


Managing pharmaceutical shortages during the COVID pandemic: An exploratory analysis of European collective and national government responses

The Journal of Medicine Access
2022, Volume 6: 1–12
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DOI: 10.1177/27550834221123425
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Abstract

Prior to the outbreak of the COVID pandemic, pharmaceutical shortages were already recognised as a major policy problem by most, if not all, European governments; and virtually all European national governments today publicise official shortage lists. Policy making in the area has been centred on the national government level, which meant that the understanding, definition, and response to shortages has remained highly heterogeneous. When the advent of the COVID pandemic exacerbated shortages, this situation continued against a background of a weak collective European response. As part of their responses to COVID-shortages, the medicines regulators of European countries expanded the range of products pharmacies could manufacture, process and distribute as well as their procedural authority in issuing, handling and processing prescriptions. While these measures were fairly common across Europe and alleviated some bottlenecks or improved medicine access for some patient groups, other responses were highly individualistic and included export bans of certain medications as well as efforts to draw on veterinary supplies. Our own data analysis of officially recorded shortage data during the first COVID wave (to October 2020) indicates that countries that had prepared for these types of crisis and maintained an active policy stance (e.g. Germany and Norway) were more likely to encounter fewer shortages than others. We also note that there is no direct correlation between officially recorded numbers of shortages and the ways in which national governments responded to these – which indicates that cultural expectations also might have been a significant policy driver.

Keywords

COVID pandemic, medicines shortage, Europe, Germany, France, Spain

Date received: 5 February 2022; accepted: 11 August 2022

The purpose of this article is to provide an exploratory, descriptive overview of the measures adopted by different European nation states in response to medicine shortages arising in connection with the COVID-19 epidemic. Prior to the outbreak of the COVID pandemic, pharmaceutical shortages were already recognised as a major policy problem by most, if not all, European governments; and virtually all European national governments publish official shortage lists. Policy making in the area has been centred on the national government level, which means that the understanding, definition and response to shortages has remained highly heterogeneous. When the advent of the COVID pandemic exacerbated shortages, this situation

continued, against a background of a weak collective European response. As part of their responses to COVID shortages, the medicines regulators of European countries expanded the range of products pharmacies could manufacture, process and distribute as well as their procedural authority in issuing handling and processing prescriptions. While these measures were fairly common across Europe

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and alleviated some bottlenecks or improved medicine access for some patient groups, other responses were highly individualistic and included export bans on certain medicines, as well as efforts to draw on veterinary supplies. In this article, we were interested particularly in whether the levels of heterogeneity in national approach would be impacted by the onset of the COVID epidemic. Our data analysis of officially recorded medicines shortage data during the first COVID wave (to October 2020) indicates that countries that had prepared for these types of crisis and maintained an active policy stance (e.g. Germany and Norway) were more likely to encounter fewer medicine shortages than others. We also note that there is no direct correlation between officially recorded numbers of shortages and the ways in which national governments responded to these – which indicates that cultural expectations also might have been a significant policy driver.

The first part of our article will provide introductory background information on medicine shortages in Europe. The second part of the article will provide background information, by identifying some of the main medicines shortages associated with the COVID pandemic, and by discussing collective European (EU) responses to COVID-related shortages. The third part of the article will then look in greater detail at the challenges faced by individual European countries together with some of the more widely publicised measures that their national governments adopted. We will conclude by comparing these approaches and briefly discuss currently emerging national policy trajectories.

Introduction: the pre-COVID landscape of pharmaceutical shortages in Europe

Prior to the outbreak of the COVID pandemic, management of pharmaceutical shortages was already recognised as a major policy problem by a number of European governments. This included both larger and smaller European countries. As a consequence, more or less extensive policy packages had been adopted nationally in most European countries pre-COVID which aimed at monitoring, mitigating or managing pharmaceutical shortages, with virtually all countries establishing national data bases on shortages.¹ Despite the broad availability of national data on shortages, this material lacked international comparability since national data bases used widely divergent definitions of what constituted a shortage and should be counted as such.² A similarly pronounced level of variation applied to national policies aimed at mitigating or managing shortages. The first part of this article will explore differences in approach and system of shortage management in three of the larger member States, France, Spain and Germany, chosen because these three countries developed distinct approaches to shortages management in the pre-COVID

period. Both France and Spain enacted elaborate policy packages seeking to address pharmaceutical shortages following marked pre-COVID increases in the number of reported shortages. Government sources suggest that in France shortages of essential medicines had increased to 897.³ For Spain, a government publication reported 1332 shortages for the pre-COVID year.⁴ In Germany, the pharmacy regulator reported around 250 registered shortages for the same year, but was criticised for potential omissions due to the voluntary nature of the country's shortage reporting system.⁵ Comparison of these data are at best roughly indicative, as each country has a different basis for determining a shortage, and a different system for acknowledging and recording them.

France

Pre-COVID policies to combat medicine shortages began to take shape in France from about 2011 onward as administrative measures undertaken in line with the *European Directive on medicinal products for human use*.⁶ A 2012 implementation decree made it a legal duty for 'marketing authorisation holders [MAHs]. . . to ensure an appropriate and continuous supply of [medicines to] wholesalers for them to meet their public service obligations'⁶ (p. 472) and made the reporting of anticipated shortages mandatory. Measures adopted in 2016 then required MAHs to create plans to manage medicine shortage for medicines of major therapeutic interest (MTIs) and prohibited exports of MTIs in shortage.⁶ Pharmaceutical manufacturers could incur penalties if they failed to provide information on shortages, failed to propose solutions/had no plan, and failed to assist health professionals in shortage management.⁶ With a lack of a notable effect on ameliorating shortages, these measures have been criticised for a lack of precision in the definition of each party's obligations⁷ and a failure to acknowledge the global nature of pharmaceutical manufacturing.⁸ Responding to these problems, France then introduced a new 4-year plan to tackle medicine shortages in July 2019, to be implemented by a *Comité de Pilotage* and a multi-ministerial task force. This plan placed emphasis on voluntary industry improvements,⁹ rather than seeking to compel compliance through the threat of legal sanctions. It was hoped that the new measures would encourage MAHs to disclose risky aspects of their supply chain,¹⁰ as well as encourage them to develop detailed risk management plans, especially among MAHs that have experienced supply disruptions.⁹

Spain

The first Spanish public policy in relation to medicine shortages was around 2013, when there was a suspicion that diversions of pharmaceuticals from the Spanish market had resulted in scarcities. Policy makers initially relied

on enforcement of existing distribution contracts and requirements to inform authorities of suspected medicine diversions.¹ New rules followed in 2015 which prioritised medicine supply to national pharmacies and assigned the main role in shortages management to the medicines regulator Agencia Española de Medicamentos y Productos Sanitarios (AEMPS) which could authorise export bans.¹ While AEMPS started to play a central role in reporting medicine shortages, dissatisfaction with the detail and accuracy of shortage information provided by them, led to the creation of a new registry by the Spanish national pharmacist organisation.¹

Following a further worsening of the situation the Interterritorial Council of the National Health System, which coordinates actions among the autonomous regions, approved the *Plan of Guarantees of Supply of Medicines* prepared by the national medicines regulator AEMPS in May 2019.⁴ This 4-year plan includes the following measures:

MAHs that have caused large number of shortages are to submit prevention plans which will be scrutinised by AEMPS⁴ (3, 3.1.2).

