Title	**Searching and Analyzing Patent-Relevant Information for Evaluating Covid-19 Innovation**
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Abstract:	The Covid-19 pandemic has prompted several institutions to offer free, dedicated websites and tools to foster research and access to urgently needed innovation by facilitating the search and analysis of information within the large amount of scientific and patent literature which was published in a very short period of time. This situation is clearly exceptional and challenging for patent information professionals searching for relevant data and disclosures in a reliable manner. This article provides an overview of search criteria and strategies, main databases and websites, origin and number of publications, biological sequence information and experimental data sets covering Covid-19 findings within scientific and patent literature disclosed between January and August 2020. The analysis of non-patent literature is focused on the identification, date assignment, disambiguation, and access to experimental data. The analysis of patent literature is focused on the trends found within the earliest filed and published patent documents as observed in the patent databases, and for the main jurisdictions, worldwide. Some practical advice and strategies for future technical, medical, or patentability assessment of Covid-19-related innovations are suggested by this quantitative and qualitative analysis across information resources.
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1. Introduction

Beyond the human tragedy, the Covid-19 emergency has required large communities and many economic sectors worldwide to pursue their activities in an unprecedented and unpredictable environment. Compared to infectious diseases that have periodically emerged during the last few decades, the Covid-19 pandemic combines many of their features (such as geographic distribution, transmissibility, and pathogenicity) but an impact that is possibly amplified by imbalances and weaknesses of our complex global ecosystems [1]. As of November 2020, the situation in many countries is testing not only the preparedness of their health system for viral outbreaks but also public administrations, education, transportation, communication, and economy as a whole. The public and private research institutions are now called to very quickly adapt their governance and priorities to support innovation, strengthening collaboration efforts to deliver efficient and viable responses to this evident Research and Development (R&D) "gap" [2].

The Covid-19 crisis is also profoundly and abruptly impacting R&D budgets and priorities for financing innovation, pushing for major changes in both high technology and traditional sectors that may affect work life and everyday activities, both locally and globally [3], requiring a much higher level of coordination among national and international Science, Technology, and Innovation policies, as recommended by the Organization for Economic Co-operation and Development (OECD) [4]. As suggested in a survey on innovation and patent activity during Covid-19, companies are quickly adapting their R&D strategies and innovation lifecycle across their organization [5]. In light of such a global and complex challenge, the pharmaceutical & biotech industry has come together to fight COVID-19 in a way that is clearly exceptional, with potentially far-reaching and long-lasting consequences on financial, ethical, and operational policies that apply to the identification and follow-up of subjects with specific medical needs, or to the access to diagnostics and therapeutics. Initiatives such as the "Accelerating COVID-19 Therapeutic Interventions and Vaccines" partnership (ACTIV) shows this unprecedented level of collaborative research among industrial, non-profit and governmental entities worldwide in R&D and clinical activities [6]. Many other initiatives are being established across academic entities worldwide using novel data sharing and cooperation models for aggregating data from clinical sites and research institutions to increase opportunities and anticipate further outbreaks, explore risk factors, validate therapies, or define post-Covid syndromes [7].

Patenting activities contribute to the dissemination of novel technical solutions and products, and of innovation in general. The COVID-19 emergency has also affected activities of patent offices and the overall "patent industry", in parallel to the legislative and regulatory frameworks, as summarized by World Intellectual Property Organization (WIPO) in a dedicated webpage [8] or by the World Trade Organization (WTO) in a working paper about the national patent-related policies in WTO Member states during COVID-19 pandemic [9]. These and other international organizations are reconsidering the health, trade and IP approach in promoting access to medical technologies and innovation to respond to the COVID-19 pandemic and other global health [10,11]. It is difficult to anticipate if and how patent offices, courts, governments and health authorities may decide to enact specific country-specific policies applicable to patent rights or other types of commercial exclusivity for both encouraging innovation and promoting access to it. In particular, human rights issues related to the pandemic and its consequences may affect how intellectual Property (IP) rights will be established and enforced at a (inter)national level, pushing for far more exceptions to legal and commercial policies than those presently applied. Various stakeholder groups are directly or indirectly concerned with IP rights related to the development and manufacturing of technologies and products, with at least partially conflicting attitudes towards open access to methods, drugs, and equipment in the fight against Covid-19 [12,13]. This is a major challenge for present economic and IP models for validating, giving access, and exploiting innovation, with potential unintended, legal consequences, but also new opportunities to share or pledge IP rights for fighting Covid-19 more efficiently [14,15].

Since the official declaration of the Covid-19 global outbreak, many publishers and institutions have made several tools available for extracting and aggregating potentially relevant information from "classical" sources (namely peer-reviewed articles and patent literature) or those less formally defined and structured (unreviewed publications, experimental and clinical data, blogs, information from social networks). Such a situation is obviously made possible by newly available technologies and is hardly comparable to past viral outbreaks (for instance Ebola virus or AIDS), in terms of dimension and speed. This continuous stream of publications of uneven quality, consistency, and completeness has far-reaching consequences on the attitude of public opinion towards institutional communications. The Covid-19 global impact has motivated some people to find support within patent literature to conspiracy theories about plans to create this pandemic, as reported for Twitter communications [16]. For instance, some French websites indicated a European patent filed in 2004 (!), referring to a coronavirus strain that was isolated in Hanoi (Vietnam), as the "Coronavirus Patent" (Figure 1).

In this fast-moving situation, this article intends to provide patent information professionals with an overview of criteria, data, and sources useful to Covid-19 searches as made available until November 2020. Moreover, an analysis of major sources of patent and scientific information (including biological sequences and non-textual datasets for drug and diagnostic development) was performed for the period between January and August 2020, summarizing some qualitative and quantitative features of Covid-19 information that has been created and disclosed in this period. In particular, main features of the earliest published patent publications that refer explicitly to Covid-19 were reviewed, suggesting some key issues to be taken into consideration for establishing strategies, when searching for and using patent information in this domain.

2. Methodology

The databases and webpages cited from the websites of the aforementioned scientific publishers, patent offices, or other institutions were initially accessed, searched and reviewed for this article during July and August 2020. The final data reported in tables and figures covering publications in the period between January and August 2020 were generated using the indicated search strategies and databases between September and October 2020. All the website addresses, references, datasets, databases, and contents herein are cited as available on Nov. 30th, 2020.

The details of webpage names and address for searching non-patent literature, clinical information, experimental data, and biological sequences cited in Sections 3 and 5, are listed in Table 1. The scientific literature that was published during the period Jan.-Aug. 2020 and explicitly citing Covid-19, or relevant synonyms, in the title, abstract, and/or indexing was extracted from PubMed and The Lens Scholarly Works. The results of searches were downloaded in csv or xlsx format, manually reviewed, compared to each other and to the published Covid-19 datasets (as indicated in Section 3), normalized for format, and consolidated using a spreadsheet in files listing the main bibliographic and indexing details. These files have been used to generate Tables 2-3 and 9-10 and Figures 2-4 and 8-9.

The details of providers, webpage names and Internet address for searching patent literature cited in Section 4, are listed in Table 4). Covid-19-specific criteria that are presented in the cited patent databases for establishing relevant datasets commented in Section 4, are listed on the website as indicated in Table 5. The patent documents that explicitly cite Covid-19, or relevant synonyms, in the title, abstract, and/or claims and that were filed and published during the period Jan.-Aug. 2020 were searched for in the following databases and websites: Derwent Innovation, Patentscope, DepatisNet, Lens Patents, Espacenet and EP Full text Search (both available in the EPO website). The search results were downloaded in csv or xlsx format, 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, Russia, and Spain). The format of the patent data was normalized and consolidated using a spreadsheet into a single xlsx file (the "Early Covid-19 Patent Dataset") that contains the references to 1130 patent documents, including their publication numbers, type of document, title (in English and/or in the original language), details on the patent classification as IPC Groups (when available), relevant dates by month (earliest priority, publication, and grant), range in the number of days between earliest priority date and publication and/or grant date (in 15-day intervals), and technological field (as identified on the basis of available IPC Groups and/or title). This xlsx file was used to generate Tables 6-8 and Figures 5-7).

Additional details are provided in the text commenting on the tables and figures.

3. Profiling Covid-19 Scientific Literature and Data as Published in Jan.-Aug. 2020

Covid-19 Scientific Information: Providers, Dedicated Websites and Nomenclature

Many private, public, and academic providers of scientific information have responded to the Covid-19 crisis, and the flow of new research findings and publications as well as interest from a new, enlarged audience, by quickly adapting their own websites and databases throughout 2020. A review of the main webpages or portals dedicated to the Covid-19 scientific literature has been performed, consolidating the URLs in Table 1. The content of some freely available databases has been compared (Figure 2) to highlight those providing access to the largest repository of documentation that is selected as being relevant for Covid-19. These documents are mostly regular scientific articles and books but, in many cases, other types of disclosures are also extracted and included: preprints, news, reports on clinical activities, experimental datasets, and other electronic-only disclosures. These absolute figures regarding the size of these databases should not be used to make any conclusion or to rank such resources accordingly, as many other criteria should also be taken into consideration. Examples of such features include the coverage (i.e., any coronavirus research or data published even before 2020, or focused only on Covid-19 findings in 2020); the list of keywords and other selection criteria that have been used to establish the database; the available features for searching for and extracting either specific information or full text documents; the frequency of updates, or the reliability in checking for duplicates, format, or completeness of contents. This continuous stream of publications of uneven quality and consistency also has far-reaching consequences on public opinion towards institutional communications. Phenomena such as misinformation, information overload, or "*infodemics*" may encourage people to question not only the scientific peer-review systems but also the respect of measures that health authorities and governments are trying to apply and enforce, and it is itself becoming an area of study [17,18].

A major challenge for the patent examination and evaluation may come from the many, possibly conflicting sources about the content and date of disclosure of Covid-19 information. As a preliminary step, patent information specialists should verify which scientific keywords are the most appropriate to search for Covid-19 disclosures in scientific or patent literature. Similarly to previous situations where a novel entity of major importance is identified by different people and, therefore, competition for establishing some kind of primacy or leadership starts, the process of naming Covid-19 biological and medical concepts to be consistently and univocally used in literature and databases (and thus also to be used for future searches) has not been linear or fully standardized. Until 2019, six main coronaviruses were known to infect humans: HCoV-229E, HCoV-OC43, HCoV-NL63, HCoV-HKU1, severe acute respiratory syndrome (SARS-CoV-1), and Middle East Respiratory syndrome (MERS-CoV), As summarized in the World Health Organization (WHO) website [19] and in one of the many reviews about this topic [20], the infectious agent responsible of the novel pneumonia detected in

Wuhan, China, during December 2019 was described as a new coronavirus (CoV or nCoV; order Nidovirales, Family Coronaviridae, Subfamily Coronavirinae, and Genus Betacoronavirus) and thus initially named as "2019 novel Coronavirus", "2019-nCoV" or "Wuhan coronavirus". Only in early February 2020 this novel Coronavirus was defined as SARS-CoV-2, meaning "severe acute respiratory syndrome coronavirus 2", to make this virus distinguishable from "SARS-CoV-1 which was isolated as the agent responsible for outbreak with less dramatic consequences in 2002-2004 and present some sequence similarity. It was also agreed that the illness caused by SARS-CoV-2 and overall symptoms of the SARS-CoV-2 infection should be called COVID-19 (meaning "Coronavirus Disease 2019").

Even a quick search in the scientific literature shows that not only the variants of the official names or acronyms of the virus and the disease are used (for instance Covid-2019 or SARS-CoV2) but also that more generic names found in newspapers, websites, or social networks such as SARS, Coronavirus, Corona, or Covid are becoming quite common. Moreover, aside from potential ambiguity with respect to previously identified Coronaviruses (such as SARS, MERS, or SARS-CoV-1), further sources of confusion may affect the recall and precision features of a search in a large, general database or when using full-text search engines including the names of companies similar to Covid or SARS, and some acronyms used in scientific literature. Examples of such potentially confusing acronyms are NCO-based acronyms referring to Cyanate (NCO) chemical group or CoV-based acronyms referring to Coefficient of Variation (NCoV may be used to indicate "Naïve Coefficient of Variation").

This problem was recognized by databases providers, starting from the alternative names that the National Center for Biotechnology Information (NCBI) has listed for official scientific indexing (Severe Acute Respiratory Syndrome Coronavirus 2, SARS-CoV-2 [21]and Covid-19 [22]), some of the websites listed in Table 1 provide users with details of the criteria that have been used for creating literature listings. Main examples are the listing of websites and databases updated regularly by the EPPI (Evidence for Policy and Practice Information)-Centre [23], the search criteria indicated for searching EuropePMC_[24], or the list of keywords that were used by the Center for Disease Control and Prevention (CDC) to consolidate a database for Covid-19 literature covering several sources and integrated in the WHO Global Literature on Coronavirus Disease webpage in October 2020 [25].

The analysis of search criteria in the pages cited above together with the browsing of search results looking for sources of potential name variants (alternative spellings, acronyms, or even typos), has been used to establish a list of Covid-19 keywords that were categorized into five Groups (Table 2):

(1) Main names and acronyms, with the most frequent variants;
(2) Alternative phrases referring to "novel coronavirus" and other elements from Group (1);
(3) Phrases or keyword combinations referring to coronavirus identified in Wuhan area;
(4) Short acronyms related to SARS or CoV;
(5) Coronavirus in general.

The Group (1) criteria includes the most relevant criteria that would present the lowest possibilities of confusion with other topics such as Coronaviruses other than the SARS-CoV-2 or even completely different topics, for keywords categorized under Group (4) criteria in particular. However, it is important to point out that the different criteria categorized in Group (2)-(5) criteria, as well as new ones may appear in the next future would still be relevant for elaborating on search strategies for performing the most complete Covid-19 prior art search. However, the search results obtained using these latter criteria may call for a specific review for evaluating their actual relevance or may be filtered by combining these results with other criteria such as imposing a publication date later than Dec. 2019 or adding names of authors, institutions, compounds, or medical topics related to Covid-19.

Analysis of Covid-19 Scientific Publications in PubMed and in Other Databases

A detailed bibliometric analysis of the Covid-19 scientific literature is not an objective of this article. Some articles have been published throughout 2020 in which detailed analyses of scientific production have been pursued using various criteria and visualization approaches for selecting databases and sources, selecting and combining search criteria, categorizing and linking publications, focusing on the production of specific countries, institutions or authors [26-30]. It may still be useful for patent information specialists to evaluate which publication or indexing details are relevant when examining a publication before or after a given date. A good starting point is the PubMed database in the NCBI website, possibly the most commonly used free database for biomedical non-patent literature that indexes publications with Medical Sub-Heading (MeSH) system and that has been updated in 2020, independently from Covid-19 crisis, with a new layout and some new features [31].

