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Crisis-Critical Intellectual Property: Findings From the COVID-19 Pandemic

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Abstract—A pandemic calls for large-scale action across national and international innovation systems in order to mobilize resources for developing and manufacturing crisis-critical products efficiently and in the huge quantities needed. Nowadays, these products also include a wide range of digital innovations. Given that many responses to the pandemic are technology driven, stakeholders involved in the development and manufacturing of crisis-critical products are likely to face intellectual property (IP) related challenges. To (governmental) decision makers, IP challenges might not appear to be of paramount urgency compared to the many undoubtedly huge operational challenges to deploy critical resources. However, if IP challenges are considered too late, they may cause delays to urgently mobilize resources effectively. Innovation stakeholders could then be reluctant to fully engage in the development and manufacturing of crisis-critical products. This article adopts an IP and innovation perspective to learn from the currently unfolding COVID-19 pandemic using secondary data, including patent data, synthesized with an IP roadmap.We focus on technical aspects related to research, development, and upscaling of capacity to manufacture crisis-critical products in the huge volumes suddenly in demand. In this article, we offer a set of contributions. We provide a structure, framework, and language for those concerned with steering clear of IP challenges to avoid delays in fighting a pandemic. We provide a reasoning why IP needs to be considered earlier rather than too late in a global health crisis. Major stakeholders we identify include 1) governments; 2) manufacturing firms owning existing crisis-critical IP (incumbents in crisis-critical sectors); 3) manufacturing firms normally not producing crisis-critical products suddenly rushing into crisis-critical sectors to support the manufacturing of crisis-critical products in the quantities that far exceed incumbents' production capacities; and 4) voluntary grassroot initiatives that form during a pandemic, often by highly skilled engineers and scientists in order to contribute to the development and dissemination of crisis-critical products. For these major stakeholders, we draw up three scenarios, from which we identify associated IP challenges they face related to the development and manufacturing of technologies and products for 1) prevention (of spread); 2) diagnosis of infected patients; and 3) the development of treatments. This article provides a terminology to help policy and other decision makers to discuss IP considerations during pandemics. We propose a framework that visualizes changing industrial organizations and IP-associated challenges during a pandemic and derive initial principles to guide innovation and IP policy making during a pandemic. Obviously, our findings result only from observations of one ongoing pandemic and thus need to be verified further and interpreted with care.

Index Terms—Coronavirus, COVID-19, global health crisis, incumbents, innovation, intellectual property (IP), licensing, new entrants, pandemic.

I. INTRODUCTION

an outbreak of a novel coronavirus in Wuhan, Hubei province, China, manifested itself as a global health tragedy. The World Health Organization (WHO) announced it as a public health emergency of international concern on January 30, 2020 [1] and as a pandemic on March 11, 2020 [2]. The virus, later named SARS-CoV-2 [3], can cause mild flu-like symptoms (or even be asymptotic) but can progress to acute pneumonia-like respiratory illness called novel coronavirus-infected pneumonia (NCIP). The overall clinical syndrome is known as COVID-19 [4]. Until today, there are no vaccines or medical cure for the disease yet [5], and the disease has a fatality rate that is unconfirmed due to lack of testing data for many countries but is likely to be around or above 1% [1]. In just less than six months since its emergence, the virus is affecting more than 212 countries, with more than 4 million onfirmed cases worldwide [2]. The virus has a stronger transmission capacity than the "conventional" annually recurring flu. On average, without social distancing measures in place, one infected person passes the virus to 2–2.5 others (that range is subject to change and can vary largely by geography, age group, and time) [8], [9]. The current COVID-19 pandemic creates enormous demand surges for products that are crisis relevant as well as a need for rapidly developing innovations to address crisis-specific problems. Innovation efforts require pooling of and repurposing of resources, capabilities, and capacities from actors owning relevant or capable of creating new intellectual property (IP) to develop these crisis-critical innovations. The literature that investigates IP challenges during times of global crisis appears very limited (see, e.g., [3]). A limited number of papers focus on IP challenges during economic crises, such as the global financial crisis in 2008–2009. During that crisis, strong IP protection was found to be beneficial for companies to recover, e.g., through facilitating collaboration, IP monetization, licensing, and the use of IP as collateral [4], [5]. Another small set of papers actually focuses on global health crises (see, e.g., [6]–[11]). Most authors, however, focus on crises that unfold much slower than the current COVID-19 pandemic, such as the HIV/AIDS pandemic. For ending the global HIV/AIDS pandemic, IP rights were found to be a barrier for low-income countries to access HIV/AIDS medicines after they became available [7], [12]. As a consequence, parallel import options and compulsory licensing were introduced at the international level to relax IP restrictions on essential medicines [6], [7]. Existing literature also studies compulsory licensing [6], [7], changes to patent laws, such as fast track grant procedures [6], "western subsidies" [8], restricted patentability standards, and patent pools involving voluntary nonexclusive licenses among private innovators (e.g., UNITAIDS Medicine Patent Pool) [9], [10]. While these papers undoubtedly discuss topics that are potentially relevant to the COVID-19 pandemic (compulsory licensing has already been enacted by a few countries), findings from those papers must be treated carefully and should not be overly generalized to the COVID-19 pandemic. The current pandemic spreads so much faster than the global health crises studied in prior literature. However, two general conclusions can be drawn from prior literature focusing on IP in the context of crises that are very much in line with what is known from extensive economic research on IP and innovation. First, IP seems to play a role as an innovation incentive; second, IP needs to be considered for accessing crisis-critical products (CC-P), such as vaccines and treatments. We can thus conclude that the

