5 Lessons from the COVID-19 critical care surge

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The COVID-19 pandemic placed enormous strain on critical care resources. After introducing a framework for critical care surges, this chapter analyses the prepare and absorb stages of the response to the COVID-19 pandemic by OECD countries, identifying strengths and weaknesses. Capacity was increased with the introduction of more resources. Alternative uses of critical care resources were reduced, increasing their availability for patients with COVID-19. Organisational changes improved the efficient use of these resources. The use of modelling was valuable and widespread, but required data about resources and information to be developed. Increasing investment in critical care should be planned carefully to balance resilience and sustainability. Improving resilience in the future, including for threats beyond COVID-19, will need to build on the gains made during the pandemic response.

Key findings

The ability to manage a critical care surge is key to a health system's resilience. Critical care is the provision of medical care to those who have acute, life-threatening illness or injury.

Prior to the COVID-19 pandemic, in 2019, there was a fifteen-fold difference in intensive care unit (ICU) capacity between OECD countries. Increasing the availability of critical care to serve patient needs was an early challenge that countries faced when absorbing the impact of the pandemic.

This challenge needed to be met alongside widespread shortages of staff, physical space and supplies, while ensuring patient and staff safety from infection. Despite these obstacles, intensive care capacity increased by 8% from 2019 to 2020 across 16 OECD countries.

Almost all (95%) of OECD countries used modelling to predict demand and, therefore, the required critical care capacity. Modelling needed to be based on timely valid information about available resources and the demand for critical care to facilitate effective action. This was not always possible because of the novel nature of the virus and the initial lack of data and fit-for-purpose data systems.

OECD countries implemented containment and mitigation measures to reduce the number of patients requiring critical care at a point in time. Cancelling and delaying procedures increased the availability of critical care resources for patients with COVID-19. Occupancy in ICUs fell from 71% to 64% among reporting OECD countries in 2020 compared to 2019.

Improvements in information and co-ordination meant that countries made better use of the available resources. Load-balancing – moving critically ill patients to where there was available capacity – was a successful intervention. However, shortages in essential medical products (such as personal protective equipment and ventilators in the initial months of the pandemic) and persistent health workforce shortages were problematic.

Over three-quarters of reporting OECD countries (16 of 21) experienced a surge for which crisis standards of care were introduced. A legally and ethically justifiable basis for equitable resource allocation must be put in place prior to a crisis occurring.

Countries should build on the successful elements of the critical care surge response and address some of the less successful elements. COVID-19 admissions for critical care and, in some cases, local surges are still occurring; therefore, a degree of surge capacity is still required. Policies could include:

- enhancing the data infrastructure and data collections that facilitate effective resource management and load-balancing decisions, and ensuring interoperability of systems
- retaining and evaluating the modelling capacity used during the pandemic, including considering whether to extend modelling from COVID-19 demands to a more general all-hazards approach, which has the potential to lower the opportunity cost when responding to critical care surges
- continuing the load-balancing arrangements adopted during the pandemic, which may require changes in governance and financing arrangements
- ensuring the availability of adequate supplies and staff, and their equitable distribution within countries in times of crisis.

COVID-19 has not been eliminated; the potential remains for future increases in critical care requirements from subsequent waves. Beyond COVID-19, more work needs to be undertaken to ensure the right balance between permanent and staffed intensive care and critical care beds. The ability to increase critical care surge capacity, while minimising the opportunity cost for other essential care, will foster health system resilience for the next shock.

5.1. Critical care reduces morbidity and deaths

The COVID-19 pandemic placed enormous strain on intensive and critical care resources around the world (Abir et al., 2020[1]). This strain was neither uniform over time nor geographically. It was more intense in some areas and periods than others, including in Wuhan, People's Republic of China; Lombardy, Italy; and New York, United States during 2020 (Bottiroli et al., 2021[2]; Rezoagli et al., 2021[3]). The pandemic saw demands exceed the ability of critical care facilities to serve their communities (Elke et al., 2021[4]).

If critical care – the provision of medical care to those who have acute, life-threatening illness or injury – is not accessible when required, mortality and morbidity increase. This also occurs when critical care resources are stretched but not overwhelmed. Increasing occupancy of intensive care units (ICUs) has been demonstrated to be associated with increasing mortality (Bravata et al., 2021[5]). When this occurred during the COVID-19 pandemic, the mortality rate increased for those infected – in some cases more than doubling (Ebinger et al., 2022[6]).

Critical care involves not only provision of care in ICUs but also other hospital and out-of-hospital services (Schell et al., 2018[7]). Availability of critical care resources is an important component of absorbing a shock. However, maintaining a large surplus of critical care facilities is extremely costly, and must be balanced against the benefit those resources would offer if used in alternative ways. Therefore, it is important that critical care availability can be mobilised and "surged" when required in response to a shock.

The response to a shock comprises four stages (see the chapter on key findings and recommendations). These stages are prepare, absorb, recover and adapt. *Prepare* includes the steps taken to prepare critical functions to avoid and mitigate shocks. This occurs prior to the disruption. *Absorb* occurs after the shock commences, comprising the capability of the health system to maintain core functions and absorb the consequences without collapse. Thus, limiting the extent of the disruption and minimising the morbidity and mortality impact. *Recover* involves regaining the disrupted functions as quickly and efficiently as possible. *Adapt* is the capacity of the health system to "learn" and improve its capacity to absorb and recover from shocks, reducing the impact of similar threats in the future.

This chapter is divided into three sections. Section 5.2 outlines a framework for critical care surges and the response to them. It also discusses the pre-pandemic capacity of OECD countries. Section 5.3 outlines implementation of the surge in critical care capacity during the absorb stage of the COVID-19 pandemic. It discusses the strengths and weaknesses of the approaches taken, with an emphasis on minimising the opportunity cost through modelling of critical care requirements. The final section (5.4) suggests adaptations for the future and important resilience considerations for surges in critical care capacity.

5.2. Surge capacity is essential and requires co-ordinated efforts

5.2.1. Surge capacity needs to be managed during a health crisis

Surge capacity is the ability to respond to a sudden increase in patient care demands (Therrien, Normandin and Denis, 2017[8]). A surge in critical care capacity is essential to health system resilience (Haldane et al., 2021[9]). It is the primary method of responding to a sudden increase in acute care demand during a mass critical care event. As demonstrated by COVID-19, pandemics can generate prolonged and substantial surges simultaneously across multiple countries. Planning for critical care surges uses an "all-hazards approach", with common resources used for different scenarios, such as pandemics, large numbers of trauma victims, armed conflict, terrorist attacks or disasters.

An effective response requires clinicians, hospital leadership, regional and national governments, and health systems to co-ordinate their efforts. At the extreme, normal clinical care standards during a crisis surge cannot be maintained and require modification. The four Ss – staff (trained personnel), space (in which to treat), supplies (and equipment) and systems (policies and procedures) categorise potential areas of deficit encountered during a surge (Hick et al., 2014[10]). Ideally, a critical care surge can be managed without interrupting essential services to the population (Therrien, Normandin and Denis, 2017[8]). Plans to enact critical care surge responses require continual review, updating and re-evaluation of potential threats (Sheikhbardsiri et al., 2017[11]).

A common framework for assessing surges and their implications follows the responses required for a conventional, a contingency and a crisis surge (Table 5.1). As identified in reviews of critical care surges (Hick et al., 2014[10]), there is a distinction between contingency capacity (i.e. increasing critical care capacity without a substantial impact on routine care) and crisis capacity (i.e. when changes to critical care capacity are likely to have an impact on routine care) (Abir et al., 2020[1]). The scope of strategies used in a crisis scenario may be considerable, requiring routine practice to be modified, as occurred during the COVID-19 critical care surge.

Table 5.1. Categorisation of critical care surges

Magnitude of Surge	Minor	Moderate	Major
Increased capacity required	20%	100%	200%
Response	Conventional	Contingency	Crisis
Standard of care	No significant alterations	Some changes in standards and processes of care	Significant alterations in standards and processes of care

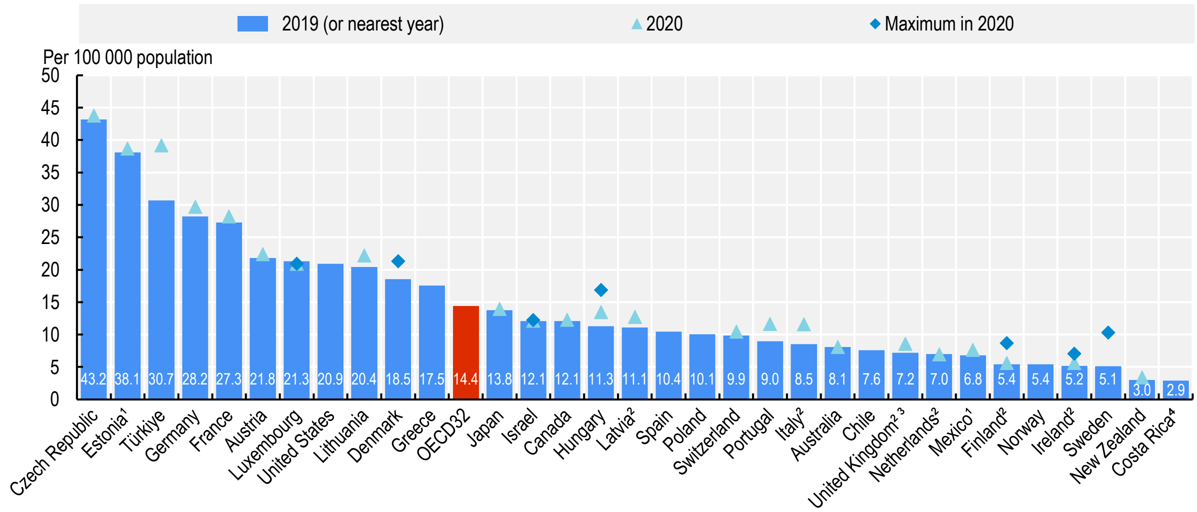
Source: Adapted from Christian et al. (2014[12]), "Introduction and Executive Summary: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement", https://doi.org/10.1378/chest.14-0732.

