A life-saving collaborative network: repairing ventilators in Brazil

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Abstract

Purpose – This paper aims to investigate the formation of an inter-organizational collaboration network that made it possible to repair 2,516 mechanical respirators that were inoperative in Brazil during the first wave of the COVID-19 pandemic.

Design/methodology/approach – A qualitative approach was used in a single case study with semi-structured interviews. The interviewee selection process was non-probabilistic through snowball sampling.

Findings – The results suggest that society, through different social groups with their different roles, can organize itself quickly through the formation of collaborative networks, and this organizational configuration can be an alternative for facing crises where actions isolated would be insufficient or slow to urgently address complex situations.

Practical implications – This paper aims to (1) demonstrate that society, through different social groups with their different roles, can organize itself quickly through the formation of collaborative networks; (2) favor the understanding and dynamics of the formation of a network; and (3) contribute to a possible replication of this initiative in future contexts.

Originality/value – The case portrays an unprecedented formation of a collaboration network involving more than 144 organizations that mobilized quickly in a complex context of a pandemic and that generated remarkable results through the reintroduction of equipment that were responsible for the preservation of thousands of lives during the year from 2020.

Keywords Collaboration Networks, Respirators, Pandemic, COVID-19, Volunteering

Paper type Case study

Introduction

COVID-19 has created one of this century's greatest global health challenges, and has been the first pandemic ever to be caused by a coronavirus (WHO, 2020). With over 200 million cases worldwide and more than four million dead as of August 2021, the disease revealed the dearth and uneven distribution of a necessary device for the treatment of severe cases: mechanical ventilators. These devices provide assisted patient ventilation. Each ventilator is

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estimated to be able to save 15–20 lives (Walker and Whittaker, 2020), which makes the equipment essential and strategic combatting the pandemic.

Before the pandemic, Brazil was the best-equipped country in Latin America when it comes to ventilators, with 32.10 devices per 100,000 inhabitants (Wallace, 2020), but regional distribution is uneven (Rache *et al.*, 2020). Notwithstanding, these numbers are far from ideal, particularly since, out of the 65,411 ventilators available in the public and private healthcare networks, approximately 4,000 were out of commission (Ministry of Health, 2020). The context is aggravated by the fact that 20% of the world manufacturing capacity for ventilators concentrate in China (Wallace, 2020) and Brazil only has four manufacturers of the equipment, with total production capacity for 10 thousand units per year, versus an estimated demand for 14.1 thousand units in the first 90 days of the pandemic alone (Ministry of Health, 2020).

Ventilator scarcity and the inability to quickly manufacture the equipment in the numbers needed to address the pandemic in Brazil drew attention to the approximately four thousand out-of-commission ventilators in public- and private-sector hospitals. The main reasons for their decommissioning included lacking maintenance or the absence of essential parts. They were good targets for effective action, as their reintroduction into the healthcare system would save additional lives. They had to be repaired quickly. However, relying on government measures alone to undertake this appeared risky, particularly in the light of the incumbent administration's negationist attitude during the health crisis (Giovanella *et al.*, 2020; Fonseca, Nattrass, Lazaro, & Bastos, 2021).

Given this context, this paper aims to examine the advent of a specific phenomenon created by collective actions taken to address a portion of the dearth of ventilators in the public healthcare system: the formation of an interorganizational collaborative network. The initiative involved more than one hundred actors that devoted efforts to emergency repairs to more than four thousand faulty mechanical ventilators. **The article's driving question is: How did the interorganizational collaborative network form to repair ventilators?** To answer it, the study will rely on the concept of organizational networks and a multi-level case study approach, as discussed in the upcoming sections.

It is worth mentioning that the pandemic and the formation of a collaborative network to face it can be seen as a case of disrupted contexts as introduced by Hällgren, Rouleau, and De Rond (2018). According to them, extreme events like the COVID-19 pandemic may encourage organizations to act outside the boundaries of their core activities or communities, and are often portrayed as unique, unprecedented, or even non-classifiable. Therefore, and unlike contexts of risk, they do not usually enable organizations to prepare in advance. In this sense, this article may also be of assistance in the quest for answers on how organizations may operate in disrupted contexts by studying the roles of the various stakeholders involved in the initiative to create a collaborative network.

Theoretical background

Interorganizational collaborative networks

The subject of organizational networks is traditionally part of the organizational studies area. They are treated as a theoretical alternative to the understanding of the novel and complex relationships involving organizations and the many agents that form a dynamic and uncertain environment. Although it may occur in different contexts, the formation of networks may provide the basis for the construction of mutual support frameworks and collective action facing epidemics and pandemics (Pisano, Sadun, & Zanini, 2020; Kenis, Schol, Kraaij-Dirkzwager, & Timen, 2019).

Networks are therefore multi-organizational arrangements formed to address problems that cannot be easily approached by a single organization (Gausdal, Svare, & Möllering,

2016). The relationship between members may be voluntary, their activities may be mutual or reciprocal and belonging to a network does not imply effects in terms of the members' autonomy and independence.

Denoting a reciprocity condition, an organization may join a network if it has some kind of resource (information, service or good) relevant to the other participants, in the same way that the organization itself seeks to obtain resources from its partners. "Network structure" concerns the manner in which relationships connect the organizations, that is, through direct (strong) or indirect (weak) relationships. In direct relationships, organizations interact without the presence of intermediaries. In indirect relationships, by their turn, they only interact through other organizations with existing relationship ties in place.