AEMPS will streamline inspection and regulatory requirements and create a list of essential medications on which regulatory attention will focus⁴ (p. 4).

These measures will be backed up by a strengthening of existing sentencing guidelines which will focus on those offences that have the potential of causing damage to public health⁴ (pp. 4–5).

There is to be a focus on early detection through the creation of sentinel pharmacies and the creation of new duties to report potential shortages for manufacturers, alongside improved processes for the identification of therapeutic alternatives to shortage medicines⁴ (5, 3.2.1).

Information to the public is to be improved via a semi-annual report which seems to imply an element of a naming-and-shaming⁴ (7, 3.3.1).

Finally, like the recent French measures which have considerable similarities with those adopted in Spain, the Spanish plan emphasises European collaboration with European Medicines Agency (EMA) involvement⁴ (8, 3.4.1.)

Germany

While also emphasising European Collaboration, pre-COVID, the German approach differed from the French and Spanish approaches in that it emphasised a two pronged approach centering on:

- (a) Expert involvement in the identification of impending or likely shortages at the active ingredient level.
- (b) Senior government involvement in conjunction with industry in the prevention or mitigation of potential shortages experts had identified.¹¹

Decisions on these preventive and mitigation measures have been the subject of regular ‘*jour fixe*’ meetings between the country’s medicines regulator, other relevant government agencies, affected stakeholder groups such as the national pharmacists’ association and key industry representatives. This approach evolved from about 2009 onwards when amendment 15 to the Arzneimittelgesetz (hereafter AMG, medicinal products law) specified manufacturer and wholesaler responsibilities to maintain adequate stocks and supplies.¹² As one of its activities, the German pharmaceuticals regulator Bundesinstitut für Arzneimittel und Medizinprodukte (BfArM) monitors the number of producers of a relevant Active Pharmaceutical Ingredient (API) with a view towards identifying those APIs for which there are only very few manufacturers, and where the loss of a manufacturing venue could lead to widespread shortages. Problem cases are then discussed during the ‘*jour fixe*’ meetings and where it is expected that stakeholders representing different groups joint contributed to mitigation or prevention measures.

The impact of the outbreak of COVID-19 on pharmaceutical shortages

The COVID-19 outbreak began to take hold in Europe in early 2020. The disease had a devastating global impact and by June 3, 2020 more than 6 million deaths had been recorded, with many hospital systems being overwhelmed by patient numbers.¹³ This situation also impacted on pharmaceutical supplies of course.

Kanji et al.¹⁴ (p. 1406) stated as early as May of the first COVID year that the pressures created by the pandemic differed markedly from the pharmaceutical supply problems that had been previously encountered in that: ‘during a global health crisis such as the coronavirus disease (COVID-19) pandemic, medicine shortages are less predictable with little time for mitigation strategies. Medicine supplies are also vulnerable to community-based consumer panic buying, prescribing, and stockpiling (footnotes omitted)’. In particular, COVID presented special challenges in terms of securing adequate pharmaceutical supplies, on account of the concentrated increase in demand in categories like critical care for which supplies had already been strained, as well as other unique factors like local disruptions of production, and temporary export bans as well as hoarding.

Regarding demand increases, Mazer-Amirshahi et al.¹⁵ (p. 246) correctly predicted the possibility of medicine shortages arising from the increase in the number of patients requiring mechanical ventilation, in the categories of sedative, analgesic, and paralytic. They also suggested (p. 246) that ‘multifocal pneumonia and sepsis would require treatment with antibiotics and vasopressors, which

have also already been affected by medicine shortages'. These observations were mirrored in the list of 'essential medicines at greatest risk of shortage' proposed by Kanji et al.¹⁴, which included sedatives (propofol, midazolam, dexmedetomidine, and ketamine), opioid analgesics (hydromorphone, fentanyl, and morphine), neuromuscular blocking agents (NMBAs, such as cisatracurium and rocuronium) and vasopressors and inotropes (norepinephrine, epinephrine, vasopressin, dopamine, dobutamine, and milrinone). Many if not all of these medicines are used in cardiac arrest and rapid sequence intubation, which increased in occurrence as a result of COVID.¹⁶

Collective European (EU, EC) responses to COVID-related shortages

Most countries in Western Europe reported cases of people infected at the end of February 2020. In a number of countries, the pandemic spread extremely rapidly. Cordeiro et al.¹⁷ (p. 221) report that 'confirmed cases across Europe had doubled over periods of three to four days, and even doubling every two days for some countries'. According to Villani et al.¹⁸ the pandemic spread from its first European epicentre in Italy to a number of western European countries including the United Kingdom, Sweden, Spain, France, and Belgium, with the highest first-wave standard mortality rates (SMRs) occurring in Belgium (1.8) the UK (1.39), Spain (1.2), Sweden (1.18), Ireland (1.06) and Italy (1).

Responding to the health emergencies occurring in these countries in particular, the European Commission redirected funding for vaccine research and launched, on 28 February 2020, procurement calls for personal protective equipment, on 26 March 2020 for ventilators.¹⁹ Apart from involvement in joint procurement and the provision of funding for future stockpiling, EU involvement in managing post-COVID shortages, involved calls to "states to optimise supply and availability of medicines"²⁰ as well as the recognition that European countries were vulnerable to shortages on account of their high rate of pharmaceuticals imports. Studies undertaken on behalf of the EU at that time indicated that "40% of the finished medicines marketed in the Union come from third countries, which [had] resulted in a loss of Europe's health independence" which could only be addressed through an increase in production in member states (European Parliament, 2020). This focus on recommendations, explains why excepting its joint procurement initiatives for vaccines, the EU's handling during the early phase of the COVID crisis, including the issue of pharmaceutical shortages, is now largely viewed critically by policy analysts. For example, a report in *Frontiers in Public Health* entitled "The European Union and Public Health Emergencies: Expert Opinions on the Management of the First Wave of the COVID-19

