems and other health disorders. This paper details the transmission of coronavirus, drivers and restraints of the global vaccine market, regional market insights, and competitive intelligence report on medical devices for coronavirus. The results demonstrate that filing of human coronavirus patents, particularly COVID-19 patents, have been rapidly increasing. Harvard College and University Toledo play an outstanding role in developing medical Devices for saving mankind from Coronavirus. The leading role of inventors and companies is increasingly apparent. Balancing public interest, enterprise profit, commercial competition, and knowledge sharing is a significant challenge.

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## Introduction

Coronavirus is a type of virus that belongs to either of the two subfamilies, Coronaviridae or Toroviridae which affects the respiratory tract of mammals [1]. In Latin, the word 'corona' means crown and is thus called Coronavirus, as it has a crown-like appearance. In 1960, Human coronaviruses (HCoV) was revealed by examining through naval chamber of victims affected with seasonal flu. Coronavirus is spread through droplets through coughing or sneezing and it is also contagious to pass from person to person through close contacts [2]. Sore throat, coughing, fever, respiratory infection, and difficulty in breathing are some of the commonly seen symptoms of coronavirus infection [3]. Endorsed measures to prevent infection include regular hand hygiene, keep up social distance from others, observing quarantine, coughing and sneezing by covering with your bent elbow, and purify grubby hands with right germicide or lather. The benefit of personal protective equipment and breathing mask has been put forward

by health authorities in public settings to cut down the threat of distribution. Health officials have mandated the use of medical-grade face masks, such as N95 masks, to be used by healthcare workers, first responders, and lifeguards who in person mind for the infectious [4].

Fever is the most regular sign of COVID-19 but is tremendously fluctuating in intensity and dispensing. Other common symptoms include cough, loss of appetite, fatigue, shortness of breath, sore throat, runny nose, sputum production, muscle, and joint pains [5-7]. Indications such as gagging, spewing and the runs have been noticed in differing proportion. A reduced perception of smell or disruption in taste has also been noticed. An early solution to the detection is the rhythm of the sickness. Early symptoms may include a wide variety of symptoms but infrequently involves shortness of breath. Asthmatic usually advances some days after early sign [8]. Asthmatic that set about right away onwards with fever and cough is presumably to be concern than COVID-19. The most critical days of illness tend to be those following the development of shortness of breath. Some precautions that can be taken to minimize the effects of Coronavirus infections include protecting the eyes, exercising, proper hand hygiene, apparatus

\* Corresponding author

E-mail address: rajkrishnand@gmail.com (Er. Rajkrishna Rajan)

cleanse, the systematic utilization of shielding masks, and make use of Personal Protective Equipment (PPE) [9].

## Transmission of the Coronavirus

Coronavirus spreads through sneezing, coughing, or sharing cups or bottles of water being used by someone infected. Here the virus is transmissible and can roll out via man to man along material communication. Particularly, COVID-19 spreads largely when people are in close contact, and one person inhales small droplets produced by an infected person. The WHO recommends 1 meter (3 ft) of social distance; the U.S. Centers for Disease Control and Prevention (CDC) advocate 2 meters (6 ft). Sometimes the viruses cease to appear some signs and are transmissible too. It is found that those infected are asymptomatic to be 40-45% [10]. People are most infectious when they show symptoms (even mild or non-specific symptoms) but may be infectious for up to two days before symptoms appear (pre-symptomatic transmission). They remain infectious an estimated seven to twelve days in moderate cases and an average of two weeks in severe cases [11].

When the contaminated droplets fall to floors or surfaces, they can remain infectious if people touch contaminated surfaces and then their eyes, nose, or mouth with unwashed hands. On surfaces, the amount of active virus decreases over time until it can no longer cause infection, and surfaces are thought not to be the main way the virus spreads. Surfaces are easily decontaminated with household disinfectants which kill the virus outside the human body or on the hands. Moreover, SARS-CoV-2 exhibited high sensitivity to thermal treatment at 55 °C, UV light at 300 mJ/cm<sup>2</sup> for 300s, and pH 11 [12].

## Global Coronavirus Vaccine Market: Drivers and Restraints

The 2019 – 2020 outbreaks in Wuhan City, China, and its rapid spread across the globe is expected to endanger millions of lives. The demand for drugs and other related products is rising exponentially as countries around the globe are preparing for a potential outbreak. This is a vital feature contemplate to pilot expanding economy to a notable stretch. Key players in the know about market, counting medicinal firm and testing organizations for-instance the National Institutes of Health (NIH), the US, are being assisted by governments to develop novel vaccines and drugs to combat this deadly virus. The companies currently engaged in the development of novel drugs for treating coronavirus include BioCryst Pharmaceuticals, Inc., AbbVie Inc., Regeneron Pharmaceuticals, Inc., and companies exploring the development of vaccines as a preventive measure include Inovio Pharmaceuticals, Inc., and Novavax, Inc [13].

Technological advancements in the pharmaceutical sector include the development of nucleic acid vaccines that are DNA- and RNA-based, and which enable the human body to produce vaccine antigens. Such initiatives and activities are projected to support market growth to a significant extent.

Other major factors involve the increased expenditure on the healthcare sector, growing concerns regarding outbreaks at regular intervals, and rising need to protect the population from known and unknown viruses. This Coronavirus outbreak hurts the growth of various markets, thereby affecting global Gross Domestic Product (GDP). Governments and healthcare authorities are striving hard to get aid in the form of drugs for treating infected individuals, as well as to avoid the further spread of the virus.

However, the high cost involved in the research and development of therapeutic drugs and vaccines, and the time required for each

phase of clinical trials are among some of the major factors that could hamper the market growth.

## Regional Market Insights

The North American market is expected to account for the highest revenue share in the global coronavirus vaccine market, followed by the Europe market with the second-highest revenue share. This can be due to different outbreaks in the recent past presence of major players in different countries, increasing investments in R&D activities, along strong support from the government. Income coming out of Asia Pacific market is estimated to inflate with respect to a remarkably towering Compound Annual Growth Rate (CAGR). In addition, rising demand and need for novel therapeutics and vaccines for use as preventive measures is another factor expected to drive the growth of the market.

## Drug Store Distribution

The merchandize for Coronavirus inoculate is fragmented in this way

- 1) Market analysis by infection type (Caused by coronavirus)
  - a. HCoV-229E: causes common cold, pneumonia, and bronchiolitis.
  - b. HCoV-OC43: causes respiratory tract infection and pneumonia in infants.
  - c. SARS-CoV: causes severe acute respiratory syndrome (SARS).
  - d. New Haven CoV: causes Kawasaki disease, aneurysms of the coronary arteries.
  - e. HKU1-CoV: causes acute respiratory distress and bilateral pneumonia.
  - f. MERS-CoV (Middle East respiratory syndrome Coronavirus): causes bronchial infections [14].
- 2) Segmentation by vaccine type
  - a. Inactivated Coronavirus vaccine: Inactivated vaccines use a killed (inactive) category of the virus in the sense that contributes an infection. This variety of vaccine gives rise to an immune reaction nevertheless not the germs. Here this kind of vaccine frequently is in need of numerous dosage, accompany by supporter doses, to produce continuing protection. Generating the particular variety of vaccines might be in need of administering of substantial catching viruses.
  - b. Live attenuated Coronavirus vaccine: Live vaccines make use of incapacitate (diminished) make of the virus that bring out a sickness. The present variety of antibody gives rise to an unsusceptible feedback without creating infection. The expression attenuated measure a certain inoculates' potential to create sickness has been minimized. No matter how, live virus vaccines repeatedly be in need of boundless well-being trail. Few or more live viruses as it may be imparted to a human who isn't inoculated. This is a worry for population who experience reduced unsusceptible structure.
  - c. S-Protein based Coronavirus vaccine: The part of S protein in ligature, and the adherence and merging of cell membrane stipulate that inoculates established on the S protein may generate immunoglobulin to obstruct germ unbreakable and binding or counterbalance virus contamination. Out of every structural proteins of SARS-CoV, S protein is the foremost virulence portion particularly in charge of generating host immune retaliation, nullifying antibodies, and/or shielding immunity abreast virus contamination. S protein has on that account been determined as a prime earmark for inoculation

and anti-viral spread [14].