existing literature hardly provides suitable frameworks, terminology, evidence, and guidance for (governmental) decision makers to make informed choices to best utilize IP, and to steer clear of IP associated challenges and risk during and beyond global crises. This article aims to contribute to the many efforts to contain the pandemic as quickly as possible. We offer a set of contributions with two primary purposes. First, we hope we contribute reasoning on why IP considerations need to be addressed early rather than later during a pandemic. Second, we provide a structure (if not conceptual framework) that is hopefully helpful for those concerned with steering clear of IP challenges, e.g., policy makers, governments, international organizations, large IP owners, new entrants, and many voluntary initiatives that are part of the grassroots movement. This article focuses on three critical areas for fighting a pandemic, all of which are technology dependent: 1) the prevention (including measures to limit its spread and vaccines to prevent future outbreak); 2) diagnosis (including professional and self-testing); and 3) treatment, with the latter including the direct treatments (e.g., development of drugs) and the treatment of symptoms, i.e., related to the medical equipment needed to keep bodies alive (e.g., ventilators and intensive care unit (ICU) beds).

Deriving findings from secondary data of the COVID-19 pandemic, including patent data, this article contributes a structure, framework, and language for those concerned with steering clear of IP challenges to avoid delays in fighting a pandemic. We identify relevant stakeholders and describe associated IP challenges they face related to the development and manufacturing of technologies and products for prevention (of spread), diagnosis of infected patients, and the development of treatments summarized in an adopted IP roadmap. Major innovation stakeholders we identify include the following:

1) governments;

2) manufacturing firms owning existing crisis-critical in- tellectual property (CC-IP) [incumbents in crisis-critical sectors (CC-S)];

3) manufacturing firms normally not producing CC-P sud- denly rushing into CC-S to support the manufacturing of CC-P in the quantities that far exceed incumbents' production capacities;

4) voluntary grassroot initiatives that form during a pandemic, often by highly skilled engineers and scientists in order to contribute to the development and dissemination of CC-P.

Particularly, new relationships that are formed rather suddenly during a pandemic appear to be associated with various IP related uncertainties with the particular problem that negotiating licensing agreements is typically time consuming and that new IP emerges during the pandemic, which can be owned by new entrants.

II. METHODOLOGY

To contribute to filling the knowledge gap concerning IP considerations during pandemics, we deploy an exploratory method [13] employing an IP and innovation perspective (see Fig. 1). One could argue that we treat the COVID-19 pandemic as a single longitudinal case study [14], [15] to make better informed decisions during this, but also future global health crises. Our findings are based on secondary data collected during the ongoing COVID-19 pandemic. The data include publicly available documents, such as news articles, government announcements, press releases,

industry reports, and patent data. We complement our analysis of secondary data with a patent analysis for the severe acute respiratory syndrome (SARS) Coronavirus, where we make use of the open patent data sets compiled

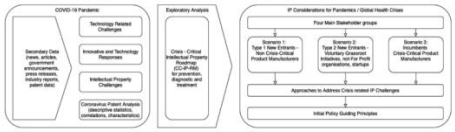

Fig. 1. CC-IP exploratory methodology for the COVID-19 pandemic.

by Lens.org,1 to enhance our understanding into preventive, diagnostic, and treatment measures. We focus on the broader spectrum of coronaviruses to identify patterns from earlier out- breaks that could be applied in the case of SARS-Cov-2. We use the data set compiled by Lens.org "Coronavirus: Broad Keywords Based Patents" and extract all the related patent information.2 We choose to focus on the keywords to capture a large variety of coronavirus-related patents, in a time of high uncertainty, to improve our overall understanding.