As critical care surges move past conventional to contingency or crisis, it is common to reduce the usual activities of the hospital or health system and to increase resources to the servicing of critical care. The size of the system under consideration usually increases with the move from a conventional to a crisis surge. Conventional surges are often resolved at a local level, whereas crisis surges often require a regional, national or international approach.

5.2.2. There was nearly a fifteen-fold variation across OECD countries in pre-COVID intensive care capacity and acute care occupancy

Prior to the COVID-19 pandemic, the number of ICU beds per capita in OECD countries ranged from 2.9 ICU beds per 100 000 population in Costa Rica to 43.2 beds per 100 000 in the Czech Republic (Figure 5.1). Definitional differences between countries lower confidence in the comparisons (OECD, 2021[13]).

Figure 5.1. Adult intensive care beds, 2019 (or nearest year) and 2020

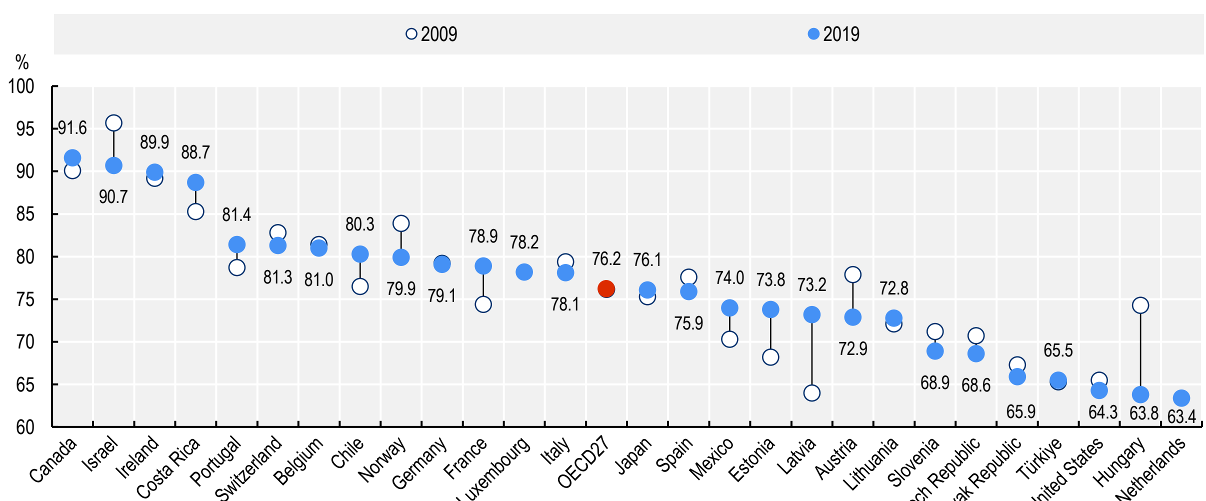


1. Data include neonatal and paediatric ICU beds. 2. Data cover critical care beds only. 3. Data refer to England. 4. Data cover public sector only.

Sources: OECD Health Statistics 2022; Joint Questionnaire on Non-Monetary Health Care Statistics 2022 (unpublished data); OECD (2021[13]); National sources.

Higher numbers of physical beds may imply greater surge capacity, but this relationship can be confounded by occupancy (Sheikhbardsiri et al., 2017[11]). The total number of specialist ICU and more general curative (or acute) care beds give an indication of the available space and associated staff. Occupancy rates give an indication of the spare capacity in the existing system (Figure 5.2.) The four OECD countries with relatively high occupancy rates in curative beds in 2019 (>85%) – Canada, Israel, Ireland and Costa Rica – also have below-average ICU bed numbers per capita.

Figure 5.2. Occupancy rate of curative (acute) care hospital beds, 2009 and 2019 (or nearest year)



Source: OECD Health Statistics 2022; OECD (2021[13]). *Health at a Glance 2021: OECD Indicators*, https://doi.org/10.1787/ae3016b9-en.

Increased occupancy can reduce the ability to mount a critical care surge response within the existing capacity (DeLia, 2006[14]). However, for a critical care surge response, it is the available capacity – both existing within the system and that can be created – that services demand.

5.2.3. Interconnected systems can support or hinder an effective critical care surge response

Critical care surge responses require management at a high level, often involving multiple systems within and beyond the health system. For most critical care surges, the issue is not simply an increase in acutely unwell patients who require care. The cause of the surge also generates other stresses, for example: destruction of infrastructure; loss of logistical capacity; interruption of usual governance practices; or reduction in available staff and supplies.

This occurred during the COVID-19 pandemic, when the strain on critical care resources was not independent of other pressures. Direct pressures came from the increasing number of infections, leading to an increased number of people requiring critical care. Indirect pressures came from measures to contain and mitigate the growing number of infections (see the chapter on containment and mitigation) and the requirements of other health services and systems. This can also occur with other disruptions like armed conflicts or earthquakes, which often destroy infrastructure, disrupt systems, and reduce the availability of staff. Successful management of a critical care surge requires a health system that contains, manages and mitigates these co-existing pressures.

Effective critical care relies on and is relied on by other systems in health care, including primary care, rehabilitative services and long-term care, among others. When healthcare service delivery is reduced in hospitals and other critical care providers, increased use of primary care is required for services that would have otherwise been provided in hospital. Medically fragile patients are likely to require additional support and may deteriorate without the usual pathways to care (see the chapter on care continuity).

There is potential for disruptions and feedback loops between these systems, as occurred during the pandemic. Patients with COVID-19 had increased care and resource requirements: personal protective equipment (PPE), increased space and increased infection control were necessary (Anesi, Lynch and Evans, 2020[15]). These changes resulted in an effective reduction in healthcare capacity and placed extra strain on the system in other settings. Similar issues can occur during other disruptions – for example, during an outbreak of a resistant pathogen, bioterrorism or a chemical leak. The prioritisation of resources may also worsen outcomes in other settings. For example, diversion of PPE to hospitals leaves other medical and non-medical services with less protection, in turn worsening health outcomes. This was evident in long-term care facilities in the first year of the pandemic (see the chapter on long-term care).

Patients are typically discharged from critical care into wards or rehabilitative settings. If resources are moved to critical care from other settings, the ability of these other settings to absorb the increased load may be compromised. This could potentially result in delayed discharge of patients from critical care settings. Prior existing shortages may become exacerbated, and poor transitions of care may harm patients or cause unnecessary readmissions into hospital (Hick et al., 2014[10]).

Critical care systems are typically nested within hospitals and hospital support systems (Einav et al., 2014[16]). They require pharmacy, laboratory, radiology, allied health, nutrition, patient transport, pre-hospital emergency services, mortuary and logistics services, among others. Increasing demand for these support services in the context of a critical care surge may affect other clinical services that require them. Alternatively, if support services cannot be scaled in proportion to the requirements of the critical care surge, it may affect the quality of services provided (see the chapter on securing supply chains). It is recommended that planning and consideration of this issue is undertaken before the critical care surge occurs (Hick et al., 2014[10]).

5.3. A substantial surge in critical care capacity was implemented during the pandemic

The requirement for critical care resources at the beginning of the pandemic, based on early evidence, was expected to be enormous. The treatment of patients admitted for COVID-19 early in the pandemic demonstrated a high rate of invasive ventilation and critical care admission, for example reports of 5% of patients infected with COVID-19 requiring critical care admission in early 2020 (Doidge et al., 2021[17]). Those admitted with COVID-19 pneumonia and organ failure at the beginning of the pandemic had a relatively long period of ICU admission and were likely to require invasive ventilation (Aziz et al., 2020[18]).

Many OECD countries increased critical care capacity in response to the expected requirements. This was achieved by both freeing up resources from within the health system and increasing resources to the health system. Improved information led to a greater ability to co-ordinate and better use of the available resources. However, capacity constraints in physical supplies and the workforce hampered the response.