3) Segmentation, by End User:

- a. Hospitals
- b. Clinics
- c. Research Institutes [14]

The several Immunisation that are being created include,

- 1) Immunisation made from Genetic code – Further Coronavirus accept genes are used in vaccines to induce an immunological response.
- 2) Immunisation against viral vectors – Vaccines that introduce the genes for the coronavirus into cells using a virus. The specific cells put together viral proteins, triggering an immune response, but the virus cannot replicate as a result.
- 3) Immunisation based on peptides – Vaccines that elicit an immunological response by using a Coronavirus gene or a protein fragments.
- 4) Immunisation against entire viruses – Vaccines that induce a resilient comeback in a class of virus that is dead or reduced.
- 5) Immunisation reconfigured – Vaccines already in use to prevent other diseases that may offer COVID-19 protection. [14]

**Validated Vaccines by WHO**

The vaccines that got the green signal for use by WHO are listed below in table 1.

**Store for Coronavirus Illnesses**

As shown in table 2, the global coronavirus contamination market can be segmented based on:

- 1) Diagnosis: The COVID-19 contamination market is divided into swab tests, blood tests, tissue sample tests and more. The specimen of the swab test as it may be extracted via the nose or oropharynx.
- 2) Treatment: The COVID-19 contamination market is divided into treatment, palliative care, and more. Palliative care encompasses respiratory aid, for-instance accelerated airing. Blood plasma transfusions can be example of other treatments.
- 3) End-users: The COVID-19 contamination market is divided into hospitals, home care, specialty clinics, and more

**Table 1: Vaccine list validated for use by WHO [13]**

Sl. No.	Name of the vaccine	Official trail registration number
1	University of Oxford/AstraZeneca	ISRCTN89951424, NCT04516746
2	Sinovac	NCT04456595, 669/UN6.KEP/EC/2020
3	Sinopharm (Wuhan Institute of Biological Products)	ChiCTR2000034780
4	Sinopharm (Beijing Institute of Biological Products)	ChiCTR2000034780
5	Moderna/NIAID	NCT04470427
6	BioNTech/Fosun Pharma/Pfizer	BioNTech/Fosun Pharma/Pfizer

**Table 2: The global COVID-19 drug delivery devices market**

Product	Prefilled Syringe, Needle-free Injectors, Inhalers, Patch
Route of administration	Parenteral, Nasal, Dermal
Distribution channel	Hospital pharmacies, retail pharmacies, online drugstore
Region	North America, Europe, Asia Pacific, Latin America, Middle East & Africa

- 4) Distribution channel: The COVID-19 contamination market is divided into hospital pharmacy, online pharmacy, retail pharmacy, and more. [15-18].

**Vogue, chance, and impression of COVID-19 epidemic on Medical Management Market:**

Major driving factors of the covid-19 infection market are an increase in the rate of communicable diseases, disposable income in emerging countries, increasing number of hospitals, and rising health hygiene of individuals across geographies. Technological advancement and innovation in respiratory infection treatment have also triggered the growth of the coronary infection market. On the other hand, a huge amount of capital involved in the market would most likely impede the growth of this market.

Relentlessly emerging positive patients are creating the call for breathing machine over the earth. About 5% of the entire assured COVID-19 patients are fairly acute and request for breathing apparatus has emerged. The majority of the firms have broadened their manufacturing dimensions to encounter the in-progress call for instance Philips has enlarged its breathing machine making scope from ~1000 breathing machine a week to ~2000 breathing machine range a week. In parallel, Medtronic publicize to prime its

**Table 3: Inventions of small-scale labs**

Invention	Small-scale labs	Ref
Automatic mask machines	Sixth Element Furnishing Solutions	[19]
Ruhdaar: The low-cost frugal innovator	Islamic University/IIT Bombay	[20]
Jeeva Setu ventilators	REVA University	[21]
Low-cost PPE	National Research Development Corporation (NRDC)	[22]
Advanced washbasins	Diesel Locomotive Works	[23]
COVSAFE: Transporting patients	Aureus Institute of Medical Sciences	[24]
Safe swab: Phonebooth testing	BMC	[25]
CoronaOven	Log 9 Materials	[26]
Vistar	Indian Institute of Technology (IIT) Madras	[27]
Milagrow Seagull	Milagrow	[28]
Dozee	Turtle Shell Technologies	[29]

making by 40% and is running persistently to fabricate it in pairs in the future. GE Healthcare in addition pops up with an assent with Ford to infuse the aperture linking boom and bust. To boot, numerous competitors like Mahindra Group, Ford, and Maruti Suzuki are striding into the medicare production.

Numerous firms are remodeling their manufacturing route to unite the combat upon COVID-19. Besides, there are numerous producers and boutique resorts that are set foot in the disinfectant masks and seclusion hub aid. Innumerable fresh ventures are also play a part in to the combat against COVID-19 by launching applications that assist to traces COVID-19 patients. A venture Canada-based firm Emerge is instituting a public safety system application termed Civitas to aid community officials in various countries.

Similar to the large MNC's, multiple small-scale labs and startups took a lead in innovating technologies that are cost- effective with significant efficiency during the COVID times. The inventions which are worth mentioning are presented in table 3.

### **Products Developed by Sree Chitra Tirunal Institute of Medical Sciences for Covid 19**

- 1) Chitra Acrylosorb Fluid Solidification System: The development of project is for disinfection and body fluid solidification by using superabsorbent material. Acrylosorb hold a decontaminant for in situ disinfection and could absorb liquid twenty times added to its dry mass. The indicated technology put together the dumping secure and simple by bringing down the peril for hospital workers, demand for workforce for purifying and scrubbing the bottles and tin for reprocessing them.
- 2) Chitra Emergency Breathing Assist System (Chitra EBAS): It is a traverse breathing apparatus pre-owned for negligible time to little days in cases with tolerant to acute breathing complication preliminary to typical automatic airing. The apparatus instinctively cut down the call for help for human in the seclusion chamber by permitting productive, shielded and bronchi safeguarding performance for humans with Covid. The apparatus toil with an administered amount of demise thereupon permitting constructive compulsion airing.
- 3) Digital Sanitization Systems: To bring down the group outbreak of Covid 19 infection along proximity tops, a stunted severity rupture of visible light or UV light in secure field administered by a cellular application is toured. The torch (wide-ranging light) on individual cellular telephones is twinkled at a cost considering a definite time span utilizing the cellular application. As a substitute, the UV light presumably coupled to the Universal Serial Bus cable of the cellular phone. The cellular telephones may be concentrated on palm, or some items to be cleansed and switched on for certain time scale.
- 4) Chitra Isolation Pods: The proposal focus at expanding a quarantine room to accommodate the long-suffering and put a stop to the outbreak of germs in the time of moving and therapy on condition of widespread sickness. It supply guarded quarantine with interior obstructive force and the gases let out by the sufferer is diminished and nullified.
- 5) Emergency Response Isolation Systems: The proposed concept utilizes locally available PVC pipes; binds and meteorology impenetrable material for elevating portion in speedy schedule with least expertise and employment which is portable in quarantine rooms, hospitals, ICUs.
- 6) UV Based Disinfection Systems: The suggested component is for disinfecting the protective masks prior to getting rid of so that keeping away from the likely outbreak of Covid - 19. It comprises of a dustbin body, a controller and a UV disinfection lamp, which cleanse and depollute the pre-owned used protective masks prior to dumping.
- 7) Examination Booth: To propose guarded and well organized inspection room to generate bring off security for primary care executive who is inspecting Covid conjecture.
- 8) Chitra Swab Collection Booth: To evolve shielded and well organized swab gathering room to produce engineering line of security for primary care executives gathering long-suffering specimen from Covid suspects. The suggested swab gathering room will also manage discard contagion in top section, which put a stop to feasible situation contagion.
- 9) Chitra Disinfection Gateway: The Chitra Disinfection Gateway is denoted for the disinfection of workforce set foot in a washed commercial area from a widespread room. Aforementioned is provided in the company of ordering for giving rise to hydrogen peroxide film along with ultraviolet beam. Hydrogen peroxide film will cleanse garments, hands along with container an individual transport. The ultraviolet process will disinfect the room at one point the individual has depart.
- 10) Antigen detection kit for Covid 19: To progress the demonstrative apparatus that could determine the existence of Covid 19 antigen. Immunoglobulin in case of SPIKE protein will be put out of action on strips/stick and the apparatus will be progressed for antigen distinguishing established on lateral flow or dipstick approach.
- 11) Rapid Detection Kit for IgG/IgM Antibody: To advance the analysis apparatus that can disclose the availability of immunoglobulin (IgM/IgG) peculiar to Covid 19 infection in serum, plasma or entire blood. Licensed to spot germs and seclude humans without indications but Covid suspects.
- 12) Nylon Flocked Swabs (Nasopharyngeal and Oropharyngeal): The progressed invention hold nasal-cavity and throat wipe in the company of a bendy stick fabricated of polypropylene owning a tension, with electrostatically thronged nylon as well organized assembly of copy. Two alternatives besides, throat or nasal cavity are scheduled to be furnished located on the area of embodiment regaining. NP wipe can be making use of trail for persons having no symptom of illness.
- 13) Oropharyngeal Sample Collection Kit: Examining of Covid 19 imply gathering of aggressive pack in Viral Transport Medium (VTM) deploying a synthetic nasal or throat wipe. The outline put forward blooming of Phosphate Buffered Saline (PBS) and Glycerol established VTM forum down with the synthetic throat cavity wipe for gathering the specimen. The indicated apparatus can be making use of singly or as an attachment element for the specimen gathering apparatus for sample gathering from throat area.
- 14) Chitra LAMP-N RT-LAMP Kit: It is an examination instrument and equipment for speedy sensing of Covid 19 making use of RT-LAMP technology.
- 15) Chitra Magna RNA Isolation Kit: Develop a kit for RNA isolation from swab samples.
- 16) Development of a cost-effective ventilator: A general-purpose ventilator with simple, cost-effective, and reliable on fast-track mode for adult and paediatric use.