The COVID-19 data are then synthesized in technology- related challenges, innovative and technology responses to the COVID-19 pandemic, and IP-related challenges. Using this information, together with the patent analysis, we synthesize a crisis-critical IP roadmap to effectively provide a systematic compilation, description, and analysis of IP considerations. For that, we adapt the IP roadmapping template proposed by [16] and [17] structuring it along three time-interdependent pandemic phases: 1) prevention (reducing the spread, including vaccine development), 2) diagnosis (increase our understanding about the coronavirus and its early identification using test kits or symptom identification), and 3) treatment (treatment development of the acute respiratory pneumonia caused by COVID-19, with a preventative vision). From this initial analysis and development of the CC-IP roadmap, we identify four main stakeholder groups. We then develop a terminology that can be used for conceptualizing IP issues during a crisis. For different stakeholder constellations, we identify and describe three scenarios. The outcomes of the scenarios lead into a CC-P/sector framework for how industrial organization can change during pandemics.We use what we have learnt from the scenarios, again using our terminology to reflect on current policy responses from different countries, which leads us to formulate initial guiding principles for IP and innovation policy making.

III. development and manufacturing of diagnostic testing

From an IP and innovation perspective, this section synthesizes relevant observations from the current COVID-19 pandemic. Based on publicly available secondary data, we identify technology-related pandemic challenges, describe innovative and technology responses, and finally summarize observations related to IP issues that emerge during the ongoing pandemic.

A. Major Technical Pandemic Challenges

From our observations of the current COVID-19 pandemic, five major technology-related challenges emerge. Some relate to novel technologies highlighted in the WHO's Coordinated Global Research Roadmap for COVID-19 [18], while others emerge from operational needs in frontline healthcare. First and foremost, the challenge of finding a vaccine and treatments for the acute respiratory pneumonia caused by COVID-19 has initiated large-scale R&D efforts. Second, the pandemic has created a sudden and massive demand for the development and manufacturing of diagnostic testing kits in extremely large volumes, not only with high accuracy that can be conducted in a high-throughput

manner (e.g., for several weeks, Germany alone has carried out 160 000 tests per week [19]) but also innovative ways of organizing testing (e.g., COVID-19 isolation pods, drive through testing). Third, the pandemic caused a sudden need to treat a large number of patients in hospitals requiring an extraordinarily large ICU capacity, particularly with an enormous need for ventilator capacity (e.g., U.K. ventilator challenge [20]) by far exceeding the number currently available in many hospitals and countries, leading to supply shortages. Fourth, the COVID-19 pandemic has caused an exceptionally high demand for skilled medical staff, doctors, and nurses, particularly with ICU experience, such as anesthetists and critical care nurses, all of whom need to be equipped with personal protective equipment (PPE). Due to the high infectivity of the virus, in this pandemic, PPE such as protective clothing, face shields, goggles, and gloves are critical to protect healthcare staff from infection with SARS-CoV-2. Fifth, the pandemic created a strong need for digital innovation, including artificial intelligence (AI)-enabled tracking apps for cases and spreaders and epidemic modeling to monitor and understand the spread and development of the virus across populations. Of course, a pandemic that cuts across ll parts of life raises various other technical and nontechnical challenges. Those include, for instance, the security of supply chains for essential goods; securing of food supply with supermarket chains plays a major role, but so does the optimization of delivery route planning, quick adjustments to online booking systems, e.g., for rationing certain goods or prioritizing delivery slots to the elderly and vulnerable. Other challenges are associated with unprecedented numbers of people working from home, i.e., video conferencing platforms and equipment (e.g., Google and Microsoft announced free access to teleconferencing and collaboration tools [62]) as well as internet service providers relieving data caps. Then, there are urgent logistical challenges, for instance, to efficiently reorganize supply of CC-P in the midst of drastically reduced passenger and cargo transport routes, the repatriation of national citizens from abroad, but also internal operations processes in hospitals as wards, has been repurposed, and specific COVID-19 testing pods have been set up to innovate at health system and infrastructure level to cope with testing and treating huge numbers of people.