The Covid-19 pandemic has prompted not only the introduction of two distinct Supplementary Concepts in PubMed MeSH system ("severe acute respiratory syndrome coronavirus 2" and "Covid-19"; [32]) but also to change own policies for including preprints [33] for supporting rapid identification and assessment of relevant scientific publications, whatever names and keywords authors have used. A previous paper [34] compared the total results obtained by combining different types and formats of keywords until mid-June 2020. Our analysis has taken a different approach by considering both the global number of entries in PubMed and the indexing speed in PubMed during a nine-month period from Dec. 2019 (when Covid-19 literature was absent) until Aug. 2020 (Figure 3). The results were generated by comparing the Group (1) criteria with other criteria described above but referring specifically to the entry month, i.e. the month when the article is indexed in PubMed, independently from the official publication date). This approach, focusing on the actual availability and searchability of the scientific literature in PubMed, shows that less than 80 entries are found in Dec. 2019 (and less than 900 entries for the whole year 2019) by searching PubMed for "Coronavirus", while in 2020 several thousands of publications relating to Covid-19 Group (1) criteria have been entered each month, at least since April 2020. These data are compared not only with those obtained by including Covid-19 Group (2)-(5) criteria but also with overall PubMed entries, indicating that this rapid increase has made Covid-19 the topic of almost 9% of all entries in PubMed in Aug. 2020. This number of publications largely outweighs the newest publications about other important medical topics, such as malaria which is still a major health problem at least in some parts of the world. It is also important to observe that, even if only a small number of publications is identified by using the Covid-19 Group (2)-(5) criteria, an important percentage of the publications presenting the Covid-19 Group (1) criteria in the title or abstract are not indexed with either specific MeSH Supplementary Concepts. This number of such publications significantly outweighs the number of those indexed with the MeSH Supplementary Concepts, specific for Covid-19, even two months after the publication date. When elaborating and performing searches in PubMed, it is consequently important to take into account this delayed and possibly incomplete indexing process within PubMed, which may be pursued retrospectively over several months after an article is formally added into the database.

The importance of integrating at least main name variants when drafting Covid-19 search strategies in PubMed (and possibly in other scientific or patent databases) is suggested by other qualitative and quantitative observations upon Covid-19 searches in PubMed summarized in Figure 3. For instance, since Apr. 2020 the number of publications found in PubMed with Covid-19 Group (1) criteria reaches around 70% of those indexed for a broad health subject such as cancer. An important fraction of publications is indexed for both cancer and Covid-19 Group(1), indicating the interest in evaluating the impact of Covid-19 on the medical management of other pathologies such as cancer, a topic which has recently been reviewed [35] and which may become of interest also for patenting activities. A further topic of interest is also how the increase in Covid-19 during Aug. 2020 may actually be a consequence of a specific review process, with previously published documents that have been recently added (or newly indexed) in PubMed during a short period of time. LitCovid, the NCBI webpage proposing a subset of PubMed entries intended to be specific for Covid-19 [36], shows weekly data confirming that a peak of more than 4300 Covid-19 publications were entered in the last week of August 2020, while approximately 2000 Covid-19 publications are regularly entered in PubMed every week since May 2020 until Nov. 2020. Other discrepancies were observed, for instance, with respect to one of the first articles about Covid-19 pandemic, highlighting the potential for international spread via commercial air travel of a *"pneumonia of unknown aetiology"* that is indicated in PubMed as having its earliest date on Jan. 17th, 2020 [37] when the journal website indicates the publication on Jan. 14th, 2020 [38]. These observations confirm how it is important to carefully verify the official publication date of search results in PubMed, when required for patent evaluation, given the variable discrepancy or delay (from a few days up to several months) between such date and the other information about dates for a given article in this database, thus potentially impacting both actual searchability of articles within PubMed and the conclusions about applicable prior art.

The relevance of observations made for Covid-19 publications in PubMed, in the period between Jan.

and Aug. 2020, can be compared with the features of datasets available from other providers of Covid-19 scientific literature. Three other Covid-19 scientific literature datasets were used for comparison: the scientific publications that can be extracted using the Covid-19 Group(1) criteria from the databases of scientific publication present in The Lens Scholarly Works website [39], the Covid-19 database [40] that was established by CDC in March 2020 until October 2020 (when it was integrated within the corresponding resource in the WHO website), and the dataset published together with a publication about Covid-19 scientific publications [41]. All three providers list PubMed as a source of the literature but it is interesting to evaluate how much they actually overlap with PubMed (and with each other) and how many and which type of references may be additionally found in these datasets which integrate other sources but this analysis for aggregating or disambiguating references in the literature is extremely difficult. Given the different format of authors' names, titles and/or bibliographic details among databases, the references common to two or more sources can be precisely defined on the basis of identification codes such as the PubMed ID (PMID), the PubMed Central ID (PMC), or the Digital Object Identifier (DOI) only. If the identification codes for references extracted from PubMed were fairly complete and reliable, the situation is unfortunately quite different for documents that are selected in these other sources as being relevant for Covid-19, mainly because a large fraction of references in these databases do not list, or list in incorrect format, such identification codes, leading also to potentially duplicated entries. Moreover, the date indicated in these four datasets, when exported or searched, can be either the entry date (in the database) or the publication date (as provided by the source or publisher, either as in electronic or printed format).

Still taking into account such limitations, it is possible to make some quantitative and qualitative evaluation of Covid-19 publications made available through these four sources using Covid-19 Group (1) criteria for extracting them (Figure 4). At the total number of references, The Lens Scholarly Works and the CDC datasets provide at least double the references present in PubMed (even if there are some duplication and uncertain identification issues). The trends over the first eight months of 2020 show how the datasets in the article and in The Lens Scholarly Works, which were meant to cover the period until Aug. 2020, do not include all the latest Covid-19 publications already included in PubMed. A further analysis can be carried out for the origin of publications indexed in different databases. As expected, the majority of publication sources extracted from PubMed, and almost entirely included also in the other three datasets, are leading publishers of biomedical and scientific literature, preprint services (bioRxiv/medRxiv) [42], or open access publishers (PLoS) [43]. Together with some specific publications in scientific domains such as epidemiology, virology, or environment, this selection of journals comprises approximately 15% of all Covid-19 publications that were indexed in PubMed during Jan.-Aug. 2020. A summary of additional sources found in the scientific literature datasets other than PubMed was made (Table 3). Aside from undetermined references , the datasets obtained from CDC and Lens.org include publications from a wide range of sources of potential interest depending on the specific objective of the search: additional preprints or open-access publication platforms, journals having more limited distribution (and often published in a non-English language), reports and communications from institutions, journals in domains other than purely biomedical ones (generally covered by PubMed in a limited manner), or references to clinical trials.

This analysis of scientific publications by means of the proposed groups of Covid-19 search criteria and the databases selection is far from being complete but still provides some insights and issues relating to the search and analysis of Covid-19 scientific literature in general and for patent evaluation. The extension of the search in two or more databases is even more fundamental than usual in order to appropriately cover literature potentially relevant for evaluating the patentability requirements of inventions claimed as being useful for fighting Covid-19. However, the patent information specialist should be particularly careful to a number of details when searching in general or Covid-19 dedicated databases of scientific literature datasets. On one hand, the choice and the evolution of names or keywords used by investigators since the beginning of the pandemic should be attentively evaluated. On the other hand, database and specific datasets containing such literature may differ quite significantly for both their coverage and overall searchability in terms of indexing, presence of identification codes, search tool, and delay from official publication date.

The continuous flow of several thousands of Covid-19 articles published each month since April 2020 is making the search in databases with already existing problems of quality, consistency, and formats even more difficult. It should also be highlighted that preprints, or even publications that were made hastily available through websites and databases without a proper peer- and publishing review, may later on be republished with modifications, or even retracted, as already indicated in a dedicated webpage [44]. A further uncertainty remains about whether and how these datasets will be maintained in the future to allow patent information specialists to evaluate prior evidence correctly with respect to current legal standards. This situation may evolve in the future towards a more structured and integrated way of making available scientific publications, as the later creation of the Covid-19 literature database in the WHO website suggests. These recent events further justify specific attention when searching for, re-extracting, or maybe even saving copies of all relevant Covid-19 information as available at a given date, if to be considered at a later time during the patent proceedings or legal challenges. For instance, the notice of concurrent patent filings or license is mentioned within the dedicated section of the text for a number of Covid-19 articles published in high impact factor journals that oblige authors to notify potential conflict-of-interest or financial matters related to the content of article. This information is unfortunately irregularly, or not all, indexed in PubMed entries introducing a specific search field (Conflict of Interest Statements) and thus it is hardly searchable and quantifiable without a detailed article-by-article analysis, but it may have a patent or business relevance.

Expanding Covid-19 Scientific Literature: Business, Clinical & Experimental Information

Additional resources for Covid-19 information beyond scientific literature databases may be important to identify details relevant to expand the search criteria and provide patent information users with more complete reports. This consideration applies to requests for searches that are related not only to getting a more global coverage of a specific product or technology but also to the origin or confirmation of statements found within the huge amount of information about Covid-19 on social or general media that may have received more or less deserved attention.

A first example of such resources are dedicated websites of journals with a structured and commented-on selection of Covid-19 medical and scientific news reports, where further details relevant to patent-related topics may be found for products and technologies that investigators and entities may disclose in parallel or even before the actual scientific publication. Major scientific publishers such as *Science* [46], *Nature* [47], *JAMA* [48], or *BMJ* [49] have consolidated news, links, and other contents within a specific webpage in their portals, covering their own and other publications. Other information webpages have established fully or partially free portals to consolidate their articles and news coverage where the economic or business aspects are also reported with potentially useful details and insights. Among them, the dedicated webpages of *The Economist* [50], *The Scientist* [51], *Genetic Engineering News* [52], and *Bioworld* [53] are worth a mention for their generally higher standards in selecting and reporting specific Covid-19 news, often covering both scientific and business details not always present elsewhere.

A second example are the websites reporting clinical trials, and in general the activities that clinical institutions have established to validate findings of diagnostic and therapeutic relevance in human subjects. These trials are cited in scientific publications or news but not always reported in a detailed or updated manner. The search and analysis of such clinical information that is disclosed between the initial discovery and the much later formal publication of clinical results at conferences or in journals has always been difficult due to the wide variety of completeness, standards, and search features in dedicated databases. The Covid-19 crisis has provoked an intense interest from a large audience in any clinical progress in this field, even at most preliminary stage, and this has pushed traditional providers of clinical information to consolidate and update data on Covid-19 clinical trials in a more complete and transparent manner. The main website covering clinical trials worldwide, Clinicaltrials.gov, has established specific webpages with a summary [54] and an indexing system [55] for Covid-19 clinical research. Similarly, the EU Clinical Trials Register has specifically indexed the protocol and results information on Covid-19 clinical trials, especially those conducted in the European Union [56]. Updated listings and links to national clinical registries are also accessible through the International Clinical Trials Registry Platform at WHO [57]. Several authors have also started to pursue further detailed analysis of clinical trial protocols dedicated to Covid-19, extracting data globally [58], for specific categories of drugs such as antivirals [59], or at a national level such as in India [60] or China [61]. Additional information resources associating clinical research and official reviews for drug authorization can be found in the dedicated pages of the Food & Drug Administration (FDA) [62] and the European Medicine Agency (EMA) [63],

A third example is experimental data that authors cite in a publication but are not fully reported in the corresponding official PDF file as searchable full text, tables, or graphics of the document. This definition covers multimedia contents (for example, videos or audio descriptions of protocols), structural information of chemical or biological compounds (as sequence or bi- or tri-dimensional representations), and information related to experimental values as originally defined and measured over a number of samples (such as inhibitory, stimulatory, or antiviral activity) or in a human population (such as clinical or epidemiological data). Such data may be provided by the authors by means to either links in the corresponding webpage of the publication or to a stand-alone file within a dedicated public repository. These types of disclosures are generally briefly cited in the official text of the article as supporting information, supplementary materials, or otherwise, and made available to readers for further analysis as links to web-only material in various formats (PDF or Word files, csv/xlsx Excel-compatible files, txt or xml files, or other data-specific formats that may be not easily used). The experimental data or other files associated with a publication within an article may be extracted and compared only by reviewing the webpage of the article. At most, only specific databases, such as PubMed or PMC have an "associated data" filter that would allow searchers to identify articles with information such as secondary sources [64], but this feature does not guarantee that all articles with additional files will be selected.

This publication trend started in the early 2000s, in parallel with pressure upon authors and publishers for more transparency about the access and quality of original data used for a publication. Accessibility and extensive applications of technologies allow for the generation and elaboration of an exponentially increasing amount of data, even though the actual impact and use by authors of such raw data is not well studied in the literature apart from a few studies relating to specific biomedical topics or journals [65]. Indeed, similar files, in alternative formats and/or versions, can be uploaded by authors even in locations other than the publisher's website, such as webpages or repositories that are maintained by various universities and organizations. Obviously, a number of Covid-19 articles have also been published alongside similar additional files, for example an article that provides readers with a supporting spreadsheet file summarizing predicted or experimental binding affinities of more than 8000 compounds as candidate inhibitors of a SARS-CoV-2 protease [66].

Some websites have tried to consolidate such data in electronic repositories where these files, and other datasets made available by investigators independently from any publication or submission as preprint, are aggregated in a more or less organized manner into databases, allowing data mining across documentation in various formats. Among these searchable databases listed in Table 1, the most interesting are COVID-19 Open Research Dataset (CORD-19 [67]), established by Allen Institute for

Artificial Intelligence (but available from SemanticScholar website and searchable using AWS, TIManalytics, or Vespa search engines), Mendeley Data, Zenodo, GitHub, Figshare COVID-19 research data, and Google COVID-19 Open Data.

Finally, biological sequences or chemical coordinates are exceptions since authors can make use of well-established, dedicated databases that are freely accessible worldwide and allocate definitive and unique accession numbers to the data that is deposited for each molecule. The investigators can use this information and indexing in their publications and for searching specific entries by applying text, sequence, and/or chemical information criteria (further details are provided in Section 5 below).

4. Extracting and Comparing Covid-19 Patent Literature as Published in Jan.-Aug. 2020

Covid-19 Patent Information: Providers and Criteria

Since the official announcement of the Covid-19 outbreak in Feb. 2020, patent offices have started a series of initiatives to support applicants and general users of patent system, with the formalities, the payments, the filing 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. These initiatives were often associated by patent offices with actions aimed at facilitating the filing and examination of new patent applications relating to Covid-19, as well as the access to patent information in the Covid-19 field, including those pertaining to equipment and drugs relevant for coronavirus and pandemics in general.

The World Intellectual Property Organization (WIPO) has started providing patent information users at large (investigators, companies, policymakers) with information collected from patent offices worldwide, reports, and specific tools. As indicated in the WIPO general webpage about Covid-19 [68], this assistance is intended to support the UN General Assembly Resolution on "*global solidarity to fight Coronavirus disease 2019 (COVID-19)*" [69], and its *"Calls for intensified international cooperation to contain, mitigate and defeat the pandemic, including by exchanging information, scientific knowledge and best practices".* Together with the COVID-19 IP Policy Tracker [70], the WIPO website also provides users with a glossary containing key concepts related to the technologies applicable to Covid-19 in English and nine other languages [71] and a dedicated COVID-19 Search facility within their own patent search tool Patentscope [72]. Similar initiative taken by WIPO as well as other patent offices have been reported in *World Patent Information* [73,74] and reviewed in this Section together with other patent information tools identified by authors in the websites of patent offices and listed in Table 3. The related links are provided in Table 4.