Pandemic and Suggestions for Future Emergencies"²¹ concludes that: "the limited EU mandate in health hinders proper actions to prevent and tackle infectious disease outbreaks" and "significantly impacted the European Centre for Disease Control, as the Member States' competence did not allow the agency to have more capacity". Overall the authors concluded (p. 1) that: "The complex politics of public health at the EU level have led to the fragmentation of its governance for effective pandemic responses. This ongoing pandemic has shed light on the fragility of the political and structural systems in Europe in public health emergencies". A detailed comment on the report notes that the EU's focus on preventive health measures such as border closings and guidelines was unable to prevent significant national variations in the implementation of policies, which in turn undermined trust in European policy making.²²

Original research conducted by the authors for this article, presented in the following section on 'National responses' confirms the heterogeneity of national policies adopted in response to the problems of COVID-related pharmaceutical shortages. It also shows that these responses were only poorly related to the actual extent of shortage challenges face by individual countries. Our final section then discusses some of the broader policy changes that some of the larger European countries – namely France, Spain, and Germany – now seek to apply to their existing approaches to the management of pharmaceutical shortages.

National responses of European states to COVID-related shortages

As this was an exploratory study in an area which knowledge is still unfolding, we adopted two methodological approaches suitable to the novelty of the subject matter. These were:

1. Print media analysis with reliance on the LexisNexis data base (and drawing on language skills of the author) using search terms associated with medicine shortage, response to medicine shortage, measures taken to address/mitigate medicine shortage. In doing so, we followed the precedent of Coleman et al.²³ who investigated food shortages, stockpiling and panic buying ahead of Brexit as reported by the British media
2. Using the list of national shortage websites provided by Bochenek et al., we investigated whether, and to what extent, the high risk shortages identified/predicted by Kanji et al. occurred in any of the European countries in our study.

One of the most well-documented areas through which individual European countries have sought to address

Table 1. Measures aimed at increasing the supply of sanitisers, by country.

Country	Measures to increase supply of sanitisers
Austria	Pharmacists are temporarily allowed to use biocides in the preparation of disinfectants
Czech republic	Pharmacists are given permission to prepare alcoholic antiseptic solutions in accordance with WHO recommendations
Finland	Pharmacists can prepare IPL-based disinfectants
France	Pharmacists can prepare hydroalcoholic gels if these are not in stock in accordance with WHO recommendations
Germany	Pharmacists can prepare hydroalcoholic gels in accordance with WHO recommendations
Netherlands	Pharmacists can manufacture Ethanol-based disinfectants
Poland	Pharmacists can manufacture Ethanol-based disinfectants
Dispensing/Supply/Administration of Other products	
Italy	Pharmacists can provide patients with oxygen and can also give oxygen to patients in their home
Expanded procedural authority	
Netherlands	Pharmacists can (with Doctor agreement) decide on intervals for dispensing pharmaceuticals/refills and renewals
Ireland	Pharmacists can fill/refill on the basis of electronic prescriptions

WHO: World Health Organization.

pharmaceutical shortages arising from the COVID pandemic concerns national alterations to regulations governing the role of pharmacists. This typically entails an expansion in the list of products pharmacists can manufacture or work with, as well as changes to procedural rules such as the use of online prescriptions and decisions regarding prescription renewals or refills.^{24,25} These changes have been introduced with support from different stakeholders, drawing to a greater or lesser degree on government agencies or professional organisations. Perhaps unsurprisingly, they differ from country to country, but fall into a number of broad categories including: (a) measures aimed at increasing supply of sanitisers and (b) measures associated with dispensing/supply/administration of other products (expanded procedural authority).

Some of the earliest changes introduced in European countries in response to pharmaceutical shortages include the following measures aimed at increasing the supply of sanitisers (Table 1).²⁶

While these measures bear at least some similarities, a greater level of heterogeneity can be observed with regard to country-specific measures aimed at managing or mitigating COVID-related pharmaceutical shortages, with some countries relying on a single measure and others introducing a series of changes to existing laws and regulations. Here we list countries in alphabetical order, for those countries for which this information has been available. Our focus again is on the early phase of the pandemic, (which we consider to have lasted roughly until November 2020) and it has to be kept in mind that the information presented here is necessarily patchy as it relies on public pronouncement made by the respective governments. Also, the number of measures variable which we presented here is not necessarily a measure of effectiveness of a government's response to COVID-related shortages, but at best represents a proxy for the level of national government engagement with the problem (Table 2).

Overall, the responses of European countries to COVID-related shortages differ widely. This heterogeneity relates to the type of measures undertaken, as well as the number of measures adopted by individual countries. In terms of agency, national medicines regulators seem to have played a major role. One exception to this is Spain, where the private sector and a large pharmaceutical wholesale cooperatives as well as regional governments appear to have attracted some media attention as sources of policy innovation.³⁷ In terms of measures, most European countries have enacted provisions aimed at facilitating the production of sanitisers in line with WHO recommendations. More controversially, several European countries provided for temporary export restrictions via the imposition of export licence requirements in order to protect national supplies of certain COVID-relevant medicines (Greece, Spain, Romania and Germany). Such restrictive export licences continued with European Commission acquiescence until about June 2020.⁴²

Some of the more creative responses to actual or potential supply shortages, included the drafting of watchlists to monitor and inventory supplies of medicines which were at risk of being affected by shortages either on account of increased COVID-related demand, or because of global supply chain issues, and notably those resulting from production or export disruptions in China and India. In addition a number of countries (including Czech, Ireland, the Netherlands and Spain) attempted to improve access to pharmacy services, in order to ease pressure on pharmacies and their customers through various means, including electronic prescriptions, alternative approaches to prescribing or prescription renewal and extended opening times. Finally, a number of countries sought to mobilise existing supplies of veterinary pharmaceuticals or APIs for human needs (Belgium, Norway, Sweden and Spain). Other anti-shortage measures taken include efforts to restrict hoarding especially of over the counter medicines,

Table 2. General measures adopted by national authorities to cope with COVID-related medicines shortages, by country and number of measures.