B. Innovative and Technology Responses to the Pandemic

During the past weeks, we have observed a number of responses to the five technical challenges. Pharma, biotechnology firms, and universities have joined forces to develop vaccines [21] and treatments [22], also testing whether existing antiviral drugs could be repurposed, e.g., malaria/HIV drugs or development of novel COVID-19 specific drugs [23]. For instance, a collaboration of Clover and GSK has been announced [24]. Another consortium includes life sciences companies such as Novartis, Bristol Myers Squibb, and GSK [25]. Others started to develop novel diagnostics, such as BOSCH who recently announced that they developed their own COVID-19 test kit [26]. Manufacturing companies from all kinds of sectors have started to repurpose production lines to support the production of CC-P, involving large engineering/manufacturing firms such as those involved in the U.K. ventilator challenge consortium (e.g., Airbus, GKN, Roll-Royce, Siemens, and Smiths group) [20], [27], [28], and luxury brands (e.g., French LVHM) using perfume manufacturing facilities to make hand sanitizers [29]; small- and medium-sized enterprises (SMEs) have started to produce

sanitizers [30]; textile manufacturers (e.g., ZARA in Spain [31], Trigema in Germany [32], and Prada in Italy [33]) are mass producing face masks. We also observe that various volunteering initiatives emerge, such as those run by scientists and engineers to develop open hardware/source designs of ventilators; develop new PPE designs, e.g., 3-D printed face shields [34] and ventilator valves [35]; and develop new ways to mass produce PPE [35], [36]. Last but certainly not least, digital innovations have sprung up widely, e.g., data/software approaches by scientists for prevention, diagnostics, and treatment. In terms of prevention, scientists have focused on developing open data platforms and epidemiological models to forecast growth curves of the virus and model the impact of government responses [37]; analyzing geospatial models to understand the distribution and spread of the virus [38]; deploying causal-effect models to understand symptoms of the virus and limit its spread through behavioral science; and tracking applications [39]. In the diagnostic sphere, scientists utilize AI and more specifically deep convolutional neural networks to detect COVID-19 from X-ray images. This has also been particularly useful in diagnostic analysis of symptoms to predict the development of a patient's case [40]. A high number of efforts have also been concentrated on treatments, where scientists have developed AI-based text and data mining tools to help the medical community to prioritize scientific questions and potential lead treatments. Efforts have focused on the development and summarization of genome-specific precision medicine based on host response, as well as on modeling and simulation of the virus propagation and efficiency of interventions [41].

From what emerged during this crisis, one can categorize the crisis-critical activities in three categories, most of them related to innovation or massive capacity building/upscaling to provide CC-P in sufficient quantity in a short period of time. The first category is prevention, including digital innovations to track the virus spread, sanitizers, PPE, etc., in order to slow down the spread of the virus, and vaccine developments to control future outbreaks. The second category is diagnostics, predominantly the need for an incredible volume of nucleic acid and antibody testing kits which are accurate, and delivering speedy results. The third category is treatment, including development of treatments for the acute respiratory pneumonia caused by COVID-19 through repurposing or existing drugs, development of new antiviral drugs, and ventilators for ICU critical care in hospitals around the world. We use this prevention–diagnosis–treatment framework throughout the remainder of this article. C. IP-Related Challenges During the Pandemic IP-related challenges (including examples) across the three phases of the prevention–diagnosis–treatment framework employing an IP roadmap structure adapted from [16] and [17]. This section provides only a brief description for some of those challenges worth highlighting particularly. Table II provides a draft overview of COVID-19-related vaccines under development. IP issues hardly surfaced during the early stages of this pandemic but have been the focus of several initiatives more recently. The Wellcome Trust appears to be among the first prominent organizations that understood the relevance of IP for this pandemic [67], [109]. On January 31, 2020, the Trust called for journals, publishers, etc., to allow widespread sharing of all potentially relevant research and data set. This initiative is geared toward encouraging publishers to not to put any COVID-19 relevant publications behind a paywall. The pledge seems to be a huge success as a wide

range of renowned organizations have signed up, including leading journals, such as Nature and The Lancet, the European Commission, publishers (e.g., Cambridge University Press), national academies of science (e.g., Academy of Medical Sciences, The Royal Society), foundations (e.g., Bill & Melinda Gates Foundation), research councils (e.g., Medical Research Council), ministries (e.g., Indian Department of Biotechnology, Ministry of Science and Technology), and a wide range of other organizations, including companies (e.g., BenevolentAI and Johnson & Johnson). By now, more than 24 000 research papers are available online [66]. In the past weeks, some other organizations have started raising awareness that IP might become an issue during the pandemic and have called for the government and private sector to respond. For instance, on March 27, 2020, Doctors Without Borders publicly announced their concern that firms might try to profiteer from the crisis [113] and the government of Costa Rica called the WHO to organize the pooling or pledging of IP [82]. By now, a few governments have passed compulsory license resolutions for CC-IP, e.g., Chile and Canada [59], [101]–[104], and some even authorized issuance of compulsory license, e.g., Israel's compulsory licensing for Kaletra [103].