The tools and quick comments of Table 5 are clearly not exhaustive, and they will need further evaluation by patent information users in the coming months, but some general observations can be made, also in view of the benchmarking made in a presentation at EPOPIC 2020 [75]. It should be noted that the two major patent offices - the United States Patent and Trademark Office (USPTO) and the Japanese Patent Office (JPO) - have preferred (at least until end November 2020) not to establish any specific search facilities on their websites, preferring to concentrate on a series of procedures and programs providing support to inventors and patent applicants as indicated in a joint statement issued in June 2020 [76]. These patent offices have proposed compiling a database of patent licensing data, as the one accessible through the USPTO's COVID-19 Response Resource Center [77]. A further observation is that the Covid-19 patent search facilities can be divided into those providing users with full details about the search criteria used to generate the datasets on their websites (thus, giving the possibility to adapt them to users' needs) and those not explicitly describing the criteria used to establish and update their datasets. The first category includes only the dedicated patent search tools in WIPO (Patentscope), EPO (Espacenet), IP Australia, and The Lens Patents. Aside from patent offices, the Lens.org and Medicine Patent Pools websites provide users with patent datasets that are either covering biological sequences (in the former) or are more drug-focused (in the latter). In general, all such listings broadly cover products and technologies applicable to Coronaviruses, other virologic pathogens, and epidemics, without imposing any time limit.

The analysis of the patent literature related to Covid-19 has been pursued by some authors mostly for pre-2020 patent filings, sometimes combining references from scientific literature and patent-based findings about coronavirus on the basis of previous outbreaks caused by SARS-CoV-1 and MERS-CoV, that still require confirmation as being applicable during this pandemic These publications are not always describing the search criteria and methodology used to establish their selection of patent literature starting from technical information and needs related to Covid-19. For instance, some publications have focused on potentially relevant patent filings related to vaccines and other drugs of various natures, highlighting some relevant chemical structures and patent classifications [78,79], antiviral strategies involving small molecules and biologics [80-83], natural compounds with anti-viral properties [84], or in specific domains such traditional Chinese medicine [85], and nanotechnologies [86]. Two blogs have published short evaluations of the USA situation with respect to the Coronavirus-specific US patent filings [87] or of the overall number of US patent filings during 2020 [88].

It is not easy, when comparing the features and outcomes of the search strategies proposed in these publications (where available) or in the free patent information facilities listed above, to evaluate which are most interesting for future searches. However, it seems interesting to consolidate the search strategies that were explicitly disclosed and meant to be applied by users in the same websites proposing them, such as those present in the WIPO, EPO, and The Lens websites between Feb. and Nov. 2020. The main features of these and other free databases for searching patent information have been previously review [89] but some major improvements have been introduced in 2020 and have been exploited to design strategies dedicated to Covid_19 search.

An overview of the search criteria defined in Patentscope, Espacenet and The Lens Patents, for a total of almost 300 search strategies, have been consolidated in xls file and analyzed. This review has been performed by separating keywords, the International Patent Classification (IPC) codes, 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 listing shows some specificities of choices made by either each provider compared to the others or by the same provider for different topics. For instance, Patentscope search strategies all present at least a technology-specific IPC code (but no CPC codes) and, where present, always the same combination of Coronavirus-related keywords (including viral classifications and synonyms but, interestingly, not the official virus name SARS-CoV-2). The Espacenet search strategies presented in the "Fighting Coronavirus" website [90], associate Coronavirus-specific keywords (but in various alternatives comprising different names, acronyms, and even some non-English terms, and again never SARS-CoV-2) to technology-specific keywords, IPC and/or CPC codes, sometimes choosing very specific classification codes. The search strategies proposed by The Lens Patents are those more broadly referring to Coronavirus-related matters (by keywords only) and applicable technologies (by IPC only). At the level of specific topics, it is interesting to compare some broader choices of patent classification codes made in Patentscope compared to those made for searching Espacenet, for instance with respect to informatics, medical equipment, or drug classifications (with Espacenet not listing any IPC code under A61P, quite strangely).

The Early Covid19 Patent Dataset: Construction, Analysis, and Comparisons

The observations made above regarding presently available Covid-19 patent literature analysis and search strategies have motivated the authors to evaluate patent publication by restricting the search, on one hand, to the main names and acronyms found in the Covid-19 scientific literature analyzed in Section 3 and, on the other hand, to the patent documents actually filed and published during the same first eight months period (between January and August 2020). The search was performed in a selection of patent search facilities and confirmed by later searching in the patent registry and databases of major patent offices, limiting the presence of the main Covid-19 keywords (those identified as Group (1) criteria in Section 3) to title, abstract, and claims which illuminate the patent literature, where the potential usefulness in any aspect of Covid-19 medical management is more explicitly indicated. Obviously, such a search cannot be considered as a complete search of Covid-19 findings in patent literature but is intended only to point out how and where users of the patent system have chosen to file patent applications and improve the visibility of their own patent activities under such unusual circumstances, even by requesting an accelerated examination and publication in many cases. The search was initially performed in databases covering several patent authorities and then confirmed or refined using the databases and registers of national patent offices. Further details on the search process and of the construction of this patent literature dataset, named "Early Covid-19 Patent Dataset" and comprising 1130 entries, are provided in Section 2.

A first level of analysis of the Early Covid-19 Patent Dataset is made with respect to jurisdictions and types of documents filed in such jurisdictions (Table 6) to evaluate how the different types of patent protection available in each country, as summarized for PCT Contracting States in the dedicated WIPO webpage [91], have been preferred by applicants for early patent examination and disclosure. This overview clearly shows major differences, with China and India filing more than 80% of total documents, with only occasional filings submitted at major international offices (WIPO and EPO), or in most other countries. Another interesting trend is the one observed in countries where it is possible to search the early publication of details of provisional patent applications or of Innovation Patents, such as in the United Kingdom, Australia and Singapore. In this subset of patent document (totaling almost 10% of Early Covid-19 Patent Dataset), the actual level of disclosure is very uneven, with titles being mostly quite generic but sometimes with details about chemical or biological products. This information points, nonetheless, to inventors and applicants that may file regular applications on these topics using provisional patent filings as priority documents in the following 12 months, similarly to those authors of scientific publications that have declared the filing of patent application comprising data present in the article. Other countries of interest are China, South Korea, and Russia where applicants have completed the full process from the examination up to patent grant in less than 6 months. The number of USA patent filings is mostly consequential to the use of US-specific provisions to continue and re-submit pending applications with additional information. Finally, applicants from other countries like Germany, Israel, Brazil, or Spain show some limited interest in achieving earlier patent protection even at a national level, sometimes with preference for utility models.

This data seems to indicate a general preference for making use of national rather than international authorities to accelerate the patent proceedings but with major differences across countries. In China, according to a study of listed Chinese companies [92], the applicants appear engaged in a kind of "patent race", but other considerations may then affect the preference of domestic applicants with respect to the patent examination and renewal process [93], Non-Chinese companies, in contrast, could expect to be disadvantaged by "technology protection", as a recent study would suggest [94]. In any case, the Chinese Patent Office provided an unusual visibility to applicants that obtain an early patent grant, as shown in the press release about a COVID-19 vaccine [95]. In India, the situation is more complex since the country has improved own "patenting record" since the compliance to TRIPS requirements in 2005, but still with uncertainties about how patent protection for pharmaceutical inventions will be possible under existing Indian law provisions [96].

A second level of analysis in the Early Covid-19 Patent Dataset is made with respect to the type of patent documents, in general and by earlier filing or publication date (Figure 5). The data show a strong preference for standard patent proceedings but as indicated above, the preference for utility models or provisional patent applications is clear in specific countries. When these data are analyzed by the month indicated as the earliest priority date (or initial filing) and the publication date between Jan. and Aug. 2020, the earliest patent filing date found was in mid-January, with the earliest publication dates in March 2020. The global trend of the two dates is fairly predictable, with an increase of publications over the selected period of time and the peak filings in March 2020 which follow the same pattern as the number of months between initial filing and publication (on average slightly higher than 3 months). However, a burst of filings appeared, especially those of provisional patent applications and utility models between February and April 2020. Since May 2020, the number of already published patent filings reached a kind of plateau, if not decreased (taking into account that, for example, provisional patent applications have a statutory, official publication of less than two months from filing).

A third type of analysis in the Early Covid-19 Patent Dataset was carried out with respect to the technological domains where early patent filings and publications were pursued (Figure 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. These four technological areas are Diagnostic (means to identify or predict Covid-19 infected subjects), Therapeutic (means to treat Covid-19 infected subjects), Protection (means to avoid Covid-19 infection by blocking virus contact or propagation mechanically), and Cleaning (means to avoid Covid-19 infection by removing or destroying the virus). This categorization was used to simplify the analysis of topics that are present in the early filed and published patent documents and should not be obviously considered as a definitive status, with patent documents that may disclose findings relevant or exploitable in more than one domain. As patent classification criteria, the IPC Group was chosen since it is considered providing a level of information granularity sufficient to identify main technological features.

When the consistency and the number of IPC Groups is compared, first within each technological domain and then between technological domains, some distinctively featured documents can be identified. Within Diagnostic Technologies, the IPC Groups C12Q1, G01N33 and C12R1 (identifying processes and assays for investigating, measuring or testing or analyzing materials, using microorganisms, nucleic acids, enzymes, etc.) are largely prevalent, where patent applications may combine two or more Subgroups within these IPC Groups. A frequently present 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 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 IPC Subclasses when summarizing the pharmaceutical use and preparations of chemical, biological, or otherwise defined compounds. A large variety of IPC Groups under A61K are present in patent documents categorized under Therapeutic Technologies, with the expected prevalence of A61K31 (defining medicinal preparations containing organic active ingredients, often associated with reformulation of drugs for medical uses, as in drug repurposing) and A61K39 (broadly defining medicinal preparations containing antigens or antibodies, including vaccines). The frequency of A61K36 (defined by medicinal preparations containing ingredients undetermined constitutions from algae, fungi, or plants, such as herbal medicines) may be surprising but can be explained by the prevalence of patent applications and applicants from China and India where such preparations are important in traditional medicine.

This analysis further shows that Protection Technologies are mostly associated with IPC Groups under A41D (which includes a series of outerwear, accessories, and protective garments, in particular for medical personnel and uses) and A62B (which includes a series of life-saving devices and products such as those related to respiratory apparatus, helmets and filters for breathing-protection purposes). Patent documents categorized 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 disinfection, sterilization or purification methods for human safety and health) with Diagnostic or Cleaning Technologies, given the possibility that such devices may combine features or be useful in other domains. Patent documents categorized under Cleaning Technologies also share a comparable distribution in a number of different IPC Groups (somehow between the distribution observed for Diagnostic and Therapeutic Technologies) but present specific IPC Groups related to preparations, chemical compounds, methods or apparatus for disinfecting, sterilizing materials (A61L2, A01P1 A61L101) or air-conditioning and ventilation (under F24F Subclasses).

The analysis of IPC Groups in the Early Covid-19 Patent Dataset may suggest other trends. For instance, the IPC Groups related to novel chemicals or biologicals are not strongly represented, possibly because generating and characterizing novel compounds requires more time and/or because applicants having the resources to generate them prefer to pursue patent proceedings in a more traditional manner, taking advantage of the 12 month-priority with publication at 18 months. Earlier filed and published patent documents referring to Covid-19 applications seem to mostly refer to novel uses or adaptations of existing compounds, preparations, or methods. However, even if present in a limited number of patent documents, novel compounds can be identified according to IPC Groups, the most frequent being listed in Table 7. Among them, there is a clear prevalence of proteins (in the form of antigens or antibodies, for instance), but IPC Groups under C12N defining cell-based products and technologies are also present, and in fact are more present than classical IPC Groups for small molecules such as those under C07D or C07C Subclasses. The presence of IPC Group C07F9 is explained by the fact that some phosphorus-containing compounds are known as nucleotide analogues having anti-viral properties, including the candidate Covid-19 drug Remdesivir [97].

The representation and trends described for the Early Covid-19 Patent Dataset using the IPC Groups may be compared to the results obtained using the almost 300 Covid-19 search strategies proposed by Patentscope, Espacenet, and The Lens Patents. If such criteria are applied to these patent documents published and filed between Jan. and Aug. 2020, a large variability in the number of hits is observed, with 71 search strategies with no hits (almost half of them from Patentscope), 130 strategies with 1 to 9 hits, and less than 50 search strategies (almost all from Espacenet) with 20 or more hits. The approach for constructing the Early Covid-19 Patent Dataset was based only on the nomenclatures suggested by scientific literature published during 2020, thus quite different from those proposed by these patent search platforms. However, it is interesting to note which IPC Groups are shared by these approaches. As expected, a large number of IPC Groups are present in both the predefined searches and in the Early Covid-19 Patent Dataset. The large majority of the IPC Groups listed in Figure 6 are present in one or more of the published search strategies with a few exceptions, mainly for Cleaning Technologies (A61L101, A01N59, A01P1, and F24F13). However, quite a number of IPC Groups proposed in Patentscope, Espacenet, and The Lens Patents search strategies are rarely or not at all represented in the Early Covid-19 Patent Dataset, as summarized in Table 8. These IPC Groups cover quite a variety of topics, in particular with respect to transportation, appliances, materials, information technology, disinfection, or medical uses that are either more often represented in the Early Covid-19 Patent Dataset by other IPC Groups or, apparently, absent from the Early Covid-19 Patent Dataset.

Future searches in the Covid-19 patent literature will allow a conclusion of whether the observations made above on the basis of Early Covid-19 Patent Dataset are fully or partially reflecting the applicants' attitude that are active in specific countries and/or in technological areas (lack of interest, patent filings still to be completed, or simply prosecuted in a more standard, not accelerated manner). Obviously, the search criteria may explain some trends as inherent, on one hand, to the choice of keywords made by authors for constructing Early Covid-19 Patent Dataset and, on the other hand, the choice of IPC codes and keywords for establishing the search strategies for Covid-19 matters that are proposed by patent information providers. In any case, extending the search to include both CPC codes and keywords related to Covid-19 in the full-text and in the granted claims will return a more complete analysis of innovation trends consequent to or triggered by this crisis during the year 2020. Further trends in the Early Covid-19 Patent Dataset may be defined on the basis of the above mentioned four technological domains and filing trends (Figure 7). As expected, a majority of patent documents in the Early Covid-19 Patent Dataset are associated with either diagnostic or therapeutic uses, with an even higher preference for Therapeutic Technologies among provisional patent applications. However, the distribution according to the days between the filing and publication month suggest that, independently from the filing month (only a limited difference was observed among the technologies was observed according to this criteria), those assigned to Cleaning or Protection Technology were often published earlier (at least 70% were published less than three months from filing) than those for Diagnostic or Therapeutic Technologies (at least 70% were published between two and four months), aligning more to the trend of patent applications. Regarding the distribution and prevalence of the IPC Groups described above, often only later, more in-depth searches in the patent literature explain and confirm these initial observations about prevalence or preference of choices made by applicants when taking the decision about patent filings in connection to Covid-19.

5. Covid-19 Chemical Information and Biological Sequence Information

Access to Covid-19 Chemical & Biological Structural Information

As indicated in Sections 3 and 4, the access and searchability of biological sequences and chemical structures within scientific and patent literature is facilitated by the dedicated databases established by many organizations and their specific policies for managing such information. In particular, two research institutions, NCBI (National Centre for Biotechnology Institutions, USA) and EBI (European Biotechnology Institute, UK), should be mentioned since they have made a major effort to aggregate and offer a structured access to biological and chemical data about SARS-CoV-2 biology in various formats. Main Covid-19 resources in NCBI and EBI websites are summarized in Table 9. A major repository of raw, primary functional data available through NCBI is associated with NCATS (National Centre for Advancing Translational Science) which organizes its own screening and biological data into four main sections, as described in a related publication [98]. A further NIH Covid-19 dedicated webpage summarizes its own and external resources for data under separate, searchable sections. EBI has announced a series of initiatives about providing timely information on SARS-CoV-2 and Covid-19 research [99] that are pursued internally or in collaboration with other research entities in the United Kingdom or with EMBL (European Molecular Biology Laboratory, Germany). As explained in the EBI website, the main Covid-19 resources are grouped in a separate portal [100] that is intended also to facilitate data submission, sharing, and analysis from external users.

