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European countries' responses in ensuring sufficient physical infrastructure and workforce capacity during the first COVID-19 wave ☆

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ABSTRACT

The COVID-19 pandemic has placed unprecedented pressure on health systems' capacities. These capacities include physical infrastructure, such as bed capacities and medical equipment, and healthcare professionals. Based on information extracted from the COVID-19 Health System Reform Monitor, this paper analyses the strategies that 45 countries in Europe have taken to secure sufficient health care infrastructure and workforce capacities to tackle the crisis, focusing on the hospital sector. While pre-crisis capacities differed across countries, some strategies to boost surge capacity were very similar. All countries designated COVID-19 units and expanded hospital and ICU capacities. Additional staff were mobilised and the existing health workforce was redeployed to respond to the surge in demand for care. While procurement of personal protective equipment at the international and national levels proved difficult at the beginning due to global shortages, countries found innovative solutions to increase internal production and enacted temporary measures to mitigate shortages. The pandemic has shown that coordination mechanisms informed by real-time monitoring of available health care resources are a prerequisite for adaptive surge capacity in public health crises, and that closer cooperation between countries is essential to build resilient responses to COVID-19.

1. Introduction

The COVID-19 pandemic has confronted health systems with unprecedented challenges in securing sufficient supply of physical infrastructure and health workforce to respond to the rapid rise in demand from COVID-19 patients. Countries had to increase surge capacity quickly, especially in hospital settings. Creating surge capacity required not only extending hospital capacity for COVID-19 inpatient treatment in terms of more acute and intensive care beds. It also necessitated ensuring sufficient supply of personal protective equipment (PPE), medical equipment (e.g. ventilators), pharmaceuticals, medical supplies, and IT, as well as ensuring adequate availability of health professionals trained to treat and care for COVID-19 patients [1]. This paper seeks to compare how countries have expanded capacities in terms of human resources and physical infrastructure (both hospital capacity and medical and protective equipment) and to draw on the lessons learned during the pandemic. The paper will derive policy lessons on how best to achieve agile and adaptive surge capacity for future pandemic preparedness.

To understand how countries have responded to the COVID-19 crisis and the rapidly rising number of COVID-19 patients requiring inpatient treatment, it is important to depict the starting point of countries' capacities in regard to hospital infrastructure and the health workforce. Prior to the outbreak, acute and intensive care unit (ICU) bed capacity varied widely across countries, ranging from 2 hospital beds per 100 000 in Sweden to 8 beds in Germany (both 2018) and from 5 ICU beds per 100 000 in Ireland (2016) to 34 in Germany (2017) [2]. Some countries in Eastern Europe such as Bulgaria, Lithuania, Hungary and Romania had relatively high hospital capacity with many hospital beds and low bed occupancy rates. In contrast, countries such as Italy, Ireland

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and Spain entered the pandemic with relatively low numbers of acute hospital beds and very high occupancy rates [2]. In regard to health professionals, most countries in Europe experienced an uneven distribution of health professionals across regions and a shortage of certain professions such as nurses or specialist doctors [3–5]. Norway, Switzerland and Iceland had the highest numbers of doctors and nurses per capita prior to the pandemic, while countries in central and Eastern Europe such as Poland and Latvia had fewer doctors and nurses per population [2]. Pre-crisis capacities influenced how quickly countries were able to deploy existing resources while gaining time to increase capacity and provide the necessary flexibility [6].

Existing research on health system capacity to treat COVID-19 patients has mainly focused on modelling the required surge capacity of ICU beds [7–10], and generally shows that hospital capacities had to be increased to avoid preventable mortality from COVID-19. McCabe et al. [11] found that hospital provision measures such as procurement of equipment, redeployment of staff and creation of additional facilities alleviated significant shortfalls in the NHS in England in terms of intensive care nurses, beds and junior doctors. Williams et al. (2020a) showed that all countries have used a variety of strategies to repurpose and mobilise the existing health workforce, while also augmenting the workforce by hiring additional health workers, bringing back inactive health workers or utilising students and volunteers. In early April 2020, the WHO released technical guidance and tools to help countries plan and develop strategies to increase and create surge capacity. The guidance introduces the four S's of creating surge capacity for acute and intensive care (space, supplies, staff and systems) which will frame this paper [12,13].

2. Methods

Evidence included in this analysis builds on the content compiled in the COVID-19 Health System Response Monitor (HSRM), available at https://www.covid19healthsystem.org/. The HSRM tool was established in March 2020 and designed in response to the COVID-19 outbreak. The HSRM collects and disseminates up-to-date information on how countries, mainly in the WHO European Region, are responding to the crisis, focused primarily on the responses of health systems. It is a joint undertaking of the WHO Regional Office for Europe, the European Commission, and the European Observatory on Health Systems and Policies.

The HSRM content is structured broadly around the standard health system functions [14], capturing information on policy responses in six areas: (I) preventing transmission, (II) ensuring sufficient physical infrastructure and workforce capacity, (III) providing health services effectively, (IV) paying for services, (V) governance and (VI) other non-health system measures. The information is collected and regularly updated using an evolving set of questions that serve as prompts for the country health policy experts contributing to the platform. By following a structured questionnaire and having a team of Observatory staff editing the responses, information is collected in a way that enables broad comparisons across countries. However, it must be noted that the level of detail of information reported in the HSRM is not systematically harmonised across countries. Country authors used different approaches to collect information and report on their health systems.

This paper aims to analyse countries' policy responses implemented or planned to mitigate shortages of physical infrastructure. Physical infrastructure includes acute and intensive care unit (ICU) beds, personal protective equipment (PPE) and medical equipment (e.g., ventilators). In addition, the article covers health workforce capacity, defined as health professionals working directly with patients. The section on the workforce includes information on countries' measures to maintain or enhance capacity, the responsibilities and skill-mix of the workforce and initiatives to train and redeploy health workers.

