



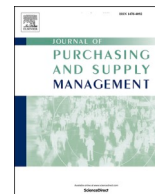
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# Improving resilience of the healthcare supply chain in a pandemic: Evidence from Europe during the COVID-19 crisis

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## ABSTRACT

The severe scarcity of critical medical supplies caused by the COVID-19 pandemic led to considerable procurement challenges in the healthcare supply chain (HCSC). As ensuring the availability of such supplies during disruptions is critical, the debate on how to increase supply chain resilience in healthcare has gained new momentum. We present empirical evidence from a multi-tier case study spanning nine European medical supplies manufacturers and hospital groups. Based on the resource dependence theory, we investigated procurement-related strategies to improve medical supplies availability. We conducted semi-structured interviews with 39 procurement and supply chain management experts and derived seven propositions on buffering and bridging approaches for managing evolving resource dependencies and thereby strengthening supply chain resilience in a pandemic. Overall, we confirm the resource dependence theory's applicability for explaining companies' mitigation measures in a pandemic disruption. We find that bridging measures within the healthcare supply base, such as offering procurement support for suppliers or leveraging long-term buyer-supplier relationships, are more effective for securing medical supplies than buffering measures. Complementing bridging with buffering, such as extended upstream procurement or resource sharing among hospitals, can lead to superior risk mitigation as capacities of the present supplier base may not suffice. Furthermore, we extend the resource dependence theory by showing that the severity of disruptions caused by a pandemic triggers new forms of buffering external to the HCSC. Both traditional and new buffering measures establish novel flows of medical supplies in the HCSC that can enable higher supply security in a pandemic.

## 1. Introduction

Growing cost pressure, rising demand, and increasing competition have driven efficiency awareness and increased interdependencies in healthcare supply chains (HCSCs), leading to higher complexity (Abdulsalam et al., 2015; Chakraborty, 2019; Hussain et al., 2018). When a supply network's complexity increases, risk increases, and the supply chain (SC) becomes more vulnerable (Blackhurst et al., 2018; Wagner and Bode, 2006). Those vulnerabilities became apparent when the COVID-19 pandemic posed devastating challenges for HCSCs worldwide. Severe scarcity of critical medical supplies such as personal protective equipment (PPE), ventilators, or drugs for COVID-19 treatment has affected hospitals globally (Chamola et al., 2020; Moss et al., 2021). Healthcare professionals described themselves as "firefighters putting out fire without water" (Cohen and van der Rodgers, 2020). Medical supplies manufacturers had to cope with supply shortages

themselves for materials and components required for production (Chowdhury et al., 2021; Govindan et al., 2020). Export bans, border crossing restrictions, and infection prevention measures impeding production capacities were prominent root causes for these challenges (Bhaskar et al., 2020; Cohen and van der Rodgers, 2020; Govindan et al., 2020). Ensuring sufficient COVID-19-related medical supplies or required production materials and components has become a core challenge and brought hospitals' and medical supplies manufacturers' procurement capabilities into focus (Chowdhury et al., 2021; Cohen and van der Rodgers, 2020; Vecchi et al., 2020).

With the COVID-19 pandemic revealing the vulnerability of global HCSCs, the debate on how to increase supply chain resilience (SCRES) gained new momentum (Craighead et al., 2020; van Hoek, 2020). SCRES is defined as an SC's capacity to return to its original or a better state after absorbing an SC disruption (Tukamuhabwa et al., 2015). SC disruptions are unplanned and unanticipated events that disturb the

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normal flow of goods (Bode and Wagner, 2015), such as the supply shortages caused by lockdowns and border crossing restrictions during the COVID-19 pandemic. These disruptions' negative consequences were exacerbated by the multifold demand increase for PPE and other medical equipment (Cabral and Xu, 2020; Cohen and van der Rodgers, 2020). In the HCSC, the primary SCRES objective is to "save lives providing the best quality of care" (Senna et al., 2020). Supply shortages can endanger that goal as failure to deliver healthcare services can put human lives at stake (Mandal, 2017).

High dependence on global SCs and overstrained suppliers and manufacturers were a root cause for the lack of medical supplies in the COVID-19 crisis (Cohen and van der Rodgers, 2020; Finkinstadt and Handfield, 2021; Friday et al., 2021; Vecchi et al., 2020). Finkinstadt and Handfield (2021) suggested that lifting such dependencies could enable a more robust HCSC in the face of crises. In this context, Craighead et al. (2020) identified the resource dependence theory (RDT) as a suitable theoretical lens to explore evolving dependencies in a pandemic. RDT offers a framework to examine firms' external dependencies on essential resources during high uncertainty events (Pfeffer, 1989), which is appropriate for investigating dependence shifts and strategies to improve supply security in the unpredictable COVID-19 environment (Craighead et al., 2020).

Medical supplies manufacturers' and hospitals' purchasing decisions and supplier management have considerable consequences for the HCSC's resilience (Chen et al., 2013; Finkinstadt and Handfield, 2021; Meehan et al., 2017; Vecchi et al., 2020). Resilience-related studies and investigations on strategies to ensure medical supply security in the context of a pandemic remain limited in HCSC literature (Friday et al., 2021; Senna et al., 2020; van Hoek, 2020). Scholars conducted literature reviews to derive theoretical suggestions for more effective risk management (Friday et al., 2021), provided anecdotal evidence on how single HCSC organizations have dealt with the COVID-19 pandemic (Francis, 2020; Moss et al., 2021), developed viewpoint articles on managing COVID-19-related disruptions (Bhaskar et al., 2020; Vecchi et al., 2020), or provided studies on specific resilience levers (Finkinstadt and Handfield, 2021; Govindan et al., 2020; Mehrotra et al., 2020). Furthermore, a systematic literature review of COVID-19-related SC studies found that most articles only investigate a single strategy, whereas a more comprehensive view on different approaches is called for (Chowdhury et al., 2021). However, an empirical investigation that explores the various HCSC tiers' measures to improve supply availability or manage the evolving dependencies in the COVID-19 pandemic is currently missing. Moreover, while scholars acknowledged that resource dependencies were affected during the COVID-19 pandemic (Craighead et al., 2020), it has not been investigated which dependencies in the HCSC increased and required critical mitigation measures. To fill the discussed research gap, we formulated three RQs:

**RQ1.** How do resource dependencies for medical supplies manufacturers and hospitals increase during a pandemic?

**RQ2a.** How can medical supplies manufacturers manage resource dependencies in a pandemic to improve supply availability?

**RQ2b.** How can hospitals manage resource dependencies in a pandemic to improve medical supplies availability?

The disruptions caused by the COVID-19 crisis represent a novelty as they differ considerably from other SC disruptions due to their scale, duration, and high levels of uncertainty (Ivanov and Dolgui, 2020). In such an explorative setting, the case study method is a reliable investigation approach (Yin, 2014). To address our RQs, we, therefore, present evidence from a multi-tier HCSC case study. We interviewed 39 experts across nine companies (six medical supplies manufacturers, three hospital groups) that had to cope with the COVID-19 pandemic. Buyer-supplier relationships (BSRs) regarding COVID-19-related medical supplies existed between every manufacturer and every hospital group within the sample. We ultimately derived seven propositions on

how resource dependencies can be managed to improve SCRES in the HCSC during a pandemic.

This paper's remainder is organized as follows: In Section 2, we provide the theoretical background on SCRES, RDT, the HCSC, and derive our research model. Section 3 explains the multi-tier case study methodology employed in this research project. In Section 4, we present the individual case results before the discussion and formulation of propositions in Section 5. Section 6 concludes our study with theoretical and practical implications as well as limitations and opportunities for future research.

## 2. Theoretical background

### 2.1. Supply chain resilience

In a healthcare context, an SC disruption can be defined as "an unexpected event that can hinder the delivery of healthcare services to patients" (Mandal, 2017). Considering the direct implication for human lives and the fact that uncertainty is inherently high, mitigation, preparation, and management of such disruptions are especially critical in the HCSC compared to other industries (Zepeda et al., 2016).

Due to the higher severity and frequency of SC disruptions in the last decades, SCRES has seen an increasing interest among SCM scholars while several literature reviews addressed the concept's definition, main antecedents, and characteristics (Gligor et al., 2019b; Hohenstein et al., 2015; Hosseini et al., 2019; Tukamuhabwa et al., 2015). Hohenstein et al. (2015) conducted a comprehensive literature review and identified three main objectives for SCRES: financial performance, market share, and customer service level. In a healthcare context, the service level dimension and therefore the ability to consistently deliver patient treatment can be considered the most prominent one (Abdulsalam et al., 2015). Accordingly, Mandal (2017) defines SCRES for a HCSC as "the capability of healthcare SC entities to work in a synchronized manner so as to provide uninterrupted treatments and care to patients in the event of a disruption." This definition reiterates the objective of mitigating service interruptions at all costs. It further emphasizes coordination, mirroring the fact that a HCSC is a system with complex interdependencies (Meehan et al., 2017). Compared to other risks, the COVID-19 pandemic has shown unique characteristics such as unprecedented demand surges and supply shortages, increased volatility, and an extraordinarily long duration (Govindan et al., 2020; Ivanov and Dolgui, 2020). The crisis revealed severe vulnerabilities of the HCSC and has made improving SCRES a key concern among researchers and practitioners (Friday et al., 2021; van Hoek, 2020).

Looking at the factors that constitute SCRES, Tukamuhabwa et al. (2015) and Hohenstein et al. (2015) determine that *flexibility*, *redundancy*, *collaboration*, and *visibility* are the most prominent antecedents. Senna et al. (2020) and Jafarnejad et al. (2019) confirmed these SCRES antecedents' importance in the healthcare context. Various procurement practices can enable these critical SCRES antecedents in a HCSC. Standardization of products and procedures can increase HCSC actor's sourcing flexibility and hedge against supplier failures (Abdulsalam et al., 2015; Friday et al., 2021). Hospitals can build redundancy by onboarding multiple suppliers to hedge against delivery shortfalls (Aldrighetti et al., 2019). Collaboration, for instance, via increased information sharing and co-creation between hospitals and their suppliers, can further help to mitigate risks (Chakraborty, 2019; Zepeda et al., 2016). In terms of visibility, implementing vendor-managed inventory systems can improve a HCSC's product flow transparency (Bhakoo et al., 2012).

### 2.2. Resource dependence theory

RDT provides a well-established theoretical framework to investigate organizations' responses to SC disruptions (Bode et al., 2011; Pfeffer and Salancik, 1978). The theory postulates that no organization is

self-sufficient and actors form inter-organizational relations to access critical resources. These relations create dependence on external actors, cause power imbalance, and eventually introduce a potential source of adversity for the firm (Touboulie et al., 2014). SC stakeholders aim to minimize their dependence on other actors or maximize other organizations' dependence on them to reduce uncertainty (Nandi et al., 2020; Pfeffer, 1989). Various research studies have investigated such efforts' potential to mitigate risk and increase SCRES. Nandi et al. (2020) and Pfeffer (1989) suggested that effectively managing external dependencies determines an organization's success and is considered a greater lever for improving SCRES than internal capabilities. Bode et al. (2011) and Manhart et al. (2020) showed that better control of external resources and decreased dependence on exchange partners reduces uncertainty as well as vulnerability and enables a company's risk mitigation capability.