Among these data, those related to biological properties of small organic molecules that may be validated as Covid-19 candidate therapeutic compounds are also of particular interest for patenting analysis. In this domain, the NCBI and EBI databases that cover chemical compounds of biological interest (PubChem [101] and ChEMBL [102], respectively) present chemical and experimental data about potential SARS-CoV-2 activities of specifically indexed compounds listed therein. It is not easy to list, let alone to compare, similar websites or dedicated sections in terms of origin, amount, and overall quality of their content, even though articles have tried to do this [103]. It is equally difficult to evaluate how many publications, and possibly patent applications already filed, may have exploited evidence found in these repositories. Apart from a few articles broadly analyzing NCBI and EBI databases (for instance to generate a SARS-CoV-2 protein interaction map [104] or Structure-Activity relationships [105] suggesting candidate compounds for drug repurposing), the link between the content of a (non-)patent publication and the use of open-access or raw data in repositories can be , at most, suggested by the name of authors and the detailed analysis of such ”deep” information.

Identifying Covid-19 Protein Sequences & Related Publications

A separate analysis should be dedicated to the search and analysis of biological sequences (i.e., nucleic acids and proteins). The NCBI and EBI portals usually covering this type of information have established some specific webpages and other resources for the analysis of newly identified SARS-CoV-2 sequence data, such as in COVID-19 UniProtKB [106] or Ensembl COVID-19 [107] for protein and nucleic acid sequences, respectively. These websites and resources in other websites may also cover and compare nucleic acids or proteins of previously identified Coronaviruses (being potentially relevant for present SARS-CoV-2 patent and research activities), often together with those human sequences that interact with SARS-CoV-2 or are somehow involved in SARS-CoV-2 biology or pathology. Two further tools of interest are those available in the “Human Coronaviruses Data Initiative” portal in Lens.org, using their own PatSeq Finder search tool to extract prior Coronavirus-related sequences that are described in the patent literature (as of May 2020), as well as a database established at Oxford University and named CoV-AbDab dedicated to antibodies recognizing SARS-CoV-2 proteins [108]. Additional tools and databases for analyzing biological sequences related to SARS-CoV-2 biology and interacting human sequences are listed in Table 1,

A deeper analysis of these resources and information is beyond the scope of this article but patent information professionals should be aware that, as in many other biomedical domains, for SARS-CoV-2 there is also a wide number of codes, names, and representations with respect to the same biological sequence that may be found in different databases or publications. A main example is represented by proteins that are encoded by SARS-CoV-2 genome whose RNA sequence was first released on Jan. 10th, 2020 [109] but then integrated on the basis of several findings accumulated since then by analyzing clinical samples worldwide. The details of SARS-CoV-2 biology, genomic variability, and candidate targets for therapeutic intervention are reviewed in some articles [110-112] and they can be summarized as follows. The majority of the SARS-Cov-2 RNA genome is translated within human infected cells as two large polyproteins (named ORF1a polyprotein, or Replicase polyprotein 1a, and ORF1ab polyprotein, or Replicase polyprotein 1ab). These proteins undergo a proteolytic process generating a further 16 proteins (named as NSP1-NSP16, which have mainly replicative roles or enzymatic activities). The remaining part of the genome codes for4 proteins mainly performing structural functions (generally indicated as S, E, M, and N proteins) and for a series of accessory proteins whose actual existence in vivo, number, and function is still an object of intense study. They appear coded by Open Reading Frames (ORFs) in the SARS-CoV-2 genome that are partially overlapping with each other or with the ORF sequences of structural proteins. Apart from the 6 main accessory proteins (named as ORF3a, ORF6, ORF7a, ORF7b and ORF10), at least other 4 ORF sequences have been identified by different investigators.

Some important details need to be taken into account when searching for names and sequences of the SARS-Cov-2 proteins are indexed in NCBI, EBI, and Lens.org websites. The names and codes identifying SARS-Cov-2 proteins for a total of 29 sequences (including some sequences that appear either unreviewed or as errors) are assigned in NCBI webpages to separate records as protein sequences and/or as separate Supplementary Concepts in MeSH thesaurus. On the EBI website, SARS-CoV-2 proteins are identified in the UniprotKB protein database under a specific taxonomy code which is associated with only 13 reviewed entries (10 directly coded proteins, the 2 polyproteins, plus another ORF not specifically identified as such in NCBI) but UniProtKB further lists more than 11,000 different, unreviewed, partial protein entries ranging from 8 to 7097 amino acids. Aside from obviously different identification codes between EBI and NCBI databases, it should be also noted that some preferred names for SARS-Cov-2 proteins in the two databases are often different, with a variable number of alternative names for each protein in the database record. Thus, if the search of patent-relevant information involves the specific structure, activity, and/or interactions of a specific SARS-CoV-2 protein, it is important to identify and use correctly at least the names that NCBI, MeSH, and UniprotKB list. An even more detailed, and complex, prior analysis of such databases would be then required to evaluate naming, coding, and actual sequences for SARS-CoV-2 nucleic acids, in particular for diagnostic uses and early detection of relevant mutations within clinical samples.

It is still too early to identify which SARS-Cov-2 biological sequences will be more often present in patent literature, but SARS-Cov-2 protein names can be used to search PubMed, using both MeSH Supplementary Concept and the main scientific names (Figure 8). The details on SARS-Cov-2 proteins (names, size, and codes) that were identified in NCBI and EBI resources are consolidated into Table 10. This analysis shows that only few among the annotated SARS-Cov-2 proteins are cited in scientific articles listed by PubMed for the Jan.-Aug. 2020 period, with protein-specific Supplementary Concept being associated with a variable, but still quite low, fraction of total PubMed entries presenting the protein name in the title or abstract. In particular, four of them (S/Spike protein, NSP5/3C-like proteinase, NSP12/RNA-dependent RNA polymerase, and N/nucleocapsid protein) appear as those most extensively studied in Covid-19 scientific literature and thus, possibly, will be the most present in future patent literature as well. A similar analysis was performed in an article published at the end of July 2020, reviewing the publications about the chemical compounds that have been found interacting with SARS-CoV-2 (or human proteins involved in SARS-CoV-2 infection), arriving at similar conclusions [113]. However, most recent scientific literature has highlighted how both the biological activities and coding capacity of SARS-CoV-2 are still partially unexplored, with other poorly characterized, minor viral ORFs having potential regulatory or functional relevance [114-117].

Moreover, it has highlighted how the published studies on human genes and proteins that are involved in either SARS-CoV-2 biology or Covid-19 pathologies is concentrated only on a fraction of those suggested by various experimental evidences and potentially useful findings may be still overlooked [118]. Future studies about the sequence and properties of SARS-CoV-2 proteins and their interactions with human molecules may suggest additional targets and strategies for developing novel therapeutic or diagnostic applications, and thus opening new opportunities for patent filings.

6. Conclusions

During the last few months, a lot of things have happened and, unfortunately, the Covid-19 crisis is continuing in many countries. During the fourth quarter of 2020, when the draft of this paper was completed, the pandemic was still a key topic impacting the health systems and economy worldwide and is likely to remain so for at least the first half of 2021. This paper does not (and cannot) list and analyze, all the relevant websites and data sources in this ever-changing landscape but our findings suggest some considerations about future searches and analysis of patent information. The searches and the websites listed in the text or the Supplementary Files, together with the cited references, can be used to select patent-related publications and events to be compared with the sequence of major Covid-19 medical and scientific events, showing how the situation evolved just before the declaration of the Covid-19 pandemic, and for the first 6 months following (Figure 9).

First of all, any quantitative and qualitative analysis of information made by this report, as of November 2020, is not able to predict any future findings in patent literature released after the statutory delay for patent publication (18 months from an earlier, priority date, in general), nor conclude (somehow more important) whether or how available and valuable "Covid-19 specific" datasets and documentary repositories will be. During the preparation of this article, the contents of quite a number of websites dedicated to Covid-19 research have been aggregated, ceased to be regularly updated, or have simply disappeared already in the period from June to November 2020. Given the increasing amount of information daily, there is no guarantee that all providers will continue to allocate the time and resources required to keep the databases updated and correct in general, or only for specific topics or sources. This uncertain situation could potentially lead to confusion regarding future technical or patentability assessments. In fact, it has been recently observed that possibly hundreds of online-only, open-access journals may have already vanished [119]. Such issues related to stability and availability of scientific publications may affect the prior art evaluation process, and in particular for biomedical inventions, where non-patent literature is often predominant over patent literature as relevant prior art, thus affecting the usual disclosure and transfer of novel technologies in the public domain through patent filings [120,121].

It should also be noticed that, lacking any specific treatment for Covid-19, the only immediately available option was to face the emergency by exploiting possibly incomplete, novel Covid-19 findings when testing equipment and drugs already commercially available (or otherwise known from virologic, respiratory, or other clinical research). This approach is not new and has generally been defined in pharma domain as "Drug Repurposing", but in the present case it may lead to a potential "tsunami" of such projects based on serendipitous observations or more systematic, large scale analysis of candidate compounds [122-124]. Patentability of findings about known materials, compounds, or other products used to fight against Covid-19 may then be challenged by means of open access preprint repositories or by other approaches summarized in a report published by WIPO Magazine [125]. Indeed, the impact of the flood of non-patent literature and data freely available during 2020 still has to be assessed for the patentability of novel biological or chemical entities that will be claimed in patent applications filed and published from late 2020 onwards, after pursuing more "normal" and lengthy drug discovery programs. Moreover, artificial intelligence may be not only support data mining activities but also "invents" COVID-19 drugs [126].

Another aspect is how the "frontrunners" having not only filed patent applications earlier but also having had their publications, examinations, and even grants accelerated, will be provided with fully enforceable patent rights. A first hurdle may be the pressure of public opinion and governments requiring immediate, "IP rights-free" access to potentially life-saving technologies, limiting standard policies that define market exclusivity [127], in view of the growing health and economical inequalities in absence of herd immunity and lacking means to avoid future outbreaks [128-130], platforms for pledging patent rights [131], and new IP policies that may be established at national levels, even in the frame of present TRIPS policies [132]. A second hurdle may be the possibly incomplete search and the quick patent examination. Aside from the potential complexity of defining the disclosure date for relevant publications in 2020, it is also uncertain how pre-2020 patent filings and disclosures about Coronavirus-related matters in general (or with respect to previous SARS-CoV-1 or MERS outbreaks) actually predict and apply to specific features of SARS-CoV-2 biology and medical management that are still progressively being understood and disclosed. Indeed, the limited access to biological samples and appropriate equipment in the early months of the pandemic would suggest that only a limited number of early patent filings contain reliable and specific data supporting the claimed invention with respect to SARS-Cov-2 biology, Covid-19 medical management, or even to Coronaviruses in general.

On Jan. 5th 2020, WHO has published what may be considered as the first official report about a pneumonia of unknown etiology detected in Wuhan City, Hubei Province of China [133] and, even as of November 2020, there are still major uncertainties when identifying factors associated with the mortality and origin of these infectious agents, possibly foreshadowing similar pandemics in the future [134]. Since then, COVID-19 has possibly irrevocably changed not only many aspects of daily life and health systems but also economy and innovation. Many governments are facing some "moments of truth" after the first and, in some countries, the second lockdown exit that still require not only major efforts but also adequate leadership, strategy and capabilities [135-137]. Further efforts will be required to overcome consequences of this pandemic on other clinical conditions or in specific populations, for example associated with particular immunological profiles [138], children [139], factors affecting mortality [140], "Long Covid" or other chronic conditions affecting the return to normal health status [141-143], racial disparities [144], or disparities in medical management across countries [145] or in the use of telemedicine [146]. The patent system will not avoid new challenges which question some attitudes and policies well established over the last few decades. The way it adapts itself to the new conditions might prove as important as many other reforms for health, innovation, and economic policies. The efficient and transparent standardization of the process underlying the retrieval, analysis, and public access of scientific and patent information would be a good starting point for contribution to the global efforts in overcoming this emergency.

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Table 1

Provider	Webpage Title	Web Address
ACS	Chemistry in Coronavirus	https://pubs.acs.org/page/vi/chemistry_coronavirus_research#
arXiv (Cornell Univ.)	Covid-19 Preprints in arXiv	https://arxiv.org/search/advanced?advanced=&terms-0-operator=AND&terms-0-term=COVID-19&terms-0-field=title&terms-1-operator=OR&terms-1-term=SARS-CoV-2&terms-1-field=abstract&terms-3-operator=OR&terms-3-term=COVID-19&terms-3-field=abstract&terms-4-operator=OR&terms-4-term=SARS-CoV-2&terms-4-field=title&terms-5-operator=OR&terms-5-term=coronavirus&terms-5-field=title&terms-6-operator=OR&terms-6-term=coronavirus&terms-6-field=abstract&classification-physics_archives=all&classification-include_cross_list=include&date-filter_by=all_dates&date-year=&date-from_date=&date-to_date=&date-date_type=submitted_date&abstracts=show&size=200&order=-announced_date_first&source=home-covid-19
Authorea	COVID-19 Preprints	https://authorea.com/browse-all?tags=%5B%22covid-19%22%5D
BioWorld	Coronavirus	https://www.bioworld.com/articles/topic/517
BMJ	Coronavirus Hub	https://www.bmj.com/coronavirus
Cambridge Univ Press	Coronavirus Free Access Collection	https://www.cambridge.org/core/browse-subjects/medicine/coronavirus-free-access-collection
CDC	COVID-19 Articles Database	https://www.cdc.gov/library/researchguides/2019novelcoronavirus/researcharticles.html
	COVID-19 Articles search strategy	https://www.cdc.gov/library/docs/covid19/SearchStrategy_9Oct2020.pdf
Cell Press	COVID-19 Content Archive	https://www.cell.com/covid-19-archive
ClinicalTrials.gov (NIH)	COVID-19 Studies	https://clinicaltrials.gov/ct2/covid_view
Cochrane Library	Coronavirus evidence	https://www.cochranelibrary.com/collections/doi/SC000039/full
	Covid-19 Study Register	https://covid-19.cochrane.org/

Provider	Webpage Title	Web Address
EBI	Ensembl SARS-CoV-2 genome	https://covid-19.ensembl.org/index.html
	COVID-19 Data Portal	https://www.covid19dataportal.org
	SARS-CoV-2 protein sequences	https://covid-19.uniprot.org/uniprotkb?query=*
EBSCO	Covid-19	https://covid-19.ebscomedical.com/
Elsevier (Sciencedirect)	Coronavirus	https://www.elsevier.com/novel-coronavirus-covid-19
	Selected articles	https://www.sciencedirect.com/articlelist/covid
Elsevier (Scopus)	COVID-19 Research Outputs	https://covid19.elsevierpure.com/en/publications/
EPPI-Centre	COVID-19 evidence	https://eppi.ioe.ac.uk/cms/Default.aspx?tabid=3765
	COVID-19 Resources	https://eppi.ioe.ac.uk/cms/Projects/DepartmentofHealthandSocialCare/Publishedreviews/%20%20%20COVID-19Livingsystematicmapoftheevidence/COVID-19Resources/tabid/3767/Default.aspx
European Commission	TIManalytics	https://www.timanalytics.eu/TimTechPublic/main.jsp?analyzer=esociogram100&dataset=98746
GEN	COVID-19 Drugs & Vaccines	https://www.genengnews.com/category/covid-19-candidates/
GitHub	Covid-19	https://github.com/topics/covid-19
Google	COVID-19 Open Data	https://console.cloud.google.com/marketplace/product/bigquery-public-datasets/covid19-open-data
Harvard University	COVID-19 Data Collection	https://dataverse.harvard.edu/dataverse/covid19
Homeland Security Digital Library	Coronavirus Disease Special Collection	https://www.hsdl.org/?search&all=&searchfield=&collection=public&any=&exact=&without=&begindate=&enddate=&fct&advanced=&submitted=Search&tabsection=Coronavirus+Disease+%28COVID-19%29