Data collected for this article refers to information provided between March 2020 and August 2020 on the HSRM, to cover the first wave of the pandemic. The selected countries reported relevant information on country measures to mitigate shortages of physical infrastructure (hospital beds, PPE and medical equipment) and workforce during the study time period. The countries included in the analysis are part of the WHO European Region, and a total of 45 countries were included in the analysis. England only from the UK is included as more complete information on this country is available from HSRM, whereas data is missing for devolved nations (Northern Ireland, Scotland, Wales). The absence of specific countries in the analysis does not necessarily mean that these countries did not take any measures regarding physical infrastructure and workforce capacity, but that limited information was available at the time of data collection on these topics. As a result, the summary tables included are not meant to be exhaustive given that the HSRM's country pages contain different levels of information. This paper also uses other country material, key documents and literature.

The paper is structured along the four S's of creating surge capacity for acute and intensive care. This is a widely used concept to operationalise and systematically approach surge capacity. The WHO European Region technical guide 'Strengthening the Health System Response to COVID-19′ defines the four S's as space, supplies, staff and systems of coordination for optimum surge capacity response [12,15,16]. The WHO further specifies the four S's of surge capacity as follows: 1) space refers to structure (including hospitals and beds) and facilities for emergency purposes, 2) supplies are about the availability of specific equipment such as intubation equipment, mechanical ventilators and personal protective equipment, 3) staff means ensuring sufficient numbers of appropriately skilled health (and social care) workers and, 4) systems relate to management systems that ensure ongoing and proactive planning for optimum surge capacity response [12].

3. Results

The COVID-19 crisis necessitated countries to rapidly mobilise hospital capacity, medical equipment, PPE and workforce. All countries in Europe prepared and implemented plans to create sufficient physical infrastructure and mobilise the health workforce at the start of the COVID-19 pandemic. Policy mechanisms to increase capacity, such as existing emergency and contingency plans, widely varied across countries, which in turn influenced country responses. The following sections provide details about how countries managed to create separate capacity for COVID-19 patients in hospitals (space), responded to the lack of PPE and medical equipment (supplies), monitored surge capacity (systems) and mitigated workforce shortages (staff).

3.1. Space: creating acute and intensive care capacity for COVID-19 patients

A primary concern regarding physical infrastructure was to provide enough capacity to keep COVID-19 patients in separate wards. These spaces needed to be equipped with adequate capacity for therapy with oxygen, ICU beds and ventilators. All countries quickly initiated emergency hospital plans to free up capacity for COVID-19 patients and to set up additional acute and ICU beds within existing facilities. In all countries, wards and hospital beds were re-configured to concentrate COVID-19 patients in separate wards and maintain COVID-19 free spaces for other urgent hospital treatments (Table 1) [17].

Table 1
Strategies to create hospital surge capacity.

Country	Reorientation of hospital departments/Creation of ICU, intermediate and acute care beds for COVID-19 patients	Designation of hospitals to treat COVID-19 patients	Creation of transition centres for recovery and/or quarantine	Use of private hospitals	Creation of new COVID-19 temporary/military field hospitals	Inter-hospital transport of COVID-19 patients to adjust for needs in local/national capacity	Use/set-up monitoring systems of bed capacity
Armenia	x		x (recovery and quarantine)		x (triage centre with beds)		
Austria	x	x (planned)			x		
Azerbaijan	x		x (quarantine)		x (new modular hospitals)		
Belarus	x	x	x				
Belgium	x		x (recovery)			x	x
Bosnia and Herzegovina	x	x			x		
Croatia	x	x	x (quarantine and recovery)				
Cyprus	x		x (isolation)	x	x (permanent new ICU with 28 beds)		
Denmark	x			x (planned)	x (use of military hospitals, planned)		x
Estonia	x		x		x (military)		
Finland	x				x		
France	x			x	x	x	
Georgia	x		x (quarantine)	x			
Germany	x		x (planned)		x	x	x
Greece	x	x		x			x
Hungary	x		x (quarantine)	x	x (military and temporary)		
Iceland	x						
Ireland	x			x			
Israel	x		x (recovery and quarantine)				x
Italy	x	x	x	x	x	x	
Kyrgyzstan	x	x	x		x		
Latvia	x						
Lithuania	x						x
Luxembourg	x						
Malta	x			x	x (planned)		
Monaco	x					x	
Montenegro	x		x (isolation)		x (600 beds)		
Netherlands	x		x		x (temporary with 960 beds)	x	x
North Macedonia	x			x	x (mobile military hospital with 130 beds)		
Norway	x (planned)						x
Poland	x	x					
Portugal	x			x (planned)	x		
Republic of Moldova	x						
Romania	x				x (mobile hospitals)		
Russian Federation	x	x		x			
San Marino	x			x			
Serbia	x	x	x	x	x	x	
Slovakia	x	x					
Slovenia	x	x	x (recovery)				
Spain	x		x (recovery)	x	x (16 field hospitals)	x	
Sweden	x				x (2 field hospitals)	x	x
Switzerland	x	x		x		x	x
Turkey	x	x				x (2 new hospitals)	
Ukraine	x	x (planned)					
United Kingdom (England)	x		x (recovery)	x	x	x	x

Source: HSRM; plus (39).
Notes: WHO (2020); x – measure implemented; recovery – (re-adapted) rooms (e.g. in hotels or dormitories) for discharged patients requiring low intensity surveillance to recover from COVID-19 and to free up hospital capacity; isolation - rooms provided for persons with proved COVID-19 infection; planned - measure planned to be implemented in case of shortage of capacities; quarantine - rooms provided for people that need to be quarantined; recovery - accommodate discharged patients requiring low intensity surveillance.