We have also observed some initial approaches that firms have taken related to IP during this pandemic. Some companies have taken steps against the risk of counterfeit products being distributed in the crisis, e.g., PPE masks [114], [115]. Some companies enforced IP lawsuits against other companies developing CC-P. For instance, Labrador Diagnostics LLC sued BioFire, a company developing COVID-19 testing kits for infringing two of its patents [77] but later announced a royalty-free licensing to anyone developing COVID-19 tests [79]. Some firms have already filed patents or other forms of exclusivity, e.g., Gilead applied for "orphan drug" designation for potential COVID-19 treatment Remdesivir [116], [117] but dropped the application a few days later after public criticism [116]. Very recently, we have seen a limited number of firms adopting at least some selective open IP approaches, particularly pledging [105] relevant IP, such as Fortress [79], AbbVie [75], and medical device companies manufacturing ventilators (including design specifications and files), such as Irish Medtronic [107] and U.K.-based Smiths Group [108], and even individuals. A recent initiative of scientists and lawyers has also launched the Open COVID Pledge (www.opencovidpledge.org) calling IP owners to not assert relevant IP during the crisis defined until one year after the WHO declares the pandemic to be over [69]–[71]. Some of the world's largest patent owners have joint the Open COVID Pledge, such as IBM,Microsoft, and Intel. Very recently, the Open COVID Pledge has joined forces with a similar Asian initiative from Japan, to which companies such as Canon and Toyota have signed up [42]. D. Coronavirus Patent Landscape One of the main IP challenges, both in this pandemic and in general, is the availability of open data for analyzing the progression of the virus [86], as well as the different analysis types deployed [87]. In an outbreak as severe as the COVID-19, where the reported cases have grown exponentially from around 1 million at the beginning of April 2020 to more than 4 million in just six weeks, any available data set is potentially helpful to derive insights into the disease. This section reports results from a patent analysis (see method section for details on the data set, provided by Lens.org3). the descriptive statistics and correlations for the patent data set, and shows some initial results from the Coronavirus Patent Analysis. reveals that the mean publication

year is 2010, with a median of 2011, and a mode of 2005, which is also supported by Fig. 2(c). The mean number of applicants is 2, and the number of inventors is approximately 4. It is important to note here the large number of forward citations, with the mean around five citations and the max at 555. We find the expected behavior about forward citations, with a positively skewed distribution representing the technological impact of patent [88]. Also, worth mentioning is the fact that these patents have a large mean simple family size of approximately 14 members and a mean extended family size of approximately 21 members. Fig. 2(a) shows the top ten cooperative patent classification (CPC) classification distribution at the subgroup level. It is evident that the highest number of patents belonging to the primary CPC subgroup classification is in C07K14/005. This is the organic chemistry subclass, for peptides with more than 20 amino acids and specifically for viruses, which constitute viral proteins.

This is followed by subgroup A61K39/215 (medicinal preparations containing antigens or antibodies materials for immunoas ay for coronaviridae) and C12Q1/701 (measuring or testing processes involving enzymes, nucleic acids, or microorganisms involving virus-specific hybridization probes). These are followed by C12N7/00 (preparation of viruses bacteriophages compositions, medicinal viral antigen, or antibody compositions),

G01N1 covering investigation processes for measuring or testing other than immunoassay, involving enzymes, and C07K16/08 for investigation of immunoglobulins from RNA viruses. Interestingly, within the top ten, we also find section Y (Emerging Cross-Sectional Technology), with Y02A50/451, which is specific for genetic or molecular screening of pathogens. This indicates that within the granted patents, there are some vaccination patents available. All the top ten CPC classifications have to do specifically with the chemical characteristics of the virus for prevention, diagnostics, and treatment. Also, one could note the granularity of patent applications in these fields since some of these have 50 CPC subgroups. Fig. 2(b) shows the top ten IPC classification distribution at the subgroup level. There are 103 unique subgroups referenced on these patents. While the highest primary IPC sub group can be found at A61K39/215 (preparation for medical purposes devices or methods specially adapted for bringing pharmaceutical products into particular physical or administering forms chemical aspects of, or use of materials for deodorization of air, for disinfection or sterilization, or for bandages, dressings, absorbent pads, or surgical articles soap compositions for coronaviridae), the highest collective number is for subgroup C12N15/09 (microorganisms or enzymes compositions there of propagating, preserving, or maintaining microorganism mutation or genetic engineering culture media microbiological testing media recombinant DNA technology).