**Table 4: Top patents related to coronavirus**

Patent holder	Patent number	Title	Ref.
Harvard College	AU2017201081B2, US10245355B2	Modification of surfaces for Fluid and Solid repellency	[30, 31]
University Toledo	EP2972333A1	A Biosensor device to target analytes in situ, in vivo and/or in Real time and Methods of making and using the same	[32]

### Competitive Intelligence Report on Medical Devices for Coronavirus

The Competitive Intelligence Report has been prepared using XLSCOUT Data Analytics Platform.

#### Top Assignees

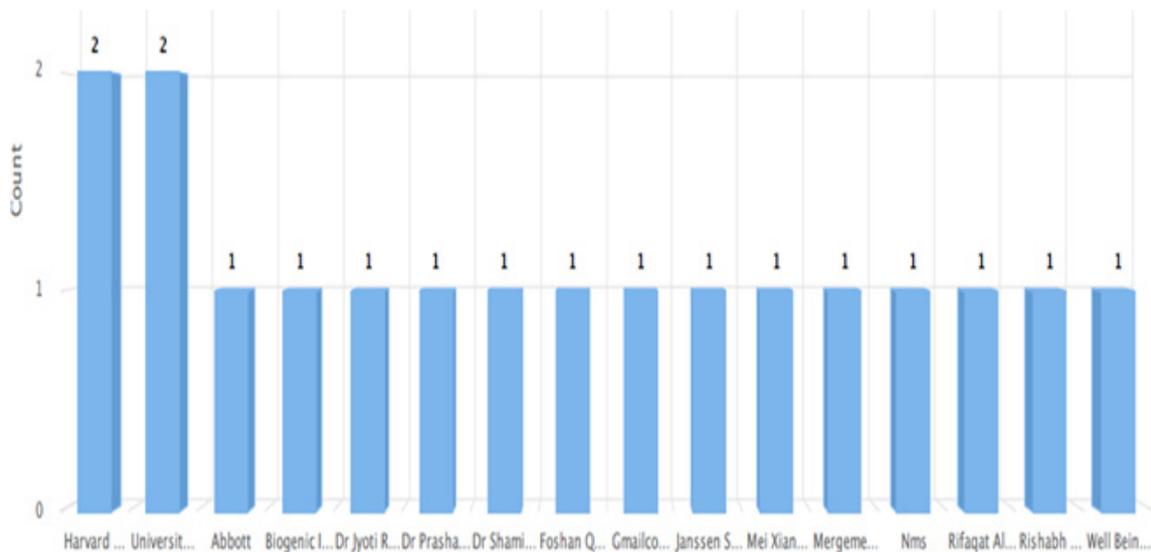
Harvard College and University Toledo are the top assignees identified, in developing medical Devices for saving mankind from Coronavirus (table 4).

While all other Assignees such as Janssen Sciences Ireland, Dr.

Jyoti Rawat, Dr. Prashant J, Dr. Shamimul Qamar, Rishabh, Gmailcom Maharashtra India, Rifaqat Ali, bbott, University Toledo, Foshan Qionglu Health, Mei Xiangjin, a Biogenic Innovations, Mergemeier Steffen, Wellbeing Biomedical have filed 1 patent each (figure 1 and table 5).

#### Assignees and concepts

The Patents filed by Dr. Shamimul Qamar, Dr. Jyothi Rawat, Gmailcom Maharashtra India, Rifaqat Ali, Rishabh, Dr. Prashant J are the key Assignees who have put in place their first Patent exercise in India on Real time concept, Composition concept and



**Figure 1: Top assignees**

**Table 5: Patents related to coronavirus**

Patent holder	Patent number	Title	Ref.
Shamimul Qamar	CN110177545A	For preventing the polyinosinic acid of the infection of the upper respiratory tract and the preparation of poly	[33]
Abbott on therapy hypothesis	JP2002511965A	Remote medical care	[34]
University Toledo on Real time concept	EP2972333A1	A biosensor device to target analytes in situ, in vivo and/or in Real time and Methods of making and using the same	[32]
University Toledo on Real time concept	WO2017062591A1	A Biosensor device to detect target analytes in situ, in vivo and/or in Real time and Methods of making and using the same	[35]
Foshan Qionglu Health on CoronaVirus concept	CN111573933A	Graphene nano purification system and technology for treating medical sewage containing new coronavirus	[36]
Mei Xiangjin on treatment concept	CN111388005A	Medical stethoscope 5G audio automatic diagnosis and treatment system and calibration method and auscultation bed	[37]

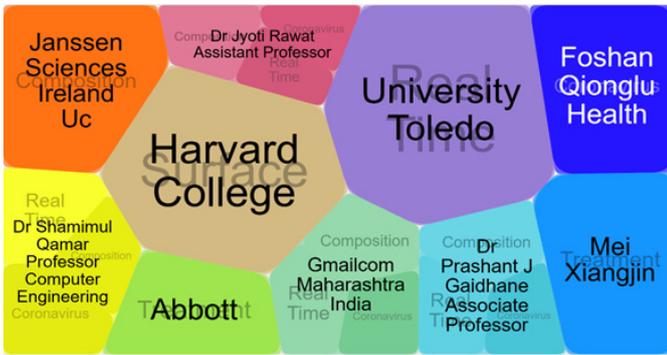


Figure 2: Assignees and concepts

Coronavirus concept are as follows:

**Assignee and First filing country**

Harvard College, University, Toledo, Abott and Biogenic Innovations have filed their Patent applications first in United States (figure 3 and table 6).

**Assignee and Potential Market**

It is observed that Biogenic Innovation, being the major assignee has potential market in United States, Mexico, Japan, Israel, Spain, Denmark, Canada and Australia. Harvard College is the second most top assignee, which has potential market in United States, Korea, Hongkong, European Union, China and Australia (figure 4).

**Core Patents in Technology**

As shown in figure 5, ssignees like Dr. Jyoti Rawat, Dr.Prashant J, Dr. Shamimul Qamar, Foshan Qionglu Health and Gmailcom Maharashtra India have patent value with a citation value between 0-2 in 2020. More the number of citations, more important are the patent which means the greater number of times it is referred to conclude a new concept for a patent. In 2019, Janssen Sciences Ireland and Havard College have a citation value of 0-2.

**Glimpse of Technology Intelligence Reports on Medical devices for Coronavirus**

The Technology Intelligence Report has been prepared using XLSCOUT Data Analytics Platform.

**Top Concepts**

The top concepts include Composition concept, Real Time concept, Surface concept, Treatment concept and Coronavirus concept as presented in figure 6 and tables 7 to 10.

**Concepts and Assignees**

We could observe that Composition concept is focused by Dr. Jyoti Rawat, Dr. Prashant J, Dr. Shamimul Qamar, Janssen Sciences Ireland, Gmailcom Maharashtra India and Mergemeier Steffen (figure 7 and table 12).