RDT is highly suitable to investigate HCSC resilience in a pandemic. First, RDT posits that an organization's ability to respond to extreme shifts in supply and demand is constrained by its dependencies (Pfeffer and Salancik, 1978). During the COVID-19 pandemic, unprecedented changes in demand and supply of medical supplies have been witnessed (Chamola et al., 2020; Govindan et al., 2020). Subsequently, severe alterations in HCSCs' power dynamics and interdependencies can be expected, making RDT an interesting theoretical lens to investigate how actors managed these developments (Craighead et al., 2020). Second, RDT inherently views organizations as embedded in a web of exchange relationships and uncertainty (Pfeffer and Salancik, 1978). This perspective is appropriate to study the HCSC, where interdependencies among its various stakeholders are particularly strong (Hussain et al., 2018; Meehan et al., 2017). Third, RDT applies a broad definition of resources (e.g., materials, human resources, cash, political support) and potential sources for these resources (e.g., suppliers, customers, competitors, governmental bodies), which caters to the diverse, multi-stakeholder healthcare system and its variety of resource flows (Craighead et al., 2020; Doyle et al., 2016; Schneller et al., 2006).

RDT is also suitable because of the two forms of dependencies it postulates. In a *symbiotic* relationship, one actor's output is the input for another (Pfeffer and Salancik, 1978). For instance, a medical equipment manufacturer might depend on critical raw materials from one of its suppliers. In a *competitive* relationship, several organizations compete for the same resources in a market (Pfeffer, 1989). In the HCSC, this can be hospitals or other actors competing for medical supplies. Dependencies between actors can be symbiotic and competitive at the same time, for example when two organizations with a BSR for one resource (symbiotic) are competing for another resource at the same time (competitive) (Pfeffer and Salancik, 2003; Xia et al., 2014). Various circumstances influence the strength and effect of both dependence types. For instance, van Raak et al. (2002) conducted a study in the healthcare industry and found that care providers' institutional environment, particularly regulatory efforts by public authorities, considerably shape symbiotic and competitive dependencies in the sector. Moreover, the strength of symbiotic and competitive dependence can predict organizations' strategic behavior as Xia et al. (2014) found in a study regarding the investment activities of emerging market firms. They showed that the higher a symbiotic dependence, the more likely a firm is to seek collaborative alliances with its exchange partners and both forms of dependence lead to higher diversification efforts.

Active management of dependencies is crucial to limit adversities and mitigate the negative consequences of SC disruptions (Bode et al., 2011; Pfeffer, 1989). Generally, two types of RDT strategies can be differentiated: *Buffering* and *bridging* (Bode et al., 2011). Buffering strategies aim to reduce an organization's exposure to an existing exchange partner and thereby mitigate potential disturbances that a dependency on this partner might confer (Bode et al., 2011). For instance, Mishra et al. (2016) explored the increase of safety stocks and onboarding additional suppliers as effective buffering strategies to reduce the dependence on individual exchange partners external to

existing relationships. In contrast, bridging safeguards a firm from SC disruption consequences by establishing stronger linkages with an external exchange partner and expanding a firm's influence on them (Mishra et al., 2016; Pfeffer and Salancik, 1978). Thereby, bridging – in contrast to buffering being external to a relationship – aims to reduce uncertainty through boundary spanning activities such as information sharing, forming of alliances, or other strategies improving an actor's power position in an exchange relationship (Mishra et al., 2016; Pfeffer and Salancik, 1978). For instance, Zacharia et al. (2019) investigated how cooperating with actors competing for the same resources can increase overall resource availability and thereby reduce uncertainty and net competitive dependencies.

Both approaches can be simultaneously applied to manage dependencies in an individual relationship (Al-Balushi and Durugbo, 2020). Moreover, Manhart et al. (2020) showed that firms leveraging both buffering and bridging strategies to manage their resource dependencies achieve higher firm performance. We reviewed existing SCM and HCSC literature and identified various SCRES measures that can be categorized as buffering or bridging strategies (see Table 1).

### 2.3. Research model

Fig. 1 displays the study's research model, depicts the HCSC actors investigated, and features the RQs' positioning. The HCSC under examination includes material and component suppliers, medical supplies manufacturers, third-party distributors, and hospitals (Bhakoo and Choi, 2013; Dixit et al., 2019; Finkenstadt and Handfield, 2021). Manufacturers can broadly be categorized into medical equipment (MedTech) producers, such as technical instruments or PPE, and drug manufacturers (Dixit et al., 2019). Due to their products' differing nature, these two manufacturer categories rely on dissimilar SCs for raw materials and components (Bhakoo et al., 2012; Jafarnejad et al., 2019). Manufacturers either directly deliver medical supplies to individual hospitals or

**Table 1**  
RDT-SCRES measures discussed in SCM and HCSC literature.

RDT strategy	SCRES measure	Sources
Buffering	Multiple sourcing	Costantino and Pellegrino (2010), Aldrighetti et al. (2019)
	Safety stocks	Mishra et al. (2016), Park et al. (2016), Bhakoo et al. (2012)
	Network adaptability	Hohenstein et al. (2015), van Hoek (2020), Jafarnejad et al. (2019)
	Product modularity/ interchangeability	Mishra et al. (2016), Pettit et al. (2010), Bhaskar et al. (2020)
	Alternate markets/distribution channels	Pettit et al. (2010), Krichanchai and MacCarthy (2017), Abdulsalam et al. (2015)
Bridging	Vertical integration	Al-Balushi and Durugbo (2020), Zepeda et al. (2016), Francis (2020)
	Information and resource sharing	Bode et al. (2011), Mishra et al. (2016), Zepeda et al. (2016), Francis (2020)
	Joint planning & decision making	Hohenstein et al. (2015), Mandal (2017), Chakraborty (2019), Friday et al. (2021)
	Long-term/strategic supplier partnerships	Mishra et al. (2016), Bhakoo et al. (2012), Doyle et al. (2016)
	Purchasing alliances	Burns and Lee (2008), Hu et al. (2012)
	Coopetition	Zacharia et al. (2019), Gligor et al. (2019a)
	Supply network visibility	Blackhurst et al. (2018), Touboulie et al. (2014), Mandal (2017)
Visibility on supplier capacity, inventory, or customer demand	Dixit et al. (2019), Finkenstadt and Handfield (2021)	
Market proximity	van Hoek (2020), Zepeda et al. (2016), Vecchi et al. (2020)	

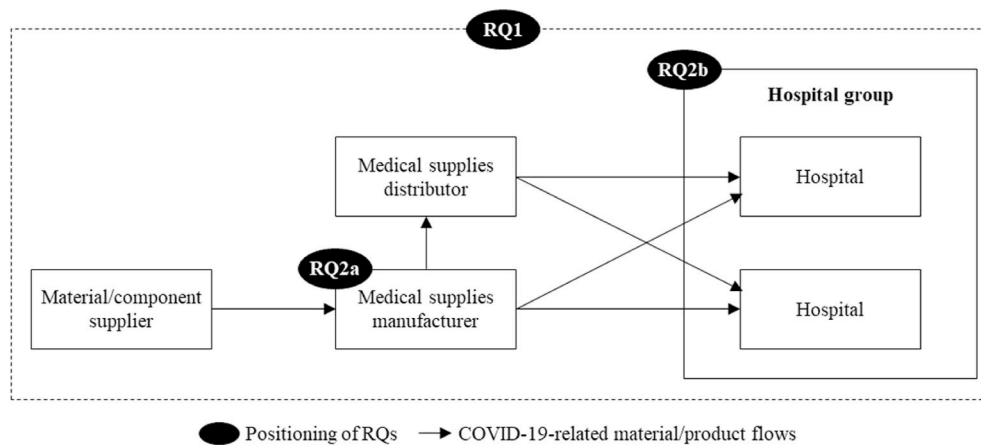


Fig. 1. The HCSC for medical supplies and hospital treatment of COVID-19 patients.

sell to intermediary distributors (Bhakoo and Choi, 2013; Krichanchai and MacCarthy, 2017). Hospitals can be broadly categorized into two groups: publicly owned and privately owned (Krichanchai and MacCarthy, 2017). Moreover, they can either be organized as single hospitals or within a group of two or more consolidated hospitals. The latter format has gained considerable prominence in the HCSC (Zepeda et al., 2016).

It is essential to understand the peculiarities of procurement in healthcare to investigate the HCSC's supply availability challenges in a health crisis (Abdulsalam et al., 2015; Chakraborty, 2019). First, procurement in the HCSC can be characterized by a comparatively high level of complexity. Healthcare procurement has to manage a high diversity in medical requirements and products and coordinate purchasing of goods with the simultaneous flows of patients (Abdulsalam et al., 2015; Hussain et al., 2018; Mandal, 2017). Second, HCSC procurement functions have to operate in an environment with strong institutional and regulatory influences (Bhakoo and Choi, 2013; Bhaskar et al., 2020). Third, supplier selection and buying decisions are often strongly based on medical professionals' individual preferences instead of evaluations by specialized procurement personnel, which demands increased coordination efforts (Abdulsalam et al., 2015; Chen et al., 2013). Fourth, many hospitals are organized in group purchasing organizations, significantly increasing interconnectedness among actors (Burns and Lee, 2008). Lastly, with the cost of medical supplies and materials representing up to 45 percent of a hospital's operating budget, procurement has a critical role in contributing to operational performance (Chen et al., 2013). Nevertheless, effective SCM practices have not been introduced in the healthcare sector to the same extent as in other industries and procurement in the HCSC is often considered immature (Chakraborty, 2019; Chen et al., 2013; Meehan et al., 2017). Significant potentials remain for improved orchestration, coordination, and alignment (Chakraborty, 2019; Schneller et al., 2006).

### 3. Methodology

#### 3.1. Research design

We employed an inductive multiple case study approach for several reasons. First, the case study methodology allows for the explorative investigation of real-world practices in their natural environment (Sigelkow, 2007). This is of particular benefit in nascent research fields (Yin, 2014), such as SCRES in pandemic-affected HCSCs. Second, case studies demonstrate great strength in uncovering interdependencies and dealing with complexities within a research field (Yin, 2014). This aspect makes them a predestined tool for investigating HCSCs, where medical services and product diversity are high and social and political pressure intervene economic goals to a great extent (Hussain et al.,

2018; Mandal, 2017). Third, this approach facilitates triangulating observations by allowing multiple data sources, thus strengthening the research findings' robustness and generalizability (Eisenhardt and Graebner, 2007). Throughout the study, we further ensured *construct validity*, *internal validity*, *external validity*, and *reliability* of our results by following Gibbert et al. (2008) and applying the measures listed in Table 2.

#### 3.2. Sampling

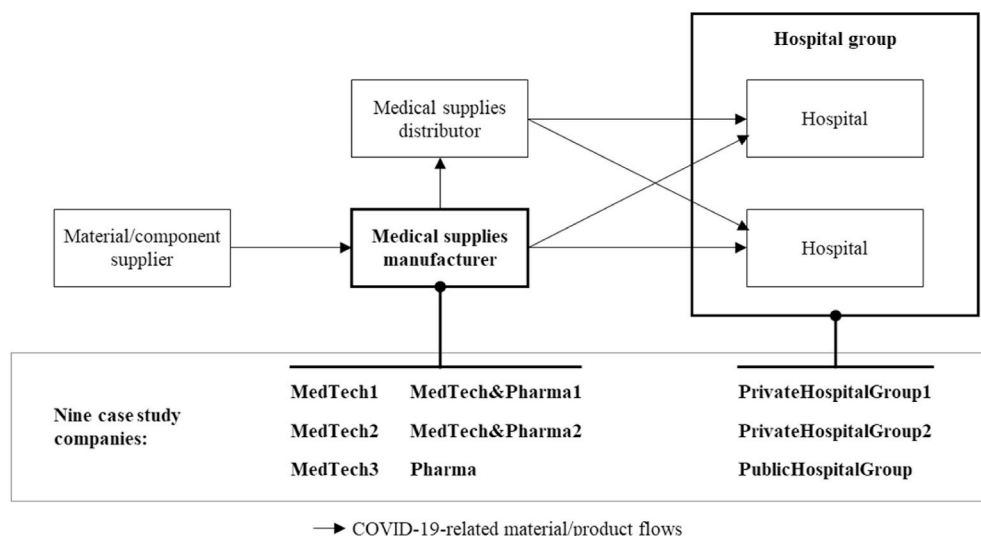
To enable generalization of our case study findings, we applied theoretical sampling by clearly defining boundaries for the population from which the case study companies are drawn (Eisenhardt, 1989). Within our sample, we differentiated between two tiers of a HCSC – manufacturers and hospital groups. By individually investigating the respective tiers, we highlighted the importance of medical equipment and pharmaceutical suppliers for the overall performance of the HCSC (Jafarnejad et al., 2019). Furthermore, the two-tier sample design enabled investigation of SCRES measures within and across tiers and in-depth exploration of BSRs. The hospital types were distinguished as publicly owned and privately owned hospitals, as they face differing preconditions in terms of procurement competencies or economic efficiency (Chakraborty, 2019; Krichanchai and MacCarthy, 2017). We deliberately refrained from including distributors due to their limited relevance to demand volumes and because overall medical supplies availability is less reliant on distributors fulfilling a pure allocation function (Bhakoo and Choi, 2013; Krichanchai and MacCarthy, 2017).