5.3.1. Systems for planning resource requirements proved to be essential

The key question on surge capacity for critical care services is "How many patients will need hospital and ICU resources on a given day?" (Aziz et al., 2020[18]). Suggestions have been made in the past to target hospital beds for a surge response at approximately 500 beds per million population (Barbisch and Koenig, 2006[19]), but this would have been inadequate for the peak of the COVID-19 critical care surge. Answering this question requires modelling the future and is aided by real-time information (see the chapter on digital foundations). Estimating the number of patients requiring critical care, the type of care required, and the current capacity is a first step in determining appropriate resourcing.

Prior to widespread COVID-19 immunisation, the requirement for ICU beds during various periods of acute infection (waves) typically doubled every 2-3 days and took four weeks to reach its peak (Kaplan et al., 2020[20]). There was a challenge when modelling early recommendations and treatment of critical care patients who contracted SARS-CoV-2 (Xie et al., 2020[21]). Given the unknown nature of the disease, early estimates of important parameters were subject to substantial uncertainty, as they were derived from observational studies subject to confounding. The generalisability of some parameters between countries and settings continues to be subject to uncertainty (Cakir et al., 2019[22]).

Almost all country respondents to the OECD Resilience of Health Systems Questionnaire 2022 used modelling to predict the required critical care capacity in response to the pandemic, and almost all found it to be useful in planning resources (Table 5.2). Data from those countries that experienced the initial surge in COVID-19 infections allowed greater sensitivity in modelling for subsequent waves (Dhala et al., 2020[23]). Similar critical shortages were noted by most countries: ICU beds and trained ICU nurses.

Table 5.2. Prevalence and usefulness of modelling during the first two years of the pandemic

Forecasting or modelling used to plan critical care and hospital resources		How useful the forecasting was considered by countries	
Yes	95%	Very useful	68%
		Useful	26%
No	5%	Moderately useful	5%
		Slightly useful	0%
		Not useful	0%

Source: OECD Resilience of Health Systems Questionnaire 2022.

The information generated by the modelling was used at multiple levels within and beyond health systems. For example, it was used at a high level for planning containment measures alongside critical care capacity, to attempt to ensure that crisis critical care surges did not exceed capacity. It was used to guide the gaining and deploying of additional resources, including decisions on the distribution of resources between regions within a country. At a local level, it was used for planning of space (beds), cancellation of surgery, staffing requirements and procurement of supplies (including PPE and essential medicines).

OECD countries used a variety of different techniques to model. These ranged from short-term forecasting based on recent trends in infections and hospitalisations to very sophisticated modelling that could be used to predict several scenarios for different containment strategies. Several countries linked models together to provide a comprehensive overview for multiple domains. For example, Canada used an epidemiological model to predict case numbers, a hospitalisation model to predict resource requirements using the epidemiological model, and a critical drug model to assess the demand of hospital-based drugs relative to the inventory.

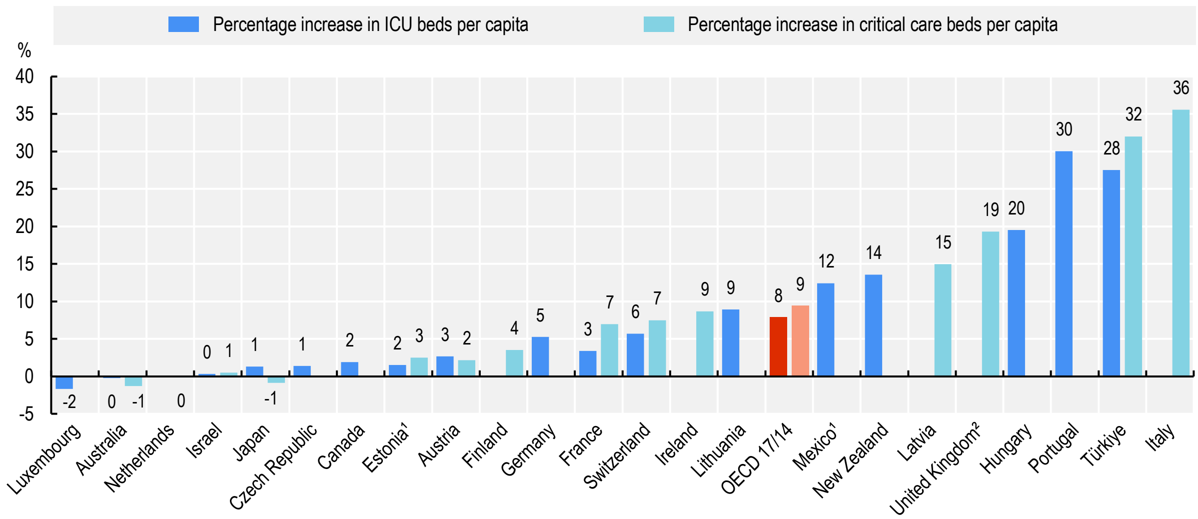
Modelling that allowed anticipation ensured that managers of health services took steps to secure or free up resources. Additionally, the modelling revealed limitations in the data made available to decision makers. For example, at the start of the pandemic, not all countries knew the numbers of ventilators and occupied hospital and ICU beds in real-time. In other countries, data were available, but differences in standards had to be overcome between regions or internationally. These limitations were compounded by uncertainty about the disease. For example, Portugal noted that it was very challenging to build scenarios under such high uncertainty – this included the initial uncertainty about the disease but subsequently also the uncertain impacts of vaccination, including its impact on transmission, waning of immunity and new variants.

5.3.2. Available space was successfully increased during the response

There are two major sources of increased supply of critical care capacity. The first is increasing the availability of staffed and supplied ICU and critical care beds. The second is increasing the ability to provide high-level critical care including invasive ventilator support in non-traditional spaces – for example, recovery rooms and operating theatres, wards and newly created temporary spaces (surge capacity).

The COVID-19 pandemic saw an 8% increase in the supply of intensive care beds per capita across reporting OECD countries (Figure 5.3). Supply of both ICU beds and more specialist critical care beds was increased across reporting OECD countries.

Figure 5.3. Percentage increase in average per capita intensive care unit and critical care beds from 2019 to 2020



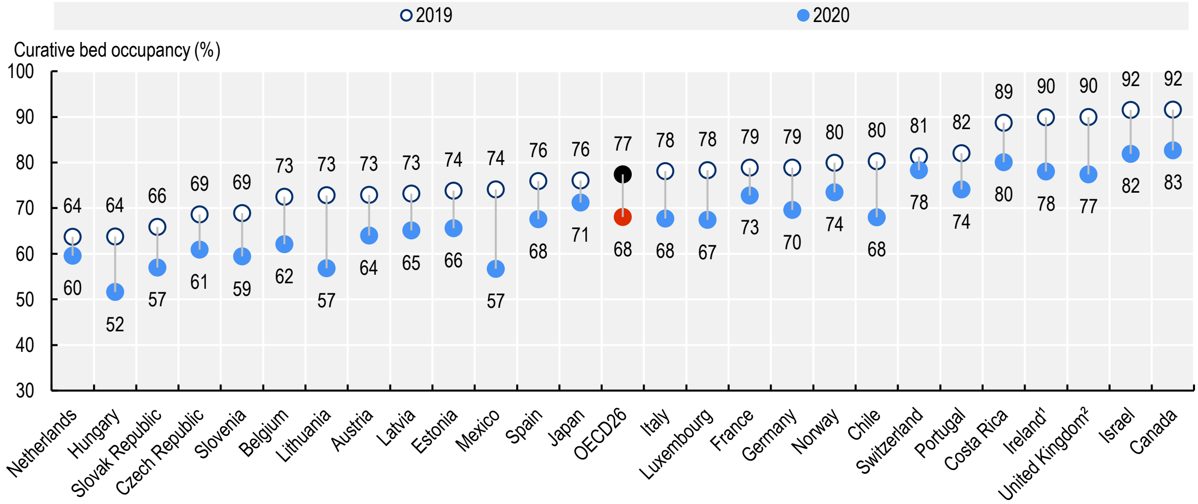
Note: The calculated OECD average is the unweighted average of all reporting OECD countries. These figures do not include increases in surge critical care capacity including ventilator support in non-ICU areas. Countries reporting the same number for ICU and critical care beds have been counted only once in the critical care bed classification. The maximum number of ICU and critical care beds is higher than the average and changes in the population resulted in small decreases in some countries. 1. Data include not only adult ICU beds but also neonatal and paediatric ICU beds. 2. Data refer to England (United Kingdom).

Sources: Joint Questionnaire on Non-Monetary Health Care Statistics 2022 (unpublished data); UK (England) data from NHS England (Critical Care Bed Capacity (NHS England, n.d.[24]), "Critical Care Bed Capacity and Urgent Operations Cancelled 2019-20 Data", https://www.england.nhs.uk/statistics/statistical-work-areas/critical-care-capacity/critical-care-bed-capacity-and-urgent-operations-cancelled-2019-20-data/, and Urgent and Emergency Care Daily Situation Reports (NHS England, n.d.[25]), "Urgent and Emergency Care Daily Situation Reports 2020-21", https://www.england.nhs.uk/statistics/statistical-work-areas/uec-sitrep/urgent-and-emergency-care-daily-situation-reports-2020-21/, were used) and the last date in December in 2019 and 2020 was used.