**Concept and First Filing Country**

Composition concept is first filed in United States, India, European Union and Taiwan [33,39-41] as presented in figure 8 and table 13.

**Concepts and Potential Market**

As shown in figure 9, we could infer that Composition concept, Real Time concept and Corona Virus concept are the 3 core areas which have potential market in India. Composition concept has captured market in India, China, United States, European Union and Taiwan. While real time concept has market in India, European Union, Hongkong and China. For CoronaVirus concept, potential market is found to be in India and China only.

**Glimpse of R&D Intelligence Reports on Medical Devices for Coronavirus**

**Top assignees**

The top assignees include Harvard College and Toledo University with 2 patent applications each as shown in figure 10.

**Top inventors**

The Top inventors includes Agarwal Anand K, Goel Vijay K, Kim Dong-shik, Lin Boren, Ingber Donald, Leslie Daniel C, Watters

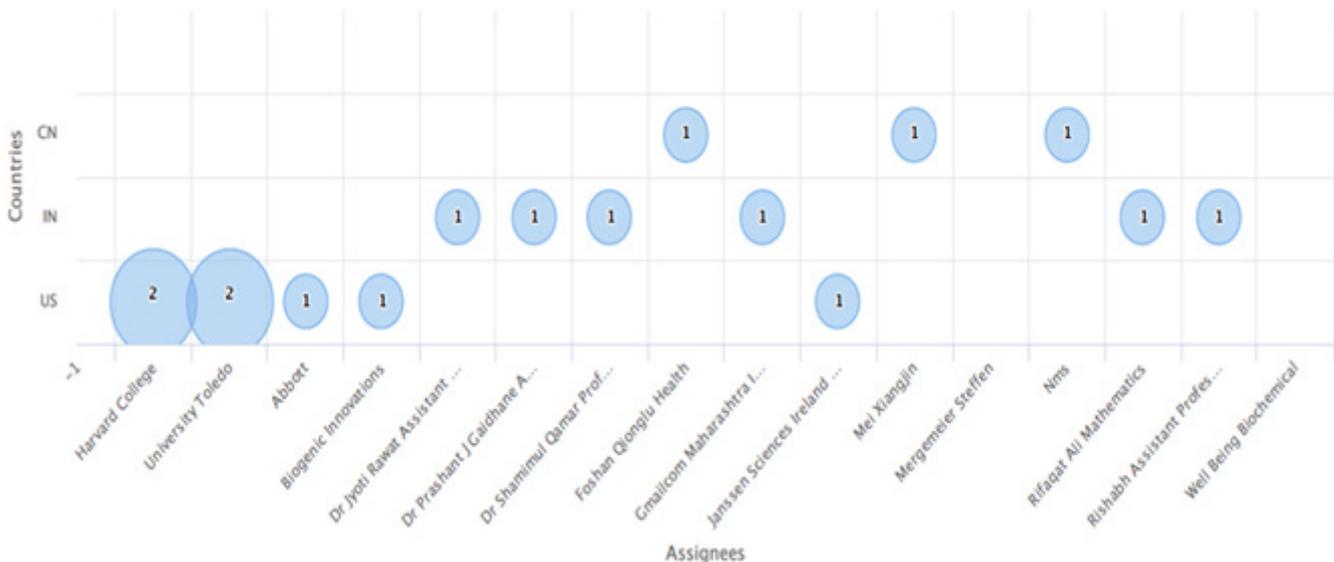
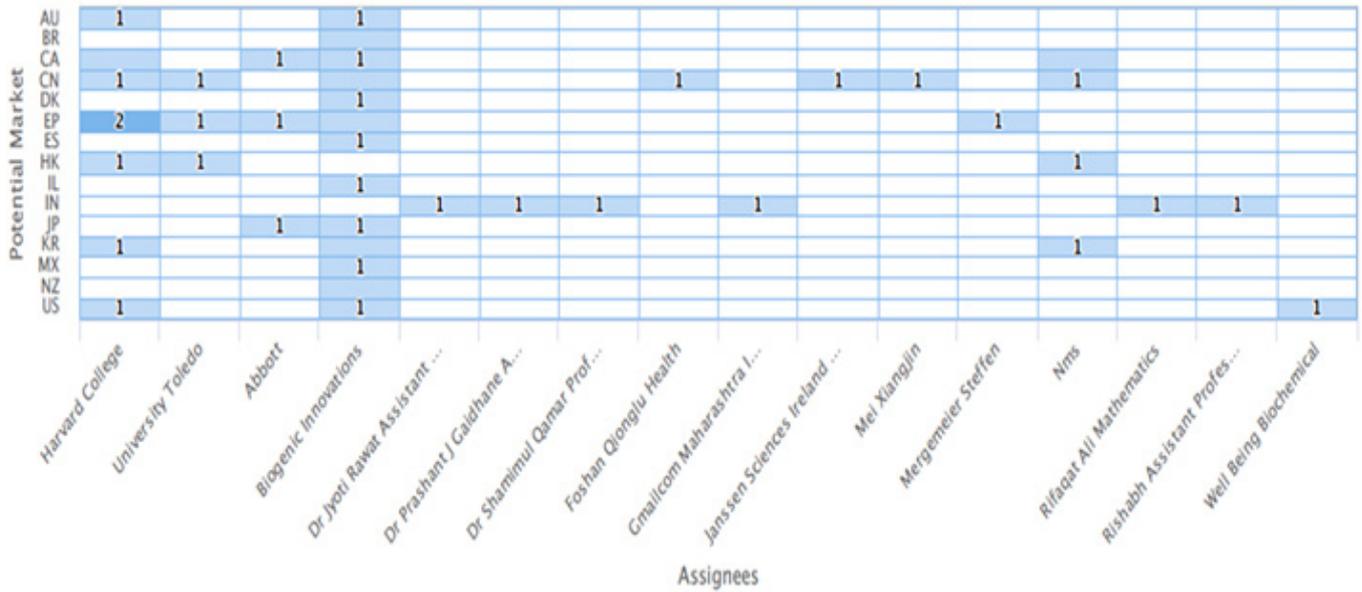


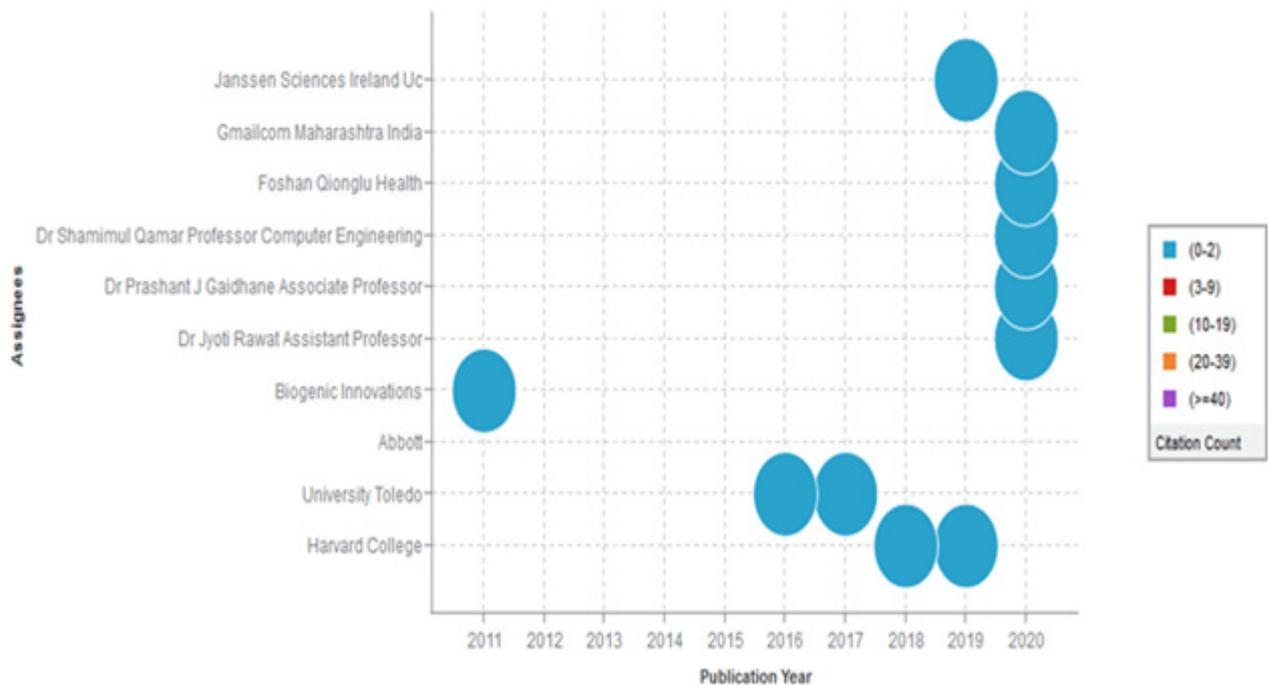
Figure 3: Assignee and first filing country