To increase generalizability and ensure comparability, we defined strict selection criteria for companies to be included in the sample (Eisenhardt, 1989; Yin, 2014). First, we solely selected companies and hospitals with a dedicated organizational unit and/or a considerable share of business through COVID-19-related products (e.g., PPE, ventilators, test kits, drugs) or treatments. Second, the majority of the case companies' operations had to be in Germany, Switzerland or Austria (GSA). This allowed for the comparison of organizations situated within a similar healthcare system and facing similar governmental interventions and spreading patterns of COVID-19. Third, the companies had to rely on a global supply network for COVID-19 related products and components to ensure comparability regarding supply challenges. Fourth, as our focus was on BSRs, case companies needed to engage in mutual business transactions concerning COVID-19-related products or services.

In case study investigations, it is more important to collect and analyze data until theoretical saturation is reached than to aim for a particular number of cases (Eisenhardt, 1989). Therefore, we added additional cases for both tiers until only marginal improvements of insights were achieved. We thereby ensured both exhaustive coverage of

**Table 2**  
Applied measures for reliability and validity of results.

	Research stage			
	Research design	Case selection	Data collection	Data analysis
<b>Construct validity</b> (relates to the correct design of research measures for the investigated concepts)	- Consultation of SCRES literature and thematical experts for interview protocol development - Interview protocol pre-tests with four practitioners	- N/A	- Triangulation through multiple sources (primary and secondary data) - Multiple informants within individual cases	- Development of chain of evidence
<b>Internal validity</b> (relates to building causal relationships between findings within a case study)	- N/A	- Documentation of sampling approach	- Analysis of potential alternative explanations	- Triangulation of data sources - Pattern matching via cross-tier screening
<b>External validity</b> (relates to creating an environment that enhances the generalizability of results)	- Inclusion of multiple cases - Theoretical sampling of cases	- Description of tiers and business context	- Interviewing experts with similar job profiles	- Analysis of differences between tiers - Iterative/replicative construct testing
<b>Reliability</b> (relates to ensuring study reproducibility by other researchers with the same results)	- Preparation of a case study protocol	- Selection based on predefined inclusion criteria	- Development of case study database - Semi-structured interview protocol design	- Usage of coding software - Independent coding by two authors per transcript and discussion of discrepancies



**Fig. 2.** Relations of investigated case study companies.

constructs and that our derived propositions were grounded in replicated evidence across cases (Corbin and Strauss, 1990; Eisenhardt, 1989). In summary, six manufacturers, divided into three from the MedTech sector, one from the pharmaceutical sector, and two operating in both sectors, as well as three hospital groups from both public and private sectors, participated in the study (see Fig. 2).

### 3.3. Data collection

Expert interviews served as primary information sources (Yin, 2014). The development of the underlying interview protocol (see Appendix) was guided by an extensive review of relevant SCRES literature and preliminary HCSC expert discussions. The final interview protocol featured a semi-structured design, which enabled us to intentionally modify its focus depending on the interviewed tier (Corbin and Strauss, 2015; Eisenhardt, 1989). We put a particular emphasis on triangulation. Triangulation can be described as using multiple data sources to achieve a comprehensive understanding of the phenomenon in question and is considered a major strength of case research (Yin, 2014). Firstly, we ensured triangulation by interviewing at least two experts per case (Eisenhardt and Graebner, 2007). Secondly, in addition to conducting interviews, we drew on multiple secondary data sources to triangulate the collected insights from the interview process and ensure high construct validity (Eisenhardt, 1989). We reviewed publicly available

information related to the case companies, including company reports, conference publications, and newspaper articles as well as secondary data concerning the HCSC more broadly such as announcements from public authorities or industry reports and magazines. Moreover, we were granted access to various internal documents by the case companies, including business reports, internal memos, strategy documents, demand and supply estimations, proposals from suppliers, and supplier evaluation frameworks.

Our final sample comprises 39 expert interviews, which were conducted between September 2020 and February 2021 (see Table 3). We carefully selected only experts with a particular focus on procurement or SCM, a high level of experience and with direct responsibility for COVID-19-related products and services. With respect to the ongoing pandemic, all interviews, which lasted between 45 and 120 min, were conducted via video conferencing or phone. We prevented investigator bias by ensuring each interview was conducted by at least two research team members (Corbin and Strauss, 2015). To capture all relevant information, interviews were recorded if agreed and otherwise documented by taking manual notes. Interviews were scheduled in intervals, which enabled us to discuss findings and refine the interview protocol between sessions (Eisenhardt, 1989). Thereby, interview data was constantly compared to and corroborated with data from secondary sources. For instance, newspaper articles or internal strategy documents were leveraged to continuously fact-check claims by interviewed experts

**Table 3**  
Overview of case companies and interviewed experts.

Case company	COVID-19-related products	Workforce (2020)	Function of respondents	Years of experience	Interview duration
MedTech1	CT scanners, blood gas systems, diagnostic devices, test kits	50 K–75 K	Head of SCM	19	75 min
			Manager SCM A	19	60 min
			Manager SCM B	7	60 min
			Manager SCM C	6	60 min
			Director procurement A	15	50 min
			Director procurement B	14	60 min
MedTech2	Ventilators, medical masks	10 K–25 K	Director production	20	60 min
			Head of SCM	21	80 min
			Director procurement	24	60 min
			Manager procurement A	31	60 min
			Manager procurement B	8	60 min
			Manager logistics	24	60 min
			Director production	23	60 min
			Manager sales A	24	60 min
MedTech3	Ventilators, dialysis machines	75 K–125 K	Manager sales B	5	45 min
			Director SCM	14	50 min
			Manager logistics	10	60 min
			Director sales	14	60 min
MedTech&Pharma1	Disinfectant, medical masks, infusion pumps, intensive care drugs	50 K–75 K	Manager sales	6	60 min
			Head of SCM pharma	46	60 min
			Head of SCM MedTech	20	75 min
MedTech&Pharma2	Diagnostic devices, test kits, intensive care drugs	75 K–125 K	Manager logistics	12	65 min
			Regional Head of SCM pharma	20	45 min
			Director procurement MedTech	19	45 min
			Manager procurement MedTech	15	60 min
Pharma	Intensive care drugs	75 K–125 K	Head of government relations	8	45 min
			Director SCM A	24	60 min
			Director SCM B	11	65 min
			Manager procurement	10	60 min
PrivateHospitalGroup1	Intensive care	50 K–75 K	Manager production	4	50 min
			Chief operating officer	23	60 min
			Head of procurement	27	75 min
PrivateHospitalGroup2	Intensive care	50 K–75 K	Head of pharma procurement	20	60 min
			Head of procurement	11	120 min
			Head of MedTech procurement	22	60 min
PublicHospitalGroup	Intensive care	10 K–25 K	Member of the board	24	55 min
			Co-head of procurement A	20	55 min
			Co-head of procurement B	12	60 min
			Head of hospital pharmacy	20	60 min
			<b>Total: 39</b>	<b>Total: 40h</b>	

or derive hypotheses to be probed in a subsequent interview. We continued to conduct interviews and analyze secondary materials up to the point when gathering additional data did not yield new insights contributing to answering the RQs and theoretical saturation was reached (Eisenhardt, 1989).

### 3.4. Data analysis

Interviews were transcribed within 24 h of the session to ensure maximized recall (Yin, 2014). Thereafter, in line with grounded theory practice (Corbin and Strauss, 1990), we applied a systematic coding procedure to transcripts and secondary materials to cluster each source's unstructured data into aggregated categories. All transcripts were coded independently by two researchers, and any discrepancy was subsequently debated until mutual agreement, which reduced investigator bias (Pagell and Krause, 2005). New insights and hypotheses were discussed within the research team after each interview, leading to adjustments to the interview protocol and the coding categories. This iterative approach allowed us to continuously test emerging hypotheses and either confirm, refine, or discard them in the research process (Corbin and Strauss, 1990). As advised by Yin (2014), we further

deployed a software for clustering qualitative data (MAXQDA) to support the high data volumes' handling and coding.

Consistent with traditional multiple case study research, our study divides into within- and cross-analyses (Yin, 2014). However, we aligned with Bhakoo and Choi (2013) and applied minor variations to the analysis dimensions, modifying traditional within- and cross-case analyses to within- and cross-tier analyses. While the traditional approach performs within-case analyses for individual companies, our within-tier analysis combines multiple companies when belonging to the same tier, thus being equivalent to traditional cross-case analysis. With this approach, we were able to contextualize the resulting case data with the main predictions of RDT and contribute to the theory's refinement. Our cross-tier analysis subsequently drives investigations by combining the different tiers. We employed this approach to account for the differing patterns in SC structures, procurement strategies, and institutional pressure within each tier (Bhakoo and Choi, 2013). Based on this process and the study's underlying RDT perspective, we investigated bridging and buffering measures in the pandemic and derived seven propositions for SCRES-improving strategies in the HCSC.