Country	Nature of measure	Number of active measures taken during first wave
Austria	Pharmacies and chemical manufacturers can temporarily manufacture sanitisers Source: Österreichischer Apothekerverband ²⁷	1
Belgium	Regulator contacts producers to encourage speedy production of certain medicines Veterinary medicines use (Proposure, a sedative containing propofol) on humans allowed Anti-hoarding measures (limits on buying of certain Over The Counter (OTC) medicines) regulator contacts producers to encourage speedy production of certain medicines Veterinary medicines use (Proposure, a sedative containing propofol) on humans allowed Anti-hoarding measures (limits on buying of certain OTC medicines) Provisions for temporary export ban in case of shortages Source: Fagg/FAMHP ²⁸	5
Czech republic	Various biocides placed on the market Measures to increase ease of access to specialised prescription for chronic diseases Source: Pavelková ²⁹	2
Denmark	Institutions to report stocks which the Medicines agency can redistribute if needed Source: Accura Advokatpartnerselskab ³⁰	1
France	State agencies can buy and distribute certain listed medicines Expanded permission for production of sanitiser from denat and non-denat alcohol Source: Actu Juridique, France ³¹	2
Germany	Exemptions to Sunday driving ban for lorries permitted Ban on export of Personal Protective Equipment (PPE) and certain medicines. Expanded right of pharmacists to alter prescriptions in case of shortage Pharmacists can prepare hydroalcoholic gel Source: SPIEGEL Commentator ³²	4
Greece	Export ban for medications going short Enhanced measure to ensure compliance with obligations to hold stocks Extended expiration dates Source: Hellas ³³	3
Ireland	Introduction of electronic prescription system Source: Health Products Research Authority Ireland ³⁴	1
Italy	State acquisition and distribution of key medicines Compassionate authorisation of trials for new medicines Emergency authorisation of medicine imports Regional closure of pharmacies Source: Regulatory Affairs, Italy ³⁵ and AIFA – Italian Medicines Regulator ³⁶	4
Norway	Provision for Norwegian Marketing authorisation to be extended to European Union/European Economic Area medicines and when necessary to medicines from outside the EU/EEA, this being allowed for up to 20 days after the shortage of the medicine has ended. Only one package of non-prescription medicine may be bought at a time Parallel export can be banned The Norwegian medicines agency has prepared an early warning list for which an increase in demand is expected. If a veterinarian has prescribed/ordered important medicines for humans, the Norwegian Medicines Agency is authorised to request or order that the pharmacy deliver a corresponding, marketed veterinarian medicine, where this exists. They state that they will exercise this authority when necessary to preserve the medicines in question for human use. Source: Rangnes and Lilleås ³⁷	7
Romania	suspends the distribution of certain medicines outside the territory of Romania (via parallel trade), for a period of six months prohibited. These medicines include those that are part of the treatment list for of SARS-COVID. Source: Anmdmr – Romanian Medicines Regulator ³⁸	1
Slovakia	Fast track procedure for assessment of marketing authorizations for medicines used in the treatment of COVID-19. Source: Slovakian State Institute for Medicine Control ³⁹	1

(Continued)

Table 2. (Continued)

Country	Nature of measure	Number of active measures taken during first wave
Sweden	Medicines regulator creates list of APIs that are made in China and potentially subject to shortages. Work begins on creation of emergency stocks Anaesthetics for animals may be used in COVID-related treatment. Source: Sverigesradio ⁴⁰	3
Spain	The medicine regulator AEMPS creates a watch-list of APIs which may be affected by increased demand due to COVID and/or suffer from reduced exports from India or China (levels of existing API stocks including those originally intended for veterinary use are identified) Pharmacies are encouraged to engage in home delivery, facilitate treatment at home and extend opening times Temporary restrictions on exports of certain pharmaceuticals Source: Rodriguez ⁴¹	3

API: active pharmaceutical ingredient.

as well as extension of expiration dates for existing medicines. Remarkably, there appears to be no clear or readily apparent correlation between the severity with which an individual European country was affected by COVID and the number of measures adopted by an individual country. Norway, an EU affiliate, which saw one of the lowest SMRs (.12) during the first COVID wave, adopted a total of seven measures to counter or address COVID-related pharmaceutical shortages, while France which experienced one of the highest first wave SMRs (.89)¹⁷ formally adopted only two measures. This appears to indicate that policy makers' or key stakeholders' readiness to engage with shortages is properly more closely related to societal expectations than to the severity of a demand increase or shortage. We will discuss this issue further following the next section, where we present data on shortages during the first COVID wave, which we have drawn from national shortage lists.

National data on shortages of COVID-related pharmaceuticals

Virtually all European countries now maintain national shortage lists. These are usually publicly accessible on the Internet, with the purpose of giving dispensing pharmacists an indication of whether a shortage is purely regional. In addition, some shortage lists give added information: on the cause of a shortage; it is likely to end; and even potential alternatives. However, these databases lack comparability on account of the lack of a common European definition of what constitutes a shortage and, relatedly, the degree of granularity to which such a definition should be applied.^{2,11} For the purpose of this analysis, we focus on some of the key COVID-relevant medicines which were identified by Kanji et al.,¹⁴ and also Mazer-Amirshahi et al.¹⁵ as being potentially at risk of shortage.

For the purpose of this analysis, our focus is on EU member or affiliate countries. While national shortage tables would allow us to identify when and for how long certain medicines are listed as being in shortage, we limit our analysis to first time listings only and focus on the number of COVID-relevant pharmaceuticals which any one country lists at any time as being in shortage. Given the shortcomings of these national data bases, this seems a reasonable proxy for the level of severity with which these EU or European Economic Area (EEA) countries have been affected by COVID-related shortages. In analysing this data, it is important to remember that shortages in European countries not only occur because demand spikes and or a shortfall of national supplied vis-a-vis demand, but also on account of parallel trade where wholesalers buy medicines from countries where they are sold more cheaply and then re-sell them in countries where they are more expensive. At a later stage of the crisis, Romanian wholesalers participated in a parallel trade with vaccines, as these had been acquired cheaply but were not used-up because the national vaccine uptake in the country was slow (Figure 1). This was not so much driven by the usual market considerations driving parallel trade but by effort to avoid waste of vaccines then in short supply (Table 3).

Given this national shortage-list based analysis, the most shortage-prone medicine for European countries due to COVID was Propofol. Belgium and the Netherlands were the countries which numerically had the most COVID-related medicines listed as being subject to shortages. In case of Belgium, this probably relates to the severity of the first COVID wave in that country, whereas for the Netherlands' poor shortage management and poor logistics also seem to have played a role.⁴³ Norway had a very mild first wave and engaged in a large number of measures aimed at mitigating or managing shortages.