**Table 6: The patents filed by universities and inventors**

Universities and inventors	Patent number	Title	Ref
Biogenic Innovations	AU2010281739A1	Use of methylsulfonylmethane to modulate microbial activity	[38]
Mergemeier Steffen	EP2376092A2	Polyvinylpyrrolidone as a therapeutically active compound for the treatment and prevention of diseases involving Bacterial, Viral and Fungal Pathogens	[39]
Wellbeing Biochemical Corp	TW200425923A	Antibacterial, Antiviral and Antifungus Composition, its preparation and Use	[40]



**Figure 4: Assignee and potential market**



**Figure 5: Assignees and their yearly publications**

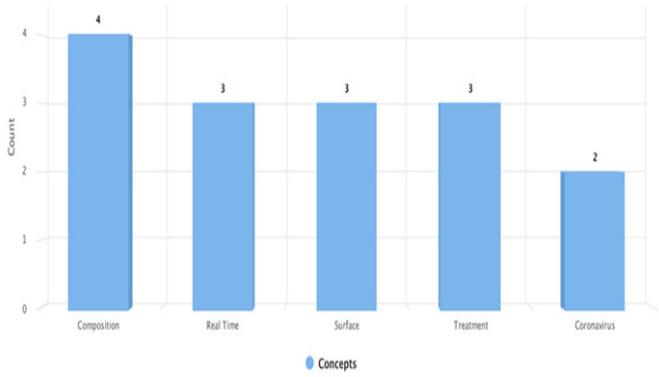


Figure 6: Concepts and core

Table 7: The Patents under composition concept

Patent number	Title	ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
EP2376092A2	Polyvinylpyrrolidone as a therapeutically active Compound for the treatment and Prevention of diseases involving Bacterial, Viral and Fungal Pathogens	[39]
CN110177545A	For Preventing the Polyinosinic acid of the infection of the upper respiratory tract and the preparation of Poly	[33]
TW200425923A	Antibacterial, Antiviral and Antifungus Composition, its preparation and Use	[40]

Table 8: The Patent applications filed under real time concept

Patent number	Title	Ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
EP2972333A1	A biosensor device to target analytes insitu, invivo and/or in Real time and Methods of making and using the same	[32]
WO2017062591A1	A biosensor device to detect target analytes insitu, in vivo and/or in Real time and Methods of making and using the same	[35]

Table 9: The Patent applications filed under surface concept

Patent number	Title	ref.
CA2878060C	Physical AntiMicrobial Method	[42]
AU2017201081B2	Modification of surfaces for Fluid and Solid Repellency	[30]
US10245355B2	Modification of surfaces for Fluid and Solid Repellency	[31]

Table 10: The Patent applications filed under treatment concept

Patent number	Title	Ref.
EP2376092A2	Polyvinylpyrrolidone as a therapeutically active compound for the treatment and prevention of diseases involving Bacterial, Viral and Fungal Pathogens	[39]
CN111388005A	Medical stethoscope 5G audio automatic diagnosis and treatment system and calibration method and auscultation bed	[37]
JP2002511965A	Remote medical care	[34]

Table 11: Patent applications filed under Coronavirus concept

Patent number	Title	ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
CN111573933A	Graphene nano purification system and technology for treating medical sewage containing new coronavirus	[36]

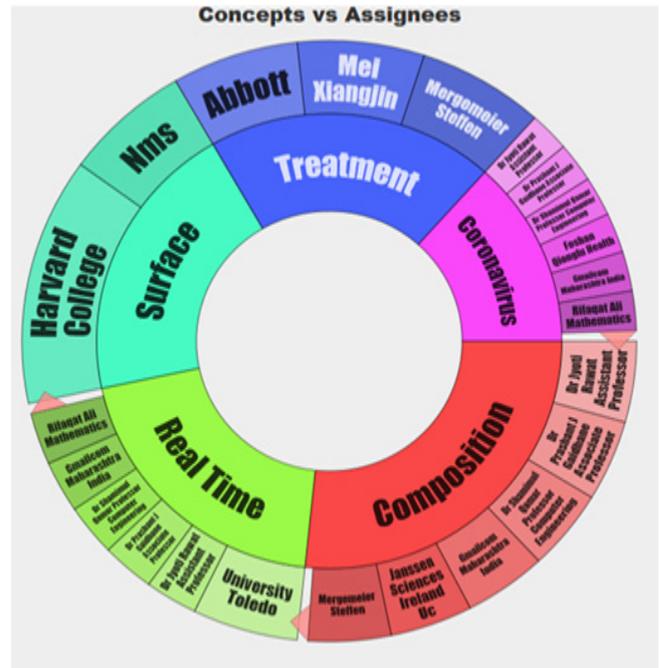


Figure 7: Concepts and assignees

Alexander L, Super Michael, Waterhouse Anna and Dr. Prashant J. All inventors except Dr. Prashant J have filed 2 patent applications each (figure 11).

**Potential market locations**

China has soaring potential for market with 7 patent appeals. Followed by Canada with 4 patent petitions, United States has 3 patent appeals (figure 12).

**Publication country**

There are 3 patent applications published in China, 2 patent applications in European Union and Australia and one each at India, Canada, United States, Japan, and Taiwan respectively (figure 13).

**R&D locations**

United States has been identified to carry out R&D activities for 7 patent applications, followed by China with 3 patent applications. India, European Union and Taiwan have only 1 patent application each (figure 14).

TW	1				
EP	1			1	
IN	1	1			1
CN			1	1	1
US	1	2	2	1	
	Composition	Real Time	Surface	Treatment	Coronavirus

Figure 8: Concepts and first filing country

Table 12: Patent filed by universities and inventors

Universities / inventors	Patent number	Title	Ref.
Dr. Jyoti Rawat, Dr. Prashant J, Dr. Shamimul Qamar and Gmailcom Maharashtra India	IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
Janssen Sciences Ireland	CN110177545A	For Preventing the Polyinosinic acid of the infection of the upper respiratory tract and the preparation of Poly	[33]
Foshan Qionglu Health	CN111573933A	Graphene nano purification system and technology for treating medical sewage containing new coronavirus	[36]

**Filing trends**

Recording of patent appeals has reached maximum in 2014 and 2017 subsequently. While filing of priority applications have reached a peak in 3 consecutive years -2012, 2013, and 2020. Likewise the issuing of patent petitions has reached a pinnacle in 2020 (figure 15).

**Types of applicants**

Companies have recorded 5 patent petitions while universities and

inventors have issued 4 patent appeals each (figure 16 and tables 15-17).

**Application Vs Granted**

Out of 13 Patents, only 3 are granted patents while the remaining 10 are in the application stage [30,31,42], as shown in figure 17 and table 18.

**Top problems addressed by assignees**

Drug Problem: In each and every current practice, the utilization of antimicrobial medicines outcomes in the making of a huge figure of drug-resistant strains (figure 18). In CA2878060C titled Physical

Table 13: Patent application filed for Composition Concept

Patent number	Title	Ref
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
EP2376092A2	Polyvinylpyrrolidone as a therapeutically active compound for the treatment and prevention of diseases involving Bacterial, Viral and Fungal Pathogens	[39]
CN110177545A	For Preventing the Polyinosinic acid of the infection of the upper respiratory tract and the preparation of Poly	[33]
TW200425923A	Antibacterial, Antiviral and Antifungus Composition, its preparation and Use	[40]

Table 14: Patent application filed for Real Time Concept

Patent number	Title	Ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
EP2972333A1	A biosensor device to target analytes insitu, invivo and/or in Real time and Methods of making and using the same	[32]
WO2017062591A1	A biosensor device to detect target analytes insitu, in vivo and/or in Real time and Methods of making and using the same	[35]

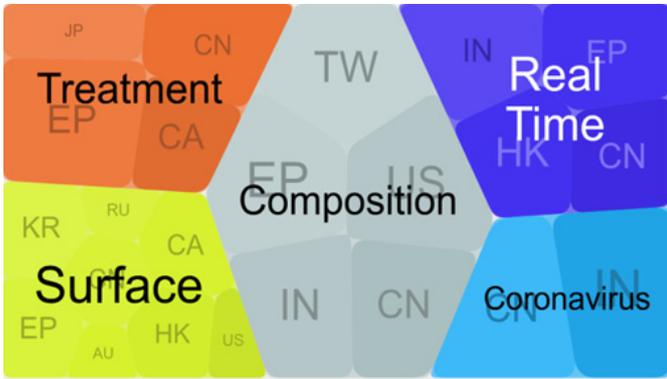


Figure 9: Concepts and potential market

Antimicrobial Method provides a physical antimicrobial method to solve the problem of drug-resistant strains caused by antibacterial drugs by physical methods and the antimicrobial mechanism of the present invention is to rupture E. coli cell membrane by the physical effect of static electricity of charges to thereby inactivating the pathogen. Thus, the difficulty of antidote fight caused by antibacterial antidotes is solved [42].