**Table 4**  
Circumstances complicating symbiotic and competitive HCSC dependencies during the COVID-19 pandemic.

Type of increasing dependence <sup>1</sup>	Effect in stakeholder relationship <sup>2</sup>	Evidence collected from manufacturers						Evidence collected from hospital groups		
		MedTech1	MedTech2	MedTech3	MedTech& Pharma1	MedTech& Pharma2	Pharma	PrivateHospital Group1	PrivateHospital Group2	PublicHospital Group
Symbiotic dependence	Supply restrictions at material and component (sub-) suppliers	- Suppliers unable to match demand rise for CT scanner & diagnostic device parts - Suppliers of CT scanner & diagnostic device parts unable to maintain production capacity due to lock-downs - Suppliers lack financial stability, un-able to finance production increase - Suppliers of CT scanner parts increase prices - Suppliers provide un-reliable capacity & delivery data	- Suppliers unable to match demand rise for ventilator parts & me-dical masks - Suppliers lack financial stability, close plants after order drops in other industries - Suppliers provide un-reliable capacity data	- Suppliers un-able to match demand rise for ventilator & dialysis machine parts	- Suppliers un-able to match demand rise for infusion pump parts, disinfectant & drug ingredients - Suppliers of infusion pump parts unable to maintain production capacity due to lockdowns & missing PPE - Suppliers lack financial stability, close plants after order drops in other industries - Suppliers provide un-reliable capacity & delive-ry data	- Suppliers lack financial stability, plant closures after order drops in other industries - Suppliers of diagnostic device parts increase prices - Suppliers provide un-reliable capacity data	N/A	- Manufactu-rers of all COVID-19-related products unable to match de-mand rise - Manufactu-rers of COVID-19-related products unable to fulfill supply contract due to lockdowns & missing PPE - Suppliers of PPE increase prices, termi-nate contracts & neglect quality - Suppliers pro-vide unreli-able delivery data	- Manufactu-rers of all COVID-19-related products unable to match de-mand rise - Manufactu-rers of COVID-19-related products unable to fulfill supply contract due to lockdowns & missing PPE - Suppliers of PPE & drugs increase pri-ces & termi-nate contracts - Suppliers pro-vide unreli-able delivery data	- Manufactu-rers of all COVID-19-related pro-ducts unable to match de-mand rise - Manufactu-rers of COVID-19-related prod-ucts unable to fulfill supply contract due to lockdowns - Suppliers of PPE increase prices, termi-nate contracts & neglect quality - Suppliers pro-vide unreli-able capacity & delivery data
	Logistics restrictions at service pro-viders	- Restricted sea & air freight capacity, price increas-es (Asia to EU)	- Restricted sea & air freight capacity, price increas-es (Asia to EU) - Restricted land freight capacity (EU)	- Restricted sea & air freight capacity, price increas-es (Asia to EU) - Restricted land freight capacity (EU)	- Restricted sea & air freight capacity, price increas-es (Asia to EU) - Restricted land freight capacity (EU)	- Restricted sea & air freight capacity, price increas-es (Asia to EU)	- Restricted sea & air freight capacity, price increas-es (Asia to EU) - Restricted land freight capacity (EU)	N/A	N/A	N/A
Competitive dependence	Increasing procurement competition with other HCSCs	- Competition with manu-facturers for limited CT scanner & diagnostic device parts	- Competition with manu-facturers for limited venti-lator parts	- Competition with manu-facturers for limited venti-lator & dialy-sis machine parts	- Competition with manu-facturers for limited infu-sion pump parts, drug & disinfectant ingredients	- Competition with manu-facturers for limited dia-gnostic de-vice parts & drug ingre-dients	- Competition with manu-facturers for limited drug ingredients	- Competition with hospitals for PPE, disinfectant & ventilators	- Competition with hospitals for PPE, disinfectant & ventilators	- Competition with hospitals for PPE, disinfectant, ventilators & drugs
	Increasing procurement competition with public authorities	- Global au-thorities place tenders for CT scan-ners, diagnos-tic devices & test kits	- Global au-thorities place tenders for ventila-tors & PPE	- Global au-thorities place tenders for ventila-tors & dialy-sis machines	- Global au-thorities place tenders for PPE - Foreign au-thorities re-strict export of drug ingre-dients	- Global au-thorities place tenders for diagnostic devices & test kits - Foreign au-thorities re-strict export of drug ingre-dients	- Global au-thorities place tenders for drugs - Foreign au-thorities re-strict export of drug ingre-dients	- Order losses to global au-thorities buy-ing up PPE, disinfectant & ventilators - Foreign au-thorities re-strict export of COVID-19-related products	- Order losses to global au-thorities buy-ing up PPE, disinfectant & ventilators - Foreign au-thorities re-strict export of COVID-19-related products	- Order losses to global au-thorities buy-ing up PPE, disinfectant & ventilators - Foreign au-thorities re-strict export of COVID-19-related products
	Increasing procurement competition with other industries	N/A	N/A	N/A	N/A	N/A	N/A	- Industry buys PPE for em-ployee pro-tection - Retail buys PPE for B2C sale	- Industry buys PPE for em-ployee pro-tection - Retail buys PPE for B2C sale	- Industry buys PPE for em-ployee pro-tection - Retail buys PPE for B2C sale

Note: 1: first-order coding; 2: second-order coding; N/A: case company did not perceive effect on stakeholder relationship(s).



#### 4. Case results

This section introduces the collected evidence from the individual case companies, representing the foundation for subsequent analysis and discussion. First, we present circumstances leading to increased dependencies in the individual case companies' HCSCs during the pandemic (see Table 4). The first-order coding was inspired by RDT, dividing all observations into increasing symbiotic and competitive dependencies. Building on this, the second-order coding focused on the various stakeholder relationships affected by the increasing dependencies. All case companies experienced circumstances adversely influencing symbiotic relationships. The suppliers and logistics providers the case companies relied on, were repeatedly unable to fulfill the resource needs. This includes materials and parts for MedTech equipment, PPE, ingredients for intensive care drugs and disinfectants, and logistics services, among others. Both HCSC tiers equally had to cope with complications regarding this dependence type. For instance, *MedTech1* and *MedTech&Pharma1*, two companies heavily relying on a Chinese supplier base, noted that local lockdowns and the shortage of PPE and disinfectants led to supplier shutdowns and temporary supply shortages. Interestingly *Pharma* was only affected by logistics restrictions. Longer planning cycles and high inventory levels in its HCSC allowed it to withstand supplier failures for several months. Being at the forefront of fighting the pandemic's consequences, particularly hospital case companies faced increasing competitive dependencies. This becomes transparent with *MedTech2* confirming that ventilator orders in 2020 exceeded regular hospital demand eight times and multiple customers competed for the suddenly insufficient capacity. In this context, the hospital case companies did not just compete with healthcare providers but also with non-healthcare players such as public authorities, private consumers, and other industries.

Second, we present evidence on procurement measures the individual case companies undertook to manage the increased resource dependencies and ensure medical supplies availability (see Table 5). Again, we based the first-order coding on RDT and divided all observed measures into bridging and buffering approaches. The second-order buffering coding focused on different stakeholders who served as alternative suppliers or enabled the supply flow. Particularly hospital case companies opened up new sourcing options to satisfy their increased need for COVID-19-related products. For instance, *PrivateHospitalGroup1* targeted upstream suppliers, other hospitals, and public authorities. The second-order bridging coding reveals the different approaches case companies undertook to increase their power position in existing BSRs. Particularly manufacturers prioritized bridging over buffering. We observed a wide range of bridging approaches, particularly at *MedTech1* and *MedTech&Pharma1*. These companies supported suppliers' procurement activities, leveraged long-term personal contacts, and enhanced SC visibility to strengthen their BSRs or make their suppliers more dependent on them.

Based on the results depicted in both tables, Section 5 firstly discusses the circumstances increasing resource dependencies across case companies and secondly derives propositions for improved medical supplies availability during a pandemic.

#### 5. Discussion

We conducted a within-tier analysis to separately evaluate manufacturers' and hospitals' conditions, and a cross-tier analysis to identify similarities and differences between both tiers. Based on these analyses, we first summarize worsening dependencies in the GSA healthcare sector during the COVID-19 pandemic (addressing RQ1) and subsequently discuss buffering and bridging procurement measures applied by both tiers (addressing RQ2a and RQ2b). In this context, we introduce seven propositions on how manufacturers and hospitals can lift dependencies in BSRs to improve medical supplies availability during a pandemic.

##### 5.1. Increasing HCSC dependencies during the COVID-19 pandemic

Regarding symbiotic dependencies, all investigated hospitals reported a significant increase in intensive care patients, leading to a sharp rise in medical supplies demand. At the same time, all medical supplies manufacturers faced difficulties in fulfilling additional orders. This issue was exacerbated since their (sub-)suppliers were not always capable of increasing production capacities up to the new demand levels. Consequently, the suppliers' inability to match the increased demand magnified the case companies' symbiotic dependence on SC partners. In fact, the case companies' dependencies grew even further due to some suppliers' inability to maintain previously negotiated production capacities. This was mainly caused by actual COVID-19 cases at the suppliers or public authorities' infection prevention measures. Next to the capacity-related obstacles, the general economic downturn indirectly put additional pressure on symbiotic HCSC dependencies since suppliers lacked financial stability. These suppliers typically generated their biggest revenue shares by serving other industries, which were severely hit by the pandemic (e.g., the automotive industry). Moreover, we observed that all three investigated hospital groups, *MedTech1*, and *MedTech&Pharma2* experienced suppliers' tendencies towards opportunistic behavior and dubious offerings. Some firms increased prices or terminated their contracts to offer their production capacities to other customers:

*"In 2019, we successfully negotiated a contract with a new Chinese supplier for a thrombosis drug. Some weeks ago, we received a letter from this supplier. They canceled the contract and asked for a fivefold price increase without substantial reasoning." – Head of procurement, PrivateHospitalGroup2*

Other suppliers neglected quality controls and offered defective merchandise, which resulted in costs and time losses. However, due to a lack of alternative supplying options, the case companies were often forced to pay the higher prices, indicating strongly increased dependencies on their (sub-)suppliers. Moreover, suppliers repeatedly failed to provide reliable information on orders' delivery dates, delivery volumes, or critical bottlenecks. Consequently, the case companies faced uncertainty in their SCs, impairing their operational capabilities and control over suppliers.

Furthermore, manufacturers faced logistics providers restricting their services. In detail, the almost complete shutdown of passenger flights and border closures have significantly reduced cargo capacities. Hence, as manufacturers depended on the remaining capacities, bargaining power shifted towards the logistics service providers, who increased freight rates many times over.

Our analyses also revealed circumstances increasing competitive dependencies in the HCSC. We observed that all HCSC players extended their (medical) supplies procurement beyond their historical needs to meet the surge in demand for COVID-19-related products. Stronger competitive dependencies also emerged from governmental interventions. Pharma manufacturers and hospital case companies experienced political interferences in procurement and product distribution, as public authorities restricted (medical) supplies procurement to retain scarce medical supplies for their countries:

*"For some weeks, India prohibited the export of Active Pharmaceutical Ingredients, leading to more competition for the few remaining sourcing countries." – Manager procurement, Pharma*

Case companies also reported the Chinese government to retain PPE deliveries to GSA. Besides, public authorities engaged in medical supplies procurement themselves. All hospital case companies reported higher prices and decreasing procurement options due to the governments' involvement. While *PrivateHospitalGroup1* and *PrivateHospitalGroup2* kept highly engaged in procurement activities to not entirely depend on public medical supplies allocations, *PublicHospitalGroup* even