Beyond the increase in ICU beds, OECD countries also increased the potential to use invasive ventilator support in ICU and non-ICU beds. For example, Norway doubled the potential to provide ICU-level care for a limited time, as did several other countries, including Ireland and Sweden (Elke et al., 2021[4]). England (United Kingdom) expanded its capacity via several methods, including repurposing areas for additional ventilator support and use of temporary hospitals, increasing capacity by 68% (Mateen et al., 2021[26]).

Despite the increase in requirements for critical care and the increased burden of COVID-19, the total hospital curative (or acute) care bed occupancy rate fell in all countries reporting for 2020 (Figure 5.4). This reflected the reduction in elective surgery and other health services (see the chapter on waiting times).

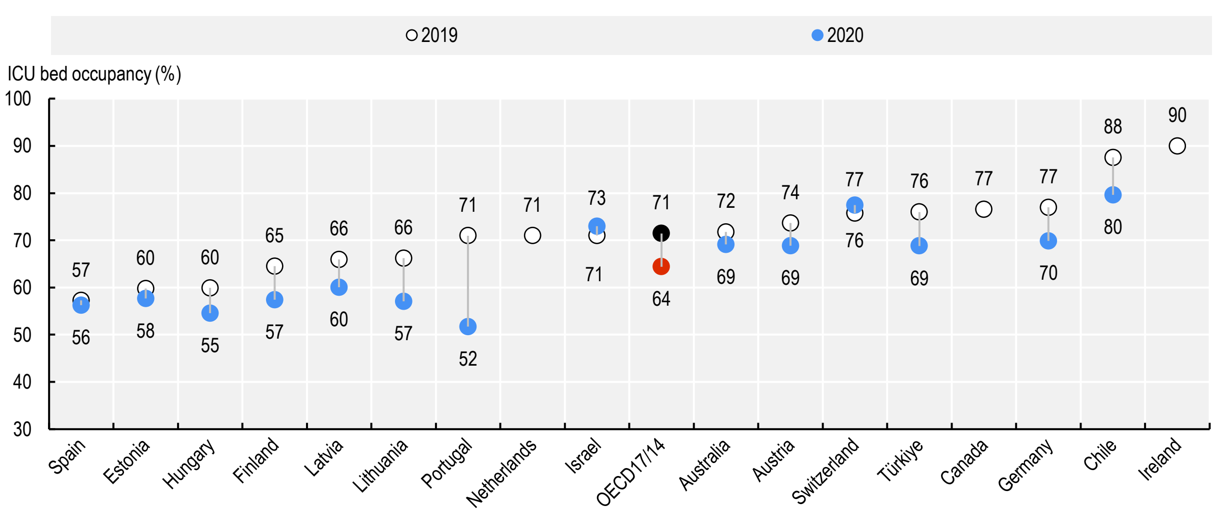
Figure 5.4. Occupancy rate of curative (acute) care hospital beds 2019-2020



Note: The OECD average is the unweighted average of the occupancy in each year. 1. Data for Ireland exclude private hospitals. 2. Data refer to England (United Kingdom).
Source: OECD Health Statistics 2022; UK (England) data from NHS England (NHS England, n.d.[27]), "Bed Availability and Occupancy Data – Overnight", https://www.england.nhs.uk/statistics/statistical-work-areas/bed-availability-and-occupancy/bed-data-overnight/.

The approaches taken successfully addressed the capacity constraints in physical space, beds (both formal increases in ICU beds and use of surge increases) and ventilator support at a national level. The data demonstrate that physical capacity was available most of the time. The four OECD countries reporting maximum occupancy of ICUs nationally during 2020 in the Joint Questionnaire on Non-Monetary Health Care Statistics (unpublished data) did not exceed 90% (Australia 81%, Hungary 89%, Israel 82% and Spain 68%). These findings are consistent with the published literature, which show that at a national level the expanded capacity was rarely exceeded (Elke et al., 2021[4]). On average, occupancy of ICU beds fell among OECD countries in 2020 compared to previous years (Figure 5.5).

Figure 5.5. Occupancy of adult intensive care unit beds, 2019-2020

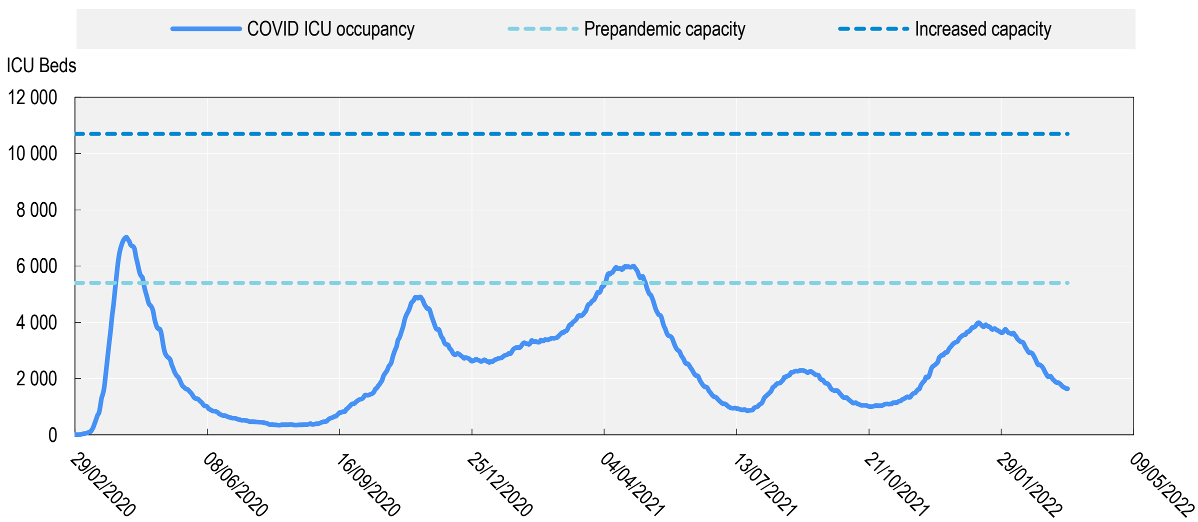


Note: The calculated OECD average is the unweighted average of all reporting OECD countries for that year. ICU capacity increased in many countries in 2020 (Figure 5.3). There are differences in the definitions used by countries for ICU beds that may limit the comparability of the data between countries. The 2019 figure for the Netherlands was sourced from 2018 – the last figure available.
Source: Joint Questionnaire on Non-Monetary Health Care Statistics 2022 (unpublished data).

However, without increasing specific components of critical care capacity, many OECD countries might not have had enough capacity to meet the demand created by the COVID-19 pandemic. In the case of France, which was close to the mean average of total ICU capacity per population across the OECD (Figure 5.6), the ventilated ICU capacity could have been exceeded several times during the pandemic if the critical care surge had not supplemented the number of ventilator-equipped beds.

Therefore, increasing the effective capacity for critical care treatment was essential during the absorb stage of the COVID-19 response. Without it, several countries would have had their pre-COVID-19 ICU capacity exceeded or almost exceeded, including the Netherlands, Sweden and the Lombardy region of Italy (Elke et al., 2021[4]).

Figure 5.6. Number of intensive care unit beds in France occupied by patients with COVID-19



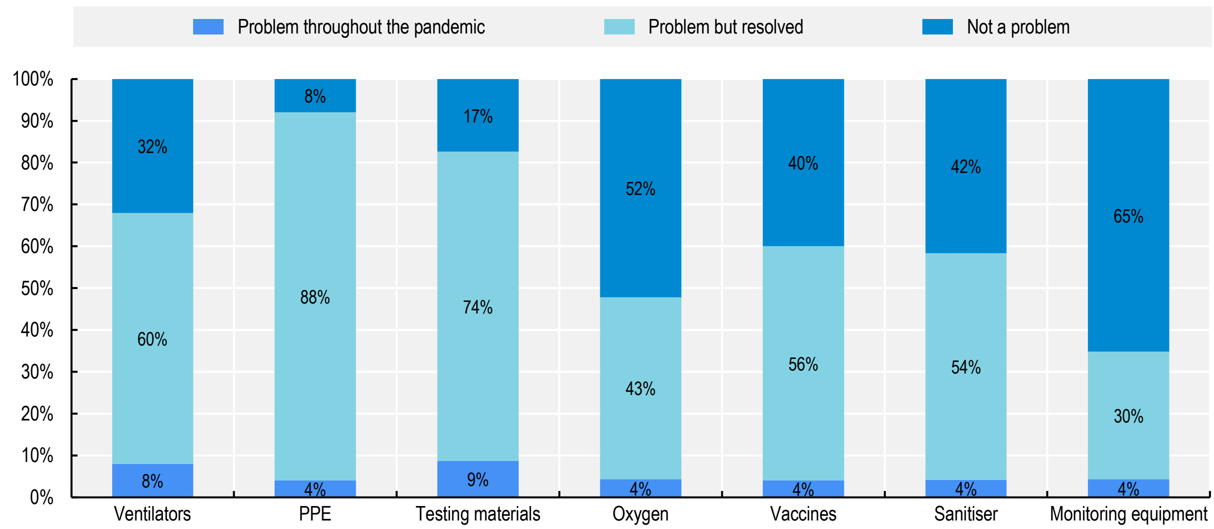
Note: Data definition is "Daily ICU occupancy (number of COVID-19 patients in ICU on a given day)".
Sources: ECDC (n.d.[28]), "Data on hospital and ICU admission rates and current occupancy for COVID-19", https://www.ecdc.europa.eu/en/publications-data/download-data-hospital-and-icu-admission-rates-and-current-occupancy-covid-19. The capacity was sourced from OECD/European Observatory on Health Systems and Policies (2021[29]), *France: Country Health Profile 2021*, https://doi.org/10.1787/7d668926-en, and refers to the number of beds with ventilator capacity.