New Corona Virus Problem: Medical sewage from hospitals holds huge quantity of microbes for example staphylococcus aureus, streptococcus pneumonia, pseudomonas aeruginosa, mycobacterium tuberculosis, Escherichia coli, enterovirus, faecal Escherichia coli, streptococcus of group B, congenital syphilis, etc. Research has shown that the coronavirus survives in the excrement of infected persons and can enter a sewage treatment system

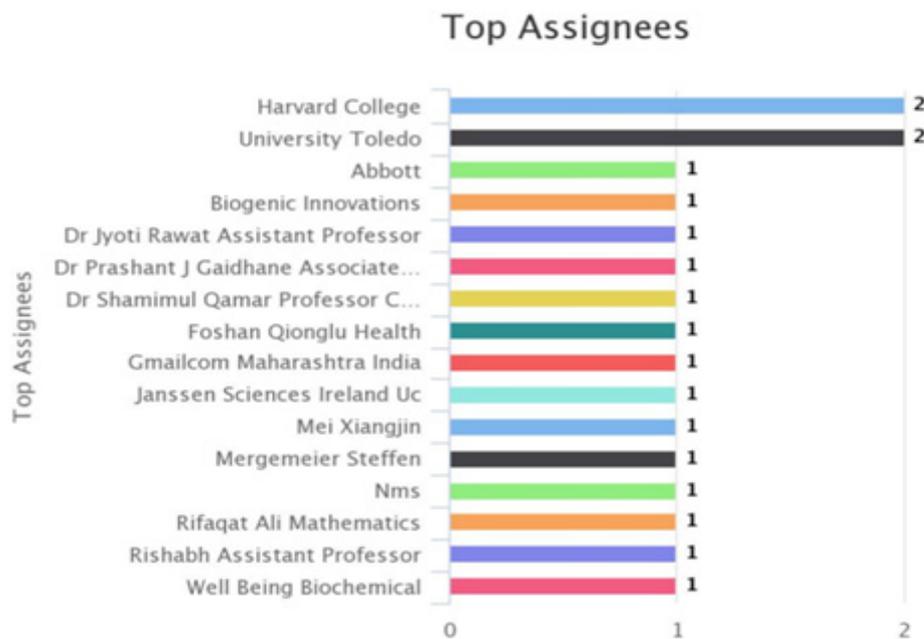


Figure 10: Patents and top assignees

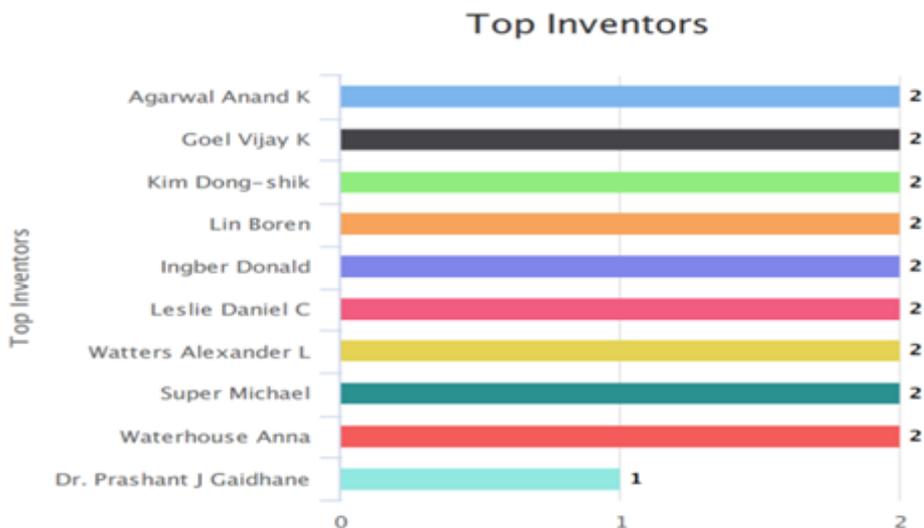


Figure 11: Patents and top inventors

### Potential Market Locations – Family(Map)



Figure 12: Potential market location

through a drainage system, which directly causes medical sewage discharged by infectious hospitals to become a high-risk pollution source. At present, no technology specially aims at the systematic and deep purification of medical sewage containing new coronavirus. In CN111573933A titled “Graphene nano purification system and technology for treating medical sewage containing new coronavirus” provide graphene nano purification system for treating the medical sewage containing the new coronavirus, which can be used for deeply killing and purifying the new coronavirus in the medical

sewage of an infectious disease hospital and make certain that the therapeutic debris of the transmissible sickness outreach the level and is released [36].

### Conclusion

The COVID-19 pandemic is responsible for one of the most serious socio-economic tragedies. This review presents a general view of the recent research studies and current patents dealing with