Provider	Webpage Title	Web Address
Intl. Standard Organization(ISO)	COVID-19 RESPONSE	https://www.iso.org/covid19
JAMAnetwork	COVID-19	https://jamanetwork.com/journals/jama/pages/coronavirus-alert
Johns Hopkins University	COVID-19 Dashboard	https://www.arcgis.com/apps/opsdashboard/index.html#/bda7594740fd40299423467b48e9ecf6
Karger	Coronavirus	https://www.karger.com/Tap/Home/278492
L·OVE Platform	Covid-19 Evidence	https://app.iloveevidence.com/loves/5e6fdb9669c00e4ac072701d?utm=ile
Mendeley	Covid-19 Data	https://data.mendeley.com/research-data/?search=covid-19
	Covid-19	https://www.mendeley.com/search/?query=COVID-19
MIT Technology Review	Coronavirus	https://www.technologyreview.com/tag/coronavirus-covid-19-news/
Nature	SARS-CoV-2	https://www.nature.com/subjects/sars-cov-2
NCBI (NLM/NIH)	COVID-19 Data in PubChem	https://pubchemdocs.ncbi.nlm.nih.gov/covid-19
	SARS-CoV-2 Resources	https://www.ncbi.nlm.nih.gov/sars-cov-2/
	SARS-CoV-2 Data	https://www.ncbi.nlm.nih.gov/labs/virus/vssi/#/sars-cov-2
		https://www.ncbi.nlm.nih.gov/labs/virus/vssi/#/virus?SeqType_s=Protein&VirusLineage_ss=Severe%20acute%20respiratory%20syndrome%20coronavirus%202,%20taxid:2697049
	SARS-CoV-2 proteins	https://www.ncbi.nlm.nih.gov/ipg?term=Severe%20acute%20respiratory%20syndrome%20coronavirus%202[ORGN]%20AND%20RefSeq[Filt]
		https://www.ncbi.nlm.nih.gov/datasets/coronavirus/proteins/
	Clinical Queries	https://pubmed.ncbi.nlm.nih.gov/clinical/
	COVID-19	https://icite.od.nih.gov/covid19/search/
	LitCovid	https://www.ncbi.nlm.nih.gov/research/coronavirus/
NCBI (PMC)	COVID-19	https://pubmed.ncbi.nlm.nih.gov/?term=covid-19 https://www.ncbi.nlm.nih.gov/pmc/about/covid-19/
NEJM	Covid-19	https://www.nejm.org/coronavirus

Provider	Webpage Title	Web Address
NIH (COVID-19)	OpenData and Open-Access Data COVID-19	https://opendata.ncats.nih.gov/covid19/ https://datascience.nih.gov/covid-19-open-access-resources https://www.nih.gov/coronavirus
	Clinical Studies	https://clinicaltrials.gov/ct2/results?cond=COVID-19
outbreak.info	COVID-19 data	https://outbreak.info/resources/search
Oxford Univ. Press	COVID-19	https://academic.oup.com/journals/pages/coronavirus
PLOS	COVID-19	https://plos.org/covid-19/
Publons	COVID-19	https://publons.com/publon/covid-19/?sort_by=date
Retraction Watch	Retracted COVID-19 papers	https://retractionwatch.com/retracted-coronavirus-covid-19-papers/
SAGE Journals	Coronavirus	https://journals.sagepub.com/coronavirus
Science	Coronavirus	https://www.sciencemag.org/tags/coronavirus https://www.sciencemag.org/collections/coronavirus
ScienceOPEN.com	Coronaviruses, COVID-19	https://www.scienceopen.com/search#('context'~('collection'~('id'~'d6ba10ea-809d-4f28-96b9-d2ed475ec319'_'kind'~0)_'kind'~11)_'v'~3_'kind'~77)
SemanticsScholar (CORD-19)	COVID-19 Open Research Dataset	https://www.semanticscholar.org/cord19/get-started https://www.semanticscholar.org/search?q=covid-19&sort=pub-date
SSRN (eJournal)	Coronavirus & Infect. Dis. Res.	https://papers.ssrn.com/sol3/Jeljour_results.cfm?form_name=journalBrowse&journal_id=3526423 &Network=no&lim=false&orderBy=ab_approval_date&orderDir=asc&strSelectedOption=5
The Economist	Coronavirus	https://www.economist.com/coronavirus-pandemic
The Lancet	Covid-19	https://www.thelancet.com/coronavirus/archive
The Scientist	Coronavirus	https://www.the-scientist.com/tag/covid-19
Univ. Stanford	Antiviral Therapy	https://covdb.stanford.edu/
WHO	COVID-19 Dashboard & Global literature	https://www.who.int/emergencies/diseases/novel-coronavirus-2019 https://covid19.who.int/info https://search.bvsalud.org/global-literature-on-novel-coronavirus-2019-ncov/
Wiley Online	Covid-19	https://novel-coronavirus.onlinelibrary.wiley.com/
Wolters Kluwer	Covid-19 Ovid	https://coronavirus.ovidds.com/discover/results?q=Coronavirus%20OR%202019-nCoV%20OR%20nCoV
Zenodo	Coronavirus	https://zenodo.org/communities/covid-19/?page=1&size=20

Table 2

Category of search criteria for Covid-19 topics	Combination of relevant keywords
Highly specific for Covid-19 *Group (1)*	"covid-19" OR "covid 19" OR "covid19"
	"SARS-CoV-2" OR "SARS-CoV2" OR "sarscov2"
	"2019 ncov" OR "2019-nCoV" OR "2019nCoV"
	"covid-2019" OR "covid 2019" OR "COVID2019"
	"severe acute respiratory syndrome coronavirus 2"
	"2019 novel coronavirus" OR "coronavirus disease 2019"
	"novel corona virus" OR "novel coronavirus" OR "new corona virus" OR "new coronavirus"
	"Wuhan coronavirus"
Less specific for Covid-19 (potential applicable to coronavirus research in general, potential typos, or ambiguous wording)	*Group (2) "Alternative phrasing"* "SARS-Coronavirus-2" OR "severe acute respiratory syndrome 2" OR "severe acute respiratory coronavirus 2" OR "coronavirus disease-19" OR "coronavirus 19" OR "coronavirus 2019" OR "coronavirus disease-2019" OR "coronavirus-2" OR "coronavirus 2" OR coronavirus2
	Group (3) "location phrasing" (wuhan OR hubei OR huanan) AND ("severe acute respiratory" OR outbreak OR betacoronavir* OR coronavir* OR virus OR "Middle east respiratory" OR SARS OR MERS)
	Group (4) "Alternative acronyms" "novel cov" OR "ncov-2019" OR "ncov-19" OR "ncov" OR "cov 2" OR CoV2 OR "MERS-COV" OR SARS2 OR "sars-cov" OR Covid
	Group (5) "General Coronavirus" Betacoronavir* OR coronavir* OR "Corona virus" OR "corona viruses"

Table 3

Categories of publications not or poorly covered in PubMed	**CDC Research Articles**	**Lens Scholar**	**Santos 2020**
ArXiv, SSRN, and other Open Access or preprint providers (other than BiorXiv and MedrXiv)	√	√	√
References with obsolete PMID, incomplete details on the origin of publication or identification codes	√	√	√
Homeland Security Digital Library	√	√	
WHO publications	√	√	
National & intl. journals in law, politics, economics	√	√	
National journals in biomedical sciences (in non-English language, mainly)	√	√	
References to Clinical Trials	√		

Table 4

Provider	Webpage name	Web Address
China Patent Information Center (CNPAT)	Information platform for patents on COVID-19	https://ncp.patentstar.cn/en/Home/SpecialDB
EPO	Fighting coronavirus	https://www.epo.org/news-events/in-focus/fighting-coronavirus.html
IPAustralia	Patent Analytics Hub	https://www.ipaustralia.gov.au/tools-resources/patent-analytics-hub
South Korean Intellectual Property Office (KIPO)	Covid-19 Patent Information Navigation	https://www.kipo.go.kr/kpo/BoardApp/ApplInfoAppE
Lens	COVID-19 Datasets: Patents	https://about.lens.org/covid-19/
Medicine Patents Pool	MedsPal	https://www.medspal.org/?keywords=covid&page=1
Patentscope (WIPO)	COVID-19 INDEX	https://patentscope.wipo.int/search/en/covid19.jsf
Spanish Patent & Trademark Office (SPTO)	Coronavirus: Diagnosis and therapy (alerts)	https://www.oepm.es/en/informacion_tecnologica/informacion_gratuita/Alertas_Tecnologicas/detalle.html?id=68400&n=CORONAVIRUS:%20DIAGNOSIS%20AND%20THERAPY%20IN%20HUMANS
	Coronavirus: Diagnosis and therapy (bulletin)	https://www.oepm.es/en/informacion_tecnologica/informacion gratuita/boletines_de_vigilancia_tecnologica/boletines_oepm/coronavirus/index.html
Taiwanese Intellectual Property Office (TIPO)	Epidemic Prevention Zone	https://gpss3.tipo.gov.tw/gpsskmc/gpssbkm
Italian Patent & Trademark Office (UIBM)	Fighting coronavirus	https://www.uibm.gov.it/biotech/covid-19.html

Table 5

Provider	Main features (search criteria, relevant dates)
WIPO	Webpage listing almost 100 search strategies for 10 technological areas, including IPC codes, with or without Coronavirus-related keywords (launched on Apr. 21st, 2020)
EPO	Webpage listing almost 200 search strategies in four broad themes and multiple sub-categories, with xlsx files and links to corresponding search strategies in Espacenet format, including CPC codes, IPC codes, and/or Coronavirus-related keywords (launched on June 22nd, last updated in Nov. 2020)
Lens.org	Search strategies and datasets covering 16 technologies, including CPC codes and/or Coronavirus-related keywords (launched on Jan. 28th, 2020, last updated on May 19th, 2020)
IPAustralia	Patent information on the latest COVID-19 technology is organized in six sections with graphical analysis and related search strategies (for Derwent Innovation and EPOQUE syntax) that are provided in a separate xls file
CNPAT (China Patent Information Center)	Two separate datasets of Chinese and non-Chinese, "world patent documents", divided into 9 categories and several categories, linked to reports analyzing the data (in Chinese only, established on April 29th, 2020; without explicit description of search strategy to define them)
KIPO (Korean Intellectual Property Office	Five separate datasets of patent documents (no explicit description of search strategies) that are divided into several categories (established on Mar 24th, 2020)
TIPO (Taiwan Intellectual Property Office)	The main page of in the Global Patent Search System has a link to this Zone in which a database of patent documents is searchable using various criteria, under three main categories and several sub-categories (in Chinese only, without explicit description of search strategy to define them)
Spanish Patent Office	Since March 2020 website offers two distinct tools dedicated to new patent publications related to Covid-19 in the form of a quarterly bulletin (PDF file, in Spanish only) and weekly updated technological alerts (as html, xls or PDF file, also in English), without explicit description of search strategies
Italian Patent Office	List of patent applications filed in Italy between 2009 and 2019 disclosing products and technologies applicable to Covid-19, using categories and selection method adapted from WIPO Patentscope Covid-19 Index (in Italian only)
Medicine Patents Pool	Database for patents covering essential medicines, searchable for the patented medicines being tested for the treatment of COVID-19, and organized by country

Table 6

Patent Office	No. of patent document	Commentaries
China	822	Including 34 utility models and 26 granted patents
India	119	All patent applications whose bibliographic information are published in the Official Journal of the Indian Patent Office
United Kingdom	55	Including 54 provisional patent applications (only one regular patent application)
Australia	43	Including 13 Innovation Patents and 27 provisional patent applications (only one regular patent application)
South Korea	15	Including 7 granted patents
USA	14	Including 10 Continuation-in-Part applications, with earlier priority dates between 2013 and 2019 (one already granted) and 4 patent applications filed in 2020 (one already granted), mostly related to either diagnostic or therapeutic technologies
Singapore	14	Including 13 provisional patent applications (only one regular patent application)
Germany	12	All utility applications, for either diagnostic or protective means
Russia	12	Including 9 granted patents, all related to either diagnostic or therapeutic technologies
Israel	6	Including both utility models and patent applications
Brazil	5	
Spain	4	
Philippines	2	Isolated utility models or patent applications
WIPO	1	
EPO	1	
Colombia	1	
Chile	1	
Italy	1	
Taiwan	1	
Norway	1	
TOTAL	**1130**	Prevalence of patent documents from China and India (>80%)

Table 7

IPC Group	No. of patent documents in Early Covid-19 Patent Dataset	Commentaries
C07K14	38	Protein sequences containing more than 20 amino acids from SARS-CoV-2 (or human ones recognizing SARS-CoV-2 sequences), to be used for developing diagnostic and/or therapeutic applications
C07K16	31	Antigens from SARS-CoV-2 (or human ones recognizing SARS-CoV-2 sequences) or related antibodies, to be used for developing diagnostic and/or therapeutic applications
C12N5	22	Human, animal or plant cell products and technologies, to be used for developing diagnostic and/or therapeutic products
C07K19	19	Peptides-based products to be used for diagnostic and/or therapeutic products
C12N7	16	Bacterial cell products and technologies, to be used for developing diagnostic and/or therapeutic products
C12N1	8	Viral products and technologies, to be used for developing diagnostic and/or therapeutic products
C07F9	6	Compounds containing elements of Groups 5 or 15 of the Periodic System (essentially Phosphorus-containing compounds)

Table 8

Technologies listed in "Patentscope Covid-19 Index"or in EPO "Fighting Coronavirus" patent datasets that are poorly or not represented within Early Covid-19 Patent Dataset	
IPC (Sub)class or Group	**Short definition**
A41D19	Gloves (with anti-viral properties)
A47B-D; E04B-C	Tables, chairs, partitions, panels, and other specially adapted furniture
A47K	Sanitary equipment (for disinfection)
A61B18,42	Surgical instruments, gloves, containers for surgical/diagnostic tools
A61F7	Thermal appliances for medical or therapeutic treatment
A61G3	Medical transportations
A61H31	Artificial respiration or heart stimulation
A61M1	Suction or pumping devices for medical purposes
A61P33	Antiparasitic agents
A62D5,7	Materials for coverings, clothing protecting from harmful chemicals
A62D9	Composition of chemical substances for use in breathing apparatus
B08; B15	Chambers or hoods for preventing escape of dirt or fumes
B25J9	Programme-controlled manipulators, robot
B29C; B33Y	Additive/3D manufacturing or plastics (for protections, face masks)
B32B	Layered products (with imprinted surfaces having antiviral properties)
B60N; B60R	Arrangements, seats specially adapted for vehicle
B61; B64	Railways, aircrafts (arrangements)
B65D83	Sterilizing air, objects involving spraying
C07D	Heterocyclic compounds (with anti-viral properties)
C07H	Sugars and nucleotide derivatives (with anti-viral properties)
C09D	Coating composition with inactivating or repelling effect against viruses
C12M3	Cell or virus culture apparatus
C12P	Fermentation or enzyme-based processes for preparing compounds
F24F9,12,24	Screen, ventilation to prevent entry or contact with virus
G02B21,23,37	Microscopy, instruments for viewing inside bodies
G06F3,19	Digital computing or data processing equipment or methods
G06N5,7	Artificial Intelligence for medical uses
G16C	Chemoinformatics
H01J49	Detection or analysis of virus