Bryson, Crosby, and Stone (2006) define interorganizational collaborative networks as a connection, or the sharing of information, resources, activities and abilities of organizations from two or more sectors toward an outcome that could not be attained separately in a single sector. Such networks may be regarded as a means to address social and population issues like pandemics by bringing to bear a set of resources and increased capabilities (Hoberecht, Joseph, Spencer, & Southern, 2011). In many cases, such networks are also inter-sectoral, as many public challenges demand collaboration involving the government, business firms, nonprofits, communities and/or the public at large (Popp, Milward, MacKean, Casebeer, & Lindstrom, 2013).

The collectively perceived urgency of collaboration in the face of a pandemic may be useful to understanding network formation based on the logic of tact as introduced by Kornberger, Leixnering, and Meyer (2019), whose central purpose is to offer an alternative means of understanding how decisions are made in times of crisis. According to the authors, relevant social groups (RSGs) can make "tact"-oriented decisions under conditions of bounded rationality and transgression of their individual identities. Tact, in this sense, indicates the prudence and caution the various agents should show in the face of the severity of the pandemic, marked as it was by an exponentially increasing death count and the inertia of Brazilian government agents (Fonseca *et al.*, 2021). In other words, the logic of tact may enable the parties involved to retain their decision-making ability while acting collectively, even in the absence of a shared set of governing rules.

Understanding the formation of interorganizational networks

In a groundbreaking work on organizational networks, Oliver (1990) pointed out certain contingent factors for the formation of interorganizational networks, without however providing details on how they concur to the formation of such networks: resource needs, power asymmetry, reciprocity (which foster cooperation, collaboration and coordination between organizations); organizational efficiency; stability; and legitimacy (supported by institutional theory).

The construction of collaborative networks finds strong theoretical support in New Institutional Economics (NIE), as seen in Ménard (2004), which has been providing highly valuable theoretical and explanatory approaches to understanding the boundaries of the business firm. These theoretical approaches seek to find the extent of competitive advantages based on the institutional arrangements that ensure efficiency in certain contexts (Barzel, 2005).

Therefore, according to Ménard (2004), hybrid forms of organization evade the costs of rigid organizational hierarchies. The authors argue that networks may operate beyond the efficiency frontiers of contracts. In this sense, the formation of a ventilator-repairs network as portrayed in this paper, free from contractual ties between participants, represents lower formalization, as expected according to NIE.

The identification and study of alternative organizational arrangements has been a lengthy and ongoing process. Recognizing this diversity has an important consequence for theoretical developments, but also for policymakers: in most cases, there is no one-size optimal solution to organize transactions. Addressing the pandemic crisis may thus provide a lab for testing interorganizational networks.

Appio, Martini, Massa, and Testa (2017) provide an alternative approach to understanding the formation of interorganizational networks that relies on the Input – Process – Output (IPO) framework. From a positivist point of view, conditioners (relational, structural, cognitive and mixed factors) enable the creation and evolution of collaborative networks by means of process elements (models, governance and value management and alignment), fostering innovation and potential performance gains.

Despite the relevance of the constructs articulated by Appio *et al.* (2017) to understand aspects of the formation of collaborative networks, the authors' theoretical view cannot explain the uniqueness of the phenomenon at hand, nor the absence of similar collaborative networks in other contexts and countries even where the same elements and conditioners were present.

An alternative way of understanding network formation is through the multilevel framework as proposed by Pozzebon and Diniz (2012). This is a dynamic theoretical model that articulates concepts from the IPO framework, in particular those that concern the "process" of collaborative networks creation.

The multilevel framework is a pluralistic theoretical and methodological framework based on concepts derived from Social Shaping of Technology (SST), contextualism and structurationism. It was devised to explain the advent of socio-technological phenomena and has been used in almost one hundred studies, including some involving network creation and methodology-in-practice (Lavoie, Pozzebon, & Gonzalez, 2011).

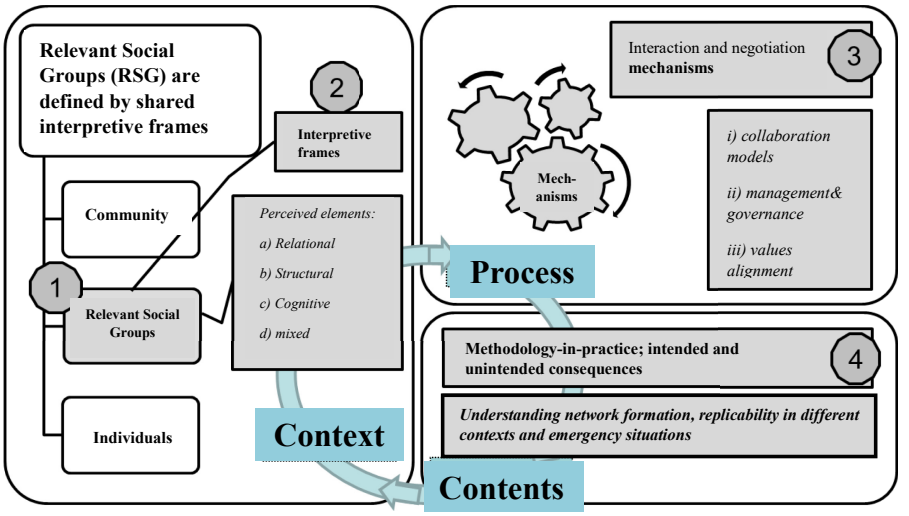
The core concepts of the multilevel framework are RSGs, interpretive frames, negotiation and interaction process and technology or methodology-in-practice. These four concepts articulate on three analytical dimensions: context, process and content.