### Publication Country

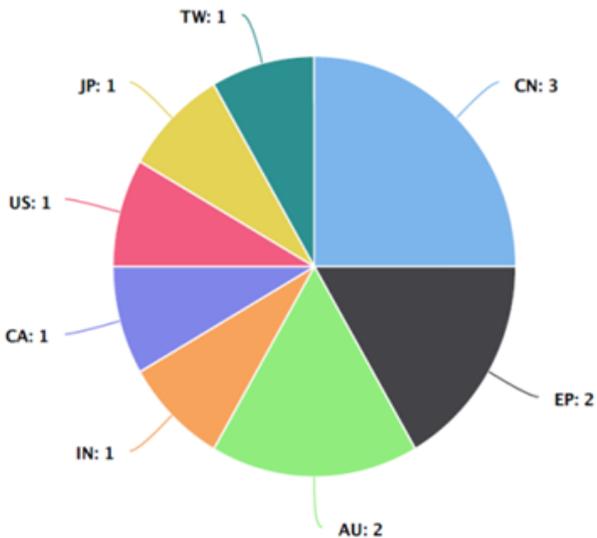


Figure 13: Publication country

### R&D Locations (Bar)

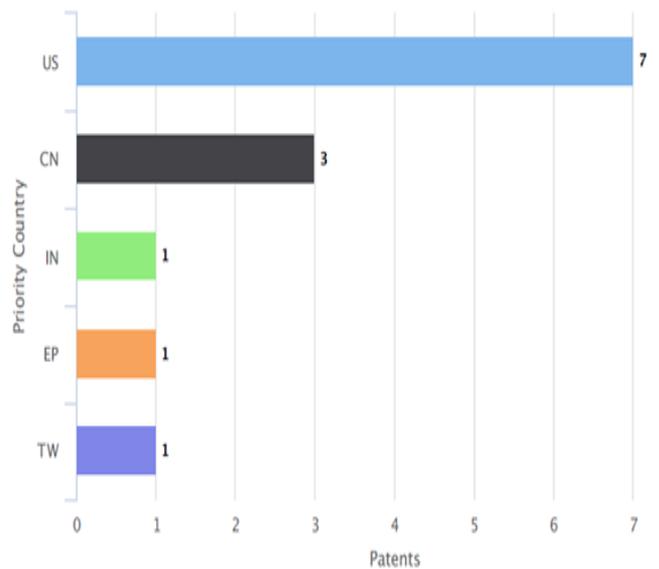


Figure 14: R & D locations

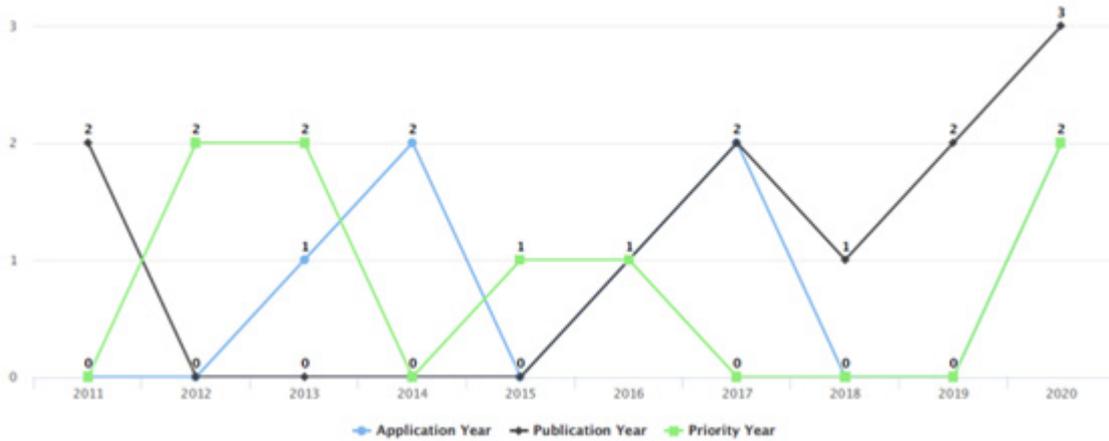


Figure 15: Filing trends

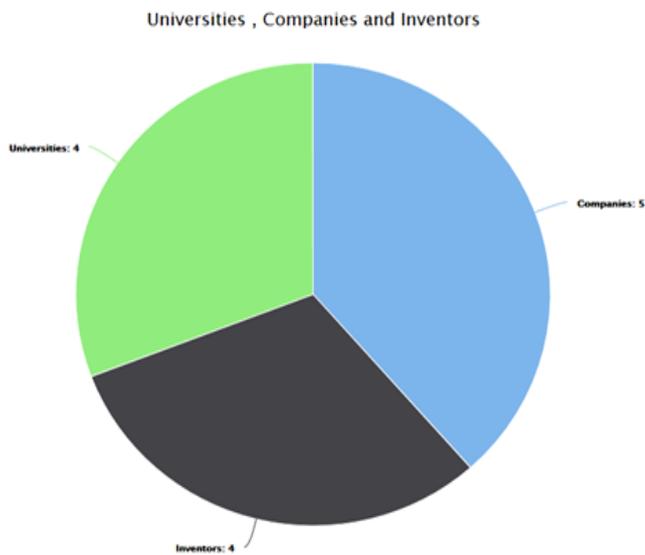


Figure 16: Types of applicants

Table 15: Patent applications filed by companies

Patent number	Title	Ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
CA2878060C	Physical AntiMicrobial Method	[42]
CN110177545A	For Preventing the Polyinosinic acid of the infection of the upper respiratory tract and the preparation of Poly	[33]
TW200425923A	Antibacterial, Antiviral and Antifungus Composition, its preparation and Use	[40]
AU2010281739A1	Use of methylsulfonylmethane (MSM) to modulate microbial activity	[38]

Table 16: Patent applications filed by universities

Patent number	Title	Ref.
EP2972333A1	A Biosensor device to target analytes in situ, in vivo and/or in Real time and Methods of making and using the same	[32]
AU2017201081B2	Modification of surfaces for Fluid and Solid Repellency	[30]
US10245355B2	Modification of surfaces for Fluid and Solid repellency	[31]
WO2017062591A1	A biosensor device to detect target analytes insitu, in vivo and/or in Real time and Methods of making and using the same	[35]

Table 17: Patent applications filed by inventors

Patent number	Title	Ref.
IN202021016563A	Intelligent Methods For Detecting Coronavirus Using RNA, DNA and Share The Real Time Location Using IoT	[41]
CA2878060C	Physical AntiMicrobial Method	[42]
EP2376092A2	Polyvinylpyrrolidone as a therapeutically active compound for the treatment and prevention of diseases involving Bacterial, Viral and Fungal Pathogens	[39]
TW200425923A	Antibacterial, Antiviral and Antifungus Composition, its preparation and Use	[40]
CN111388005A	Medical stethoscope 5G audio automatic diagnosis and treatment system and calibration method and auscultation bed	[37]

Table 18: granted patents

Patent number	Title
CA2878060C	Physical AntiMicrobial Method [42]
AU2017201081B2, US10245355B2	Modification of surfaces for Fluid and Solid Repellency [30][31]

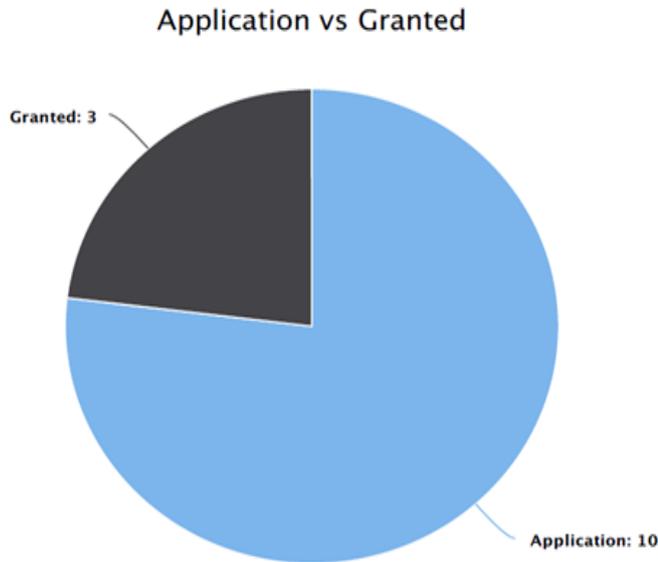


Figure 17: Application Vs Granted

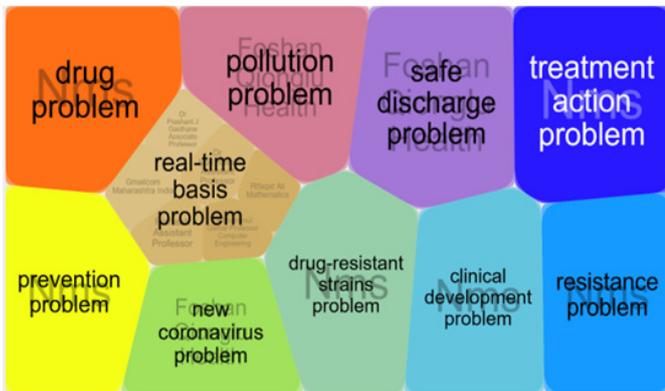


Figure 18: Problems Vs Assignees

aspects of virus diagnosis and treatments, worldwide. The US holds the most patents, as well as the bulk of top assignees and foreign collaboration partners. China is also a prominent inventor nation, playing a key part in the assignee collaborative network. Governments own a large number of patent rights, and academia is also a significant technological force in worldwide cooperation.

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### References

1. Fehr AR, Perlman S., Coronaviruses: an overview of their replication and pathogenesis, *Methods Mol Biol* 1282, 1-23 (2015).
2. Van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN., Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1, *New England Journal of Medicine*, 382, 1564-1567 (2020).
3. Hafeez A, Ahmad S, Siddiqui SA, Ahmad M, Mishra S., A review of