**Table 5**  
Buffering and bridging SCRES measures in the HCSC during the COVID-19 pandemic.

SCRES strategy <sup>1</sup>	Strategy application <sup>2</sup>	Evidence collected from manufacturers						Evidence collected from hospital groups		
		MedTech1	MedTech2	MedTech3	MedTech& Pharma1	MedTech& Pharma2	Pharma	PrivateHospital Group1	PrivateHospital Group2	PublicHospital Group
Buffering	Upstream HCSC tier as alternative source	N/A	N/A	N/A	N/A	N/A	N/A	- Procurement of ingredients for own disinfectant production (skip manufacturer) - Site visits, negotiations & logistics organization with foreign PPE manufacturers (skip distributor)	- Procurement of ingredients for own disinfectant production (skip manufacturer) - Negotiations & logistics organization with foreign PPE manufacturers (skip distributor)	- Procurement of ingredients for own drug & disinfectant production, (skip manufacturer)
	Same HCSC tier as alternative source	N/A	N/A	N/A	N/A	N/A	N/A	- Exchange of MedTech, drugs & PPE during regional shortages, mainly within hospital group - Inventory system for sharing PPE, MedTech & drugs stock levels within hospital group to facilitate pooling - Bundling of hospital group procurement activities in central warehouse	- Exchange of MedTech, drugs & PPE during regional shortages, mainly within hospital group - Inventory system for sharing PPE, MedTech & drugs stock levels within hospital group to facilitate pooling - Bundling of hospital group procurement activities in central warehouse	- Exchange of drugs & PPE during regional shortages, mainly outside hospital group - Online platform for sharing PPE & drugs stock levels outside hospital group to facilitate pooling - Allocation of purchasing alliance orders to hospitals most in need
	Public authorities as alternative source	N/A	N/A	N/A	N/A	N/A	N/A	- Purchasing PPE from public tenders - Negotiation of public guarantees to procure MedTech equipment - Allocation of PPE & electronic spare parts to the HCSC	- Purchasing PPE from public tenders - Negotiation of public guarantees to procure MedTech equipment	- Purchasing PPE, ventilators & CT scanners from public tenders - Negotiation of public guarantees to procure MedTech equipment & test kits - Allocation of mechanical & electronic spare parts to the HCSC
Bridging	Other industries as alternative source	- Sheet metal parts from automotive and machinery for CT scanners - Hardware from electronics for CT scanners	N/A	N/A	- Foil from automotive for medical skirts - Ethanol from spirits producers for disinfectants	- Synthetics from machinery for diagnostic devices	N/A	- Medical masks from automotive	- Medical masks from automotive	- Ethanol from spirits producers for disinfectants - Medical masks from automotive
	Improved power position towards SC partners through procurement support	- Support of supplier PPE, material & logistics procurement - Sharing of material with suppliers	- Support of supplier material procurement - Sharing of material with suppliers	N/A	- Support of supplier material & logistics procurement - Sharing of PPE with suppliers	- Sharing of PPE with suppliers	- Sharing of PPE with suppliers	N/A	N/A	N/A
	Improved power position towards SC partners through leveraging long-term BSR	- Leveraging personal supplier contacts to influence supply allocation - Support of supplier capacity extension with purchase	- COVID-19 supplier performance as future selection incentive - Prioritized ventilator sale to long-term customers	- Prioritized ventilator & dialysis machine sale to long-term customers	- Prioritized disinfectant, medical mask, infusion pump & drug sale to long-term customers	- Leveraging personal supplier contacts to influence supply allocation - Support of supplier capacity extension with production	- Prioritized drug sale to long-term customers	- Leveraging personal manufacturer contacts to influence supply allocation - COVID-19 manufacturer performance as future selection incentive	- Leveraging personal manufacturer contacts to influence supply allocation - COVID-19 manufacturer performance as future selection incentive	- Leveraging personal manufacturer contacts to influence supply allocation - COVID-19 manufacturer performance as future selection incentive

(continued on next page)

Table 5 (continued)

SCRES strategy <sup>1</sup>	Strategy application <sup>2</sup>	Evidence collected from manufacturers					Evidence collected from hospital groups			
		MedTech1	MedTech2	MedTech3	MedTech& Pharma1	MedTech& Pharma2	Pharma	PrivateHospital Group1	PrivateHospital Group2	PublicHospital Group
		guarantees & production know-how - Development of joint continuity plans - COVID-19 supplier performance as future selection incentive - Prioritized CT scanner sale to long-term customers					know-how - Development of joint continuity plans - Prioritized diagnostic device, test kit & drug sale to long-term customers - COVID-19 supplier performance as future selection incentive			
	Improved power position towards SC partners through enhanced visibility	- Weekly queries on supplier status - Ad-hoc supplier ERP data integration - Sub-tier SC mapping - Critical re-view of customer order quantities	- Up to daily queries on supplier status - Sub-tier SC mapping - Critical re-view of customer order quantities	- Weekly queries on supplier status - Critical re-view of customer order quantities	- Weekly queries on supplier status, shorter cycles for key suppliers - Sub-tier SC mapping - Demand forecasts based on infection patterns - Demand forecast collaboration with universities	- Weekly queries on supplier status - Sub-tier SC mapping - Demand forecasts based on infection patterns	- Bi-weekly queries on supplier status - Sub-tier SC mapping - Critical re-view of customer order quantities	- Up to daily queries on manufacturer status - Use of public online platforms on drug availability - Historical demand benchmarking of single hospitals	- Up to daily queries on manufacturer status - Use of public online platforms on drug availability - Live demand benchmarking of single hospitals - Real-time consumption tracking	- Weekly queries on manufacturer status, shorter cycles for key suppliers - Use of public online platforms on drug availability

Note: 1: first-order coding; 2: second-order coding; N/A: case company did not apply measure (mostly relevant for buffering which was predominantly applied by hospitals).

retreaded from some markets, particularly ventilators, and entirely relied on supply from public tenders. These findings support other scholars' observations on public procurement initiatives during the pandemic (e.g., [Cohen and van der Rodgers, 2020](#); [Vecchi et al., 2020](#)). Besides, new competitors initiated procurement activities within the usually rather cohesive HCSCs: Other industries who extended medical supplies procurement, including industry buying PPE to keep their facilities open and retail selling PPE to consumers for private protection. In sum, all findings illustrate that new dependencies within the HCSC evolved during the crisis and dependencies already existing before the COVID-19 pandemic became even stronger, making intensified SCRES efforts necessary ([Wagner and Bode, 2006](#)).

## 5.2. Measures to decrease HCSC dependencies in a pandemic

This section presents buffering and bridging procurement measures that the manufacturer and hospital case companies applied to lift dependencies in the HCSC and secure (medical) supplies during the COVID-19 pandemic. First, in Sections 5.2.1 and 5.2.2, we present four within-tier propositions that apply exclusively to manufacturers or hospitals. Second, in Section 5.2.3, we present three propositions valid for both HCSC tiers.

### 5.2.1. Measures applied by manufacturers

Supplier delivery capabilities were severely impaired by global supply constraints, impeding smooth product flows in the HCSC. In this situation, five out of six manufacturers in our sample backed their SC partners' purchasing activities and thereby increased their control over the suppliers. Procurement departments closely worked with suppliers' procurement staff and assisted them with superior purchasing capabilities. Depending on the case company, up to 20% of all direct suppliers received some sort of procurement support. For instance, *MedTech1*, *MedTech2*, and *MedTech&Pharma1* assisted their (sub-)suppliers' procurement activities with personnel, professional contacts, market knowledge, and alternative material advice. *MedTech2* organized these activities in a special task force within the procurement department:

*"We know our supply markets quite well, so sharing relevant information with our suppliers to solve their problems was a useful approach. Two of my colleagues were released from their usual responsibilities and worked closely with suppliers' procurement departments to find solutions for their constraints."* – Manager procurement B, *MedTech2*

The additional human resources and suggestions for alternative sourcing helped suppliers to intensify and effectively target their procurement efforts. In this context, the suppliers got more dependent on the manufacturers because of their procurement capabilities, leading to a better negotiation position and improved supply conditions for the case companies. On some occasions, when supporting their suppliers' purchasing activities was not sufficient, *MedTech1* and *MedTech2* also directly sent materials to suppliers:

*"We found out that one Chinese supplier lacked a special glue used primarily in our industry. Our full delivery threatened to fail just because of this missing glue; it was bizarre. So, we checked our stocks, found this glue and sent it by air freight to China to ensure our orders' timely delivery."* – Manager procurement A, *MedTech2*

Procuring PPE was another area where manufacturers supported suppliers. As with material purchasing, *MedTech1* used its procurement strength and industry contacts to secure medical masks for its suppliers. Others shared self-procured or self-produced PPE, disinfectant, and COVID-19 test kits with suppliers to keep their facilities open. All involved manufacturers reported that these initiatives helped suppliers to maintain operations and led to preferential treatment for the helpful case companies. Moreover, the challenges were not restricted to material and PPE procurement:

*"So, in fact, there were fewer failures at suppliers' plants than in their logistics. They were not able to ship their products. We had to support them in purchasing transport capacities. For instance, we closely worked with a supplier from the Philippines to get our supply over here. [...] We were able to receive even more supplies than predicted because the supplier's inventory was full, but he was unable to distribute."* – Head of SCM *MedTech*, *MedTech&Pharma1*

Hence, capturing logistics capacities was also a major supplier problem. *MedTech1* and *MedTech&Pharma1* supported suppliers' air, sea, and land freight purchasing activities. They either shared professional contacts and market knowledge or even changed Incoterms and organized transports on their own. In this way, these manufacturers gained a competitive edge over other firms not supporting logistics activities – reducing competitive dependencies – and simultaneously increased their negotiation position towards their suppliers – reducing symbiotic dependencies. As a result, the firms were able to ship urgently needed supplies to GSA. All these activities performed by manufacturers to enable suppliers' procurement activities can be summarized under the term 'vertical supplier procurement support.' With this concept, we confirm that the previous RDT finding that companies facing "uncertainty regarding key, external resources can improve their economic sustainability through vertical coordination" ([Carter and Rogers, 2008](#)) also holds true in a healthcare procurement and pandemic context. In general terms, the observed actions constitute a novel application of the established information and resource sharing bridging measure (see [Table 1](#)). As a result, we introduce our first proposition.

**P.1.** In a pandemic, medical supplies manufacturers supporting their (sub-)suppliers' material and logistics procurement operations can improve supply availability (bridging).

### 5.2.2. Measures applied by hospital groups

At all three hospital groups, the central procurement departments played an essential role. They served as warning systems for detecting imminent medical supplies bottlenecks since they were at the intersection of demand increases reported by medical staff and supply difficulties experienced from manufacturers. In this context, we observed the procurement departments expanding their traditional responsibilities. First, all three procurement departments coordinated actions with other hospital units (e.g., pharmacies, laboratories) to become more autarkic and lift manufacturer dependencies by establishing additional in-house production capacities. For instance, *PublicHospitalGroup* reactivated previously phased out machines for intensive care drugs and disinfectant production:

*"When procurement realized we were about to run out of disinfectants, we jointly built up a completely new, parallel supply chain bypassing the market. We got old machines out of the basement, and they contacted chemical companies and logistics service providers. This was an excellent initiative and definitely helped us to become more independent."* – Head of hospital pharmacy, *PublicHospitalGroup*

*PrivateHospitalGroup1* and *PrivateHospitalGroup2* reported similar disinfectant production initiatives, and *MedTech&Pharma1* confirmed that some of its customers, including hospital case companies, individually engaged in disinfectant production to extend limited manufacturer capacities. In this context, the hospital groups' procurement departments played a central role. They had to understand the new material requirements, scan the upstream HCSC, find suitable suppliers, and quickly establish a reliable business relationship. An excellent understanding of the end-to-end HCSC and medical products' composition was of utmost importance. Articles in newspapers and scientific periodicals picked up these initiatives, which helped to triangulate interview information. It is important to understand that the unique supply situation during the COVID-19 pandemic was the main driver for establishing in-house production and skipping manufacturers:

*“Under regular conditions, engaging in disinfectant production would not be an economically feasible option for us. However, the uncertainties during the pandemic were high and the duration of supply shortages totally unpredictable, so that we had to take this measure.”* – Head of procurement, *PrivateHospitalGroup2*

Second, the procurement departments at *PrivateHospitalGroup1* and *PrivateHospitalGroup2* broke new grounds to secure medical supplies by purchasing PPE directly from the leading Asian manufacturers instead of exclusively at regional distributors. This approach is remarkable since “international sourcing is not a common skill set among HCSC professionals” (Francis, 2020). Through this measure, the hospital case companies buffered dependencies by opening up alternative sources, received more reliable delivery promises, avoided opportunistic behavior of distributors, and sped up procurement processes. The private hospital groups took over all distributors’ natural responsibilities, including manufacturer negotiations and the organization of all logistics activities. Procurement departments mainly convinced manufacturers of direct business relationships with two arguments. First, they justified their purchasing activities with urgent patient treatment requirements resulting from the pandemic instead of economic objectives, creating ‘awareness of need’ at the manufacturers. The manufacturers’ willingness to collaborate on this basis confirms previous findings in the field of corporate philanthropy (Bekkers and Wiepking, 2011). Second, they shared saved distributor margins with the manufacturers to set economic incentives. Hospital executives named various success factors for this initiative:

*“In recent years, we further professionalized our procurement and logistics departments and successively added new capabilities. To give some examples, we developed a deep understanding of our supply markets beyond the distributors, added skills for quality controls, established direct contacts with international manufacturers, and built up logistics infrastructure to internally handle large quantities of procured medical supplies. These circumstances helped us to flip the switch during the pandemic and holistically skip PPE distributors for the first time.”* – Chief operating officer, *PrivateHospitalGroup1*

While *PrivateHospitalGroup2* coordinated the entire process from GSA, *PrivateHospitalGroup1* even sent procurement experts to Asia to examine the merchandise and negotiate with manufacturers directly. It is important to note that *PublicHospitalGroup* could not perform comparable measures since it lacked the necessary procurement workforce and capabilities. Overall, the procurement departments’ extended responsibilities in buffering against external dependencies by purchasing at new upstream medical supply sources led to our second proposition.