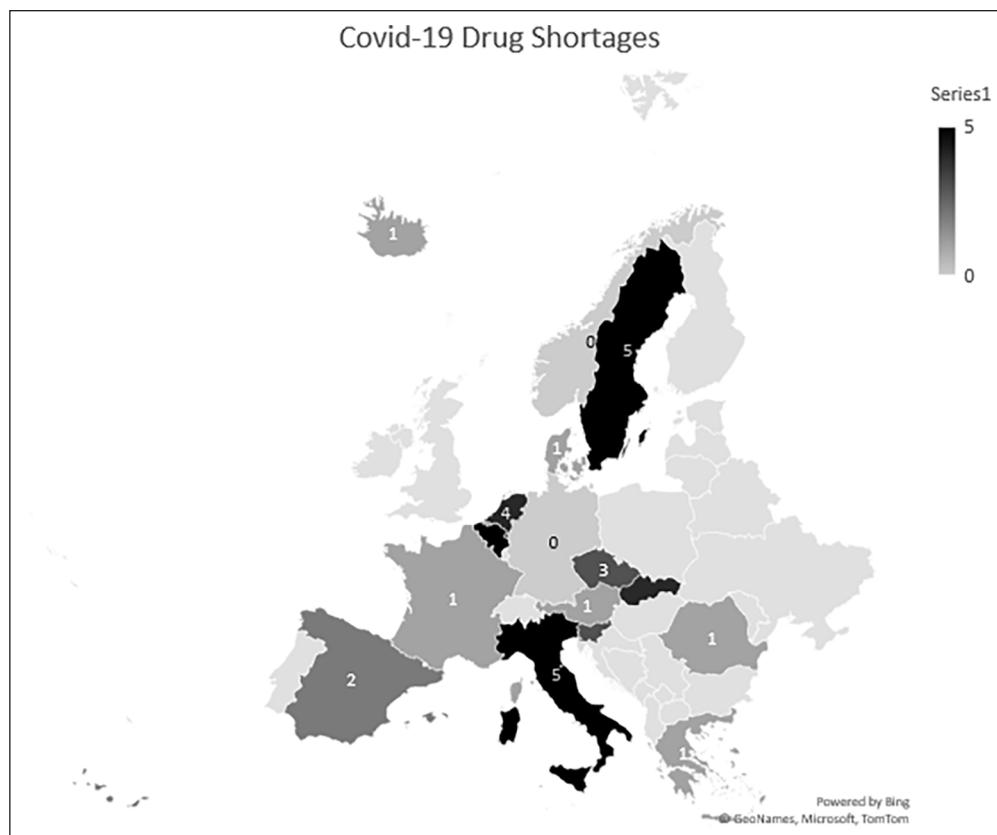


Figure 1. Shortages of COVID-relevant medicines reported by national regulators as part of publicly accessible medicine shortage lists, by country.

These seem to have worked out as the country's shortage list shows no COVID-related medicine shortages for the period. A similar pattern applies to Germany.

As an interesting aside, Norway⁴⁴ had previously included the possibility of medicine shortages as a specific issue in a crisis scenario which was part of national civil defence exercises. Germany, meanwhile, had covered a major pandemic scenario in one of the country's largest civil emergency exercises.⁴⁵ This scenario too explicitly discussed the management of potential medicine shortages in crisis situations.

Emerging policy trajectories

Researchers associated with the European Commission recognised early on that a particular vulnerability of European nations arose from the fact that these nations imported a large portion of pharmaceuticals from third parties.¹⁹ The conclusion among many nation states was to consider possibilities for encouraging domestic medicines production. Despite an overarching interest in this topic, however, this has not given rise to collective action, and approaches to tackling this issue have differed widely across European countries.

France's G5 group of large pharma manufacturers called for incentives to re-patriate production.⁴⁶ This has

been followed by a February, 2021 pronouncement by the French domiciled multinational Sanofi that they will be developing European sites in Italy, Germany, the United Kingdom, France and Hungary in a standalone company.⁴⁷ While it is difficult to evaluate fully the motives for this announcement which came early in the crisis, and it may be too early to identify a new strategy, this could possibly herald a new approach where multinational pharmaceutical companies explicitly seek support from European states in exchange for more transparent and potentially more reliable supply chains. This is potentially in line with a trend towards protectionist attitudes around localised pharmaceutical production in high-income countries.

As in France since COVID, formal state activity in relation to shortages in Spain has been limited. However, the relatively subdued role of the Spanish regulator AEMPS in particular in terms of a public discussion of shortages, may well be hiding a more active role in terms of information dissemination on treatment and medication. AEMPS maintains a publicly accessible webpage under the title 'latest information from AEMPS about COVID-19' which provides regularly updated detailed information on advisable treatment approaches, available medications, prudent use of medication such as antibiotics, as well as dangerous medication interactions and issues relating to COVID patients. This webpage also serves as public platform to

Table 3. Shortages of COVID-relevant medicines reported by national regulators as part of publicly accessible medicine shortage lists, by country.

COUNTRY	AT	BE	CZ	DK	FR	DE	GR	IS	IT	NL	NO	RO	SK	SL	ES	SE
Dexamethasone																5
Dexmedetomidine																1
Ketamine																2
Lorazepam																2
Methotrimeprazine																0
Midazolam																8
Propofol																10
Remdesivir																0
Rocuronium																6
Salbutamol																3
Vasopressors																0
		5	3			0			5	4	0		4	3	2	5

counter misinformation and is likely to be maintained as the information platform in future years.⁴⁸

Germany possibly presents as an outlier in that national policy makers neither emphasise the possibility of subsidies nor the possibility of more regulation. Instead, the policy emphasis here appears to be on what policy makers nationally describe as ‘Pharma Dialogue’. Rather than promising subsidies or benign regulations, this dialogue concept centres on the identification of elements that strengthen the country’s attractiveness for pharmaceutical research and development.⁴⁹ Concretely these measures envisage the utilisation of tax incentives for pharmaceutical research and development, as well as a prioritisation of pharmaceutical research in national research and science funding policy.⁵⁰

Although such national differentiation in post-COVID pharmaceuticals policy is understandable, given the different experiences of European countries during the crisis, as well as the differential performance of national pharmaceuticals developers, it is likely to undermine much needed collective lesson learning and collaboration. Despite differences, all of these national approaches to some degree reflect a level of dissatisfaction with the EMA’s past policy making around medicine shortages which has been criticised for failing to address the existing fragmentation of policy making in this area.²¹