VII. CONCLUSION

From an IP and innovation perspective, this article contributed to the scarce literature about the role of and challenges associated with IP during pandemics. Our findings were derived from analyzing, synthesizing, and interpreting secondary data from the COVID-19 pandemic from two major sources: 1) publicly available documents, such as newspaper articles, industry specific outlets, government reports, and announcements and 2) patent data. Obviously, our findings result only from observations of one ongoing pandemic and thus need to be verified further and

interpreted with care. We find that what makes it difficult for IP to be given its required considerations during the early stage of a pandemic is the enormous sense of urgency, which draws decision makers' attention to huge and undoubtedly urgent operational challenges. With this article, we hopefully contribute a set of arguments to raise awareness why IP needs to be dealt with earlier rather than later during a pandemic in order to avoid that IP-associated risks delay the mobilization of the resources so urgently needed for the research, development, and mass manufacturing of CC-P. This is particularly important as various responses to the pandemic are somehow technology related, which typically involves IP rights in some form. This article offered a set of contributions. We summarized IP-related issues currently surfacing during the COVID-19 pandemic in a CC-IP roadmap. We identified four major groups of stakeholders that are mostly concerned with IP considerations. These include governments (and intergovernmental organizations, such as the WHO and WIPO) who are called upon to orchestrate pandemic responses, incumbent manufacturing firms in CC-S, as well as new entrants that enter CC-S to assist incumbents. New entrants include manufacturing firms that did not produce CC-P prior to a pandemic (Type 1 entrants), as well as voluntary grassroot initiatives, start-ups, entrepreneurial scientists, etc. (Type 2 entrants). This article then identified and analyzed three scenarios in which different IP considerations emerge for the different stakeholder groups.

This article provided a terminology that helped to conceptualize IP considerations in times of pandemics or global health crises that call for urgent and large-scale actions from various innovation stakeholders that suddenly find themselves engaged in new relationships that are associated with various IP- associated uncertainties, not the least related to the use and sharng of IP with the particular problem that negotiating licensing agreements is typically time consuming. We also provided a language for policy makers and other decision makers to articulate and discuss IP challenges during pandemics, which might evolve further with specific terms being added gradually or notions being revised as we go along. We proposed a framework that visualizes how industrial organization could change throughout pandemics. That can serve as an analytical framework for others and particularly follow up studies. Results from our patent analysis show that research and IP protection for coronavirus-related inventions is not new. Patent protection for different forms of coronavirus already exists, but not for the particular coronavirus type SARS-CoV-2 that causes the COVID-19 disease. It appears evident that there is a time lag between outbreaks and the materialization of patents and a number of references to NPL, which shows the urgency of scientists for open data to put the information in the public domain. Any patent analysis is historic, thus limited to existing IP, even with a delay as patent applications get published 18 months after filing. Any patent analysis thus does not capture innovations currently being developed, even though these might result in patent applications, with some of them possibly even having been submitted. Following a systematic identification of CC-P, further specific patent analysis should be conducted to learn more about the owners of IP related to those, which can then, e.g., inform policy makers and help owners of CC-IP to form consortia with others who own complementary IP and identify opportunities for further repurposing of production capacities. For policy and

decision makers, we provide a summary of approaches to address IP concerns during the COVID-19 pandemic, such as compulsory licensing, IP pooling, and IP pledges. We derive initial guiding principles for policy makers toward using IP to maximize innovation incentives for CC-P until these are developed and then shift gradually to use policy measures to facilitate access to these key innovations, such as the vaccine. These should be subject to future scrutiny and needs further work to identify relevant literature from innovation economics. A more advanced IP risk analysis would be helpful to understand the risks for relevant stakeholders during the different pandemic phases, i.e., before/after certain key innovations have been developed, which could then provide relevant input to appropriate policy responses. In fact, currently, we lack system- atically collected evidence documenting the extent to which IP issues actually present a barrier or are a perceived possible future problem (risk) and to what extent for different actors. Evidence for this could be created for instance through a survey to those developing and manufacturing CC-P. This would provide a more sound basis for conversations with decision makers about the importance of IP issues during a pandemic.

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