**P.2.** In a pandemic, hospitals procuring directly from upstream healthcare suppliers can reduce dependencies and thus improve medical supplies availability (buffering).

Another within-tier initiative the hospital groups’ procurement departments undertook to open up alternative sources was pooling medical supplies. Particularly at the beginning of the pandemic, the hospital case companies reported spontaneous decentralized resource sharing between individual hospitals (within and across hospital groups). Shifting medical supplies between hospital locations is unconventional since it comes with additional logistics costs and organizational complexity:

*“We do not usually do this. In general, moving medical supplies between hospitals is a complex and inefficient measure. Especially when the supplies are spread across a hospital’s different wards, collecting and shipping them to another hospital is a time-consuming activity.”* – Head of procurement, *PrivateHospitalGroup1*

However, this measure was considered reasonable during the COVID-19 pandemic since regionally differing infection rates put different and dynamically evolving pressure levels on individual hospitals. In this context, the importance of cost efficiency in procurement

and logistics decreased as the healthcare providers’ main target was guaranteeing patient treatment:

*“During the first COVID wave, Eastern Germany had very few infection cases, and inventories for intensive care drugs used for ventilation were comparably high. So procurement organized special transports to get us the drugs. [...] In this situation, nobody cared about additional costs, we urgently needed the drugs to save lives.”* – Head of hospital pharmacy, *PublicHospitalGroup*

To coordinate the resource-sharing activities, *PublicHospitalGroup’s* procurement department engaged with other public hospitals they regularly work with, particularly in purchasing alliances. They established an online platform where the hospitals shared inventory levels for COVID-19-related medical supplies daily. Whenever *PublicHospitalGroup* faced severe supply bottlenecks, the procurement department could access the platform, contact other hospitals with sufficient inventory, and receive the urgently required medical supplies within few hours. This collaboration allowed to lift critical manufacturer and distributor dependencies. *PrivateHospitalGroup1’s* and *PrivateHospitalGroup2’s* procurement departments also coordinated medical supplies exchanges between heavily and little affected regions. They mainly performed these activities internally, which was possible due to their many hospital locations (>80 each). Nevertheless, requests for help from external hospitals were also supported. On a hospital group level, the medical supplies exchanges even included MedTech equipment such as ventilators. For this activity, *PrivateHospitalGroup1* and *PrivateHospitalGroup2* relied on their centralized inventory management systems for medical equipment, including information on a medical device’s location, maintenance status, and utilization:

*“Infection patterns differed between our hospital regions, and so did our intensive care units’ utilization. Leveraging our inventory systems and shifting medical equipment between hospitals was a key lever to guarantee medical treatment.”* – Head of procurement, *PrivateHospitalGroup1*

With the progressing pandemic, *PrivateHospitalGroup1’s* and *PrivateHospitalGroup2’s* procurement organizations established central warehouses for most COVID-19-related products at hospital group level. The aim was to make medical supplies pooling and distribution more effective and enable the new upstream procurement initiatives (see P.2). Manufacturers and remaining distributors were instructed to ship all medical supplies to these warehouses instead of directly sending them to individual hospital locations. With this centralized pooling measure, *PrivateHospitalGroup1* and *PrivateHospitalGroup2* further improved inventory visibility and effectively allocated medical supplies to most needy locations. Moreover, logistics complexity of decentralized pooling was diminished, which was crucial due to the transportation restrictions during the pandemic (see Table 4). The establishment of the central warehouses also gave individual hospitals more supply reliability since they could additionally rely on a big shared pool of medical supplies instead of being fully dependent on limited inventories, uncertain manufacturer deliveries, and the goodwill of other hospitals. *PublicHospitalGroup* achieved the required purchasing volumes allowing centralized pooling by leveraging the previously discussed purchasing alliances. The inventory platform introduced during COVID-19 was used to centrally allocate medical supplies obtained by the purchasing alliance to hospitals most in need.

Overall, our empirical findings support previous theoretical models that cross-hospital resource sharing can prevent medical supplies shortages (Essoussi, 2015; Mehrotra et al., 2020). We can also confirm literature-based propositions and anecdotal evidence that pooling medical supplies – either centralized or decentralized – can open up alternative sources for medical supplies and reduce dependencies on established HCSC partners in a pandemic (Francis, 2020; Friday et al., 2021). However, our findings also reveal that a more nuanced perspective on different resource pooling approaches is required since

centralized medical supplies pooling turned out more effective than the decentralized approach during a pandemic. Overall, this collaborative and cooperative behavior aligns with RDT since identical objectives can lead individual organizations to work together to decrease dependencies (Pfeffer, 1989). Similar actions were not experienced between manufacturers since full order books and specific product design requirements impeded material and component sharing. Based on our observations, we present the third proposition.

**P.3.** In a pandemic, hospitals pooling resources can reduce dependencies and thus improve medical supplies availability (buffering). Centralized pooling offers advantages in terms of reliability, inventory visibility, and logistics complexity and is, therefore, superior to decentralized pooling.

Section 5.1 discussed the governmental interventions leading to new competitive dependencies in hospital procurement markets during the COVID-19 pandemic. Nevertheless, public authorities also established new sourcing opportunities for hospitals and helped to lift dependencies. First, all three hospital case companies engaged with local governments to receive medical supplies from public tenders. The procurement departments admitted that despite the additional competitive dependencies due to increased public procurement, this alternative source helped to lift symbiotic dependencies on established manufacturers:

*“Buying COVID-19-related medical supplies from manufacturers was really challenging, basically because governments interfered and secured supplies for their own countries. [...] In the end, we were grateful for any supplies we received from our own public authorities.”* – Co-head of procurement B, *PublicHospitalGroup*

Particularly the governments' capability to exercise political pressure and procure large quantities allowed the hospital case companies to compete with other powerful players on the international markets (e.g., the centrally organized British National Health Service). Moreover, governments also engaged in financing medical supplies. For instance, *PublicHospitalGroup*, *MedTech2*, and *MedTech&Pharma2* noted that government purchases of expensive ventilators and diagnostic devices allowed quickly expanding intensive care and COVID-19 testing capacities. Under normal conditions, *PublicHospitalGroup* would not have been able to perform such investments because of budget restrictions and the consequence of overcapacities after the pandemic's end. With the advantageous conditions negotiated with the state, such acquisitions became possible.

Second, all three hospital case companies were confronted with claims for COVID-19-related medical supplies purchase guarantees. For instance, *MedTech2* and *MedTech&Pharma2* offered to expand production capacities significantly but shunned the required investments in light of the pandemic's uncertain duration. With the hospital procurement departments' limited budgets, extensive purchasing guarantees for ventilators, PPE, and COVID-19 test kits could not be offered. In these cases, the hospital procurement departments reached out to governmental bodies to request and coordinate public purchasing guarantees. These initiatives helped hospitals to buffer dependencies through additional sourcing options, leading to improved medical supplies conditions. All our hospital case companies but also two manufacturers provided related evidence, as the following example reveals:

*“Public purchasing guarantees allowed us to produce hundreds of thousands COVID-19 test kits per month. Without these guarantees, the economic risks would have been too high to produce these quantities without any specific order.”* – Head of government relations, *MedTech&Pharma2*

Third, hospitals collaborated with public authorities to secure scarce materials and components for the HCSC. For instance, *PublicHospitalGroup* identified mechanical and electronic parts and components used in other sectors that could also be leveraged for healthcare purposes, particularly spare parts for *MedTech* equipment. In this

context, *MedTech1* and *MedTech2* but also publicly available sources confirmed that capacities to produce spare parts were also constrained. Therefore, government interventions were arranged to allocate these resources to the healthcare system, decrease dependence on established manufacturers, and improve medical supplies availability.

Although all three hospital case companies benefited from governmental procurement initiatives and confirmed authorities' positive intentions and continuous efforts, they also reported several drawbacks. Public purchasing insufficiencies were repeatedly addressed both in expert interviews and secondary sources (e.g., news articles), confirming other scholars' findings from the USA (Finkenstadt and Handfield, 2021). As previously discussed, the governmental purchasing activities were one of the main reasons for more competitive dependencies and higher prices. Besides, publicly provided medical supplies, particularly PPE, were sometimes of low quality, revealing public entities' poor quality assessment capabilities. Moreover, public product allocation and delivery was often inefficient:

*“We have been waiting for additional ventilators without further notice. [...] One day, we were informed just a few hours in advance that we would receive five new ventilators from a public tender. Unfortunately, we realized that the system was wrong just when the equipment was unloaded from the truck. Normally, we work with devices from MedTech2, but we received equipment from a competitor. We could not use them at all and had to send them back.”* – Co-head of procurement B, *PublicHospitalGroup*

*MedTech2* confirmed this case and other occasions where hospitals contacted the company to complain about public procurement and distribution inefficiencies. Overall, we conclude that public purchasing constituted a new buffering opportunity as an alternative source for hospitals' medical supplies procurement. In this context, we can acknowledge that establishing relationships between procurement departments and public agencies is of foremost importance to manage a pandemic (Francis, 2020). However, we also uncovered a lack of public efficiency in medical supplies procurement and allocation in the GSA healthcare systems. As a side note, manufacturers could not benefit from governmental purchasing because it focused on ready-to-use medical supplies and not materials and components. These findings led to our fourth proposition.

**P.4.** In a pandemic, hospitals engaging in procurement activities with public authorities can reduce dependencies and thus improve medical supplies availability (buffering) – however, challenges such as quality assurance, effective resource allocation, and distribution coordination remain.

### 5.2.3. Measures applied by manufacturers and hospitals

Representatives from manufacturers and hospitals reported having tested two procurement strategies to lift competitive dependencies and secure scarce medical supplies: leveraging existing and establishing new BSRs. Overall, most case companies stated that the bridging approach, engaging with existing partners, was the more effective option.

All three hospital groups reported successful procurement activities with their long-term strategic suppliers. With a trustful business relationship and reliable personal relations in place, the procurement departments made the most effective purchasing attempts for COVID-19-related products. On many occasions, the hospital case companies could even expand previously agreed contracts and receive more medical supplies. While most of the existing suppliers were supportive and reliable, relatively new suppliers and ones with low historical assessment ratings lacked reliability and tried to exploit the hospitals' urgent demand conditions. Supplier offerings that were shown to us support these findings. In such cases, the hospitals had to spend additional efforts on convincing or sanctioning unreliable suppliers, only partially with success. In this context, all three hospital groups announced to expand their supplier criteria by including the reliability during the

COVID-19 pandemic as a separate assessment dimension. We were granted access to future supplier evaluation sheets that illustrated this adjustment.