Pozzebon and Diniz (2012) emphasize that the model is non-deterministic, that is, the presence of conditioners or other factors does not necessarily imply that a phenomenon – a collaborative network, in this case – will occur. The explanation arises from the interests and views of the RSGs, which contribute to the final social shaping of the artifact, network or system through mechanisms of interaction and negotiation. Inspired in Giddens's agency theory, and more specifically in the duality of the structure, the model tends to be dynamic and recursive. Influence is mutual between actor and subject.

What the authors fail to clearly define – and openly suggest as a gap to be filled by future studies – is how the "process" dimension occurs in practice. Given this paper's purpose of explaining the creation of a unique collaborative network, we added elements of the IPO framework to the multilevel framework to form the study's theoretical-methodological framework (Figure 1).

Context dimension. RSGs are defined by agents that share a single interpretive frame of a certain phenomenon, with similar assumptions, expectations and interests. Identification of the RSGs, requires understanding the interpretive frames of the agents, which, for the purposes of this paper, also includes how they perceive the following: (1) relational elements – relationship quality and typology, including trust and reputation; (2) structural elements – use of process-supporting structures or systems; (3) cognitive elements – knowledge, skills, experience, etc. of the parties involved; and (4) mixed network elements.

Process dimension. Interaction and negotiation mechanisms pervade the dynamic relationship between RSGs, which, for the purposes of this paper, may also be explained by (1) collaborative models, or attempts to create collaborative network taxonomies; (2) management and governance, involving partner selection, the development of a joint action



Source(s): Adapted from Pozzebon and Diniz (2012)

Figure 1.
Multi-level theoretical and methodological framework

strategy, methods and tools for network management and dispute resolution; and (3) values alignment, establishing a shared value system.

Content dimension. The interaction and negotiation process between RSGs may lead to results other than those expected at first, such as innovation in terms of an adapted artifact or process (ventilator repairs done by an ad-hoc collaborative network) or, given this study's context, a methodology-in-practice which is the understanding itself of the network's formation process, which may potentially be replicated in different contexts and emergency situations.

Methodological procedures

The qualitative approach is the one that best meets this study's objectives. Its eminently interpretive and emerging nature (Cresswell, 2007) appropriately fits the study's scope and objectives by enabling explaining or understanding a phenomenon, a process, or a combination thereof.

The case study method provides the best investigative strategy, as it is recommended for situations where one aims to understand the circumstances under which a contemporary event acts on reality (Yin, 2014). The study sought to determine how certain agents acted to create an arrangement of companies sharing a common purpose. Given certain phenomenon-specific characteristics, such as its exceptional nature and difficulty comparing it with phenomena (Lazar, Feng, & Hochheiser, 2017), the authors chose the single-case study method to conduct their investigation.

With the research strategy defined, the authors then established the boundaries of the subject at hand (Singleton & Straits, 2009): an interorganizational network devoted to repairing mechanical ventilators. They determined that understanding the phenomenon required identifying the stakeholders directly involved in the network's formation.

Based on the framework proposed by Pozzebon and Diniz (2012), we initially identified the RSGs and their interpretive frames in connection with the phenomenon at hand (context dimension), to then analyze the formative process of a unique collaborative network (process dimension) and, finally, evaluate the results achieved (content dimension).

The study also attempted to understand how the RSGs interacted to create a shared-purpose organizational arrangement. Given the uniqueness of the phenomenon and the difficulty comparing it with others (Popp, Milward, MacKean, Casebeer, & Lindstrom, 2013) the investigation used the single-case method.

Because of the lack of preexisting documentation on the phenomenon, the authors held semi-structured interviews as a preferred data-collection method. The interviewee selection process was non-probabilistic and used snowball sampling, which is recommended in situations where the relevant population cannot be clearly defined. In these cases, sample formation takes place by means of connections between actors, who refer the investigation to other actors until the sample reaches the desired size. The non-random nature of the process, however, prevents results generalization (Lazar *et al.*, 2017).

One active player on the interorganizational network was identified and interviewed; subsequent interviews took place based on referrals from previous interviewees. All eight interviews took place on the Zoom platform in June–December 2020, for a total of 520 minutes and average duration of 65 minutes. Two or more researchers took part in every interview. Interviewers took note of the most relevant points raised and the interviews were recorded and later transcribed. All interviewees were asked to provide documents and data, which this paper also employed. Their names have been omitted, and they are identified by the respective job titles. With the identification of different interpretive frames, the interviewees were grouped into RSGs (Table 1).

The interviews were encoded and categorized (Bardin, 2006), and organized into groups before any interpretation was produced. After checking for tautology and topic similarity, we arrived at three analytical classes, or codes, as follows: network agent prospects (context dimension), formation of the interorganizational network (process dimension) and effective results achieved (content dimension). The results are shown next, organized based on the three dimensions.