- COVID-19 (Coronavirus Disease-2019) diagnosis, treatments and prevention, *EJMO*, 4, 116-125 (2020).
4. World Health Organization (2020) Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19). [https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE\\_use-2020.2-eng.pdf?sequence=1&isAllowed=y](https://apps.who.int/iris/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2-eng.pdf?sequence=1&isAllowed=y) (accessed 26/03/2020).
5. Li K, Wu J, Wu F, Guo D, Chen L, Fang Z, Li C, The clinical and chest CT features associated with severe and critical COVID-19 pneumonia. *Invest Radiol*, 55, 327-331 (2020).
6. Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T, Zhang X, Zhang L, Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *Lancet*, 395, 507-513 (2020).
7. Chow EJ, Schwartz NG, Tobolowsky FA, Zacks RLT, Huntington-Frazier M, Reddy SC, Rao AK, Symptom screening at illness onset of health care personnel with SARS-CoV-2 infection in King County, Washington. *JAMA*, 323, 2087 (2020).
8. Morais-Almeida M, Pité H, Aguiar R, Ansoategui I, Bousquet, J, Asthma and the coronavirus disease 2019 pandemic: a literature review. *International Archives of Allergy and Immunology*, 181, 680-688 (2020).
9. Nagy A, Stará M, Vodička R, Ěerníková L, Jiřincová H, Kořivda V, Sedláč K., Reverse-zoonotic transmission of SARS-CoV-2 lineage alpha (B.1.1.7) to great apes and exotic felids in a zoo in the Czech Republic. *Arch Virol*, 26, 1 (2020).
10. Oran DP, Topol EJ, Prevalence of asymptomatic SARS. CoV-2 infection: a narrative review. *Annals of Internal Medicine*, 173, 362-367 (2020).
11. CDC, Ending Isolation and Precautions for People with COVID-19: Interim Guidance (2022). <https://www.cdc.gov/coronavirus/2019-ncov/hcp/duration-isolation.html>.
12. Fumagalli MJ, Capato CF, de Castro-Jorge LA, de Souza WM, Arruda E, Figueiredo LTM, Stability of SARS-CoV-2 and other airborne viruses under different stress conditions. *Arch Virol*, 167, 183-187 (2022).
13. World Health Organization (WHO) (2022). (<https://covid19.trackvaccines.org/agency/who/>).
14. Future Trends in Coronavirus Vaccine Market Size, Share and Trends by 2021 to 2030 (2022). <https://marketresearch.biz/report/coronavirus-vaccine-market/>
15. COVID-19 Infection Market: Overview, Market Share, Revenue, Covid-19 Impact on Industry, Growth Rate, Market Dynamics and Forecast upto 2027 (2021). <https://www.pharmiweb.com/press-release/2021-12-15/covid-19-infection-market-overview-market-share-revenue-covid-19-impact-on-industry-growth-rate>
16. Global COVID-19 Infection Market 2021: Future Trends Plans. (2020). <https://www.openpr.com/news/2275716/global-covid-19-infection-market-2021-future-trends-plans>
17. COVID-19 Infection Market Size, Status, Top Players, Trends and Forecast to 2027 (2022). <https://www.marketwatch.com/press-release/covid-19-infection-market-size-status-top-players-trends-and-forecast-to-2027-2022-05-16>
18. COVID-19 Infection Market Recent Trends, In-depth Analysis, Market Size Research Report Forecast up to 2028. (2020). <https://www.digitaljournal.com/pr/covid-19-infection-market-recent-trends-in-depth-analysis-market-size-research-report-forecast-up-to-2028>
19. Innovation and technology in the age of Covid-19. (n.d.). Retrieved October 12, (2020). <https://www.timesnownews.com/technology-science/article/innovation-and-technology-in-the-age-of-covid/592598>
20. Press Information Bureau, Team led by IIT Bombay student develops low-cost mechanical ventilator Ruhdaar (2020). <https://pib.gov.in/PressReleaseDetail.aspx?PRID=1618375>
21. REVA University, REVA varsity unveils affordable ventilator (2020). <https://www.bangalorefirst.in/?p=35697>
22. PTI. Defence Ministry patents low cost PPE developed by Navy in move toward mass production. Retrieved October 12 (2020). <https://theprint.in/india/defence-ministry-patents-low-cost-ppedeveloped-by-navy-in-move-toward-mass-production/421812/>
23. Coronavirus | Northern Railway develops hands-free washbasins for contactless experience-The Hindu (2020). <https://www.thehindu.com/news/national/other-states/northern-railway-develops-hands-free-washbasins-for-contactless-experience/article61945814.ece>
24. COVI-Safe: Transport system for COVID-19 patients made easy. (2020, April 03). Retrieved October 12, 2020, <https://news.abplive.com/videos/news/india-covi-safe-transportsystem-for-covid-19-patients-made-easy-1188141>
25. BMC Installed Phone Booth-Like "Safe Swab" Facility For Safer And Faster Testing Of COVID-19. Retrieved April 7, 2020, <https://>

- www.whatshot.in/mumbai/phone-booth-covid-19-testing-c-21168
26. CoronaOven Paper: This innovative product from Bengaluru startup disinfects currency notes - Here is how it works (2020). <https://www.zeebiz.com/small-business/news-coronaoven-paper-this-innovative-product-from-bengaluru-startup-disinfects-currency-notes-here-is-how-it-works-135580>
  27. IIT Madras-Incubated Startup Launches India's First Indigenously Developed Smart Air Purifier (2018). <https://www.ndtv.com/education/vistar-air-purifier-iit-madras-incubated-startup-launches-indias-first-indigenously-developed-smart-1891618>
  28. Milagrow iMap Max, iMap 10.0, Seagull Robot Vacuum Cleaners Launched in India (2020). <https://gadgets360.com/smart-home/news/milagrow-imap-max-10-0-seagull-robot-vacuums-price-in-india-rs-20000-89990-99990-launch-features-sale-2274564>
  29. This startup by IIT alumni has come up with a contactless monitoring device to fight coronavirus (2021). <https://yourstory.com/2020/04/startup-iit-alumni-contactless-monitor-dozee-coronavirus/amp>
  30. Joanna Alzenberg, Michael Alzenberg, Donald Ingber, Philseok Kim, Daniel C. Leslie, Michael Super, Anna Waterhouse, Alexander L. Watters. 2017. Modification of surfaces for fluid and solid repellency. (2017). <https://patents.google.com/patent/AU2017201081B2/en>
  31. Donald Ingber, Daniel C. Leslie, Michael Super, Alexander L. Watters, Anna Waterhouse. Modification of surfaces for fluid and solid repellency. (2015). <https://patents.google.com/patent/US10245355B2>
  32. Anand K. Agarwal, Vijay K. Goel, Dong-Shik Kim, Do-Young Yoon, Boren LIN, Hamid Feyzizarnagh A biosensor device to target analytes in situ, in vivo, and/or in real time, and methods of making and using the same (2018). <https://worldwide.espacenet.com/patent/search/family/051658931/publication/EP2972333B1?q=pn%3DEP2972333B1>
  33. B. Malcolm R. Wischelsberg. For preventing the polyinosinic acid of the infection of the upper respiratory tract and the preparation of poly. <https://patents.google.com/patent/CN110177545A/en>
  34. Capel, Kimberly Escaningham, Davidson Esseason, Regenld Elgordon, Julian Henning, Timothy Peasthorpe, Stayven Day. Telemedicine (2002). <https://worldwide.espacenet.com/patent/search/family/025399200/publication/JP2002511965A?q=pn%3DJP2002511965A>
  35. Anand K. Agarwal, Vijay K. Goel, Dong-Shik Kim, Boren Lin. A biosensor device to detect target analytes in situ, in vivo, and/or in real time, and methods of making and using the same (2017). <https://patents.google.com/patent/WO2017062591A1/en?q=WO2017062591>
  36. Cheng Jinsheng Wan Weihong. Graphene nano purification system and technology for treating medical sewage containing new coronavirus. (2020). <https://patents.google.com/patent/CN111573933A/en?q=CN111573933A>
  37. Mei Xiangjin (2020). <https://patents.google.com/patent/CN111388005A/en?q=CN111388005A>
  38. Rodney L. Benjamin, Anthony L. Keller, Jeffrey Varelman. Use of methylsulfonylmethane (MSM) to modulate microbial activity (2011). <https://worldwide.espacenet.com/patent/search/family/043922597/publication/AU2010281739A1?q=AU2010281739A1>
  39. Steffen Mergemeier. Polyvinylpyrrolidone as a therapeutically active compound for the treatment and prevention of diseases involving bacterial, viral and fungal pathogens (2011). <https://worldwide.espacenet.com/patent/search/family/041100451/publication/EP2376092A2?q=pn%3DEP2376092A2>
  40. Ji-Ru, Hushu-zhen Cai. Anti-bacterial, anti-viral, and anti-fungus composition, its preparation and use (2005). <https://worldwide.espacenet.com/patent/search/family/033448848/publication/TW200425923A?q=TW200425923A>
  41. [https://patentscope.wipo.int/search/en/detail.jsf?docId=IN297816563&\\_cid=P12-KYY3LR-58340-1](https://patentscope.wipo.int/search/en/detail.jsf?docId=IN297816563&_cid=P12-KYY3LR-58340-1)
  42. Youliang CA. Physical antimicrobial method (2017). <https://brevets-patents.ic.gc.ca/opic-cipo/cpd/eng/patent/2878060/summary.html>