Critical care services can bear an immense caseload with a rapidly spreading pandemic (Remuzzi and Remuzzi, 2020[30]). However, the demand for critical care during the COVID-19 pandemic was inconsistent within countries and over time. While the pandemic was widespread, the surges showed intense clustering, and overwhelmed local services even though capacity remained in surrounding areas (Doidge et al., 2021[17]). For many areas, the peak requirement for critical care was very high and intense. Additionally, multiple waves of critical care demand occurred, increasing and decreasing the required capacity. Finally, while availability of physical space was increased during the pandemic, this needed to be accompanied by an available workforce, equipped with supplies and timely information, to make the best use of this space.

5.3.3. A lack of supplies was devastating during the first months of the pandemic

Unmet needs for ventilators, oxygen, medicines and PPE were a problem for most OECD countries during the early months of the pandemic. The shortages of PPE were particularly critical, potentially reducing worker safety and worsening outcomes (Griswold et al., 2021[31]). Several countries took a national approach to address this supply challenge (see the chapter on securing supply chains), and most countries reported that they resolved problems with supplies of essential medical products over time (Figure 5.7.)

Figure 5.7. Percentage of countries reporting problems with the supply of essential medical products



Source: OECD Resilience of Health Systems Questionnaire, 2022.

Compounding challenges within critical care systems that come under extreme pressure may contribute to poorer system performance. As the numbers of patients increase, resources are exhausted, space becomes crowded, and staff are subject to enormous strain. Even if supply problems are resolved, diminished staffing and personnel who are less well trained may result in greater difficulty maintaining standards of quality of care, including appropriate use of PPE and infection control procedures. In turn, this leads to more infections – further reducing staffing capacity. This vicious cycle is likely to have a detrimental impact on patient outcomes.

5.3.4. A team approach was taken to leverage and develop health workforce skills

Expanding and maintaining the workforce for a surge response requires an adequate number of appropriately trained workers and protection of those staff. Workforce availability often constrains surge capacity during a crisis and this occurred during the COVID-19 pandemic (Al Thobaity and Alshammari, 2020[32]). Half of countries responding to the OECD Resilience of Health Systems Questionnaire 2022 reported that health workforce shortages had an important impact on their capacity to deal with the COVID-19 pandemic (see the chapter on workforce). In most countries doctors and nurses working in ICU were in short supply.

Previous work on resilience in critical care surges has highlighted the importance of ensuring that teams can function when some members are absent (Therrien, Normandin and Denis, 2017[8]). Hospitals with available high-technology remote facilities can provide additional support (Dhala et al., 2020[23]). Leveraging specialist personnel through telehealth is considered an important force multiplier (Dichter et al., 2014[33]). Consensus statements have outlined the importance of cross-training staff for a potential critical care surge and ensuring that specialist oversight is available, even if this has to be delivered remotely – this was prophetic for the COVID-19 pandemic (Einav et al., 2014[16]).

During the pandemic, the requirement to service critical care units resulted in relocation of healthcare workers to emergency departments and ICUs (Haldane et al., 2021[9]). Global surveys suggested that the lack of intensive care nurses was more prevalent than the lack of physicians during the pandemic (Wahlster et al., 2021[34]). The systems around staffing were altered – for example, changing staffing ratios and staff duties (Dhala et al., 2020[23]). Other activities, such as documentation requirements, were also altered (Harris et al., 2020[35]).

Virtual training was undertaken to foster and update skills (Haldane et al., 2021[9]). The pandemic produced challenges in undertaking prompt training while ensuring that safety and infection control protocols were followed. The impact of redeployment on healthcare worker safety needed to be addressed to ensure worker buy-in (Vera San Juan et al., 2022[36]).

Individual hospitals reported successful experiences of increasing their critical care surge workforce by teaming critical care nurses with other nurses to care for multiple patients (Fiore-Lopez, 2021[37]). Systematic reviews suggested that successful deployment and training facilitated strong collaboration across multi-disciplinary teams to optimise resources during the pandemic. A key factor in successful deployment was being able to match the specific roles with workforce availability, minimising the need for training. This approach requires the use of treatment teams (Vera San Juan et al., 2022[36]). The constantly changing nature of the pandemic meant that scaling up and scaling down of surge capacity was needed. This requires clear processes for decision making.

A feature of the COVID-19 pandemic, which complicated the response and potentially contributed to compounding challenges, was the chronicity of the crisis. One common approach to surging staff numbers in emergencies is increased hours and calling back staff (Sheikhbardsiri et al., 2017[11]). This may be counterproductive, however, when the surge is chronic rather than acute. Provider distress and burnout was associated with providing care to large numbers of patients with COVID-19 (Wahlster et al., 2021[34]) (see chapters on mental health and workforce). History has shown that health systems can be overwhelmed by infectious disease epidemics (Nuzzo et al., 2019[38]) and spread can occur within the health system and between hospitals.

5.3.5. Systems for extensive co-ordination were developed

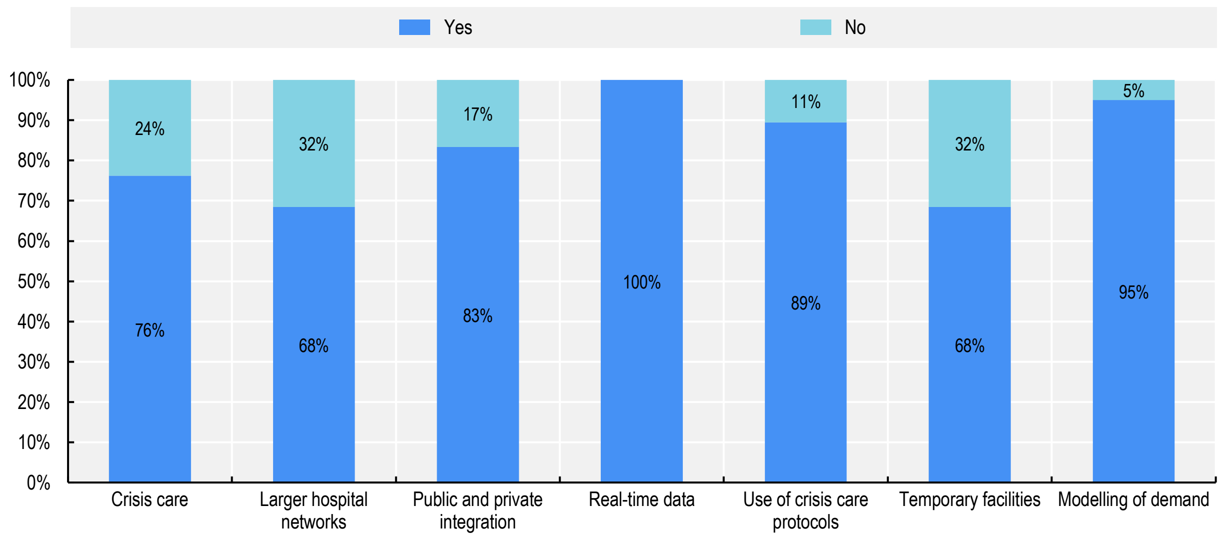
Assessing the feasibility of implementing a critical care surge is required once an epidemic's progression is modelled and the required critical care capacity is established. Not all geographical areas of a country have the same resource base. Therefore, since resources such as ICU beds, staff and ventilators may vary within a country, the required surge response above the usual capacity will differ.

Previous crises, including previous epidemics, have shown that shortages of workforce, equipment and medicines limit the response. This was also demonstrated by the COVID-19 pandemic. Three-quarters of country respondents (76%) to the OECD Resilience of Health Systems Questionnaire 2022 reported experiencing a crisis-level critical care surge (Figure 5.8).

Most countries followed common approaches to increasing critical care capacity and co-ordinating critical care resources. Efforts were made to introduce real-time data for decision making (100%). Additional resources and space (68%) were introduced into systems and services reorganised, both in scale (68%) and in the mix of public and private facilities (83%). Protocols for decision making in these situations were also introduced (89%).

The OECD country responses mirror the guidelines produced for COVID-19 (WHO, 2020[39]): suspending all but the most urgent elective medical and surgical procedures; expediting credentialing processes; reclaiming and hiring back retired critical care staff; redeploying staff from other areas; providing simulations for non-ICU staff to prepare them for their roles; maintaining a safe working environment; using telemedicine to increase the number of overseeing providers; and restructuring teams to augment the ability of experienced staff to care for as many patients as possible. Systems-level changes suggested included: clarifying a chain of command; designating hospitals to receive patients with COVID-19; ensuring mechanisms to address shortages of supplies; and supporting healthcare providers to adjust their priority settings among critical care surges.