3.1.1. Private hospitals played a key role in creating additional capacity in many countries

In more than one third of the countries, private hospitals were temporarily used as part of the public system to provide essential services to COVID-19 patients as well as urgent non-coronavirus elective procedures. This strategy was primarily used in countries that were strongly affected by the pandemic and/or that have a strong or sizeable private hospital sector. In Ireland, England, Italy, North Macedonia, Spain and the Russian Federation, the governments block-booked private hospital beds, equipment and staff to have flexible availability throughout the crisis. In Ireland and Italy (Lombardy), private hospital beds made major contributions to hospital surge capacity, counting 2000 private hospital beds and 47 ICU beds in early April in Ireland and 30% of ICU surge capacity in Lombardy. In Ireland, the state and private hospitals concluded a rapid deal that private hospitals (including health professionals, facilities and equipment) would become part of the public hospital system for a three-month period with possible extensions. In Italy and Switzerland, emergency legislation requested private facilities to make their capacities available for the admission of patients. In Switzerland, two private hospitals were entirely or primarily designated for treating COVID-19 patients.

In countries less affected during the first wave, such as Denmark and Portugal, plans were made to utilise private hospital beds in case of need. In many countries, private and army hospitals provided equipment such as ventilators for the treatment of COVID-19 patients. Army hospitals were made available to treat the general population or for medical transport of COVID-19 patients to relieve pressure from general hospitals. In Belgium, for example, patients with major burns were transferred to military hospitals. In 13 countries, mostly in Eastern Europe (e.g. Belarus, Croatia and Kyrgyzstan), existing hospitals were designated as COVID-19 hospitals, assigned to treat COVID-19 patients only. In Poland, 19 specially designated single-infection (COVID-19) hospitals treated exclusively COVID-19 patients.

3.1.2. Temporary new hospitals were created to reduce pressure on existing hospitals

In about half of the countries, COVID-19 designated hospitals were created as temporary facilities for providing care. For example, countries designed conference venues, stadiums, fairgrounds or specially constructed field hospitals to accommodate mild COVID-19 cases or severe cases once discharged (Table 1). In Spain, the IFEMA Hospital in Madrid was constructed rapidly with the support of the army. The IFEMA hospital added 5500 beds including 500 ICU beds and supported local hospitals' emergency services by treating COVID-19 patients with mild to severe symptoms [18]. In England, several temporary facilities (Nightingale Hospitals or equivalent) were built to treat mild or moderate COVID-19 cases. Montenegro built five field hospitals with 600 beds and some countries, such as Bosnia and Herzegovina, Cyprus, Turkey, Serbia and the Russian Federation, announced the creation of new COVID-19 hospitals as permanent facilities. In several countries, including England and Germany, some emergency field hospitals remained unused during the first COVID-19 wave, although this has to be considered against the context of the high levels of uncertainty related to the evolving epidemiology of the pandemic at this time [18,19].

In addition, 19 countries repurposed non-health facilities such as hotels, dormitories and rehabilitation clinics. These facilities had been vacated due to lockdown measures, and were converted into transition centres for quarantine purposes and to accommodate discharged patients requiring low intensity surveillance (Table 1).

3.1.3. Regional and cross-border collaborations saw patients transferred to areas with spare capacity

To alleviate pressure on intensive care capacity, critically ill patients were transferred between the hardest-hit regions in several countries or between different countries to areas with spare capacity. In the Netherlands, ICU and non-ICU patients were transferred to certain hospitals in northern provinces, and also to hospitals in neighbouring Germany to relieve saturated facilities [20]. Medicalising various modes of transport was often necessary to facilitate transfer of patients. In France, for example, high-speed trains, helicopters, and a warship, were deployed to move patients to other regions or neighbouring countries. The redistribution of patients to other regions and countries proved to be crucial during the first wave when hospitals were not yet sufficiently prepared in terms of appropriate capacity and knowledge of COVID-19 care. However, such transfers were only possible due to certain countries having spare capacity, often as a result of lower rates of infection [21].

3.1.4. Some countries and regions used coordinated efforts to create surge capacity

By implementing these different strategies, health systems were able to rapidly increase the number of beds to accommodate patients requiring ICU treatment in most cases. In Germany, which had the highest number of hospital beds per person prior to the pandemic, up to 13,000 ICU beds (including low care, high care and ECMO (extracorporeal membrane oxygenation)) were quickly made available for COVID-19 patients in the first wave (April 2020) with hospitals receiving a large lump-sum payment for making empty beds and additional ICU beds available [22]. In Hungary, the government required that half of total hospital bed capacity (32,900 beds) should be available for patients with COVID-19 between mid-April and mid-May [23]. In some countries, these strategies were embedded in a broader framework where predefined hospital emergency plans already existed. In Belgium, for example, hospitals activated their emergency plans earlier than required [21]. As a result, Belgium raised ICU capacity from 16.5 ICU beds per 100 000 population prior to the pandemic to 24 beds in early April 2020. In places such as Lombardy and Armenia, ICU or infection disease hospital networks managed hospitals' surge capacity. In Lombardy, the ICU Network that initially contained 15 hospitals in February quickly expanded to 72 facilities in the following weeks, creating in total 482 new ICU beds within the first two weeks of March.

3.2. Supplies: limited availability of personal protective and medical equipment

In the first wave of the COVID-19 pandemic, many countries faced significant shortages of personal protective equipment (PPE), including face masks, goggles and other protective clothing aimed to protect the wearer from infection and prevent the further spread of the virus. Furthermore, the availability of medical equipment, including laboratory materials and medical supplies (e.g. ventilators), was also strained. The combination of unprecedented and simultaneous demand for these resources at a global scale and large disruptions in the international marketplace made it difficult for all countries to urgently obtain sufficient resources for their own needs.