Overall our analysis suggests that there is no direct correlation between officially recorded numbers of shortages and the ways in which national governments responded to these – which indicates that cultural expectations also might have been a significant policy driver. This hypothesis, needless to say is somewhat speculative, on account of the fact that national shortage lists which we have utilised in this analysis are not fully comparable as they draw on definitions of ‘medicine shortages’. Similarly, our count of media reported measures adopted by governments in response to COVID-related shortages, represents a limited proxy for the level of national government engagement with this issues, whereby problems can arise from the non-reporting of measures adopted in some countries as well as

the fact that the adoption of a few or even a dingle well-targeted measures can outweigh the adoption of a multitude of measures. However, our past analysis of policies in response to medicine shortages¹¹ would suggests that expectations have a role to play in this area. France, which was very severely affected by the first COVID wave and moderately affected by shortages, is a good example of this. In a survey of 955 patients for France Assos Santé (the Association of Health System Users) concluded that ‘25% of respondents had been denied the delivery of a drug or vaccine due to shortage, with the rate rising to 31% for people with long-term illnesses’.⁵¹ Moreover, ‘45% of respondents faced with these shortages had been forced to postpone their treatment, modify it, . . . or stop it altogether’.⁵¹ This extent of shortages came as a surprise since a 2016 Law had imposed penalties on manufacturers and distributors for causing shortages.⁵² By contrast, the incidence of medicine shortages in Norway appears to be at the lower end of the European spectrum,⁵³ while government initiatives to mitigate these problem have a long and strong legacy.¹ It is therefore perhaps not surprising that French policy makers would expect less adverse publicity from the occurrence of medicine shortages during the COVID pandemic than their Norwegian counterparts would. Similar to Norway, Germany too is a country where government authorities have supported a host of measures to combat medicines shortages, which are now widely attributed not only to weaknesses in private sector supply chains but also to government failures to mitigate those.¹¹

Needless to say, the analysis presented in this article is exploratory and preliminary, with a heavy reliance on proxy variables and publicly reported information. Future research would benefit from an in-depth comparative analysis of regulatory measures adopted at national level, the debates surrounding these and the roles played by key stakeholders, such as the representatives of wholesalers and developers in the pharmaceutical sector as well as professional organisations representing pharmacists and the medical community more generally.

The long-term impact of COVID on future European policies such as the European Green Deal and European Green Deal and Sustainable Development Goal⁵⁴ is difficult to estimate, just as it is difficult to identify the relationship between the outbreak of the COVID pandemic and climate change more general. Some authors have speculated about a potential nexus between food insecurity, the use of wild meats and the COVID outbreak. This in turn ties in with climatological threats. Thus, in China, farmers had turned to poultry production, and consumers to wild meats, following the outbreak of African Swine Flu in August 2018 which resulted in the loss of approximately 40% of the country's swine population through culling and disease.⁵⁵

As yet we do not know, whether COVID will result in a reduction of climatological stresses on the planet and its food supplies. Some researchers have argued that the pandemic will require future resilience-related investments in areas such as Urban transition and that this could create competing priorities for green agendas; albeit that there may be some synergies.⁵⁶ In any case, in as far as pharmaceutical shortages are concerned, the literature has been critical of 'reshoring agendas' which appear to be of limited benefit in terms of strengthening resilience,⁵⁷ while having little likely effects on global transport volumes as they appear to envisage continued imports of active pharmaceutical ingredients.

Our exploratory analysis of pharmaceutical shortages in Europe during the COVID pandemic appears to indicate that, in times of crisis, the European Commission's role in resolving pharmaceutical shortages was extremely limited, and some individual member states returned to chauvinistic drugs management policies. One of the potential impacts of the COVID epidemic will be a return to nationalised emphasis on drug supply security, which may result in unnecessary over-production and stockpiling, which are inherently wasteful, and would have detrimental environmental and sustainability impacts.

Declarations

Ethics approval and consent to participate

This article reports a review of publicly available shortages as well as a literature review. No animal or human studies were carried out. No secondary analysis of data collected from humans was carried out. Therefore ethics approval and informed consent to participate was not sought.

Consent for publication

Not applicable.

Author contribution(s)

Matthias Beck: Conceptualisation; Data curation; Formal analysis; Visualisation; Writing – original draft.

Joan Buckley: Conceptualisation; Writing – original draft.

Acknowledgements

Not applicable.

Funding

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

Competing interests

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

Availability of data and materials

Not applicable.

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References

1. Bochenek T, Abilova V, Alkan A, et al. Systemic measures and legislative and organizational frameworks aimed at preventing or mitigating drug shortages in 28 European and Western Asian countries. *Front Pharmacol* 2018; 8: 942.
2. Büchner SM. *Coping with medicine shortages through regulatory governance: approaches and perspectives to a complex global challenge*. Master Thesis, University of Bonn, Bonn, 2016, https://www.dgra.de/media/pdf/studium/masterthesis/master_buechner_sarah_2016.pdf (accessed 20 January 2022).
3. Sénat. Pénuries de médicaments et de vaccins: renforcer l'éthique de santé publique dans la chaîne du médicament, 14 July 2019, <https://www.senat.fr/rap/r17-737/r17-7374.html#toc6%20%202019=http://www.ordre.pharmacien.fr/Les-pharmaciens/Champs-d-activites/Ruptures-d-appvisionnement-et-DP-Ruptures%202018=interpolated> (accessed 20 January 2022).
4. Agencia Española de Medicamentos y Productos Sanitarios (AEMPS). Plan de garantías de abastecimiento de medicamentos 2019-2022: Resumen ejecutivo, 8 May 2019, <https://www.aemps.gob.es/medicamentosUsoHumano/problemasSuministro/docs/plan-garantias-abastecimiento-AEMPS-2019-2022.pdf> (accessed 20 January 2022).
5. Barzilius H. Lieferengpässe bei Arzneimitteln: Ein Missstand, der nicht mehr hinnehmbar ist. *Dtsch Arztebl* 116(45): A-2060 / B-1690 / C-1654, <https://www.aerzteblatt.de/archiv/210688/Lieferengpaesse-bei-Arzneimitteln-Ein-Missstand-der-nicht-mehr-hinnehmbar-ist> (accessed 20 January 2022).
6. Bocquet F, Degrasat-Théas A, Peigné J, et al. The new regulatory tools of the 2016 Health Law to fight medicine shortages in France. *Health Policy* 2017; 121(5): 471–476.
7. Biétry G. *Medicine shortages causing tension between pharma, wholesalers and pharmacists in France*. APM Health Europe, 2018, <https://www.apmhealthurope.com/freestory/0/57018/medicine-shortages-causing-tension-between-pharma-wholesalers-and-pharmacists-in-france> (accessed 20 January 2022).