Figure 5.8. Examples of systems-level implementation for increasing surge capacity



Source: OECD Resilience of Health Systems Questionnaire 2022.

Extra resourcing helped to increase critical care capacity

Extra resources were provided for the critical care surge response from societal resources and stockpiles, thereby increasing the resilience of health systems to absorb the impact of the COVID-19 pandemic. These included all resource components for a critical care surge response: staff, supplies and space. Staff numbers were increased directly and indirectly. The workforce was increased directly through recruitment of recently retired staff and students, and deployment of reserves. It was increased indirectly by freeing up currently employed staff and redeploying them to aid the critical care surge response.

The majority of respondents to the OECD Resilience of Health Systems Questionnaire 2022 increased space (68%) through use of temporary facilities. Several countries co-ordinated stockpiles and extra resourcing of equipment and medicines in short supply at a regional or national level. Combined with the information about spare capacity, these resources could be dispatched to the areas of greatest need.

5.3.6. Delivery of effective and equitable care proved to be vital

The importance of objective ethical triage criteria has been highlighted (Sprung et al., 2010[40]). Several key challenges occur when a crisis critical care surge is required, and these need to be addressed rapidly as the surge develops. One issue is the potential for introducing crisis standards of care. This is a move from supplying each individual appropriate care to ensuring that the greatest number of lives are saved. Most countries reported in the OECD Resilience of Health Systems Questionnaire 2022 that crisis standards of care were introduced at some time during the COVID-19 pandemic

However, shocks can also involve – at least initially – some uncertainty about the nature of the shock and, therefore, the most appropriate response to it. This may manifest in concern about a lack of consistent clinical guidance (Kaplan et al., 2020[20]). Kerlin et al. (2021[41]) noted the disparate and variable nature of the strategies undertaken and a lack of consistency relative to the pandemic context. Few changes to triage protocols were implemented in anticipation during the first six months of 2020 (Kerlin et al., 2021[41]). A key issue with the COVID-19 critical surge was that outcomes worsened when critical care delivery was placed under strain but before it was overwhelmed. This suggests that continued monitoring of outcomes, as well as spare capacity, is important to delivering effective and equitable care.

Resource allocation must be ethically and legally justifiable, and non-discriminatory. Ensuring appropriate safeguards is important. Previous work has indicated that implementation of crisis standards of care should be embedded in a formal legal structure (Christian et al., 2014[12]). It has also been suggested that technologies – including pulse oximetry and telemedicine – should be used to improve efficiency of resource allocation. However, this approach may embed inequities that existed prior to a surge (Riviello et al., 2022[42]), so care should be taken to consider how these policies will balance effectiveness and equity in their implementation. Further, barriers to access for vulnerable groups should be addressed and systematic inclusion of the patient voice should be considered (Van de Voorde et al., 2020[43]).

As critical care surges divert resources from other compelling high-priority healthcare usage, crisis management cannot be conducted exclusively from a critical care perspective. It requires input from multiple stakeholders, including the public (Arabi et al., 2021[44]). There is also a need for a common understanding of the approach that will be taken (Rodriguez-Llanes et al., 2020[45]).

5.3.7. Feedback loops and complexity complicated the critical care surge

Other measures and policies in place reinforce or reduce the ability of a health system to undertake a critical care surge response. At the onset of the pandemic, growing numbers of infections resulted in the introduction of additional containment and mitigation measures (see the chapter on containment and mitigation). This resulted in reduced healthcare seeking by the population and thereby increased available resources to meet the critical care surge (see the chapter on care continuity). However, containment had a countervailing impact, diminishing resources to meet a critical care surge. Production and supply of medicines and PPE were affected by containment and mitigation efforts, such as physical distancing and the need for production workers to isolate, thereby interrupting supply chains (see the chapter on securing supply chains).

The surge in critical care demand occurred at the same time as infections increased. In turn, this increased demand for alternative uses of health resources (such as the use of dialysis machines for COVID-19 patients rather than routine kidney failure patients), and reduced supply of those very resources. Examples of other simultaneous demands included: increased demand for non-critical care of a growing number of COVID-19 patients; increased demand for the successful track and trace of COVID-19 transmission; and, later in the pandemic, increased demand to provide immunisation services. Ensuring that patients infected with the novel coronavirus did not transmit it to unaffected people also required staff and space to be organised to minimise cross-contamination. During the pandemic, infections and requirements to quarantine among healthcare staff reduced the available workforce (Pan et al., 2020[46]).

Containment and mitigation efforts, and infection control within critical care facilities, also had an impact on how the health system engaged carers and families. Family engagement is important, as it reduces anxiety both for patients who have been admitted and for their families (Dhala et al., 2020[23]). Reduced engagement may also increase the workload of staff and lead to greater anxiety (Hugelius, Harada and Marutani, 2021[47]). Some COVID-19 related studies have suggested an increase in family members' distrust of practitioners, potentially driven by a decrease in bedside relationships because of physical distancing and restrictions in attending hospital (Amass et al., 2022[48]).

Despite these challenges, controlling community spread of the virus in an unvaccinated population was a crucial component of preventing critical care facilities from becoming overwhelmed, especially after the onset of the pandemic. The interaction between the number of cases and the requirement for critical care capacity formed part of the "flatten the curve" strategy implemented in many countries, to avoid catastrophic failure of health systems (Rezoagli et al., 2021[3]). Ensuring that critical care capacity met projected demand entailed strategies for both supply and demand, involving the co-operation of everyone in society.

5.3.8. Co-ordination and an adaptive response had a positive impact

It has long been appreciated that successful management of a crisis – and the resultant critical care surge – requires implementation of pre-existing plans and adaptation to the threat as needed (Hick et al., 2014[10]). An optimal response to a novel and emerging threat requires adaptation to the situation as it develops (Therrien, Normandin and Denis, 2017[8]). As well as plans, appropriate models need to be in place for decision making. Previous pandemic preparedness research has suggested that management systems at multiple levels – including at regional, national and international levels – may be required to exercise control over resources (Sprung et al., 2010[40]).

This occurred during the COVID-19 critical care surge, when local and national systems needed to solve different issues. These systems needed to be maintained over time and through multiple waves of the pandemic. The sheer magnitude of critical care requirements often entailed changes in the systems surrounding care – for example, changes in the systems surrounding rapid assessment and triage, which was reversed when case numbers fell. The chronicity of the pandemic, while unfortunate, offered the opportunity for systems to be modified and improved.

Summaries of crisis surge strategies – including for the COVID-19 pandemic – highlight several important elements of an effective response (Rodriguez-Llanes et al., 2020[45]), which were confirmed in the country responses to the OECD Resilience of Health Systems Questionnaire 2022.

The first element of an effective response is co-ordination. This is extremely important in a dynamic situation. A surge response requires co-ordination of multiple actors at different levels and between jurisdictions. This spreads the load from an intense increase in resources, and helps systems move seamlessly between crisis critical care surges and ensuring capacity for these surges.

The second element for an effective response is anticipating key challenges to the system and implementing appropriate responses. This requires real-time data and reactive capacity (Dichter et al., 2014[33]), which is a key challenge for a resilient health system (Winkelmann et al., 2021[49]).The performance of the system requires relevant and timely information to be transmitted and used where most effective (see the chapter on digital foundations). In response to the pandemic, traditional organisational and jurisdictional boundaries were re-considered, including to allow information to be disseminated widely and to reduce administrative burdens on the movement of resources and patients (Rodriguez-Llanes et al., 2020[45]). This occurred in many OECD countries. For example, Switzerland pooled resources around newly formed networks.

A common systemic change in the pandemic response was co-ordination of critical care supply and demand at a regional or national level. Load-balancing is the transfer of patients from facilities with high occupancy or stress to facilities with low occupancy or stress (Box 5.1). Load-balancing requires several components to be successful: available physical and workforce resources, communication and co-ordination, and safe and available transport services. Load-balancing is aided by systemic changes, larger networks, integration of public and private facilities, and use of real-time data.

Box 5.1. Load-balancing and co-ordination

Load-balancing reduces the chances of failure in an institution. COVID-19 produced a demand for critical care services that was not uniform across regions or countries: this heterogeneity creates the potential for load-balancing to improve outcomes (Lacasa et al., 2020[50]).

During the COVID-19 pandemic, load-balancing was used to match the supply and demand of critical care services. This was undertaken regionally, nationally and even internationally (Winkelmann et al., 2022[51]). The use of all available critical care capacity was a common approach: over 80% of countries responding to the OECD Resilience of Health Systems Questionnaire 2022 had integrated private facilities into delivery of care.

Over 26 days, Australia rapidly developed a nationwide Critical Health Resources Information System. All public and private ICUs (both paediatric and adult) were instructed to enter data twice a day, and within three weeks 98% of ICUs were contributing data. Each ICU and transport agency (ambulance and paramedical transport) could review the data. When COVID-19 cases rose in June 2020 and a rapid and localised increase in demand was experienced, real-time data allowed rapid transfer of patients to less burdened ICUs, and standards of care were maintained (Pilcher et al., 2021[52]).