While public procurement has been at the forefront of most countries' policy responses, the pandemic has created a new and continuously changing purchasing environment. Governments have been forced to find innovative ways to purchase medical equipment and to join forces to respond to the urgent needs for PPE and medical equipment [24]. To better coordinate purchases of PPE within the EU, the European Commission (EC) activated the Joint Procurement Agreement, which was originally created in response

Table 2
Strategies for managing supply of personal protective (PPE) and medical equipment.

Strategies	Country examples*	Implementation examples
Increase supply of PPE and medical equipment		
Importing from other countries	Most countries**	37 EU and EEA countries signed the EC's Joint Procurement Agreement; import from China
Ramping up internal production	Austria, Azerbaijan, Belarus, Belgium, Bulgaria, Croatia, Czech Republic, Denmark, England, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Lithuania, Norway, Romania, Spain, Sweden, Switzerland, Turkey, Uzbekistan	Private companies started to change their production to ensure domestic production of PPE (Sweden)
Change market factors		
Prohibiting or limiting exports and/or sales	Austria (planned), Belarus, Belgium, Bulgaria, Finland, Norway, Poland (respirators and cardio-monitors), Romania, Russian Federation, Turkey, England, Ukraine	Export of quinine-based medicines, PPE and disinfectants was prohibited (Bulgaria)
Capping prices and/or reducing VAT	Belgium, England, France, Italy, Spain	Maximum price for surgical masque at EUR 0.50 (Italy)
Simplifying procedures for market authorization	Belgium, England, Italy, Finland, Romania, Spain, Sweden	Authorisation of commercialisation of PPE without CE marking (Spain), development of an Alternative Test Protocol (Belgium)
Relaxing guidelines for use or re-use of PPE	Belgium, England, Germany, Netherlands	FFP2 masks are only used when treatment may cause a lot of aerosols (the Netherlands)
Seizing PPE from private and public institutions	Italy, Spain	Medical and surgical aids and other movable property from privates and public bodies, if deemed necessary.
Coordinate sourcing and/or distribution* **		
Centralised coordination	Cyprus, Denmark, England, Estonia, Finland (distribution to five university hospitals), Germany (procurement), Greece, Italy, Lithuania, Montenegro, Netherlands, Sweden, Spain, Switzerland (procurement)	Publicly owned company acted on behalf of health authorities to ensure imports and distribution (Greece)
Decentralised coordination	Belgium (municipalities), Finland (districts), France (employer), England (distribution)	Procurement and distribution of masks managed by municipalities (Belgium)
Introducing monitoring systems for PPE and medical equipment	Denmark, England, Estonia, France, Greece, Norway, Ukraine	National system for reporting, allocation and distribution of PPE (Norway)

Source: HSRM.
Notes: * does not imply an exhaustive list of countries adopting these measures, but represents some examples taken from the HSRM; **Indicates more than 30 countries in Europe adopted this measure; PPE – personal protective equipment, VAT – value added tax; ***Some countries had a mix of centralised and decentralised coordination (e.g., national procurement but local distribution), which also changed over time; planned - measure planned to be implemented in case of shortage of capacities; PPE personal protective equipment, VAT value added tax; table indicates strategy taken in first wave.

to the H1N1 pandemic [25]. Moreover, all PPE exports outside of the EU were subject to export authorization effective March 15, 2020. Hospitals in some Central and Eastern European countries (e.g. Croatia, Kyrgyzstan, North Macedonia) with limited financial resources have received international donations or support from the WHO, the European Commission or donor countries (e.g. Norway, South Korea).

3.2.1. Countries implemented a number of initiatives to increase domestic production of PPE

At the national level, countries across Europe have responded swiftly to the lack of PPE and medical equipment. To rapidly increase their stock, the majority of countries imported PPE from other countries to supplement their existing stock, mainly from China (Table 2). However, to mitigate the strong dependency on imports and ensure the availability of PPE and medical equipment, countries also rapidly developed various strategies to increase domestic supply (Table 2). For example, many governments restricted the sale of medicines, goods and services used in health care services and encouraged or requested the domestic production of PPE by private companies, e.g. by easing regulation or simplifying procedures for market authorisation. To mitigate shortages, a number of countries relaxed guidelines for use or re-use of PPE, others regulated wholesale prices of essential products (e.g. PPE, sanitisers) to avoid excessive prices. Governments also asked for donations from private companies with available stock.

3.2.2. Hospitals were often prioritised to receive PPE at the expense of other health and long-term care settings

Overall, many countries focused on providing PPE to hospitals; this left vulnerabilities in nursing homes, primary care and other settings. In many countries, health workers had to work without adequate protection, which increased their risk of infection [26]. Professional groups such as general practitioners, physiotherapists, dentists or orthodontists had to stop practicing due to shortages of PPE, for example in France. The mechanisms in place to coordinate the distribution of PPE and medical equipment had strong impact on the availability of material, especially in non-hospital health care settings. Countries like the Netherlands, Greece and Switzerland organised distribution at national level. The Baltic countries had a decentralised coordination of PPE supply prior to the pandemic but transitioned to an organisation at national level in light of rising demand and prices for PPE. In contrast, a number of countries kept a decentralised coordination at levels of municipalities (Belgium) or providers (France). In Germany, procurement was centralised while distribution was a responsibility of the federal states (Table 2). Throughout the pandemic, countries adapted their approaches to coordination across authorities as lessons were learned from different strategies. Lithuania, for example, moved back to a decentralised distribution with owners of medical institutions being responsible for purchasing PPE.

3.3. Systems: monitoring system to manage surge capacity of beds, PPE and medical equipment

Many countries developed coordination mechanisms at the regional level to distribute available resources and collect information. In Italy and Spain, for example, COVID-19 ICU networks were established to manage the surge of patients requiring critical care with a single coordination command for the public and private health systems. In Germany, states and cities set up coordinating boards and developed a concept of cross-cluster takeover to improve allocation of patients across hospitals within and across regions.