Table 9

	OpenData COVID-19 (NCATS)	**NCBI SARS-CoV-2 data hub**
NIH-NCBI data resources	*OpenData Browser*, activities of compounds in the Approved Drug Collection and other collections in relevant biological assays)	Listings of deposited SARS-CoV-2 protein and genome sequences as deposited by researchers worldwide
	Omics Efforts, listing publications that contain publicly accessible original (or re-analyzed) data from studies in proteomics, genomics, epigenomics, etc. as generated using human samples, cell/animal models, SARS-Cov-2 variants, and/or clinical data	Links to bioinformatic tools for analyzing, geo-localizing, and comparing such sequences
EMBL-EBI data resources	**COVID-19 Data Portal**	**Other EBI Resources**
	Sequences, being *viral* (SARS-CoV-2 ones) or *host* (relevant human ones)	*UniProt COVID-19 Portal*, with latest available SARS-CoV-2 protein sequences
	Expression data at gene/protein level of human genes involved in SARS-CoV-2 activity or infection	*Ensembl SARS-CoV-2 genome browser*, with links to latest SARS-CoV-2 nucleotide sequences
	Proteins, with sequence and functional data on SARS-CoV-2 and human proteins	*PDBe-KB COVID-19 Data Portal*, listing protein sequences, structures and interactions data
	Biochemistry, with information about relevant human pathways, interactions, targets, compounds	*IntAct coronavirus dataset*, listing molecular interaction data from literature
	Links to other Data hubs, bioinformatic resources, and European research projects	*Europe PMC COVID-19 pre-prints,* indexing separately pre-prints with open data

Table 10

NCBI reference sequence name (Code) for Severe acute respiratory syndrome coronavirus 2 proteins	NCBI MeSH Supplementary Concept for Severe Acute Respiratory Syndrome coronavirus 2 proteins (date of introduction; MeSH ID)	Recommended protein name (Code) in EBI under taxonomy code 2697049	Cited in Lens.org Human Coronaviruses Data Initiative (PatSeq Finder Search) as "Wuhan-Hu1" sequence	Protein size (No. amino acids)
leader protein (YP_009742608.1)	NSP1 protein, SARS-CoV-2 (May 16, 2020; MeSH Unique ID: C000706293)	Included in either - Replicase polyprotein 1a (P0DTC1, 4405 amino acids; identified as ORF1a polyprotein under the code YP_009725295.1 in NCBI) or - Replicase polyprotein 1ab (P0DTD1, 7096 amino acids; identified as ORF1ab polyprotein under the code YP_009724389.1 in NCBI and MeSH Unique ID: C000705557)	ORF1ab	180
Nsp2 (YP_009742609.1)	NSP2 protein, SARS-CoV-2 (April 26, 2020; MeSH Unique ID: C000705667)			638
Nsp3 (YP_009742610.1)	NSP3 protein, SARS-CoV-2 (May 16, 2020; MeSH Unique ID: C000706292)			1945
Nsp4 (YP_009742611.1)	NSP4 protein, SARS-CoV-2 (May 16, 2020; MeSH Unique ID: C000706290)			500
3C-like proteinase (YP_009742612.1)	3C-like proteinase, Coronavirus (June 26, 1996; MeSH Unique ID: C099456)			306
Nsp6 (YP_009742613.1)	NSP6 protein, SARS-CoV-2 (April 29, 2020; MeSH Unique ID: C000705767)			290
Nsp7 (YP_009742614.1)	NSP7 protein, SARS-CoV-2 (April 26, 2020; MeSH Unique ID: C000705669)			83
Nsp8 (YP_009742615.1)	NSP8 protein, SARS-CoV-2 (April 26, 2020; MeSH Unique ID: C000705670)			198
Nsp9 (YP_009742616.1)	NSP9 protein, SARS-CoV-2 (April 29, 2020; MeSH Unique ID: C000705768)			113
Nsp10 (YP_009742617.1)	NSP10 protein, SARS-CoV-2 (April 29, 2020; MeSH Unique ID: C000705769)			139
Nsp11 (YP_009725312.1)	??			13
RNA-dependent RNA polymerase (YP_009725307.1)	RNA-dependent RNA polymerase, coronavirus (March 25, 2020; MeSH Unique ID: C000657944)			932
helicase (YP_009725308.1)	??			601
3'-to-5' exonuclease (YP_009725309.1)	NSP14 protein, SARS-CoV-2 (July 28, 2020; MeSH Unique ID: C000709087)			527
endoRNAse (YP_009725310.1)	Nidoviral uridylate-specific endoribonuclease, SARS-CoV-2, NSP15 (March 24, 2020; MeSH Unique ID: C000657925)			346
2'-O-ribose methyltransferase (YP_009725311.1)	NSP16 protein, SARS-CoV-2 (Aug 5, 2020; MeSH Unique ID: C000709423)			298
surface glycoprotein (YP_009724390.1)	spike protein, SARS-CoV-2 (March 19, 2020; MeSH Unique ID: C000657845)	Spike glycoprotein (P0DTC2)	Surface glycoprotein	1273
ORF3a protein (YP_009724391.1)	ORF3a protein, SARS-CoV-2 (April 22, 2020; MeSH Unique ID: C000705568)	ORF3a protein (P0DTC3)	ORF3a protein	275
envelope protein (YP_009724392.1)	envelope protein, SARS-CoV-2 (April 21, 2020; MeSH Unique ID: C000705509)	Envelope small membrane protein (P0DTC4)	Envelop protein	75
membrane glycoprotein (YP_009724393.1)	membrane protein, SARS-CoV-2 (April 21, 2020; MeSH Unique ID: C000705510)	membrane protein (P0DTC5)	Membrane glycoprotein	222
ORF6 protein (YP_009724394.1)	ORF6 protein, SARS-CoV-2 (April 22, 2020; MeSH Unique ID: C000705569)	ORF6 protein (P0DTC6)	ORF6 protein	61
ORF7a protein (YP_009724395.1)	ORF7a protein, SARS-CoV-2 (April 22, 2020; MeSH Unique ID: C000705570)	ORF7a protein (P0DTC7)	ORF7a protein	121
ORF7b protein (YP_009725318.1)	ORF7b protein, SARS-CoV-2 (April 22, 2020; MeSH Unique ID: C000705571)	ORF7b protein (P0DTD8)	??	43
ORF8 protein (YP_009724396.1)	ORF8 protein, SARS-CoV-2 (April 22, 2020; MeSH Unique ID: C000705574)	ORF8 protein (P0DTC8)	ORF8 protein	121
nucleocapsid phosphoprotein (YP_009724397.2)	nucleocapsid protein, Coronavirus (September 19, 1996; MeSH Unique ID: C099602)	nucleoprotein (P0DTC9)	Nucleocapsid phosphoprotein	419
NO	NS8 protein, SARS-CoV-2 (June 25, 2020; MeSH Unique ID: C000707895)	??	??	??
NO	NS7b protein, SARS-CoV-2 (June 25, 2020;MeSH Unique ID: C000707891)	??	??	??
NO	NS5A protein, SARS-CoV-2 (May 16, 2020; MeSH Unique ID: C000706288)	??	??	??
NO	NS5B protein, SARS-CoV-2 (May 16, 2020; MeSH Unique ID: C000706289)	??	??	??
ORF10 protein (YP_009725255.1)	??	??	??	38
NO	??	Uncharacterized protein 14 (P0DTD3)	??	73
NO	??	ORF9B protein (P0DTD2)	??	97

DESCRIPTION OF FIGURES

Figure 1: Covid-19 conspiracy theory on the street. The image was taken by the corresponding author in a street near the Université Libre de Bruxelles, Brussels (Belgium) in early April 2020.

Figure 2: Websites providing dedicated databases for searching for Covid-19 scientific literature and data. Further details for the cited databases are available in Supplementary File 1 (SF1).

Figure 3 Trend in Covid-19 scientific publications present in PubMed in Jan.-Aug. 2020. Percentage and absolute values of Covid-19 Pubmed entries compared with either total Pubmed entries or PubMed entries for different topics (A). Comparison between Cancer-related and Covid-19 Pubmed entries in the same period (B). Weekly entries in PubMed based database LitCovid, as available on Nov. 2020 (C).

Figure 4: Trend in Covid-19 scientific publications in PubMed compared to other scientific literature databases & repositories The content of four datasets of scientific publications, either determined using search criteria (in PubMed or Lens Scholar) or as made available to the public (by the CDC website or in an article identified as Santos 2020) were compared for the period Jan.-Aug. 2020. (the content of the datasets, as an absolute number of entries or their indexing (using PMID, DOI, or PMC identifying codes) was compared (A). No publications having the three codes have been found in both CDC Research Articles (since the DOI is indicated in combination only with one other code) or in Santos 2020 (since PMC is not indicated). The content is also compared with respect to the indicated months and time criteria (B). No content appeared both in Santos 2020 in Aug. 2020 (since this month was not covered in the article), and for CDC Research Articles in Jan. 2020 and Feb. (2020 since such file was started in March 2020 and the publication date is not provided for any entry). The journals (or series of journals) more often present in the Covid-19 PubMed dataset generated with the Covid-19 Group (1) or MeSH criteria for the period Jan.-Aug. 2020 are indicated with the corresponding number of PubMed entries (C).

Figure 5: Early Covid-19 Patent Dataset: analysis by document and technology type. The Early Covid-19 Patent Dataset is analyzed with respect to the type of documents, with the total numbers indicated in parentheses (A) and the earliest month indicated in the official databases for claiming priority rights (or as direct filing) and for publication (B). The percentage of documents, by priority month, for each type of document is shown in the table below the graph.

Figure 6: Early Covid-19 Patent Dataset: category of technologies and related IPC Groups. The 10 most frequent IPC Groups in the documents published with at least one IPC code (1033 out of 1130) are listed under the four technological domains defined by the authors The percentage of documents within each category of technology that present either a given IPC Group (in the histogram) or a given number of distinct IPC Groups (pie chart with the key at the bottom of the figure) is indicated. The greyed IPC Groups are those found common to two technological domains.

Figure 7: Early Covid-19 Patent Dataset: analysis by technological domain. The number of patent documents in the Early Covid-19 Patent Dataset are assigned to each of the four technological domains defined by the authors, indicating the percentage in the Early Covid-19 Patent Dataset in parentheses (A). The Early Covid-19 Patent Dataset is also analyzed with respect to the days between the date of priority filing (or direct filing) and of publication, and the four technological domains (B).

Figure 8: PubMed Entries related to SARS-Cov-2 proteins. The NCBI MeSH Supplementary Concept and related alternative names for each SARS-Cov-2 protein in EBI, NCBI, and MeSH related records, in combination with Covid-19 keywords (see Covid-19 Group (1) criteria and MeSH Supplementary Concepts), were used to search within PubMed on Sept. 16th 2020 for records entered between Jan.-Aug. 2020. The six most commonly cited SARS-Cov-2 proteins are shown. Additional details about main names and codes for SARS-CoV-2 proteins are provided in Supplementary File 5 (SF5).

Figure 9: Covid-19 patent and pandemic timeline for Jan.-Aug.2020. The listed events and the related dates have been selected from the patent information and related resources that has been presented in this article (left) and the cited literature (right).

Figure 1

Figure 2

Provider	Disclosing Covid-19 search criteria	Covering only data published in 2020
Ovid	YES	NO
EuropePMC	YES	NO
Semantic Scholar	NO	NO
Mendeley	NO	NO
WHO	NO	YES
Outbreak.info	NO	NO
ScienceOPEN	YES	NO
NCBI (PMC)	YES	NO
NCBI (PubMed)	YES	YES
NCBI (LitCovid)	NO	YES
L·OVE	YES	NO
Elsevier (Scopus)	NO	NO
Publons	NO	YES
Cochrane Library	NO	YES

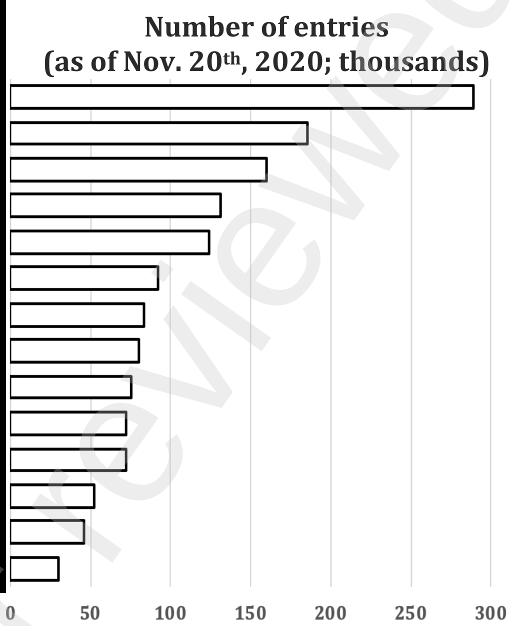
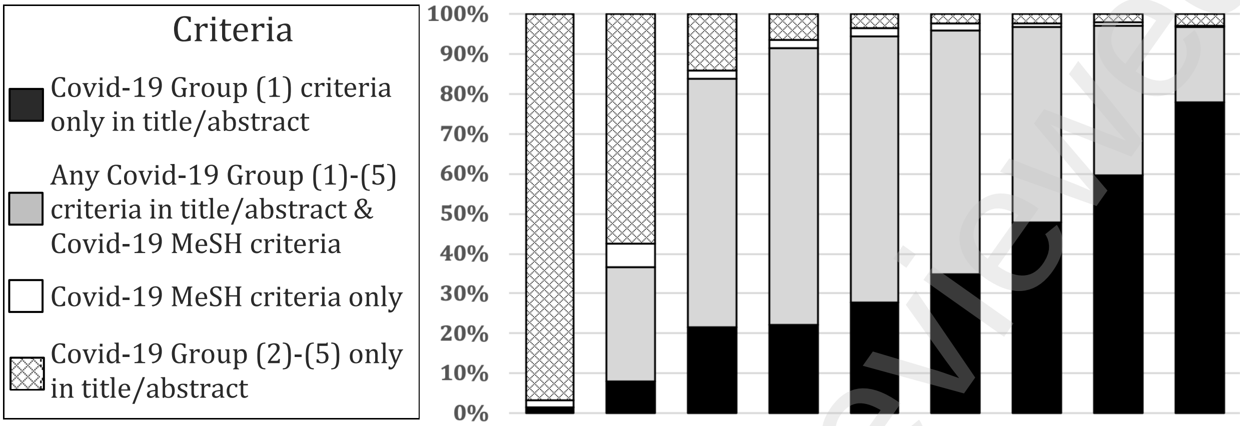