The Czech Republic operated a similar system: the newly implemented Control Centre for Intensive Care gave a daily update of available bed, ventilator and staff capacity, making it available to national and regional co-ordinators. This allowed the transfer of patients, alongside scaling up of resources at hospitals (Komenda et al., 2022[53]).

International load-balancing occurred, notably in the European Union (Winkelmann et al., 2022[51]). This brings additional complexities and further interoperability of information systems is consequently required (Sommer et al., 2022[54]).

A final element of successful crisis surge strategies is adaptability in financing and payment systems. They may generate incorrect incentives when a health system is faced with a critical care surge. For example, activity-based funding may encourage facilities to keep elective activity continuing when inappropriate. The reduction in occupancy seen in 2020 demonstrates this concern (Figure 5.4). In the context of the pandemic, countries acted to maintain budgets. For example, France instituted financial guarantees to maintain budgets despite the reduction in activity. Other countries increased fees, introduced new payments, or based payments on previous years. For example, Germany introduced payments for empty beds and compensated for cancelled surgery to preserve intensive care capacity (Waitzberg et al., 2021[55]).

Multiple critical care surges require responses to be scaled up and down

A common feature of planning a critical care surge response is to reduce or delay other health services. This reduction in demand frees up resources for an increase in critical care requirements. In a pandemic scenario, it may also reduce exposure to the virus for those entering healthcare facilities. These reductions both relieve the strain on critical care resources and allow resources to be repurposed for critical care (Abir et al., 2020[1]).

A strategy used frequently during the COVID-19 pandemic was cancellation of elective surgery (see the chapter on waiting times) (Kerlin et al., 2021[41]). A reduction in hospital services needs to be managed, however, to ensure that essential care continues to be delivered (see chapters on care continuity and waiting times).

As more resources are drawn towards provision of critical care, there is potential for delayed and deferred care to become more acute and the burden of delay more serious. A corresponding reduction in preventive, primary and secondary care can cause increased morbidity and mortality. If care is interrupted, the burden on society is increased. Balancing these issues over time is essential. For example, diverting PPE to implement a critical care surge response resulted in the inability of other services to continue during the COVID-19 pandemic, even with available staff and space. Conversely, if services continued without this equipment, the risk of infection increased (Winkelmann et al., 2021[49]).

Over time, systems became more adaptive in response to the COVID-19 pandemic. Greater confidence in understanding the demands meant that countries could more finely tune their critical care capacity requirements for COVID-19, and more flexible approaches could be used (Winkelmann et al., 2022[51]). This was very important because it lowered the opportunity cost. Achieving this adaptability is critically dependent on having both information and the means to use the information to alter treatment priorities.

5.3.9. Flexibility remains important as critical care requirements change over time

The experience of the COVID-19 pandemic demonstrates the requirement for flexibility over time in provision of medical services. As the pandemic continues to evolve, so too do the critical care demands. One source of change in critical care demand and supply is the knowledge gained during the management of a novel disease. Changes based on such learning resulted in improved survival for those admitted to ICU or critical care. They also altered treatment both within ICUs – with less invasive ventilation and renal replacement therapy (Doidge et al., 2021[17]) – and outside ICUs. This altered the mix and volume of services provided during the pandemic (Box 5.2).

There were also changes in the contagion. With the Delta variant, prior to vaccination, an increase in the level of contagiousness saw increased societal demand for critical care services. Following uptake in vaccination, the demand for ICU beds and hospital beds altered relative to requirements for other services, such as primary health care and other out-of-hospital services.

Box 5.2. Changing COVID-19 resource requirements over time

Use and substitution of intensive and critical care has changed over the course of the COVID-19 pandemic. Early reports confirmed that a relatively large proportion of those with COVID-19 required admission to hospital and critical care support, and both invasive and non-invasive ventilation support were used. Over time, however, there was a movement towards greater relative use of non-invasive ventilation and non-ICU hospitalisation, as well as use of virtual hospitals and telehealth.

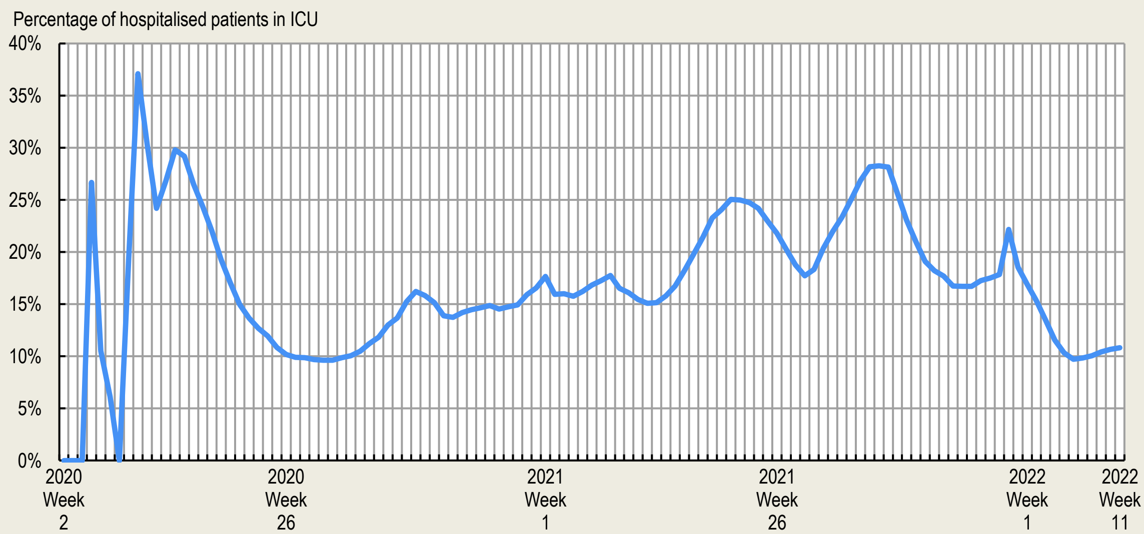
Invasive ventilation involves intubation of the trachea and use of a ventilator to provide oxygen under pressure to the patient. It is resource intensive, is usually provided in an intensive care or high-dependency situation, requires intubation (a technical and demanding skill that can involve sedation), and is associated with complications (Popat and Jones, 2012[56]). Non-invasive ventilation is provision of respiratory support without intubation. It can be provided in a wider variety of settings (such as on wards or outside hospitals). The most common type of non-invasive ventilation is provision of positive-pressure ventilation through a mask or other device.

Greater proportions of patients with COVID-19 in ICUs received invasive ventilation in the first months of the pandemic. In the United Kingdom between February and March 2020, 75% received invasive ventilation on the first day and 85% during the course of their stay. A few months later, invasive ventilation had decreased to 43% on the first day of ICU care (Doidge et al., 2021[17]). Similarly, the proportion of those requiring invasive ventilation compared to non-invasive ventilation fell in an analysis of German health insurance administrative data. Of all those receiving ventilation, 75% received invasive ventilation between February and May 2020, compared to 37% between October 2020 and February 2021 (Karagiannidis et al., 2022[57]).

As with other areas of medical service delivery, telemedicine was widely used both within hospitals and between hospitals and the community (see chapters on care continuity and mental health), including use of virtual hospitals and to expedite discharges. This may increase effective hospital capacity. For example, patients in France were discharged and continued on oxygen therapy monitoring at home using a web-based system (Dinh et al., 2021[58]). Telemonitoring and use of non-invasive ventilation was also demonstrated to be safe and feasible (Adly, Adly and Adly, 2021[59]).

The relative portion of hospitalised patients with COVID-19 requiring ICU admission was initially approximately 30% of admitted patients (Figure 5.9). The rate fell before slowly increasing over time and decreasing again in the last quarter of 2021. These fluctuations were associated with more widespread vaccination and the Omicron variant.

Figure 5.9. Proportion of hospitalised patients in intensive care units (selected European OECD countries)



Note: Includes Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungry, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain and Sweden.
Source: ECDC (n.d.[28]), "Data on hospital and ICU admission rates and current occupancy for COVID-19", https://www.ecdc.europa.eu/en/publications-data/download-data-hospital-and-icu-admission-rates-and-current-occupancy-covid-19.

5.4. COVID-19 upended the status quo and challenges remain for critical care capacity

COVID-19 – a new worldwide infectious disease requiring critical care treatment – changed the status quo. Without completely effective immunisation or other very effective preventive or early treatment care, it is likely additional critical care capacity or surge capacity will still be required for several years. There is the potential for rapid increases in demand for critical care associated with a spike in infections accompanying new variants, as occurred with the Delta variant.

Beyond these surges, the burden of COVID-19 and the response to it will add to existing demand and resource requirements in hospital and critical care. This demand results from admissions due to SARS-CoV-2 infections, both the acute disease and its long-term complications. Additional critical care capacity may be required to catch up on the delayed and deferred treatment for non-COVID-19 reasons, such as hip replacements, that occurred during 2020-2021. Beyond an increase in the number of admissions, the resources required for each admission may increase, associated with increased patient acuity.