3.3.1. Some countries implemented monitoring systems to steer hospital capacity, while others already had them in place

To better steer surge capacity and distribute patients across hospitals with available intensive care capacity, Germany, Greece, Israel, Ukraine and Switzerland set up monitoring systems. These systems assessed capacities and shortages of ICU and acute care beds and/or protective and medical equipment. Greece set up a digital registry to monitor stock and utilisation of all COVID-19 relevant equipment (e.g. gloves, masks, protective gear for medical personnel, etc.) as well as hospital and ICU bed capacity and occupancy in real time. In Germany, a new web-based intensive care register (DIVI) was created to report free ventilation places, intensive care capacities and the COVID-19 cases treated in participating hospitals. However, the register does not provide the actual number of critical care beds, but only shows whether capacities are available, limited, or full, without indicating the availability of ventilators. Israel has established a database with constantly updated data about hospital capacity and utilization which allows to steer hospital capacity, e.g. opening new COVID-19 wards, and facilitating transfer of patients from one hospital to another, if capacity is saturated. In Ukraine, an analytical dashboard displays regularly updated information on hospital's capacity and essential supplies stock (PPE, medical equipment, tests, number of beds including health workforce) across the regions. In Switzerland, a platform of ICU bed occupancy forecasting for individual hospitals (www.icumonitoring.ch) was set up during the pandemic and combines projections and real-time data on hospital occupancy [10]. However, many countries did not report to have data-based flexible planning tools in place. In Austria, for example, availability and distribution of physical resources are, in general, analysed in the Regional Structural Plans for Healthcare, which provide information on potential shortages. However, these plans are not provided electronically and thus are not available on a day-to-day basis.

Some countries had registries in place before the pandemic that capture capacities of acute and intensive care beds and ventilators. In particular, in most Nordic countries such as Norway, Finland, Sweden and Denmark as well as in the Netherlands (www.stichting-nice.nl) and the United Kingdom (www.icnarc.org), hospitals are connected to real time computer systems showing ICU and acute care beds' availability. Estonia and Norway employed monitoring systems on the allocation, utilisation and forecasts of COVID-19 relevant equipment to help ensure sufficient access in both ambulatory and inpatient care (Table 2). These digital solutions enabled hospitals and public institutions to monitor PPE stockpiles and demand.

3.3.2. Combined contingency plans consider capacities of physical and human resources

Some countries developed combined contingency plans that considered both hospital capacity and workforce simultaneously in the event of a spike of COVID-19 patients. Greece for example set up a contingency plan that foresees requisition of private clinics. The plan incorporates the number of transfer patients hospitalized in public hospitals, the increase of reference hospitals and the relocation of staff to dedicated COVID-19 hospitals. In Romania, a number of infectious disease hospitals and their support hospital network prepared for treating COVID-19 cases by procuring medical equipment, pharmaceuticals, PPE and ensuring workforce availability and training the personnel on the optimal and effective use of PPE and on other measures of limiting COVID-19 transmission. In Cyprus there was a centrally managed capacity planning for the intensive care units of the public sector, beds, personnel, ventilators and consumables to deal exclusively with COVID-19 patients.

3.4. Staff: strategies to increase workforce capacity

The pandemic has exacerbated the pre-existing shortages of health professionals in some countries or regions as health systems faced the dual problem of having to maintain essential medical services, while also providing COVID-19 related health services. Health professionals faced additional workloads. The increased workload was not only related to care of COVID-19 patients, which requires more staff due to prolonged lengths of stay in ICU and the intensity of treating COVID-19 patients [27], but also in having to adopt new procedures, regulations and hygienic standards. At the same time, the existing workforce faced supply-side pressures. In many countries, shortages of PPE forced medical staff to work without adequate protection (see above), contributing to health care workers having a three-fold risk of infection compared to the public even when accounting for higher testing frequency [26]. For instance, in April 2020, up to 20% and 13% of all recorded COVID-19 cases in Spain and Bulgaria respectively were in health care workers, while about 6% to 7% of healthcare workers in Germany and the Netherlands tested positive [28,29]. Inevitably, by having to stay home to recover and self-isolate, health workers were not able to work. Many practical barriers to working were also reported, with health workers often facing challenges in terms of finding childcare when schools closed, getting to work when public transport was shut down or running reduced services, or needing to find additional accommodation if family members were shielding. Due to the fear of infection and transmission to their families, very high workloads and safety concerns, health professionals faced significant physical and mental stress during the pandemic. These stressors potentially contribute to burnout and necessitate some professionals to take a leave of absence [30–32].

3.4.1. All countries adopted multiple strategies to create workforce surge capacity

All countries implemented strategies to create surge capacity of their health workforce. The most common strategy included mobilising final year medical and nursing students to support practicing health professionals. Other strategies involved asking health professionals to work extra hours, offering a transition from part-time to full-time work, modifying work schedules and cancelling leaves of absence (Table 3). In many countries, the military helped to ensure sufficient workforce capacity (e.g. by deploying military physicians to civilian settings, field army hospitals or testing centres).

Some countries have also asked retired or otherwise inactive professionals to return to work or recruited volunteers to help. These included activities supporting contract tracing or responding to public concerns through telephone hotlines. To facilitate and expedite the registration of health professionals, England, Germany, Ireland, the Netherlands, and Spain simplified the registration or hiring processes of health professionals. For example, in England and the Netherlands, health professionals who left the service in the previous years or with expiring licences were automatically re-registered. Germany, Ireland and England have developed strategies to bring foreign-trained but unregistered health professionals into the workforce. These measures include speeding up recognition procedures or allowing foreign-trained doctors in the process of having qualifications recognised in their host country to help in supporting roles, such as medical assistants. England extended visas for frontline workers from abroad so that they were allowed to continue working. In France, the "medical care reserve" was mobilised which includes 3800 health professionals. These professionals span across doctors, nurses, care assistants, non-care hospital workers, psychologists, professionals from regional health agencies, and others [2].