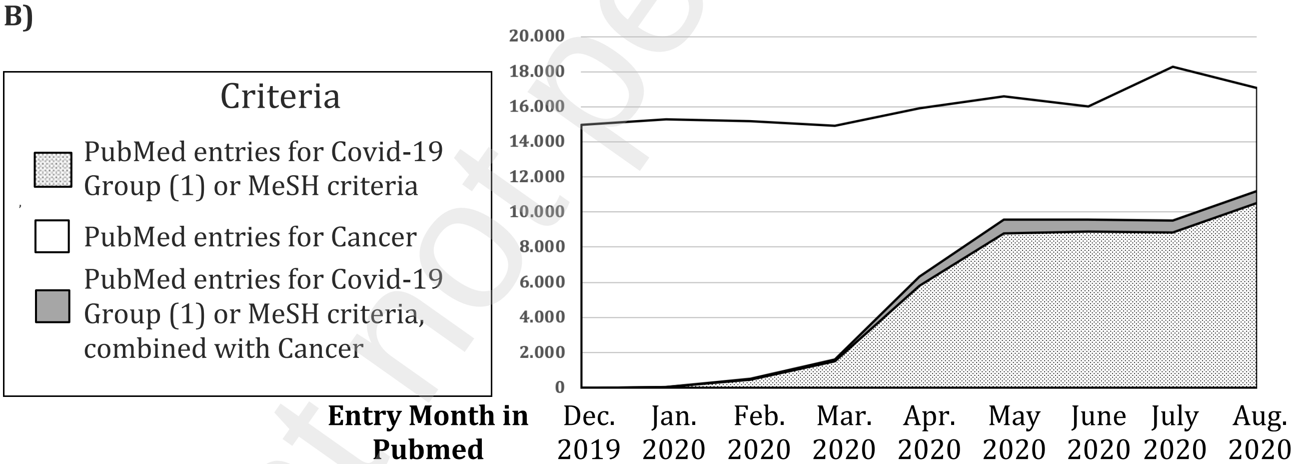
Figure 3

A)



Entry Month in Pubmed	Dec. 2019	Jan. 2020	Feb. 2020	Mar. 2020	Apr. 2020	May 2020	June 2020	July 2020	Aug. 2020
Covid-19 Group (1) or MeSH-related Pubmed entries	2	43	504	1.593	6.330	9.562	9.589	9.499	11.206
Malaria-related Pubmed entries	357	310	329	312	363	360	351	431	385
Total Pubmed entries (k=thousands)	101k	104k	104k	104k	116k	121k	117k	134k	131k

B)



C)

LitCovid entries

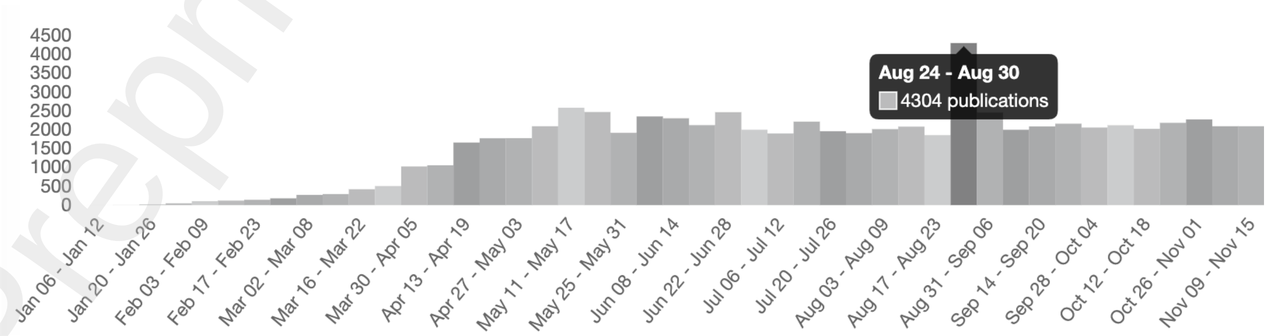
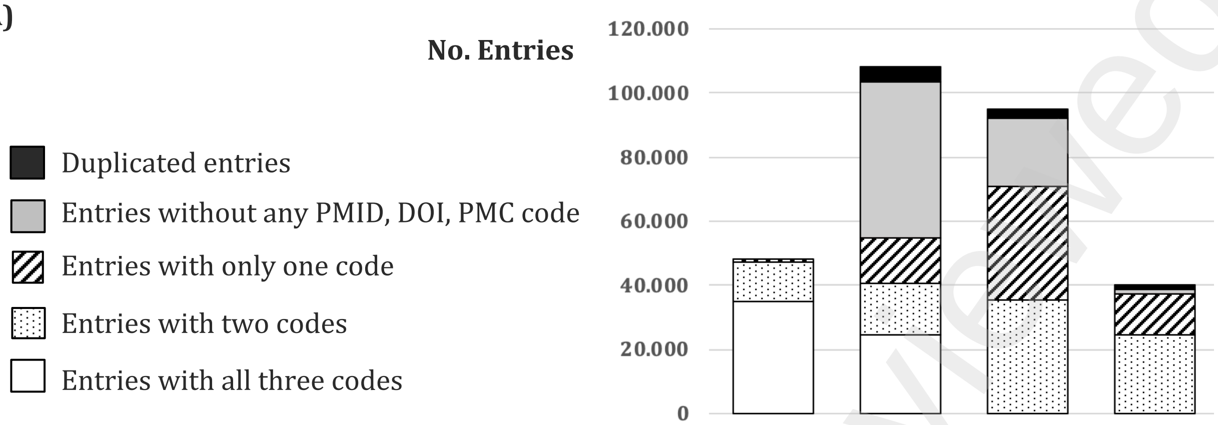


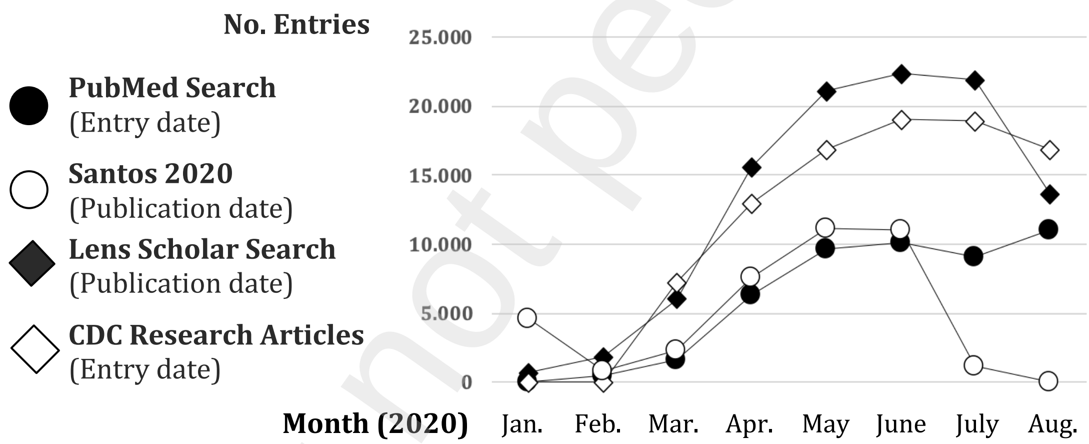
Figure 4

A)



Dataset (period Jan-Aug. 2020)	PubMed Search (Covid-19 Group (1) or MeSH criteria)	Lens Scholar Search	CDC Research Articles	Santos 2020
% Unique entries having PMID code	100%	41%	37%	64%
% Unique entries having DOI code	98%	51%	76%	95%
% Unique entries having PMC code	73%	25%	4%	0%

B)



C)

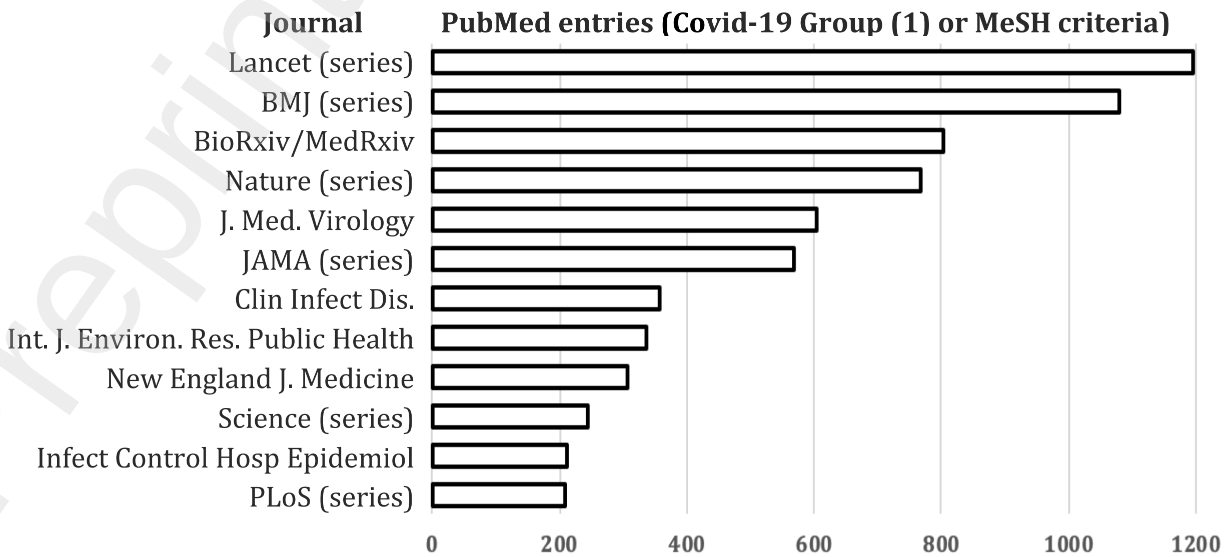
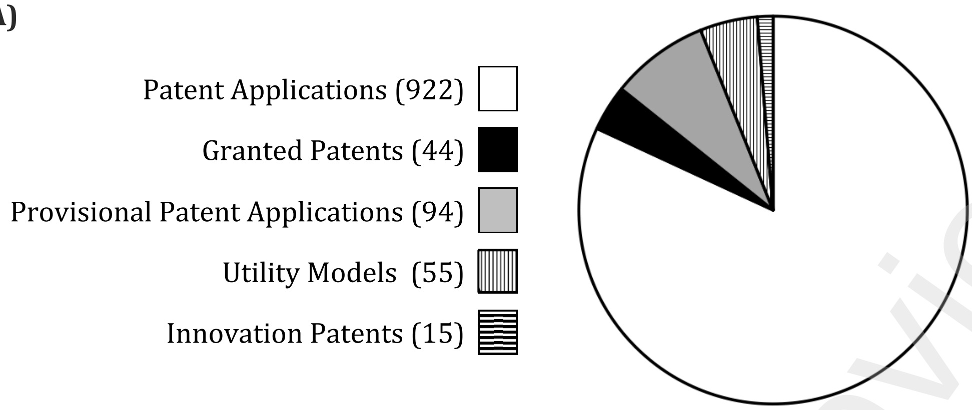
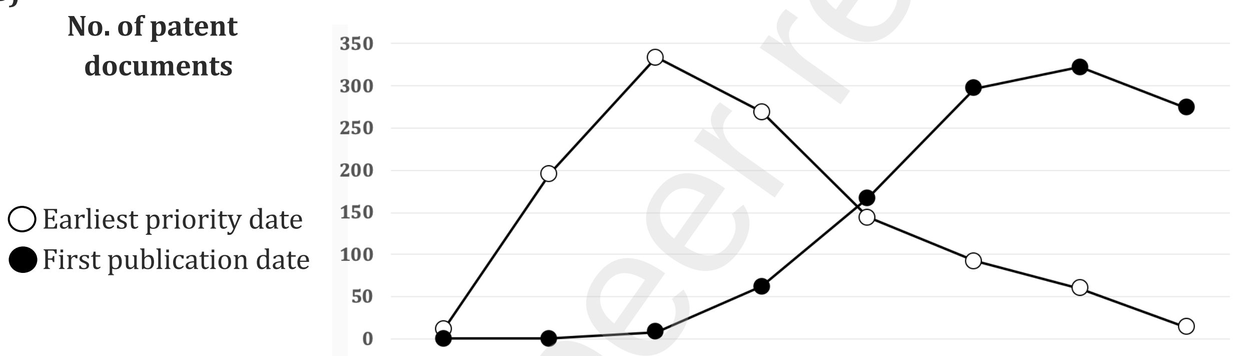


Figure 5

A)



B)



Month (2020)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
By Priority Month	Standard or Innovation Patent Applications	1%	18%	31%	23%	11%	10%	4%	1%
	Provisional Patent Applications	0%	0%	21%	29%	15%	8%	19%	8%
	Utility Models	2%	37%	17%	24%	12%	8%	0%	0%