8. Laude A and Tabuteau D. *Regards sur la réforme du système de santé*. Paris: Presses de l'EHESP, 2016.
9. Van Bael & Bellis. France presents plan to tackle medicine shortages and adds sense of urgency to European discussions. *Insights & News*, 9 July 2019, <https://www.vbb.com/insights/corporate-commercial-regulatory/france-presents-plan-to-tackle-medicine-shortages-and-adds-sense-of-urgency-to-european-discussions> (accessed 20 January 2022).
10. French Ministre des Solidarités et de la Santé (MSS). *Lutter contre les pénuries et améliorer la disponibilité des médicaments en France*. Paris: MSS, 2019, https://solidarites-sante.gouv.fr/IMG/pdf/31142_dicom_pe_nurie_de_medicamentsv8.pdf (accessed 20 January 2022).
11. Beck M, Buckley J and O'Reilly S. Managing pharmaceutical shortages: an overview and classification of policy responses in Europe and the USA. *Int Rev Admin Sci* 2020; 86(4): 622–640.
12. Anonymous. *15 AMG Novelle – Das Gesetz zur Änderung arzneimittelrechtlicher und anderer € Vorschriften* (Ausgabe 32). Pharmazeutische Zeitung, 2009. <https://www.pharmazeutische-zeitung.de/ausgabe-322009/das-gesetz-zur-aenderung-arzneimittelrechtlicher-und-anderer-vorschriften/> (accessed 20 January 2022).
13. Mazdeyasna H, Nori P, Patel P, et al. Antimicrobial stewardship at the core of COVID-19 response efforts: implications for sustaining and building programs. *Curr Infect Dis Rep* 2020; 22(9): 23–26.
14. Kanji S, Burry L, Williamson D, et al. Therapeutic alternatives and strategies for medicine conservation in the intensive care unit during times of medicine shortage: a report of the Ontario COVID-19 ICU Medicine Task Force. *Can J Anesth* 2020; 67(10): 1405–1416.
15. Mazer-Amirshahi M, Fox ER, Farmer BM, et al. ACMT position statement: medication shortages during coronavirus disease pandemic. *J Med Toxicol* 2020; 16(3): 346–348.
16. Badreldin HA and Atallah B. Global drug shortages due to COVID-19: impact on patient care and mitigation strategies. *Res Social Adm Pharm* 2021; 17(1): 1946–1949.
17. Cordeiro GM, Figueiredo D, Silva L, et al. Explaining COVID-19 mortality rates in the first wave in Europe. *Model Ass Stat Appl* 2021; 16(3): 211–221.
18. Villani L, Pastorino R, Ricciardi W, et al. Inverse correlates of COVID-19 mortality across European countries during the first versus subsequent waves. *BMJ Glob Health* 2021; 6(8): e006422.
19. Medtech Europe. COVID-19 procurement actions, 25 May 2020, https://www.medtecheurope.Org/wp-content/uploads/2020/03/COVID-19-Procurement-Actions_20052025.pdf (accessed 20 January 2022).
20. European Commission. Coronavirus: commission calls on Member States to optimise supply and availability of medicines (Press release, Brussels), 8 April 2020, https://ec.europa.Eu/commission/presscorner/detail/en/ip_20_622 (accessed 20 January 2022).
21. Gontariuk M, Krafft T, Rehbock C, et al. The European Union and public health emergencies: expert opinions on the management of the first wave of the COVID-19 pandemic and suggestions for future emergencies. *Front Public Health* 2021; 9: 698995.
22. Coan KED. How well did the EU respond to the first wave of the Covid-19 pandemic? Experts now give their verdict. *Frontiers Science News*, 21 August 2021, <https://blog.frontiersin.org/2021/08/21/frontiers-public-health-expert-verdict-eu-response-covid19-pandemic/> (accessed 20 January 2022).
23. Coleman PC, Dhaif F and Oyebo O. Food shortages, stockpiling and panic buying ahead of Brexit as reported by the British media: a mixed methods content analysis. *BMC Public Health* 2022; 22(1): 1–9.
24. Cadogan CA, Hughes CM. On the frontline against COVID-19: community pharmacists' contribution during a public health crisis. *Res Soc Admin Pharm* 2021; 17(1): 2032–2035.
25. Lynch M and O'Leary AC. COVID-19 related regulatory change for pharmacists—the case for its retention post the pandemic. *Res Soc Admin Pharm* 2021; 17(1): 1913–1919.
26. Redakcia. *Úlohu lekárnikov v boji proti koronavírusu zdôraznil aj Zväz lekárnikov Európskej únie* [The role of pharmacists in the fight against coronavirus has also been emphasized by the Union of Pharmacists of the European Union]. Slovak Chamber of Pharmacists, 13 March 2020, <http://www.lekarnici.sk/?p=2762> (accessed 20 January 2022).
27. Österreichischer Apothekerverband [Austrian Association of Pharmacists]. Was lehrt uns Covid-19 für zukünftige Pandemien? July 2020, https://www.ots.at/presseaus-sendung/OTS_20200901_OT0022/was-lehrt-uns-covid-19-fuer-zukuenftige-pandemien (accessed 20 January 2022).
28. Fagg/FAMHP. Belgian national medicines regulators – Coronavirus: het FAGG blijft essentiële geneesmiddelen leveren voor de intensieve zorgen en houdt de ziekenhuizen dagelijks op de hoogte [Coronavirus: the FAMHP continues to supply essential medicines for intensive care and keeps hospitals informed on a daily basis], 2020, https://www.fagg.Be/nl/news/coronavirus_het_fagg_blijft_essentiele_geneesmiddelen_leveren_voor_de_intensieve_zorgen_en (accessed 20 January 2022).
29. Pavelková E. Předepisovat léky za specialisty [Specialist prescriptions]. *Nova News*, 23 March 2020, <https://tn.nova.cz/zpravodajstvi/clanek/407457-leky-vam-mohou-predepsat-jinde-nez-jste-zvykli-praktici-zadaji-o-vyjimku> (accessed 20 January 2022).
30. Accura Advokatpartnerselskab. The Danish Medicines Agency's powers to prevent supply shortage in light of COVID-19 are now permanent, Lexology, 14 April 2021, <https://www.lexology.Com/library/detail.aspx?g=d941ece6-371b-49ab-85d0-b6c492dc6dd5> (accessed 20 January 2022).
31. Actu Juridique, France. Coronavirus (COVID-19) Les mesures de lutte contre la pénurie de médicaments applicables depuis le 19 octobre 2020 [Coronavirus (COVID-19): measures to combat the shortage of medicines applicable since October 19, 2020], 2020, <https://www.weblex.fr/weblex-actualite/coronavirus-covid-19-les-mesures-de-lutte-contre-la-penurie-de-medicaments-applicables-depuis-le-19-octobre-2020> (accessed 20 January 2022).
32. SPIEGEL Commentator. *WHO sorgt sich nicht vor Medikamentenmangel wegen Coronavirus* [WHO doesn't worry about medicine shortages due to coronavirus]. SPIEGEL Science, 6 March 2020, <https://www.spiegel.de/wissenschaft/medizin/coronavirus-die-wichtigsten-entwicklungen-zu-covid-19-und-sars-cov-2-a-6c39f5ce-4891-4e6d-b3dd-464a754b071b>