Table 3
Country strategies for scaling up workforce capacity.

Strategies	Country examples*	Implementation examples
Repurpose and redeploy existing health workforce		
Modify existing work practices	Most countries**	Suspending legislation on e.g. night shifts, overtime, on-call activities, minimum nurse staffing levels, emergency legislation to restrict leave
Redeploy to other specialties with greater demand	Albania, Austria, Bulgaria, Denmark, England Germany, Iceland, Ireland, Italy, Malta, Monaco, The Netherlands, Norway, Poland, San Marino, Slovenia, Spain, Turkey, and Ukraine	Additional training in person or online to re-skill health professionals to facilitate expanded scope of practice or greater task sharing, especially in intensive care units
Mobilisation of health workers to other geographic areas or health facilities with greater need	Armenia, Belgium, Bosnia and Herzegovina, Croatia, Denmark, England, Estonia, Italy, Lithuania, Malta, Montenegro, Netherlands, North Macedonia, Spain, Portugal, Romania, Russian Federation, Sweden	Online portals to match supply with demand; additional training; transfer of resident doctors to other regions
Reassignment of healthcare workers from the armed forces	Austria, Belgium, Denmark, England, Estonia, France, Italy, Germany, Luxembourg, Russian Federation, Switzerland	Medical personnel of armed forces deployed in field hospitals or test centres
Reassignment of healthcare workers from the private sector	Cyprus, England, Hungary, Ireland, Malta, Montenegro, North Macedonia	Contracts between private providers and main national/regional public provider(s); additional funding to temporarily pay contracts of private sector staff
Mobilising and recruiting additional health workers and volunteers		
Recruit new health professionals	England, Italy, Luxembourg, Netherlands, Romania, Serbia, Spain, Portugal	Additional funding; exceptional recruitment procedures; temporarily practice allowed for physicians and nurses not listed in medical register; simplified or relaxed registration/hiring processes
Mobilisation of inactive or retired health professionals	Belgium, Bosnia and Herzegovina, Bulgaria, England, France, Germany, Iceland, Ireland, Italy, Luxembourg, Netherlands, Spain	National or regional campaigns were launched (IT, IRE); online temporary registers created; direct outreach by professional associations
Deployment of medical students/volunteers	Most countries**	Temporary recruitment contracts for students; medical and nursing schools to approve early graduation; online registers or apps created to recruit volunteers
Relaxed rules or visa extensions for foreign-trained health professionals	Belgium, Czech Republic, England, Germany, Ireland, Italy, Spain	Foreign-trained physicians get a time-limited license to work; reduced language requirements for conversion exams; allow foreign-trained doctors in the process of registering to work in support roles
Support strategies for the practicing health workforce		
Mental health and well-being support	Most countries**	Helplines, websites or apps offering counselling or referrals for additional support; remote counselling sessions; wellbeing sessions in health facilities; relaxing rules to access mental health support; guidelines
Financial compensation	Albania, Armenia, Belarus, Belgium, Bulgaria, Estonia, France, Germany, Greece, Hungary, Ireland, Italy, Kyrgyzstan, Latvia, Lithuania, Montenegro, Poland, Portugal, Romania, Slovenia, Turkey	Additional funding (e.g. supplement to salary) for nursing professionals and health workers in hospitals (i.e. infectious disease wards) and long-term care
Childcare when schools were closed	Austria, Belgium, Czech Republic, Denmark, England, France, Germany, Ireland, Israel, Lithuania, Malta, Monaco, Netherlands, Norway, Portugal, Romania, Sweden	Keeping schools open for children of key workers, vouchers or financial compensation for childcare for health workers
Other practical support (free parking, free transport, free accommodation if family shielding)	England, Finland, Hungary, Italy, Malta, Kyrgyzstan, Latvia, Lithuania, Norway, Poland, Romania, Turkey	Free parking, free transport, campaigns to reduce discrimination against health workers (due to higher risk of infection), free accommodation, continuing medical education credits

Sources: HSRM, plus (1,35,39).
Notes: *This does not imply an exhaustive list of countries adopting these measures, but represents some examples taken from the HSRM; **Indicates more than 30 countries in Europe adopted this measure.

Many countries re-deployed staff from less affected health facilities to those treating COVID-19 patients or mobilised professionals to work in different disciplines (e.g. emergency departments or ICUs). A few countries (e.g. Italy, Spain) also moved health professionals with adequate skills, either as volunteers or as part of special units, to more affected regions. Emergency legislation often facilitated re-deployment and mobilisation, while additional training for health professionals played an important role in countries' strategies to optimise the skills of the existing workforce to provide support work in intensive care units treating COVID-19 patients. Additionally, seven countries (Cyprus, Hungary, Ireland, Malta, Montenegro, North Macedonia, England) have redeployed private sector staff into the public sector or even changed the work requirements of health professionals working in the private sector.

3.4.2. Creating surge capacity required changes to legislation and regulation of health workers

As mentioned, the implementation of many of these strategies has necessitated the adoption of emergency legislation [33]. A few countries reported legal changes of traditional professional task division to free up and bolster capacity of health professionals during the pandemic (Fig. 1). Non-medical health professionals were temporarily authorised to carry out tasks usually only performed by physicians or with physician referral, for example in Germany and Austria. This is particularly interesting as both countries have traditional hierarchies between the nursing and medical professions and despite various (isolated) initiatives there was no significant task shifting in health workforce governance prior to the pandemic [34].