All manufacturers in our sample confirmed the hospitals' information, stating that they mostly rejected buying requests from unfamiliar hospitals. The manufacturers prioritized their pre-COVID-19 customer base when allocating their limited products:

*"We prioritized our customers and not some other hospital that contacted us after years because it did not get anything from our competition. I do not abandon my customers who remained loyal for years despite slightly higher prices than those of the Asian competition."* – Head of SCM pharma, *MedTech&Pharma1*

The surge in medical supplies demand, fierce competition between hospitals, and the manufacturers' focus on existing customers implied that it was hard for hospitals to find new suppliers in the healthcare industry. These circumstances illustrate the exceptionally high importance of long-term strategic supplier partnerships to increase SCRES in a pandemic. Buffering initiatives were mostly only successful outside the traditional vertical HCSC (e.g., within-tier (see P.3) and cross-industry collaboration (see P.7)). Just in few cases, *PrivateHospitalGroup1* and *PrivateHospitalGroup2* managed to achieve suitable conditions from previously unfamiliar manufacturers. These two leading players in the European hospital landscape leveraged their buying power and convinced new suppliers by promising post-COVID-19 purchasing volumes. Overall, the hospital case companies had to make concessions to build up new supplier relationships during the COVID-19 pandemic by paying a price premium or agreeing to long-term contracts.

We made similar observations on the manufacturers' supply side. *MedTech1* and *MedTech&Pharma2* worked closely with their long-term strategic suppliers to develop joint continuity plans and support the expansion of production capacities. At the same time, building up new supplier relationships was challenging. The reasons that *MedTech1*, *MedTech2*, and *MedTech&Pharma2* reported were again the preferential treatment of long-term customers, high prices, quality issues, and

certification requirements. Based on the learnings that bridging dependencies by leveraging long-term BSRs with manufacturers and suppliers was the most reliable option for procuring (medical) supplies during the COVID-19 crisis, we formulated the fifth proposition.

**P.5.** In a pandemic, medical supplies manufacturers and hospitals leveraging relationships with long-term strategic suppliers can improve supply availability more effectively than by adding new suppliers (bridging).

When closely working with their suppliers to fulfill the demand rise for medical supplies, visibility on delivery capabilities played a crucial role for manufacturers and hospitals to reduce uncertainty. This finding extends previous discussions on inventory visibility for PPE during the COVID-19 pandemic (Finkenstadt and Handfield, 2021; Francis, 2020). By increasing supply-side visibility, the case companies aimed to improve their relational power positioning and governance mechanisms in symbiotic supplier dependencies, as Gligor et al. (2019b) and Touboulic et al. (2014) previously discussed. Measures to enhance visibility were manifold. All case companies in our sample increased the frequency of supplier coordination activities to a weekly or even daily routine:

*"To better understand our suppliers' situation, we sent weekly queries to our 1,000 main suppliers. We asked about their manufacturing capacities and potential constraints. We also talked to many of them when problems popped up. In this way, we had more touchpoints with some suppliers during the first weeks of Corona than in other entire years."* – Director procurement B, *MedTech1*

For instance, requested information from suppliers included available production capacities, local infection prevention regulations, potential export restrictions, or actual COVID-19 cases at the firms. The hospital groups also intensified the use of public online platforms (e.g., European Medicines Agency's shortages catalog), uncovering the delivery capabilities of pharmaceutical firms. Moreover, five manufacturers started evaluating their sub-supplier network to uncover potential bottlenecks, as the subsequent examples reveal:

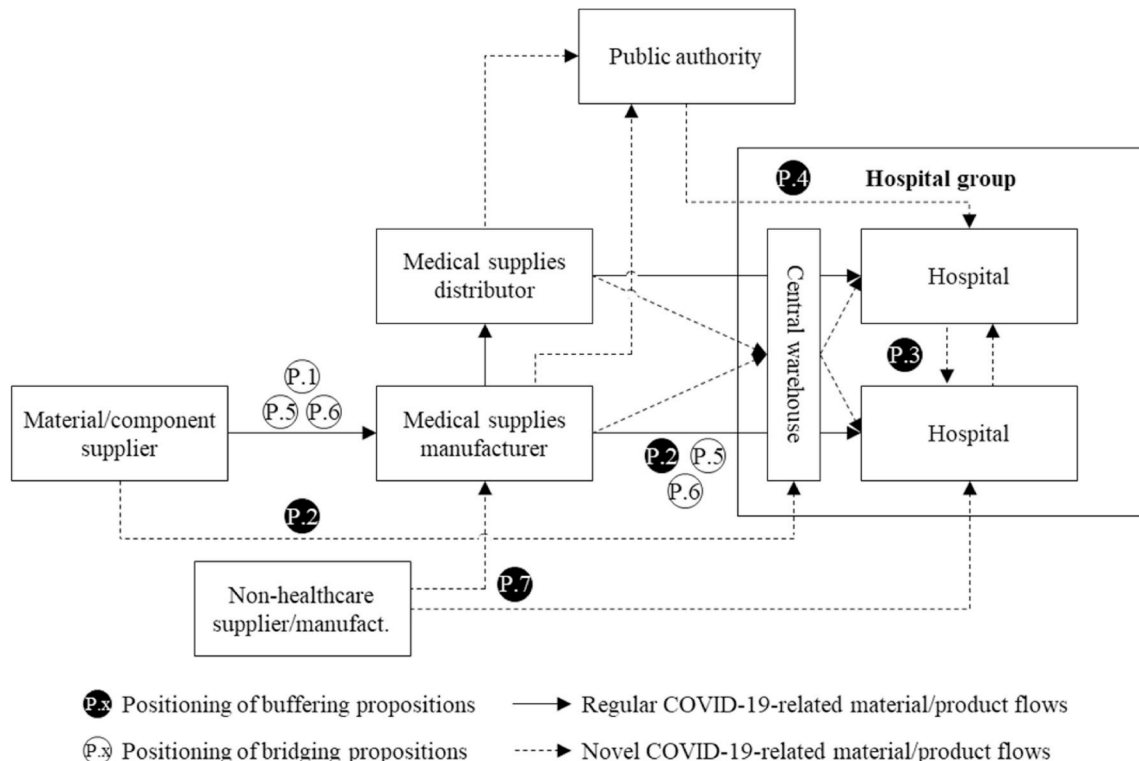


Fig. 3. Adapted flows of medical supplies during the COVID-19 pandemic.

*“For the first time, we holistically analyzed our sub-tier supplier network to timely uncover and solve potential bottlenecks. Who are these suppliers? Where are they located? Which risks could materialize? We did not regularly ask this kind of questions prior to COVID-19.”* – Director procurement, MedTech2

*“Analyzing our entire supply network was an incredibly long, painful, and somewhat incomplete exercise. However, it was totally worth it to foresee major issues in our supply chain.”* – Regional Head of SCM pharma, MedTech&Pharma2

In many cases, the manufacturers even reached out to sub-suppliers to ask for specific delivery information, a highly uncommon practice before the COVID-19 pandemic. Nevertheless, it was required due to the disruption's scale, its effect on multiple tiers, and previous experiences that upstream SC disruptions can have the most severe consequences for SC performance (Ivanov, 2020; Wagner and Bode, 2006). With these supplier visibility initiatives, the case companies managed to anticipate and counteract ripple effects – which were already predicted at the pandemic's beginning (Ivanov, 2020) – along their HCSCs.

Campaigns to improve visibility in the HCSC also included the demand-side to ensure a reliable planning foundation for procurement departments:

*“Normally, our demand is very predictable and reliable forecasts can be generated years in advance. This year, we had to reinvent ourselves and find new ways to forecast short-term demand. [...] All units from Procurement to Sales depend on reliable demand forecasting to effectively do their job.”* – Director SCM, MedTech3

Since traditional medical supplies demand forecasting failed during the pandemic, as Moss et al. (2021) also reported in a drug context, case companies started to forecast short-term product demand based on new COVID-19 infection cases or infection patterns in other world regions. Moreover, the hospital case companies reported internal hoarding attempts, which were widely observed during the pandemic (Finkenstadt and Handfield, 2021). This circumstance negatively affected purchasing effectiveness since actual demand was distorted. To better plan procurement necessities and communicate reliable demand in manufacturer negotiations, PrivateHospitalGroup1 applied a novel approach to avoid hoarding attempts. Personnel at the central procurement department critically compared internal delivery requests with historical orders and regional COVID-19 severity to distinguish between actual demand and hoarding. PrivateHospitalGroup2 took a different approach and initiated an internal benchmarking between hospitals to identify and rebuke single hospitals where hoarding was suspected. With the ongoing pandemic, PrivateHospitalGroup2 also implemented a real-time consumption tracking of COVID-19-related medical supplies. For instance, whenever medical personnel used PPE, they had to scan a barcode and register consumption. This insight empirically confirms the viability of previous suggestions that medical supplies consumption tracking can enhance visibility (Finkenstadt and Handfield, 2021) and extends practical implementation options beyond analytical models estimating consumption (Francis, 2020). All measures to improve demand visibility led to better planning possibilities of case companies' procurement departments, allowing them to position better in supplier negotiations.

Overall, improving buyer-supplier visibility was a key lever to strengthen one's information position towards suppliers and bridge dependencies, resulting in enhanced HCSC performance during the COVID-19 crisis. Therefore, we can empirically confirm previous theoretical claims that visibility on supply flows in HCSCs may improve medical supplies availability in a pandemic (Friday et al., 2021), leading to our sixth proposition.

**P.6.** In a pandemic, medical supplies manufacturers and hospitals enhancing their information position by creating visibility on supplier delivery capabilities and actual (customer) demand can improve supply

availability (bridging).

The case companies applied a variety of buffering and bridging measures within the HCSC. However, on some occasions, the entire healthcare supply base failed to serve the increased demand. In these situations, procurement departments repeatedly engaged in cross-industry collaborations with suitable suppliers and manufacturers to decrease the dependence on capacity-constrained HCSC partners:

*“The procurement market was very dynamic. Multiple companies from different industries entered the market and opened up new purchasing options.”* – Head of MedTech procurement, PrivateHospitalGroup2

*“There have been collaborations with well-known spirits manufacturers. Brands that you normally know from retail stores. They gave us their ethanol, and we used it to make disinfectants.”* – Head of SCM MedTech, MedTech&Pharma1

Overall, six case companies provided evidence on cross-industry purchasing, ranging from simple commodities to certified medical supplies. For instance, the automotive and machinery industries were reliable procurement sources, as several case companies and secondary sources (e.g., industry reports, news articles) confirmed. These firms possessed the required capabilities and had spare capacities, as already indicated in Section 5.1.

Throughout all these initiatives, the case companies' purchasing departments played a key role. First, they had to identify suitable sources. For this, the procurement staffs' market knowledge, industry databases, and cross-industry contact forums established by GSA industry associations were leveraged. Second, potential collaboration partners were contacted, either through formal requests or – far more often – through personal contacts. Third, detailed product specifications were exchanged, and the new partners had to be accompanied and advised to ensure high-quality supply. Fourth, detailed terms and conditions had to be negotiated, including quantities and prices.

Overall, the case companies reported that cross-industry collaborations for alternative sourcing were vital to overcoming scarcity and dependencies in HCSCs. The newly established supply relations accounted for up to 10% of overall supplies in some product categories, particularly PPE. Cross-industry buffering opportunities have not been addressed in RDT-based SCRES research before. Therefore, we introduce our seventh and final proposition.

**P.7.** In a pandemic, medical supplies manufacturers and hospitals extending their procurement activities by collaborating with companies from other industries can reduce dependencies and thus improve supply availability (buffering).