Results analysis

Content dimension: relevant social groups and their roles

The interviews showed that the quality of the relationships on this *ad-hoc* network, including trust between members and the reputation of one of them, enabled it to grow quickly because of the participants' shared interests: contributing to a humanitarian cause as the Ministry of the Economy's (ME) representative explained:

> It was early in the pandemic. I was talking to the Ministry of Health's Technical Consultant about ventilator production when she mentioned that the hospitals had many broken ventilators. (...).

Relevant social group	Interviewee profile	Duration (minutes)	Date
1. Government view	General Business Environment Coordinator, *Ministry of the Economy*	58 56	Jun/14/2020 Jun/22/2020
2. Healthcare management view	Expert Technical Consultant to the Health Technology and Innovation Management and Incorporation Department, *Ministry of Health*	57 52	Jun/22/2020 Jun/25/2020
3. Governance and private sector view	Director of Automotive Engineers Association (AEA)	63	Jul/21/2020
4. Technology view	Innovation Manager at *SENAI* Nacional	80	Jun/15/2020
5. Manufacturing view	Manager of a *carmaker*	63	Jul/21/2020
6. Supplier view	Manager of a *ventilator manufacturing company*	65	Dec/04/2020

Source(s): Prepared by the authors

Table 1. RSGs and interview details

> Then I thought: **if we leave it up to the government, the repairs are never going to happen.** Then I called the AEA director and suggested getting carmakers to do the repairs. He agreed and I said: You will act as coordinator on the private-sector side (...) we formed a WhatsApp group for the maintenance taskforce to get it all organized. With his agreement, the job would get done. He is quick, collaborative and reliable. (RSG1 INTERVIEW)

The professional relationship between the government officials and the AEA director was lasting and fruitful: they had previously taken part in several initiatives leading to ample collaboration. Furthermore, the interviewees described this director as someone with free transit and good connections with various actors in society's productive sectors. He was accordingly named the individual best equipped to manage the processes and relationships surrounding the taskforce, as reported by the AEA director himself:

> The Ministry of the Economy official quickly identified 3,500 broken ventilators across the country. "Are you willing to fix them," she asked. I told her to leave it to me. **After one week, I was already in touch with many companies in different industries, and we put together the taskforce**. This was only possible because I know the people involved. I knew that the people I asked to join and accepted would contribute their knowledge. (...). Every agent was important. Each of them had some kind of knowledge or resource they could offer to make it happen. (RSG3 INTERVIEW)

According to this narrative, and based on the other interviews, the people that the AEA director contacted showed a shared sense of urgency collaborating with the most in resources and expertise, each in their particular area. The use of government officials to interface with hospitals was evidenced by the depositions of the ME's general coordinator and the Ministry of Health's consultant. According to the coordinator, a memorandum was drafted to enable the hospitals to surrender the respirators to be repaired:

> As soon as we put together the maintenance taskforce's WhatsApp group, we made the memoranda available [...] to send to every hospital and collect the broken ventilators. A ME memo lent confidence to hospital managers, who might otherwise resist handing over the devices for fear of not ever seeing them again. With the document in hand (SEI Memorandum No. 77363/2020/ME), in different states and cities, it was far easier to collect the equipment for maintenance purposes. (RSG2 INTERVIEW)

The interviews also showed that there was an isolated effort of SENAI [1] – Integrated Manufacturing and Technology Campus (CIMATEC) in Bahia to carry out ventilator repairs. This was key for the network to obtain the capacity and technical skills to fix the ventilators, contributing to the cognitive-interpretive frame insofar as interviewees in general perceived that the agents involved contributed significantly to the exchange of knowledge. As the institution's National Innovation Manager stated:

> The AEA director contacted me to say that they had set up a taskforce to expedite ventilator repairs. I told him that we were doing something like that internally at SENAI. We decided to work together and join forces. Then, in less than a week, we built the protocols to train the repair sites, using our people's technical know-how and the automotive industry's processes (...) The agents helped out with the entire infrastructure needed to enable the repairs. And the AEA director coordinated the whole thing. (...) A ventilator's complexity is comparable with an aircraft's. At every repair site in each state, we had to create the structure needed to handle the job. We formed a partnership with Brazilian Association of Clinical Engineers (ABCLIN) that got us volunteer clinical engineers and calibration companies, sharing their expertise in maintenance and the drafting of the technical reports needed to make sure that the devices were working in line with the required parameters. (RSG4 INTERVIEW)

The interviews also indicated that SENAI's reputation was essential for the ME and Ministry of Health to issue a memorandum enabling the collection of ventilators for repairs. As a

hospital manager stated, the reputation and the quality of the relationship between hospital managers and local SENAI branches were key to get the ventilators repaired.