Work has been done to model the return of delayed services. For example, McCabe et al. (2020[60]) concluded that unless COVID-19 hospitalisations reduce to a very low level, enhancing critical care capacity may still be required in the United Kingdom.

Additional capacity will come at an opportunity cost, which needs to be minimised. This will require regular collection of data and updating of modelling – both of SARS-CoV-2 and of the resources required to treat it. These resources may not simply be additional ICU capacity: they will need to match the requirements of waxing and waning SARS-CoV-2 infections. The requirement may not necessarily be for a permanent increase in ICU capacity; rather, a focus may be needed on building additional surge capacity that can be escalated and de-escalated as required. The worst-case scenario would be the sudden appearance of a new variant for which vaccine immunity was low. In this case, a rapid increase in critical care capacity would be required – in space, staff, supplies and management through pre-existing systems.

While some of these stresses are unique to infectious diseases, similar relationships between factors also occur with other shocks to health systems. For example, disasters increase critical care requirements while reducing available resources. Large-scale critical care surges often occur in scenarios of reduced resources. The remaining resources become overstretched and potentially collapse. COVID-19 pandemic-related disruptions did not stop other shocks affecting health systems. In some instances, shocks (such as disasters) may result in separate requirements for critical care surge responses. In other instances, these shocks (such as cyber attacks) may not require a critical care surge response, but may nonetheless test the resilience of health systems.

5.4.1. OECD countries are building on the advantages found in modelling

Several improvements were suggested by countries to improve modelling in the future (Table 5.3). These included: increasing capacity for modelling; ensuring availability of data; and including more strategies and outcomes. Some improvements were specifically suggested for modelling the COVID-19 pandemic, including modelling the implications of vaccination. Most countries anticipated using critical care modelling in the future, either specifically for COVID-19 or for other critical care surge events.

Table 5.3. Suggestions and anticipated benefits for future critical care modelling

Capacity and general improvements	COVID-19-specific improvements	Decision making and expected benefits
• Hospital capacity and utilisation information in real-time • Common data definitions • More detailed and granular forecasts at regional and hospital levels • Inclusion of more outcomes of interest – for example, hospital bed utilisation and expected staff furloughing • Inclusion of a greater number of strategies in the modelling • Recognition of the need for modelling capacity, including identifying and developing human capacity within the public system, and tools • Development of models for simulating integrated care within and outside hospital	• Inclusion of information about variants of SARS-CoV-2 • Inclusion of new epidemiological information (e.g. sewage testing) • Inclusion of more information about vaccination (and its impacts) • Forecasting of both COVID-19 and non-COVID-19 requirements	• Linkage to hospital bed management in emergency situations • Increased co-ordination between ICUs and hospital units • Increased data availability to central health planners • Undertaking more detailed planning and contingency exercises • Planning of the number and location of ICU facilities

Source: OECD Resilience of Health Systems Questionnaire 2022.

5.4.2. OECD countries are implementing multiple critical care adaptations

Countries highlighted several changes that are being introduced or considered at a systems level to improve critical care. These include strategies for increasing both ongoing critical care capacity (for example, increasing the critical care workforce) and critical care surge capacity (for example, infrastructure that could be converted for dual use) (Table 5.4). Many countries also suggested that monitoring in real-time would continue to be used to assess spare capacity.

Table 5.4. Anticipated systems-level changes to improve implementation of critical care surge responses

Physical (space)	Workforce (staff)	Physical (supplies)	Systems
• Conversion of existing infrastructure and adaptation to future requirements for surge capacity • Use of telehealth • Increased critical care capacity • Use of non-invasive ventilation and ventilation on wards	• Training healthcare workers with critical care skills • Training pyramid teams (teams in ICUs led by a critical care nurse) • Increased critical care capacity	• National stockpiles for equipment and medicine needs across critical care • National procurement and distribution systems for PPE • Increased critical care capacity	• Improved, comprehensive and timely data flows at local, regional and national levels • Introduction of objective criteria for prioritisation • Additional services fees for accepting patients with COVID-19 who require continued treatment • Systems for monitoring and facilitating transfer of patients • Increased mechanisms for co-ordination regionally and nationally, and between public and private sectors

Source: OECD Resilience of Health Systems Questionnaire 2022.

Successful strategies should be evaluated to ensure transferability

Although many strategies were used to increase critical care surge capacity during the COVID-19 pandemic, evidence about the absolute and relative effectiveness of the strategies is limited (Winkelmann et al., 2021[49]). Successful implementation of a capacity increase, rather than its relative effectiveness, was the outcome discussed in most articles and references reviewed. In some cases the successful strategies suggested were opposites; for example, maintaining teams to leverage pre-existing trust (Yager, Whalen and Cummings, 2020[61]) versus spreading expertise (Dhala et al., 2020[23]). This suggests that solutions are likely to be both context specific and dependent on local resources and structures. Accordingly, care should be taken when translating evidence generated during the pandemic from one context to another.

5.4.3. Improving resilience involves more than critical care adaptations

Improving health systems resilience requires both “resilience by intervention” and “resilience by design” elements (see the chapter on resilience in other sectors). Resilience by design is when the system is proactively designed and resourced before a disruption, while resilience by intervention is when extra resources are provided to the health system at the time of the disruption. The experience of the COVID-19 pandemic demonstrated both resilience by design and resilience by intervention features were required.

Resilience by design features include information, modelling and co-ordination, as well as sufficient space, supplies and staff. These features should be evaluated, and those that were effective should be retained and extended.

Space

Availability of space, in the form of critical care beds, remains essential for a critical care surge response. As discussed earlier, the key issue is to expand either critical care capacity, critical care surge capacity or both. Countries will differ in their requirements – ideally steps to address these should be based on modelling and evidence. Financing should not produce incentives to over- or undercapitalise on investment in space. Indicators of the available capacity would aid estimation of resilience. Current metrics focus on the critical care capacity rather than the critical care surge capacity, but both need to be estimated.

Supplies

Supplies of essential goods were a crucial limitation in the early months of the COVID-19 pandemic. While improved supply chains will increase certainty, stockpiling and capacity guarantees are likely to be required at the beginning of another sufficiently large crisis. These would be more efficiently organised at a regional, national or international level so that they can be released to areas of need (see the chapter on securing supply chains).

Staff

Availability of critical care staff – especially nursing staff – was noted as a key limitation in the COVID-19 critical care surge response. While ventilators, space and supplies were also limitations, they were progressively overshadowed by the limitations of insufficient staff availability. Shortages of staff were compounded by the quarantining of staff after exposure to the virus.

This key shortfall is one that resilience by design would seek to overcome. For changes to be sustainable, they need to be financially feasible and maintained, entailing additional investment in staff numbers and in the skills of the health workforce. This may require consideration to be given to different models of financing and training to improve staff availability and capability, alongside increased support during and after surges to ensure staff safety and well-being. A key point in the review undertaken in Belgium was the importance of financing the co-ordinator of plans to implement surge capacity (Van de Voorde et al., 2020[43]).

Systems

Local overburdening of health services because of increasing numbers of patients requiring critical care was evident during the pandemic. An important development to minimise this effect materialising again would be the use of valid strain indicators to minimise the need for crisis triage and to allow earlier transfer of patients (Dichter et al., 2021[62]). These resilience by design features require provision of timely, valid information and associated modelling to relevant decision makers.

In the future, it is likely that requirements for surge capacity will be continued when load-balancing over the existing capacity is insufficient to deliver care. The balance between permanent increases in intensive care capacity versus surge care capacity will require careful planning.

For a surge response as large as that required for the COVID-19 pandemic, reorganisation and transformation within the health system (resilience by design) was insufficient to provide the required resources for the critical care surge. Additional resourcing, space, staff and supplies were injected into health systems in response to the disruption. This will always be the case with a sufficiently large disruption.

People changed their behaviour to reduce the peak demand for critical care services. The most obvious manifestation of this change was the widespread restrictions on movement, reduced social contact and physical distancing. A whole-of-society commitment and whole-of-government co-ordination needed to exist for this change to materialise. In many countries, previously decentralised functions were centralised to ensure efficiency and equity.

The COVID-19 pandemic demonstrated the importance of anticipating the next shortage or crisis point, and of preparing early for shocks. This requires clear communication and clear authority. It also necessitates a careful balancing of competing demands for healthcare resources, an understanding of the opportunity costs of choices, and careful monitoring for unanticipated outcomes. Appropriate information flows, having the resources to deploy and the mechanisms to deploy them are also critical to resilience by intervention.

In a worst-case scenario for COVID-19 – a new more deadly variant – extra planned resourcing will need to be injected into the health system, combined with a whole-of-government approach to limit demand. The lessons of previous years should be used to prepare for this potential risk. The changes countries are making to improve information, increase staff and space, make more effective use of resources and introduce protocols will aid decision making. These lessons will also be useful for large-scale responses to all critical care surges.

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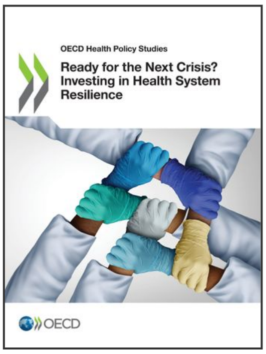

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