## 6. Conclusion, implications, and future research

The unprecedented demand surges in global healthcare systems caused by the COVID-19 pandemic led to considerable procurement challenges for medical supplies manufacturers and hospitals globally. Thereby, the crisis has put SCRES, particularly the availability of critical medical supplies in the HCSC, at the center of interest for researchers and practitioners. Embedded in RDT, this research investigated the effects of altering resource dependencies in HCSCs during a pandemic. It offers insights on procurement-related practices to ensure the availability of critical medical supplies in the ongoing COVID-19 crisis and similar future events. We conducted a multi-tier case study across six medical supplies manufacturers and three hospital groups in GSA, drawing from a large sample of 39 interviewed experts and exhaustive secondary material analyses. We solely included companies and hospitals that provided COVID-19-related products or treatments to ensure our findings' applicability to healthcare crises with significant demand increases. We further ensured that each investigated manufacturer had BSRs with each hospital group.

Our empirical findings and RDT-based propositions reveal that the



flows of medical supplies were comprehensively adapted during the COVID-19 pandemic (see Fig. 3). First, hospital groups established central pandemic supply warehouses for better visibility and allocation mechanisms. Second, hospitals exchanged scarce medical supplies between severely and less-affected regions. Third, hospitals secured medical supplies and materials at upstream suppliers. Fourth, hospitals received medical supplies from government bodies that assumed a crisis-procurement role. Fifth, hospitals and manufacturers also procured medical supplies and materials outside traditional HCSCs. All these adjustments helped the case companies' procurement departments to overcome pandemic-related dependencies.

### 6.1. Theoretical implications

We respond to calls for research on SCRES in the HCSC, the empirical investigation of companies' responses to the COVID-19 crisis, and RDT as a theoretical lens to investigate SC disruptions caused by a pandemic (Craighead et al., 2020; Senna et al., 2020; van Hoek, 2020). Our paper is among the first to offer a comprehensive and explorative study on how different tiers in the HCSC coped with the disruptions caused by the COVID-19 pandemic. By revealing how resource dependencies increase during a pandemic and investigating a holistic set of strategies to manage these dependencies, we establish a valuable baseline for a more targeted investigation of the HCSC during COVID-19. Furthermore, we extend the knowledge on how BSRs and the flow of medical supplies change between manufacturers and hospitals in a pandemic. Some of these changes might last beyond the COVID-19 crisis, as, for instance, hospitals retain higher integration and further cut out intermediary distributors.

Moreover, we applied RDT towards studying SCRES in a pandemic setting and empirically confirmed the theories' suitability for research in unpredicted supply environments (Al-Balushi and Durugbo, 2020). Based on our findings, we can acknowledge that different governance mechanisms can help companies to cope with such a challenging situation (Pfeffer and Salancik, 1978). In this context, we confirm one of RDT's central predictions, which states that organizations equally constrained by the same agents (i.e., case companies within the same SC tier) show similar behavior for managing their dependencies (Pfeffer, 1989). However, we reveal that this prediction is applicable only if the agents in comparison have the required capabilities at their disposal, as we could see while comparing private and public hospitals' differently equipped procurement functions.

Bode et al. (2011) and Manhart et al. (2020) find that SC disruptions trigger buffering and bridging activities and that these measures can contribute to successfully managing disruption risks. We confirm this effect for medical supplies manufacturers and hospitals facing severe disruptions caused by a pandemic. We derived seven propositions on procurement-related buffering and bridging strategies for both HCSC tiers. Although some well-recognized bridging mechanisms such as legal contracts (Nandi et al., 2020) were unsuitable for ensuring compliant supplier behavior and supply availability during the exceptional situation, we can conclude from our analyses that bridging measures within the healthcare supply base prove overall more effective to secure medical supplies. In this context, we reveal that Manhart et al.'s (2020) theoretically derived proposition that buffering should complement bridging for optimal risk management can be confirmed but is insufficient to describe companies' behaviors for severe disruptions such as those caused by COVID-19. We find that the present supplier base does not suffice to meet the demand. HCSC actors apply traditional buffering measures internal to the HCSC, for instance, by establishing resource-sharing flows between hospitals or shifting procurement activities upstream. However, novel to previously developed RDT perspectives, we find that the severity of the disruptions caused by the COVID-19 pandemic triggered companies' buffering measures beyond industry borders by engaging in procurement activities with public authorities or establishing cross-industry supply sources. Although basic

RDT research is well-aware of other industries' and governments' potential role in providing resources (Pfeffer, 1989), RDT-based SCRES research left such buffering opportunities widely unexplored so far. Nevertheless, the uncovered buffering measures beyond industry borders confirm previous claims that the more severe an SC disruption is, the more far-reaching the attempts to reduce SC dependencies may result (Bode et al., 2011; Manhart et al., 2020).

In the context of collaborating with public authorities for resource access, our findings reveal another important RDT implication. Previous research suggested that these relationships are tough to manage since governmental bodies usually have heterogeneous interests (Hillman et al., 2009). Our research reveals the exact opposite for an exceptional situation such as a pandemic since all involved parties had the joint target of sustaining HCSC operations. During the COVID-19 pandemic, not differing objectives but operational problems led to challenges with public authorities.

### 6.2. Managerial implications

Our propositions offer essential managerial guidance to cope with pandemic shocks. Overall, and consistent with early indications by Pfeffer (1989), our analyses suggest that with rising external contingencies on the supply-side (in our case, through the consequences of the COVID-19 pandemic), the importance of an organization's procurement function increases significantly. This result mirrors previous claims that an empowered procurement function can considerably contribute to supply-side resilience (Pereira et al., 2020) and encourages managers to more firmly embrace the critical role of procurement for better managing SC disruptions. Our multi-tier research design allowed us to derive individual implications for procurement managers of medical supplies manufacturers and hospitals.

Consistent with our general implications, medical supplies manufacturers are well-advised to focus on bridging measures with existing suppliers and complement their crisis management with buffering approaches. Building on long-term BSRs, intensifying coordination and information exchange, and actively supporting suppliers' procurement can improve supply security in a pandemic. Thereby, procurement managers should ensure timely visibility on their suppliers' delivery capability and proactively establish visibility on (sub-)supplier networks to lay the foundation for identifying support necessities and increasing reaction speed. As for complementary buffering measures, cross-industry collaborations with companies adversely affected by a pandemic can improve supply availability. Manufacturers are encouraged to develop a detailed understanding of idle capacities in a pandemic and proactively establish cross-industry network ties to leverage them when disruptions occur.

As for manufacturers, strong BSRs, effective controls, and increased SC visibility are promising bridging measures for hospitals to improve medical supplies availability in a pandemic. However, buffering measures can have an even greater complementary effect. Hospital procurement should consider expanding its activity scope upstream the HCSC by skipping distributors and directly procure at manufacturers. Such a change in procurement's activity profile will require a broader capability set, including extensive market knowledge beyond the first-tier suppliers, quality assurance competency, and the capacity to coordinate and negotiate with globally dispersed manufacturers directly. Engaging in resource exchange with other hospitals represents another effective buffering measure to reduce dependencies from capacity-constrained manufacturers. Successfully implementing such strategies demands more vital collaboration, frequent coordination, and higher transparency among different hospitals. Moreover, hospitals are encouraged to evaluate the standardization of IT systems and logistics processes across organizations to build the foundation for cross-hospital inventory visibility and the capacity to shift resources quickly. Furthermore, hospitals engaging in procurement activities with public authorities can considerably increase medical supplies availability. The

government's signaling effect and its corresponding ability to assume risk can be leveraged to ensure much-needed capacity increases on the manufacturers' side. However, with the unusual nature of this approach and public procurement insufficiencies detected in this research project, hospitals should not fully depend on governmental bodies to solve supply challenges in a pandemic. There is a clear need for better coordination and collaboration among hospital groups and public authorities engaging in medical supplies procurement. Proactive and joint contingency plans are thus recommended to clarify responsibilities, ensure transparent communication flows, and leverage the high potential of public procurement more efficiently in a pandemic.

### 6.3. Policy implications

The managerial recommendations for hospitals on improving coordination and collaboration with public procurement initiatives need to be complemented by similar actions at public authorities to be successful during a pandemic. Moreover, if governmental bodies decide to adhere to own purchasing, resource allocation, and distribution activities in future health crises, they will need to extend their healthcare procurement and logistics capabilities considerably. This includes expertise in suitable treatment methods, procurement markets and potential suppliers, logistics planning, and quality assurance. Building these capabilities can either be achieved internally or, more efficiently, by relying on stand-by expert teams, including healthcare providers, manufacturers, and logistics service providers, activated in a severe crisis. These groups should support not only strategic decision-making but also operational implementation on regional levels.

### 6.4. Limitations and opportunities for future research

As with any research, our study has limitations, which offer promising opportunities for future research. First, this study was intentionally limited to GSA countries to ensure comparability among the case companies. Even though we were already able to confirm similar findings from other geographies (Finkenstadt and Handfield, 2021), our results might apply to other regions only to a limited extent. Accordingly, we encourage conducting similar research efforts worldwide, where pandemic development and government intervention unfolded differently. This will drive comparability and generalization on a global level. Second, the study was conducted in a healthcare system with a balanced mix of private and public hospitals. We are confident that the derived propositions are similarly applicable in HCSCs with predominantly public infrastructure. However, public hospitals will require comparable purchasing capabilities and political support to reach the SCM proficiency of private players in our sample. Third, due to the research subject's novelty, this paper's findings were obtained through a qualitative and explorative case study design. The derived propositions should be tested via large-scale quantitative studies once reliable financial and operational data for the timespan of the COVID-19 pandemic become broadly available. Fourth, we deliberately limited our research scope on disruptions caused by a pandemic, yet risk management and SCRES are widely unexplored in the HCSC for many other types of risk events (Senna et al., 2020). It would be a promising path for future research to assess this paper's propositions in different risk contexts and investigate whether they can function as broader levers to increase SCRES in healthcare. Lastly, our study revealed the procurement functions' strategic role in a pandemic crisis as well as several considerable changes in its operations and activities. Future research should investigate whether HCSC actors will further strengthen the function's strategic role and importance for risk management and whether the explored changes will manifest under normal circumstances.

### Credit author statement

Alexander Spieske: Conceptualization, Methodology, Data curation, Software, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing, Maximilian Gebhardt: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing, Project administration, Dr. Matthias Kopyto: Conceptualization, Methodology, Data curation, Formal analysis, Investigation, Validation, Writing - original draft, Writing - review & editing, Dr. Hendrik Birkel: Conceptualization, Methodology, Writing - original draft, Writing - review & editing, Supervision.

### Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

### Appendix. Final interview protocol\*

#### Background information

1. What are your roles and responsibilities within your organization?
2. For how long have you been working ...
  - a. ... in supply chain management functions?
  - b. ... with your current organization?
3. What COVID-19-related products or services does your organization offer?

#### Dependencies and challenges in the COVID-19 crisis

4. When and how did you first identify the potential threats, particularly regarding supplies availability, for your organization caused by the COVID-19 crisis?
5. What were the main challenges your organization's supply chain, and particularly your procurement function, faced during the COVID-19 crisis?
6. How did these challenges affect the relationships, power structures, and interdependencies with your suppliers and customers?
7. What was the role of public authorities in that regard? How did these actors' behavior affect your ability to procure or distribute COVID-19-related medical supplies?

#### Measures to improve medical supplies availability

8. What did your organization do to address the previously discussed challenges and ensure COVID-19-related medical supplies availability, e.g.,
  - a. How did your procurement strategy change?
  - b. How did you adapt coordination with your existing exchange partners?
  - c. To what extent did you collaborate with new exchange partners?
  - d. How did you coordinate with governments and public authorities?
9. Which additional measures are you planning to implement in the next months to ensure medical supplies availability?
10. What structural changes are you planning to prepare for a potential future pandemic?

\*Note: Interview protocol was sequentially adapted after case interviews or analysis of secondary materials to enable fact-checking and iterative testing of evolving constructs.

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