If the memorandum lent institutional support to the initiative on the one hand, on the other it was the informal commitment of the SENAI staff that the ventilators would be repaired that established a trusting atmosphere. The transfer of expertise, as well as the provision of the infrastructure needed to support the network's processes, were clearly portrayed in the automotive industry representative's words:

> The AEA director put me in touch with ventilator manufacturers and suppliers. I visited their facilities to see how we might be able to help. We realized that the entire production of the only four makers in Brazil was artisanal. My team and I surveyed all of their processes. Using our manufacturing y experience, we mapped their bottlenecks, that is, what was affecting their capacity, or what we might do to improve it, increasing the supply of new ventilators. (...). With adjustments and the application of our knowledge and technology, we were able to double the ventilator production capacity. At the same time, we made available a portion of our production line to handle the ventilators coming in for repairs. (...) The car industry overall offered space, equipment, labor and cash to enable the effort. And each of the agents in the taskforce made its structure available in some way to make it happen. Because it was no use repairing a ventilator if the logistics, for example, wasn't there. And so, several strong companies with different kinds of expertise got involved as well. (RSG5 INTERVIEW)

The manager of a ventilator maker added:

> Based on a review of our process and of the technologies used, the automotive industry people quickly went over how we might be able to reorganize it all: processes, simple and inexpensive technologies, workforce training. They took the expertise from their industry and brought it into ours. We quickly doubled our production capacity. This meant more ventilators for the domestic market. In exchange, we offered our expertise to produce parts that the market was short of. They were essential to repairing the respirators. (RSG5 INTERVIEW)

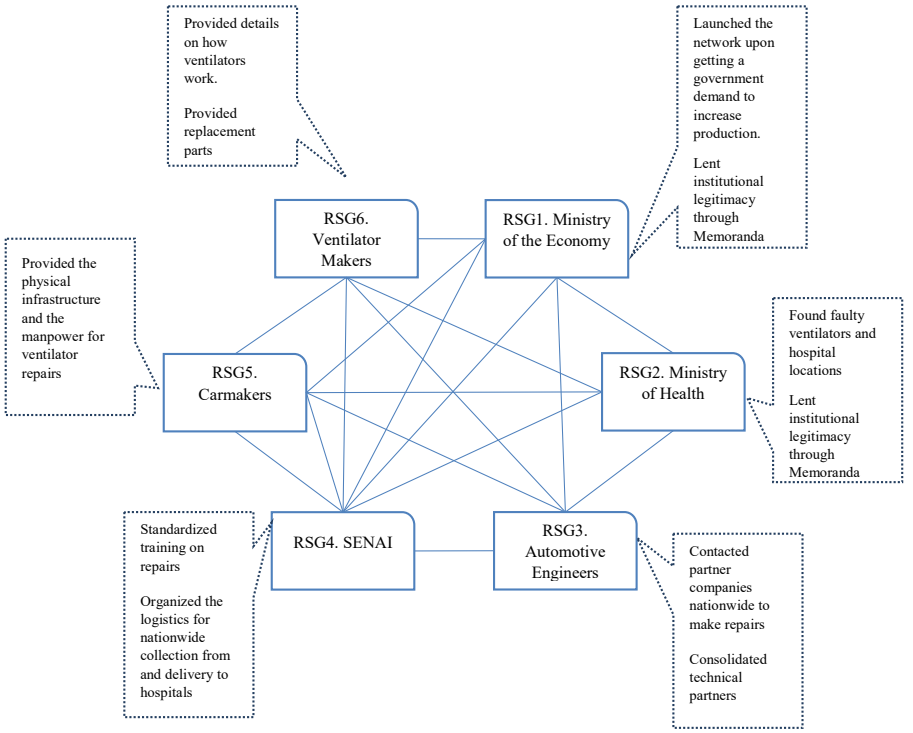
The narrative above shows the complementary and mutual interests to increase the number of ventilators repaired. Replacement parts suppliers were overpricing their goods, which prevented repairs. To address this issue, ventilator makers and the car industry perceive the same interpretive frame – cognitive – when they report the exchange of knowledge between two such different industries.

The context dimension shows that the Ministries acted mainly to (1) lend institutional legitimacy to the network before state governments and (2) remove several legal and bureaucratic hurdles, the SENAI played the key role of (3) enabling the car industry, which (4) provided the infrastructure and staff to carry out ventilator repairs and (5) organize the nationwide logistics effort. Figure 2 depicts the network created (Figure 2), interpreted in terms of the context dimension with the respective RSG's roles on the collaborative network. Based on the documents provided by interviewees, the researchers identified another 108 companies and entities that lent local support to repair sites, offering volunteer services entirely free of charge.

A collaborative network formed with more than 100 actors involved from all kinds of social groups, playing different roles that were essential to the project's success, as Table 2 describes.

Process dimension – formation of the collaborative network

The interviews show that the collaborative network was born out of an urgent need to meet a significant increase in the demand for mechanical ventilators because of the COVID-19 pandemic, as new imports and an immediate increase in domestic production capacity would be insufficient. The ME became involved in this matter from the beginning of the pandemic,



Source(s): Prepared by the authors

Figure 2.
Network representation with the relevant social groups and their roles

Funding
Parts procurement
Ventilator calibration
Technical consultancy
Project activities control
Ventilator diagnoses
Donations of parts and surgical materials
Reports issuance
Repair equipment
Physical space and infrastructure for repairs
Ambient and ventilator sterilization and hygiene
Locating parts
Parts logistics
Ventilator logistics
Electronic parts repairs
Signage
Technical support
Quality testing
Training
Volunteers

Source(s): Prepared by the authors

Table 2.
Activities undertaken by the local support networks

and was responsible for importing new devices and managing a project to increase the Brazilian production capacity for ventilators.