3.4.3. Countries also took steps to support the mental health of health workers and to offer financial and practical assistance

With frontline health workers being the most important asset in the prevention and control of COVID-19, most countries created support schemes for the health workforce. These included newly established helplines or remote counselling sessions for health care workers to safeguard their mental health and well-being. Many countries also provided exceptional financial compensation, most

Task shifting and expansion of responsibilities of health workers during the COVID-19 crisis has taken place in a few countries to free-up capacity (i.e. of physicians) and to surge capacity of certain professionals. Evaluations of the implementation of these measures and their contribution to reduce pressure on other health professionals are still outstanding.

- In Germany, the second COVID Act, adopted on March 28 2020, included a paragraph on task-shifting from doctors to skilled nurses and emergency paramedics until March 2021. Yet, as of May 2021, the federal law was only taken up in one of the 16 federal states [53].
- In Austria, the second COVID-19 Act, adopted on March 23 2020, enhanced responsibilities of certain health workers for the period of the pandemic. Biomedical analysts no longer needed a physician's referral to perform laboratory methods and graduates of natural and veterinary sciences are allowed to use laboratory methods normally restricted to biomedical analysts. Further, non-trained caregivers were allowed to assist basic health care usually restricted to health professionals.
- In France and England, the role of community pharmacists was temporarily broadened. In France, pharmacists could renew prescriptions for certain chronic conditions. In England, pharmacists were allowed to supply medicine to patients without a prescription if the patient is receiving them as part of ongoing treatment [54].

Fig. 1. Temporary authorisation of task shifting and task expansions. See Refs. [53,54].

often in the form of one-time bonuses, to recognize efforts in the pandemic. Practical support was also offered to enable health workers to keep working, with countries often keeping schools open for the children of health workers when they were otherwise closed. A smaller number of countries offered free transport and accommodation to those wishing to reduce the risk of transmission to family members [35] (Table 3). At the time of writing, no evidence is available on how the redeployment and mobilisation of health professionals as well as subsequent support measures affected the mental and physical health of the health workforce. However, it is largely recognised that the additional workload under adverse circumstances has considerably increased stress amongst healthcare workers [36–38].

4. Discussion

4.1. Strategies developed to create surge capacity provide important lessons for public health crises

Our results show that all countries reoriented hospital departments to create COVID-19 designated units and expanded hospital and ICU capacity in line with the WHO technical guidelines. Each country applied several strategies and measures to manage surge capacity of space, supply and staff [21,39], sometimes embedded in systems of coordination.

The measures taken by different countries were influenced by the impact of the pandemic, as well as the initial infrastructure and organisation of health systems (e.g. large private hospital sector, availability of beds, average bed occupancy rates). While Baltic countries—with very low numbers of COVID-19 cases in the first wave—focused primarily on supply of PPE and were not prompted to surge hospital capacity [40], countries such as Spain and Italy with very high infection rates had to combine various strategies to rapidly mobilize capacity of infrastructure and workforce [1,41]. Countries with a high density of hospital and ICU beds prior to the pandemic could use this capacity immediately to absorb increased demand for health services, creating time and flexibility to increase capacity further if required. Further, the establishment of COVID-free hospitals and designated COVID-19 hospitals appeared to be more feasible in less-densely populated or smaller countries or areas. The acquisition of additional capacity from the private sector to free-up or surge capacity was mostly used in countries with a strong domestic private health sector such as Spain, Ireland and England [39].

Some countries created surge capacity above the necessary levels by postponing non-urgent interventions [17], repurposing and using hospital departments, private hospitals or other health care facilities for COVID-19 patients [21,39]. The expected rise of COVID-19 patients requiring hospital care did not occur in some countries during the first wave of the pandemic. This resulted in only a partial use of that increased capacity. In Germany, for example, around 22% (2900 patients) of ICU beds that were made available for COVID-19 patients (13,000) were used at the peak of COVID-19 hospitalisations in April 2020 [42,43]. This raises the question of whether surge capacity during the first wave might have jeopardized care for other conditions in vain. This may have negative long-term consequences for access to care (i.e. increased waiting times), health outcomes but also public financial resources [17].

4.2. Coordination and contingency planning are key to ensure sufficient infrastructure and workforce

While the long-term effects of the creation of surge capacity on routine care are still to be evaluated, there is room for learning about how to better employ coordination tools for surge capacity and contingency planning. The WHO technical guidelines emphasize the need for coordinating systems that ensure that integrated policies and procedures can be activated to develop optimized sustainable surge capacity. Surge coordination teams should develop and manage the acute and intensive care surge plan at regional and national levels to redistribute patients, staff or available material [12]. Our results show that many countries developed coordination mechanisms at the regional and/or national level to distribute available resources. However, coordination of supply of

medical equipment and PPE across borders was absent at the early stage of the pandemic as countries prohibited exports of PPE and other medical goods to protect domestic supply [44].

In light of the massive surge in demand, most countries signed the Joint Procurement Agreement (JPA) for medical equipment to better coordinate purchases of such supplies across countries [45]. Twelve of the 37 countries had signed the JPA as of February 2020. At the time of writing (April 2021), all 37 countries have signed the agreement, under which signatories can jointly place orders. These orders cover PPE, ventilators, laboratory equipment, and therapeutic remdesivir, and the EC has launched seven calls for tenders [25]. This rise may signal the value that countries in the European region have placed on joint procurement initiatives to ensure supplies of physical infrastructure during the crisis period. The idea of the European Health Union [46] with coordinated mechanisms to monitor medicines and protective equipment across countries is a vital step towards better allocation and more solidarity. Cross-border treatment of patients based on the Directive on patients' rights in cross-border healthcare (2011/24/EU) also has the potential for more solidarity and cross-border health cooperation. Under this Directive, COVID-19 patients were transferred within and across national borders to relieve saturated hospitals [20]. However, the risk for instability of critically ill patients during transfer must be taken into account and must be weighed against possible alternatives such as the use of appropriate capacities of private hospitals.