33. Hellas. Four measures to address medicine shortages. *in.gr*, 28 January 2020, <https://www.in.gr/2020/01/28/greece/yp-yeias-tessera-metra-gia-tin-antimetopisi-tis-elleipsis-farmakon/> (accessed 20 January 2022).
34. HPRA – Irish Medicines Regulator. COVID-19 and the regulation of health products – latest information, 2020, <http://www.hpra.ie/homepage/about-us/stakeholders/covid-19-and-the-regulation-of-health-products-latest-information> (accessed 20 January 2022).
35. Regulatory Affairs, Italy. Carencia di farmaci, le azioni di EMA per contenere la crisi pandemica [Shortage of medicines, EMA actions to contain the pandemic crisis], 2020, <https://www.direzno.biz/it/carenza-medicinali-covid-19/> (accessed 20 January 2022).
36. AIFA – Italian Medicines Regulator. Donazioni Emergenza COVID-19 [COVID-19 emergency donations], 18 May 2020, <https://www.aifa.gov.it/donazioni-emergenza-covid-19> (accessed 20 January 2022).
37. Rangnes HK and Lilleås V. Medisinmangelen flatet ut for første gang på mange år [The shortage of medicines flattened out for the first time in many years], 19 November 2020, <https://www.nrk.no/vestfoldogtelemark/medisinmangelen-flatet-ut-for-forste-gang-pa-mange-ar-1.15248958> (accessed 20 January 2022).
38. Anmdmr – Romanian Medicines Regulator. To the attention of wholesale distributors, health professionals, patients and the general public, 24 August 2020, <https://www.anm.ro/medicamento-de-uz-uman/anunturi-importante-medicamento-de-uz-uman/> (accessed 20 January 2022).
39. Slovakian State Institute for Medicine Control. 2020 Abolition of extraordinary measures of the state institute for medicine control, 2020, https://www.sukl.sk/hlavna-stranka/slovenska-verzia/media/tlacove-spravy/zrusenie-mimoriadnych-opatreni-statneho-ustavu-pre-kontrolu-lieciv?page_id(accessed 20 January 2022)=5359 (accessed 20 January 2022).
40. Sverigesradio. Anesthetics for animals may be used in corona, 19 March 2020, <https://sverigesradio.se/artikel/7428495> (accessed 20 January 2022).
41. Rodriguez. Colaboración público-privada para evitar la escasez de suministros COVID [Public-private collaboration to avoid COVID supply shortages], *Gazeta Medica*, 9 July 2020, <https://gacetamedica.com/mas/farmacia-hospitalaria/colaboracion-publico-privada-para-evitar-la-escasez-de-suministros-covid/> (accessed 20 January 2022).
42. European Commission. Trade barriers which affect EU exports to non-EU countries, 19 March 2020, https://trade.ec.europa.eu/access-to-markets/en/barriers/details?isSps=false&barrier_id=15794 (accessed 20 January 2022).
43. Hoekman LM, Smits MMV and Koolman X. The Dutch COVID-19 approach: regional differences in a small country. *Health Policy Technol* 2020; 9(4): 613–622.
44. Norwegian Directorate for Civil Protection. *Analyses of crisis scenarios*. Tønsberg: Norwegian Directorate for Civil Protection, 2019, https://www.dsb.no/globalassets/dokumenter/rapporter/p2001636_aks_2019_eng.pdf (accessed 20 January 2022).
45. German Federal Office for Civil Protection. Bevölkerungsschutz, 2007, https://www.bbk.bund.de/DE/Themen/Krisenmanagement/LUEKEX/_documents/art-luekex07.html (accessed 20 January 2022).
46. Méréo F. Penurie de médicaments. *Le Parisien*, 18 April 2020, <https://www.leparisien.fr/societe/sante/penurie-de-medicaments-l-industrie-pharmaceutique-veut-un-plan-sur-cinq-ans-16-04-2020-8300436.php> (accessed 20 January 2022).
47. Tong A. Sanofi outlines big API plans as coronavirus outbreak reportedly threatens shortage of 150 medicines. *Endpoint News*, 24 February 2020, <https://endpts.com/coronavirus-outbreak-threatens-shortage-of-150-drugs-report/> (accessed 20 January 2022).
48. AEMPS – Spanish Medicines regulator. AEMPS presenta la memoria de actividades 2020, <https://www.aemps.gob.es/informa/notas-informativas/laemps/2021-2/la-aemps-presenta-la-memoria-de-actividades-2020-marcada-por-su-labor-frente-a-la-covid-19/> (accessed 20 January 2022).
49. Bio Deutschland. German government holds second Pharma Dialogue meeting, May 2019, <https://www.biodeutschland.org/en/news/german-government-holds-second-pharmadialogue-meeting.html> (accessed 20 January 2022).
50. Bio Deutschland. BIO Deutschland comments on draft bill on tax incentives for research and development – May 2022, <https://www.biodeutschland.org/en/news/bio-deutschland-comments-on-draft-bill-on-tax-incentives-for-research-and-development.html>
51. France Assos Santé (FAS). Pénuries de médicaments et de vaccins. *BVA Communications*, 2018, <https://www.france-assos-sante.org/wp-content/uploads/2019/01/Penuries-medicaments-Resultats-BVA-dec2018.pdf>
52. Mari E and Méréo F. Médicaments: d’inquiétantes ruptures de stock, *LeParisien*, 28 October 2018, <http://www.leparisien.fr/societe/sante/medicaments-pourquoi-une-telle-penurie-28-10-2018-7930134.php>
53. IQVIA reporting of medicine shortages in Europe: white paper, 1 October 2020, <https://www.iqvia.com/library/white-papers/reporting-of-medicine-shortages-in-europe>
54. Rowan NJ and Casey O. Empower Eco multiactor HUB: a triple helix ‘academia-industry-authority’ approach to creating and sharing potentially disruptive tools for addressing novel and emerging new Green Deal opportunities under a United Nations Sustainable Development Goals framework. *Curr Opin Environ Sci Health* 2021; 21: 100254.
55. Beck M and Tobin D. The 2019/2020 Novel Corona virus outbreak: an international health management perspective. *Open Public Health J* 2020; 13(1): 52–54.
56. Andreucci MB and Marvuglia A. Investigating, implementing and funding regenerative urban design in a post-COVID-19 pandemic built environment: a reading through selected UN Sustainable Development Goals and the European Green Deal. In: Andreucci MB, Marvuglia A, Baltov M, et al. (eds) *Rethinking sustainability towards a regenerative economy*. Cham: Springer, 2021, pp. 395–413.
57. Miroudot S. Reshaping the policy debate on the implications of COVID-19 for global supply chains. *J Int Bus Policy* 2020; 3(4): 430–442.