The pre-existing and ongoing relationship between the ME representative and the AEA director was vital to the network's formation, causing the latter to be asked to join a messaging app discussion group on the ventilator issue. According to the AEA director:

> We have a **lengthy relationship** with the government for industry-oriented policy [...] giving technical support for lawmaking, concepts, translations of concepts connected with the industry's activities. So they asked me to a meeting to join the group on Saturday, and there were lots of people talking on WhatsApp about what you could or could not do. (RSG3 INTERVIEW)

The ME representative was already aware of SENAI – CIMATEC's isolated efforts to repair ventilators; what was left was the challenge of replicating the experience at the national level.

When questions were raised on the number of faulty ventilators, the ME representative contacted the Ministry of Health representative to respond and asked to join the discussion group. The Ministry of Health representative reported that there was a list of decommissioned ventilators available, produced by the Unified Healthcare System Permanent Equipment and Materials Information and Management System (SIGEM), which reports to the Ministry of Health. AS the AEA director described it:

> on Sunday [March 15, 2020], at 10 a.m., the ME calls to say, "We found 3,500 broken ventilators, will you repair them?" And I said, "We will." (RSG3 INTERVIEW)

The next challenge was to obtain the technical knowledge for the car industry to become involved in ventilator repairs. SENAI transferred the required knowledge, as its National Innovation Manager explains:

> We have a huge innovation structure in place at the SENAI, but did not know how to contribute in this case. [...] With the SENAI Bahia, **we created a protocol** for how to accept, clean and maintain ventilators, because we have a highly skilled team of medical doctors and engineers there. In less than one week, we created an environment where people could get information, created a technical channel for questions, and a four-hour **skills program** for the repair sites. A new site was engaged each week, all of them volunteer, paying from their own pocketbooks. (RSG4 INTERVIEW)

The collaborative network was therefore devised with the ME, the Ministry of Health, the SENAI and the car industry – represented by the AEA director – as its main actors. The AEA director was entrusted to increase the number of participants. In his words:

> I called my friends at the SENAI in Brasília and said, "let's do this, let's get this done" and it just skyrocketed, then I got in touch with my peers at the carmakers, [...] I have a group with representatives from every carmaker and, at the same time, I am Manufacturing Director at the AEA so, in addition to the carmakers, I have the parts center by my side, I have the Academia people with seats at the AEA. So I grabbed the phone on Sunday (March 15) afternoon and **spent the whole day calling people** to see if we could do this; they joined very quickly: "sure, what do I have to do", and I said "this, and this and this". And we went and did it. (RSG3 INTERVIEW)

The industry then voluntarily took the initiative to prepare areas for this purpose. In a single week, 29 maintenance sites were created with support from every carmaker, setting up areas devoted to ventilator repairs on their production sites. "In just one week, we set up a nationwide logistics network to do the repairs," the AEA director reports.

Other industries soon joined the carmakers, forming a network of 40 repairs units supported by more than 104 local partners across the country. Table 3 shows the distribution of ventilator repair units by state.

State	Repair units
Amazonas	1. Moto Honda da Amazônia
	2. Instituto SENAI de Inovação em Microeletrônica
Bahia	3. FORD – (Camaçari)
	4. SENAI CIMATEC
Ceará	5. Troller
	6. IST em Eletro-metalmecânica
	SENAI AUA
Federal District	7. SENAI Taguatinga
Espírito Santo	8. NAI Arivaldo Silveira Fontes – SENAI CETEC
	9. Vale – Unidade Vitória
Goiás	10. SENAI Vila Canaã
	11. SENAI Rio Verde
Maranhão	12. SENAI Raimundo Franco Teixeira
Mato Grosso	13. SENAI Várzea Grande
	14. SENAI Rondonópolis
Mato Grosso do Sul	15. SENAI FATEC Campo Grande
Minas Gerais	16. Fiat Chrysler Automóveis (FCA) – Planta Betim
	17. Usiminas
	18. SENAI FIEMG – CIT
	19. Arcelor Mittal Aços Longos– Centro de Inovação ArcelorMittal para Indústria (CIAMI)
Para	12. SENAI Getúlio Vargas
Paraíba	13. Centro de Formação Profissional Prof. Stenio Lopes
	14. Instituto SENAI de Tecnologia em Automação Industrial
Paraná	15. Volvo do Brasil Veículo
	16. Renault - Planta Curitiba
	17. Instituto SENAI de Tecnologia em Meio Ambiente e Química
Pernambuco	18. Fiat Chrysler Automóveis (FCA) - Planta Pernambuco
	19. SENAI Escola Santo Amaro - PE
	20. IST em Metalmecânica - PR
Rio de Janeiro	21. Jaguar Land Rover América Latina e Caribe
	22. Fio Cruz
	23. Estúdios Globo
Rio Grande do Norte	24. SENAI Natal
Rio Grande do Sul	25. GM - Planta Gravatai
	26. Instituto SENAI de Inovação em Soluções Integradas em Metalmecânica
Rondônia	27. SENAI Rondônia
Roraima	28. SENAI Carlos Salustiano de Sousa Coelho
Santa Catarina	29. GM - Planta Joinville
	30. BMW do Brasil
	31. ISI em Sistemas de Manufatura e Processamento a LASER
São Paulo	32. GM - Plantas de São Caetano do Sul, São José dos Campos e Idaiatuba
	33. Toyota - Planta Sorocaba
	34. Honda Automóveis do Brasil – Fábrica de Sumaré
	35. Scania - SBC
	36. Escola SENAI "Mariano Ferraz"
	37. Instituto de Pesquisas Tecnológicas (IPT) e POLI-USP
	38. Mercedes-Benz do Brasil - São Bernardo do Campo
	39. Volkswagen do Brasil
	Unidade de Produção Anchieta
	40. Hyundai Motor Brasil