Creating surge capacity of equipment and infrastructure was not sufficient, unless it was combined with expansion of health workforce capacity, which proved to be more difficult than creating bed capacity [2,21]. In many countries, emergency legislation paved the way for various approaches to rapid mobilisation and recruitment of health workers [1,33]. Some responses of temporary task delegation and mobilisation of additional health workforce may provide opportunity and important lessons to strengthen the health workforce in the longer-term in terms of attractiveness and supply of professionals and to enhance skill mix.

Some countries developed combined contingency plans that considered capacity of infrastructure and workforce simultaneously, such as Greece or Romania. It must be noted that the reporting of combined contingency plans by only few countries in the HSRM may suggest that these plans were not implemented at national but rather at regional and local level.

4.3. Health systems' responses to create surge capacity require evaluation

Overall, we found that countries with sufficient and appropriate resources in place at the outset of the pandemic were better equipped to face a rapid rise in cases, which is line with other evaluations [2,47]. In the absence of sufficient resources, countries set up various strategies and coordination mechanisms to expand workforce and physical infrastructure which were continuously adapted in the course of the pandemic. While at the time of writing it is too early for a comprehensive evaluation of countries' measures to create surge capacity, our analysis allowed us to better understand how to assess a health system's capacity for ensuring sufficient physical infrastructure and workforce in a public health crisis.

Experiences from the first wave of COVID-19 already present some indicators for evaluation. In regard to space, the remaining capacities of ICU beds for COVID-19 and non-COVID-19 patients seem to be appropriate indicators to flag that health systems are in danger of being overwhelmed and have insufficient surge capacity [48]. The transfer of critically ill patients to other countries or across regions indicates shortages in the capacity of ICU beds and eventually flags uneven distribution of resources. In the opposite direction, unused capacities of emergency field hospitals indicate an excessive, potentially inefficient creation of surge capacities.

Further evaluations in regards to workforce and the effect of supplies are also possible. The failure to reach or maintain minimum nurse-to-patient ratios in intensive care may serve as an indicator for shortage of critical care staff. In regard to supply of equipment, infection rates amongst health professionals may be an indicator for the supply adequacy of appropriate PPE. Ongoing research by the Health System Policy Monitor (HSPM) network builds on this notion and aims to analyse the impact of PPE shortages on infection in health workers by developing a PPE preparedness index.

Overall, there is need for more research and evaluation of measures taken to mitigate shortages of infrastructure and health workers experienced during the COVID-19 pandemic to inform responses to future pandemics. More research is also needed regarding how surge capacity strategies relating to infrastructure in the first wave played out for the distribution of resources within the overall health system. For example, the use of private facilities implemented by many countries seemed to be an efficient solution, but it is not yet clear how this might affect the collaboration of the public and private sectors after the pandemic.

4.4. Creating agile health systems informed by real-time monitoring is a key challenge

The experiences of the first wave have shown that adaptive surge capacity is an important component of resilient health systems in preparing for and dealing with unexpected shocks [6,12]. During the first wave, the availability of critical infrastructure and essential supplies such as ICU beds, ventilators, PPE and health workforce and the effective coordination and distribution thereof has proved to be essential [49].

The ability to identify shortages, distribute resources and redeploy health professionals at the right place at the right time requires the availability of relevant and timely information [50]. Registries on availability and capacity of hospitals and facilities equipped for specific emergency needs (space), equipment for emergency deployment (supplies) and appropriately skilled and supervised health (and social care) workers (staff) are essential. Evaluations of surge responses during COVID-19 largely call for the improvement of monitoring systems and availability of timely data to inform strategic and daily planning of surge response [21,49,51].

Our results showed that a number of countries assessed the availability of resources via real-time monitoring systems. Based on this data, national and regional modelling of needs allowed providers or national and regional governments to estimate the projected number of resources. The availability of information, such as the number of ventilators and beds required for managing peak surge, was vital to support surge capacity planning [51,52].

However, in many countries there are important gaps of high-quality data on available health system resources including staff, space and supplies. In regard to workforce, for example, information is lacking on types of qualification, skill-mix, mobility and regional distribution of health professionals. This also holds for health workers in public health authorities and laboratory diagnostic services that had a central role in preventing transmission, infection surveillance, testing and maintaining services. In addition, so far relatively limited attention both from policy makers and researchers has been placed on the capacity, skills and potential for enhanced roles of these health workers during the crisis.

This study allowed for a comparative overview of how countries created surge capacity of infrastructure and workforce during the first wave of the COVID-19 pandemic and highlights the importance of data on available health resources for future pandemic preparedness. The surge strategies identified in our analysis

are largely in line with other research [1,2,21,39,53]. However, our results have to be interpreted in light of the methodological limitation regarding the heterogeneity and comprehensiveness of data collected from country responses reported on the Health System Response Monitor. Moreover, our findings only cover the first wave of the pandemic and it is likely that more countries have implemented strategies outlined, or that new strategies have emerged in subsequent waves.

5. Conclusion

The pandemic has clearly demonstrated that an adequate physical infrastructure and workforce capacity is crucial to cope with a public health crisis. Our study showed that countries used similar strategies to boost hospital and ICU capacities and mobilise additional workforce. The experience of the first wave provided a lesson that comprehensive systems need to be in place to support an optimum surge capacity response. These systems require appropriate real-time data on available resources to ensure ongoing and proactive coordination during health systems crisis. The COVID-19 pandemic posed unprecedented challenges for solidarity and coordination across countries, but has ultimately created opportunity for closer cooperation between countries. Overall, there is little evidence on how the measures to create surge capacities played out in practise. Therefore, an urgent need exists to evaluate the effects of implemented strategies but also to learn which approaches work best to achieve agile and adaptive surge capacity.

Declaration of Competing Interest

We declare no competing interests.

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