Figure 6

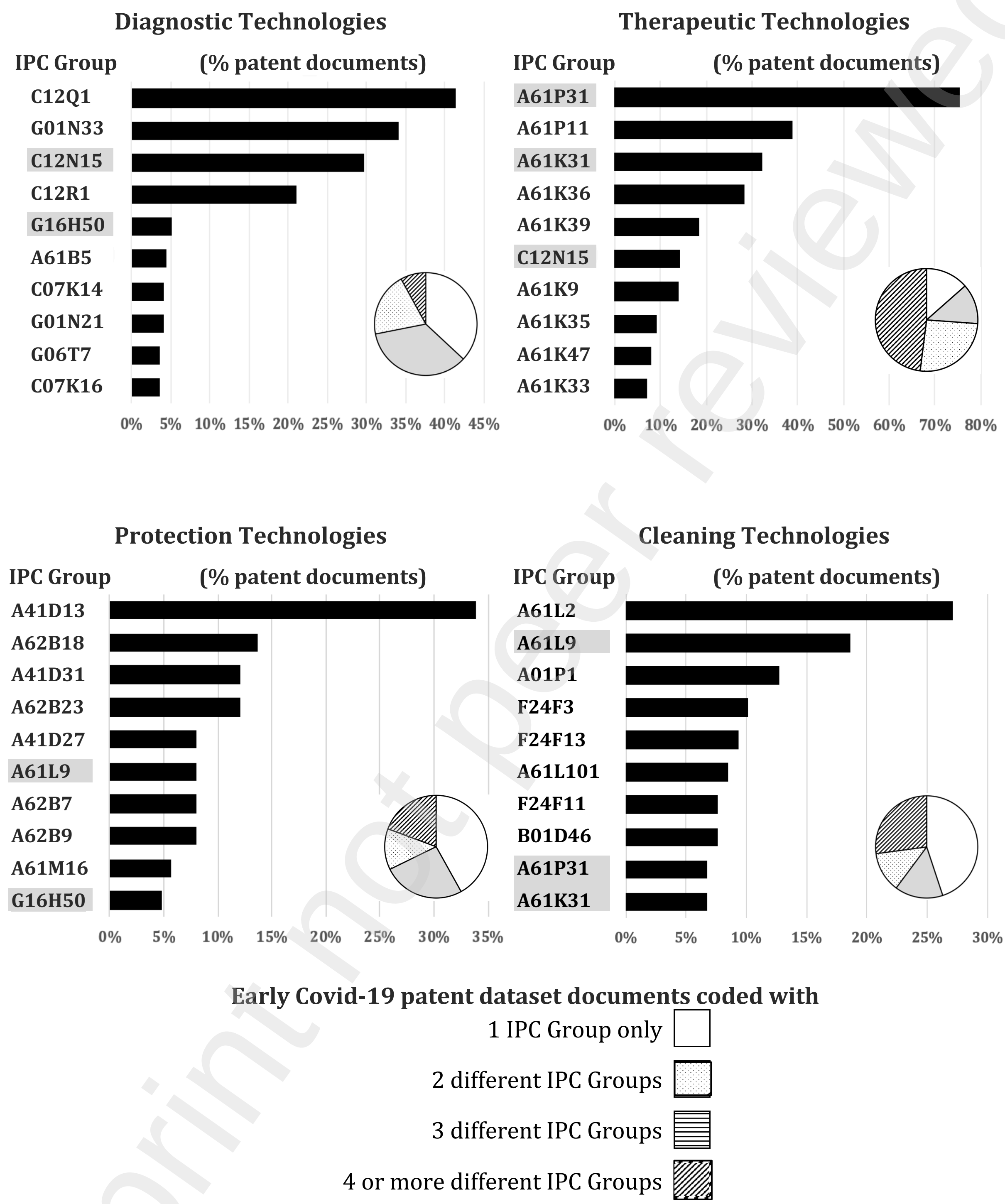
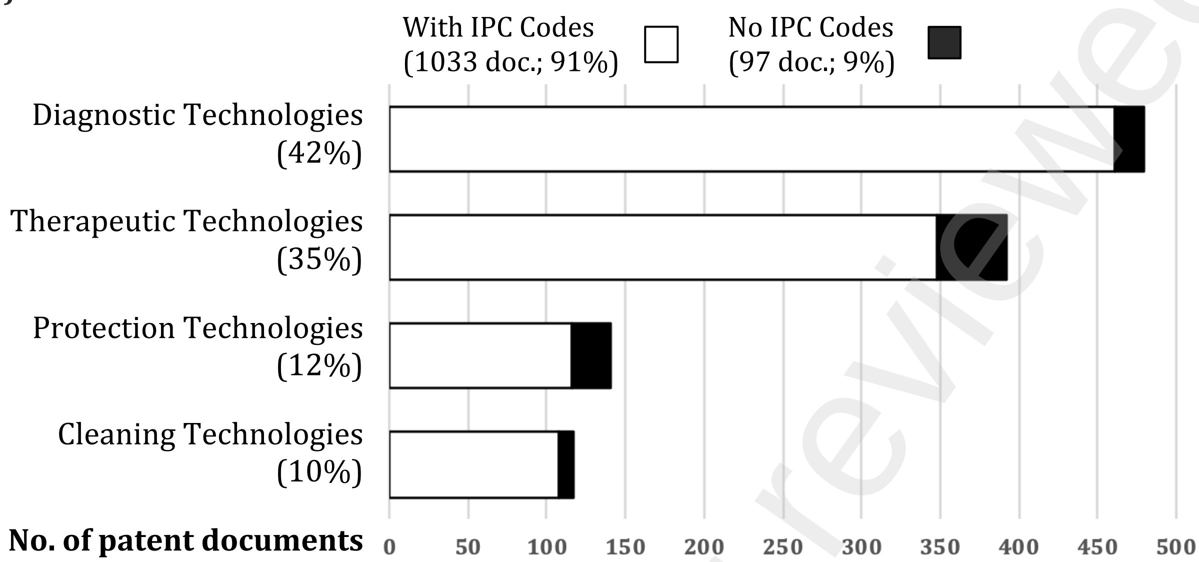
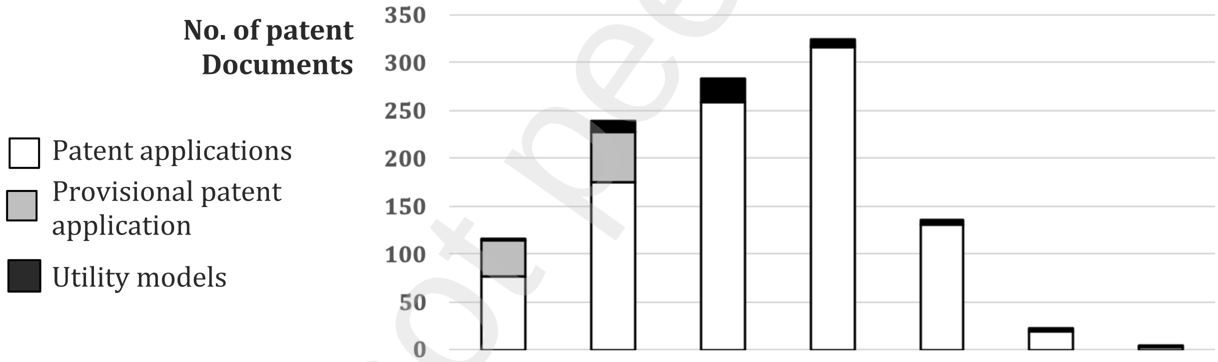

Diagnostic Technologies
IPC Group
(% patent documents)
C12Q1
G01N33
C12N15
C12R1
G16H50
A61B5
C07K14
G01N21
G06T7
C07K16
0% 5% 10% 15% 20% 25% 30% 35% 40% 45%
Therapeutic Technologies
IPC Group
(% patent documents)
A61P31
A61P11
A61K31
A61K36
A61K39
C12N15
A61K9
A61K35
A61K47
A61K33
0% 10% 20% 30% 40% 50% 60% 70% 80%
Protection Technologies
IPC Group
(% patent documents)
A41D13
A62B18
A41D31
A62B23
A41D27
A61L9
A62B7
A62B9
A61M16
G16H50
0% 5% 10% 15% 20% 25% 30% 35%
Cleaning Technologies
IPC Group
(% patent documents)
A61L2
A61L9
A01P1
F24F3
F24F13
A61L101
F24F11
B01D46
A61P31
A61K31
0% 5% 10% 15% 20% 25% 30%
Early Covid-19 patent dataset documents coded with
1 IPC Group only
2 different IPC Groups
3 different IPC Groups
4 or more different IPC Groups

Figure 7

A)

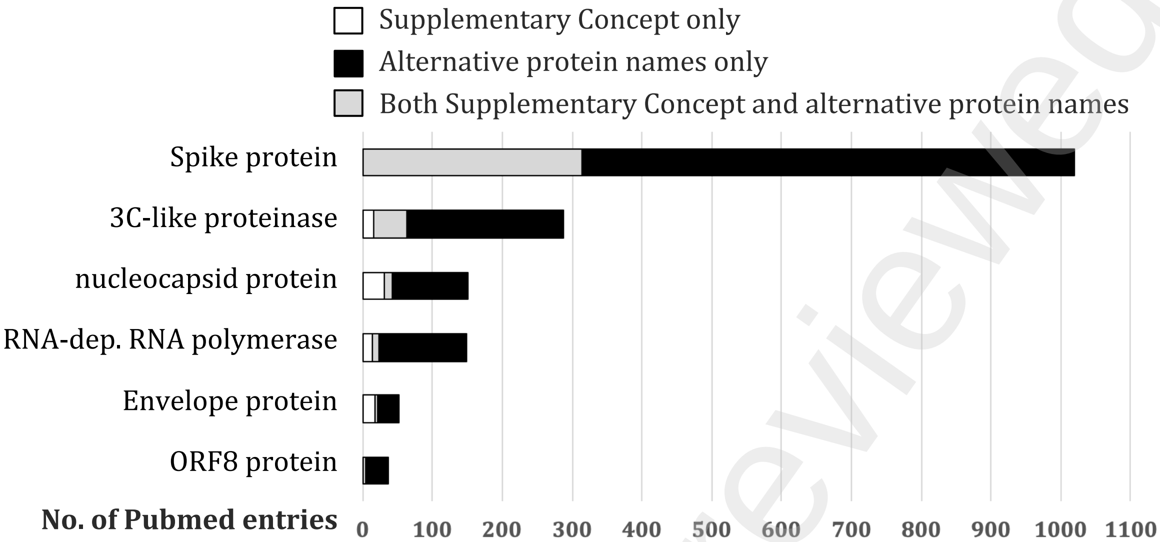


B)



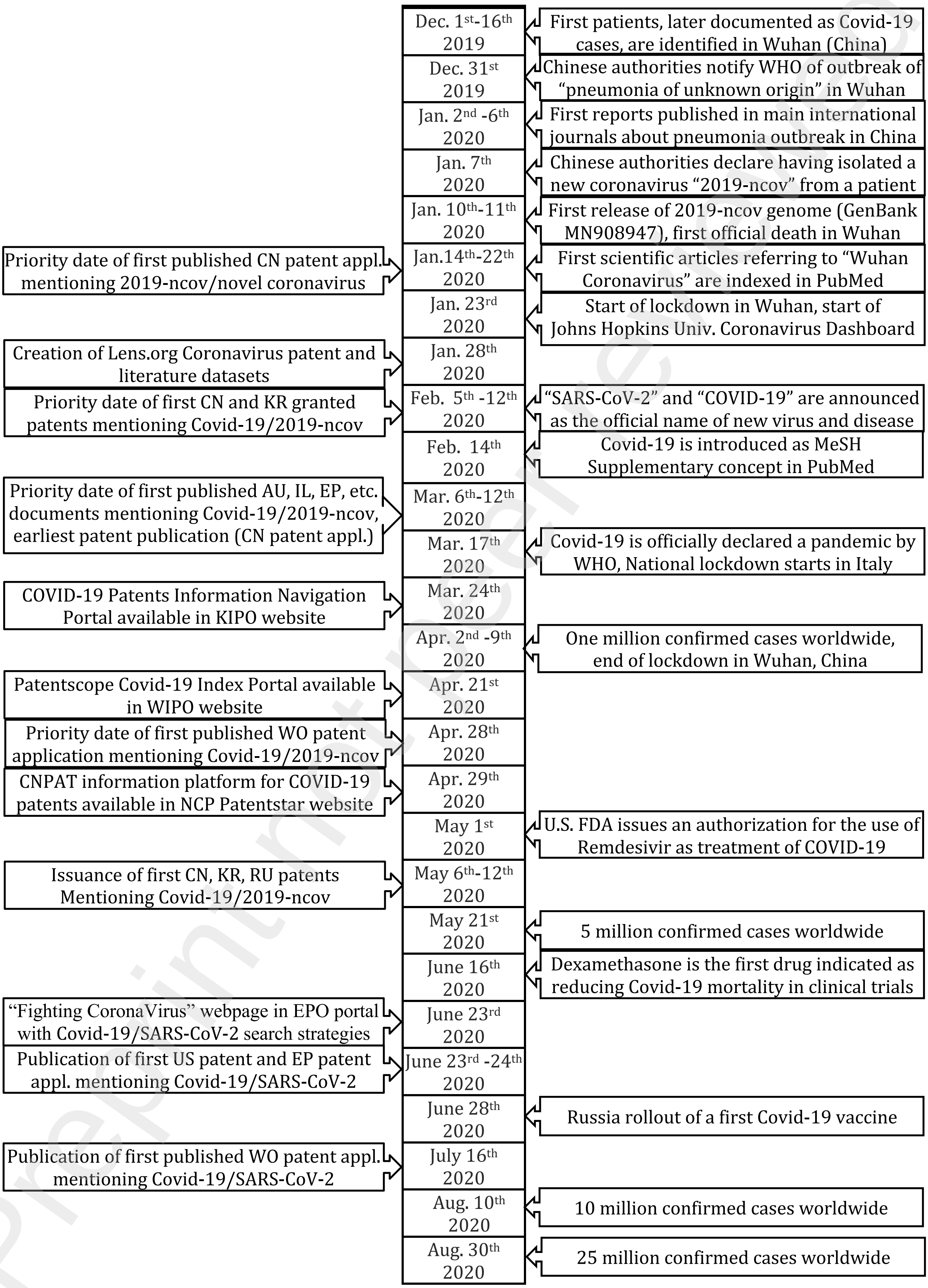
Priority to publication (days)	0-30	31-60	61-90	91-120	121-150	151-180	>180
Diagnostic Technologies	7%	21%	22%	32%	15%	2%	1%
Therapeutic Technologies	8%	21%	26%	31%	11%	2%	1%
Protection Technologies	18%	24%	32%	17%	7%	1%	1%
Cleaning Technologies	17%	27%	27%	20%	7%	1%	0%

Figure 8



Supplementary Concept only
Alternative protein names only
Both Supplementary Concept and alternative protein names
Spike protein
3C-like proteinase
nucleocapsid protein
RNA-dep. RNA polymerase
Envelope protein
ORF8 protein
No. of Pubmed entries
0
100
200
300
400
500
600
700
800
900
1000
1100

Figure 9


Dec. 1st-16th 2019
First patients, later documented as Covid-19 cases, are identified in Wuhan (China)
Dec. 31st 2019
Chinese authorities notify WHO of outbreak of "pneumonia of unknown origin" in Wuhan
Jan. 2nd -6th 2020
First reports published in main international journals about pneumonia outbreak in China
Jan. 7th 2020
Chinese authorities declare having isolated a new coronavirus "2019-ncov" from a patient
Jan. 10th-11th 2020
First release of 2019-ncov genome (GenBank MN908947), first official death in Wuhan
Priority date of first published CN patent appl. mentioning 2019-ncov/novel coronavirus
Jan.14th-22th 2020
First scientific articles referring to "Wuhan Coronavirus" are indexed in PubMed
Jan. 23rd 2020
Start of lockdown in Wuhan, start of Johns Hopkins Univ. Coronavirus Dashboard
Creation of Lens.org Coronavirus patent and literature datasets
Jan. 28th 2020
Priority date of first CN and KR granted patents mentioning Covid-19/2019-ncov
Feb. 5th -12th 2020
"SARS-CoV-2" and "COVID-19" are announced as the official name of new virus and disease
Feb. 14th 2020
Covid-19 is introduced as MeSH Supplementary concept in PubMed
Priority date of first published AU, IL, EP, etc. documents mentioning Covid-19/2019-ncov, earliest patent publication (CN patent appl.)
Mar. 6th-12th 2020
Mar. 17th 2020
Covid-19 is officially declared a pandemic by WHO, National lockdown starts in Italy
COVID-19 Patents Information Navigation Portal available in KIPO website
Mar. 24th 2020
Apr. 2nd -9th 2020
One million confirmed cases worldwide, end of lockdown in Wuhan, China
Patentscope Covid-19 Index Portal available in WIPO website
Apr. 21st 2020
Priority date of first published WO patent application mentioning Covid-19/2019-ncov
Apr. 28th 2020
CNPAT information platform for COVID-19 patents available in NCP Patentstar website
Apr. 29th 2020
May 1st 2020
U.S. FDA issues an authorization for the use of Remdesivir as treatment of COVID-19
Issuance of first CN, KR, RU patents Mentioning Covid-19/2019-ncov
May 6th-12th 2020
May 21st 2020
5 million confirmed cases worldwide
June 16th 2020
Dexamethasone is the first drug indicated as reducing Covid-19 mortality in clinical trials
"Fighting CoronaVirus" webpage in EPO portal with Covid-19/SARS-CoV-2 search strategies
June 23rd 2020
Publication of first US patent and EP patent appl. mentioning Covid-19/SARS-CoV-2
June 23rd -24th 2020
June 28th 2020
Russia rollout of a first Covid-19 vaccine
Publication of first published WO patent appl. mentioning Covid-19/SARS-CoV-2
July 16th 2020
Aug. 10th 2020
10 million confirmed cases worldwide
Aug. 30th 2020
25 million confirmed cases worldwide