Source(s): Prepared by the authors

Table 3.
Ventilator repair units in Brazil

Content dimension: results and methodology-in-practice

The organizational network's collective actions began in April 2020. The 40 maintenance sites received 4,047 ventilators, of which 2,516 were repaired and returned to the Brazilian healthcare system (both public- and private-sector). By the end of the period, 1,531 ventilators were found to be beyond repair, as Figure 3 shows. Therefore, in one hundred fifteen weeks, the network was able to repair, at no cost to the hospital care system, more than 60% of all ventilators received.

The main consequence of the return of the ventilators to the healthcare system lies, above all, on the potential to save lives. This, in fact, was a key factor behind the collaborative network's construction. As the National Innovation Manager at SENAI emphasizes:

> Every ventilator can save 10 to 20 lives in this period we are experiencing. Considering that, out of 4.021 ventilators, just under one-third was beyond repair, we are talking 2,398 ventilators that could be repaired. Come on, that's more than 24,000 lives, at least! (RSG4 INTERVIEW)

The ventilators not only save lives, but also save public healthcare system resources that could be put to other uses. Furthermore, there was a clear and unprecedented contribution to the country in terms of now to carry out processes that, under different circumstances, would not have such relevant results. As the ME representative explained:

> The process made history in several ways. First, because no one refused the invitation. They [the agents] didn't want to hear about contracts, or negotiations about what each one would contribute; the government did what it could to facilitate and, in our country, the government often gets in the way. Anyway, we did what we could on the government's end to make it happen. It didn't matter how hard we hard to work for it. The agents, on the other hand, didn't go into their usual competitive spiral. They all did what they could, without sparing efforts, without asking for anything in return. It was spontaneous. (RSG1 INTERVIEW)

This innovation in terms of how to run processes, adapting them to achieve significant gains on each end of the chain, was clear from the words of the Ventilator Maker's manager:

> Out of nowhere, you get a visit from a multinational's team at your company, looking into how to improve your processes, develop new technologies or adapt them to make ventilator production

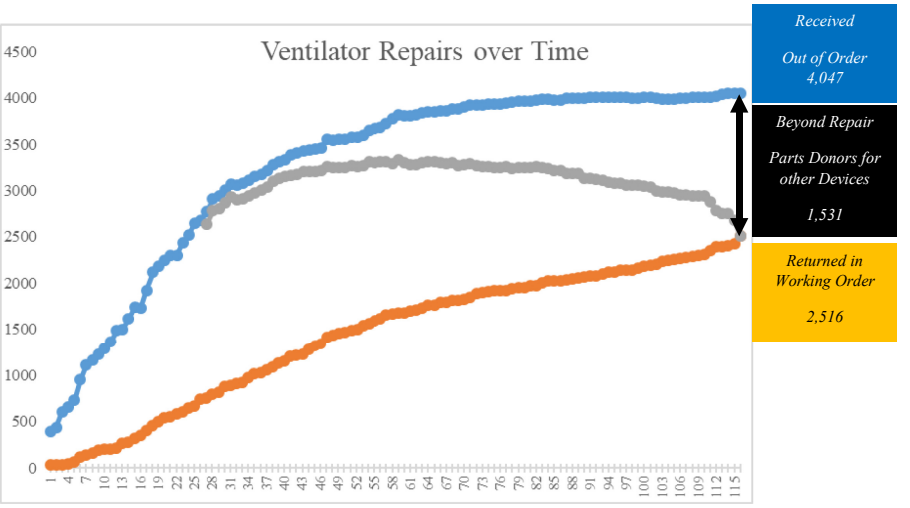


Figure 3.
Results achieved by the organizational network's collective action

Source(s): Materials provided by Relevant Group 3

> faster, more efficient. They took the effort to think alongside with us. (...). They added significant innovation to our segment with processes and ideas. Our industry has always been highly artisanal. Then comes some guy who knows a lot and transfers knowledge, thinks everything over with the firm. Without expecting anything in return. (RSG6 INTERVIEW)

Similarly, innovation took place to fill a dearth of parts on the market. As the AEA director, one of the taskforce's coordinators, put it:

> Coordination was very peaceful. It took attention to detail, but it just flowed. Every one collaborated without creating issues (...). The only ones that didn't collaborate were the parts suppliers. They wanted unreal prices for the repairs, it would be more expensive than buying new equipment. We didn't care. We made the dye casts at the carmakers. We had people with the skills for it. We left them aside and moved on. The agents were many, but the WhatsApp group made coordination easy because it was an informal and quick way of communicating. (...) If someone asks what the phases were along the process, I'll say: every group of agents was different because they were very diverse. We handled things case by case, region by region, individually. (RSG3 INTERVIEW)

Finally, the initiative produced two important outcomes: effective repairs on thousands of respirators, which was a goal from the beginning, and know-how on how to establish an emergency collaborative network, which is particularly useful in the face of public health crises. This knowledge stands as a methodology-in-practice (Lavoie, Pozzebon, & Gonzalez, 2011) and was another important and unintended consequence of the collaborative network.

Indeed, the initiative to repair thousands of ventilators, involving more than one hundred actors, was a quick response to a complex and urgent problem. Its unique, possibly unprecedented, nature can be seen in more than just the number of volunteer stakeholders driven by a common purpose. Also noteworthy is the fact that at no point was the network formally or contractually established, which may have been a determining factor for the achievement of quick solutions. On the other hand, also remarkable us the interviewees' ability to form a much more comprehensive system by connecting people and groups that lacked physical or cognitive access to one another. This, as Long, Cunningham, & White (2013) point out, is crucial to the healthcare sector, which is rich in silos and clusters of isolated agents.

Conclusions

The collaborative network that this paper discusses began within a specific context: a collective perception of various social groups of the need for concrete actions to face the pandemic. Upon receiving a demand from the government for a project to incentivize ventilator manufacturing, the social group comprised of the Ministries of the Economy and Health became aware of the number of decommissioned ventilators in Brazil. It was a unique opportunity to bring thousands of devices back into service.

The initiative to repair thousands of respirators, involving more than 140 actors, was a quick response to a complex and pressing problem. Its unique, perhaps unprecedented, nature can be seen not only in the number of stakeholders that engaged voluntarily, driven by a shared purpose. Also noteworthy is the fact that at no point was the network formally or contractually established, which was probably key to the advent of fast solutions. Dynamic events subject to great uncertainty. As those that emerge in a pandemic, appear not to respond well to formal plans or the bureaucratic structures behind them (Clarke, 1999). In the case of the network at hand, such formalization would normally be the government's purview, but the government acted deliberately in the opposite direction, choosing to remove bureaucratic and legal hurdles over institutionalizing the project, which would risk political interference, as the ME's representative reported.

As Pozzebon and Diniz (2012) argue, new social groups sharing an understanding of the interpretive frame (the pandemic itself and the government's inertia) could become involved

in the collaborative network's initiative. In this sense, expected contributions to facing a crisis was the cement that joined the other social groups involved, such as the car industry, the SENAI, and ventilator manufacturers themselves.

Relevant conditions for emerging collaboration, such as introduction of the problem to a group of people that gathered to solve it, encouragement of interaction between agents, and the development of immediate actions (Beck & Plowman, 2014) were determinant to the initiative's success. Dynamic behavior did in fact take place between the groups, through aligned values and the development of a joint action strategy, but there was also, and above all, a pragmatic approach to management of the crisis, particularly as concerns emerging coordination through relational work and rules simplification (Ansell & Boin, 2019).

Clearly, the circumstances of the network's creation also shed light on the relevant social group's ability to understand, manage and engage with complex social situations while under the influence of external pressures. In this respect, the logic of tact as introduced by Kornberger *et al.* (2019) may be used as an additional explanatory factor, and the collaborative network may serve as an example of how decisions were made during a crisis in Brazil.

Thus, while facing an unprecedented crisis like the pandemic, agents made decisions even as the present was uncertain and the future was unpredictable. Under such circumstances, action does not take place according to a given frame of meaning. Instead, participants within a crisis context are forced to learn by means of ad-hoc interpretation of the facts, even as they act in accordance to them. In other words, the pandemic generated a crisis in Brazil and the creation of the collaborative network was the RSG's response to an uncertain future in the early days of the crisis, while facing the need to make radical decisions (Kornberger *et al.*, 2019).

On the results dimension of the framework proposed by Pozzebon and Diniz (2012), this paper's findings are striking. If every ventilator is in fact capable of saving between 10 and 20 lives, then the reintroduction of repaired devices by the organization net and by collective action associated with the various social groups involved and portrayed in this paper must have saved more than 25 thousand, according to a conservative estimate.

Aside from this remarkable public-health feat, the study's results also contributed to an understanding of the formative elements and process of the collaborative network at hand, as well as to a potential replication of this know-how in other emergency contexts and situations, as methodology-in-practice. In this way, other examples of future situations that would require a rapid mobilization of different social groups, including future pandemics or extreme situations of war or humanitarian crises, could benefit from understanding the experience of creating the collaboration network portrayed in this paper.

So we would like to put that this study's results may not be capable of generalization to the formation of all collaborative networks. However, the formative elements of the network and the understanding of the dynamics of its formation may contribute to a potential replication of the initiative in future contexts.

Finally, we emphasize the interviewees' ability to connect people and groups that had no physical or cognitive access between themselves, or the foundations of trust, forming a far more comprehensive system. This, as Long, Cunningham, and White (2013) emphasize, is central to the healthcare industry, which is rich in silos and clusters of isolated agents.

Note

1. The National Industrial Learning Service ("Serviço Nacional de Aprendizagem Industrial" – SENAI) is a trade education complex active in Brazil and Latin America (http://www.portaldaindustria.com.br/senai/institucional/). Its courses train workers for 28 fields of manufacturing in Brazil, from professional initiation to graduate and post-graduate technology degrees. Since its 1942 creation, more than 73 million Brazilian workers have graduated from SENAI's programs in 28 fields of manufacturing. Its funding comes from mandatory contributions levied on contributing companies' payroll expenses.

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