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Building Resilient Supply Chains Through Flexibility: a Case Study in Healthcare

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ABSTRACT: This research seeks to understand how the capability of flexibility manifests itself for the formation of resilience in service supply chains. The survey was conducted through a single case study of a hospital chain that was impacted by the H1N1 pandemic in 2009. This analyzed chain was formed by the hospital, doctors, nurses, the Ministry of Health, State Secretary of Health of São Paulo and the pharmaceutical industry. As a result, the following categories of flexibility manifestation were identified: redesign, alteration/creation, prioritization, redundancy/availability/robustness and elimination.

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1. INTRODUCTION

The increased competition and pressure for constant innovations led companies to seek efficiency in its operations and chains (CHRISTOPHER; PECK, 2004). Because of that, companies have become leaner in their processes, reducing inventories and activities with fewer maneuver options; increased the outsourcing activities in order to focus on its core business, thus increasing the amount of links in the chains, making it longer and more complex; and, sought lower costs and higher quality, causing several activities to be located in other countries, fragmenting the chains in political contexts, economics and diverse societies (BLACKHURST et al., 2011; CRAIGHEAD et al., 2004; PETTIT et al., 2013; PETTIT et al., 2010).

The mere existence of supply chains already make them exposed to suffering disruptions, and since these factors described serve to increase their vulnerability, negative reflexes can appear in all their links, even to the final consumer (CRAIGHEAD et al., 2007; PONOMAROV; HOLCOMB, 2009).

Generally speaking, in recent years the research related to Supply Chain Risk Management focused on the study of strategies for risk mitigation either by reducing the probability of the occurrence of adverse events to the chain or on mitigating its effects once they happen, with the understanding that they can be anticipated (JÜTTNER; MAKLAN, 2011). On the other hand, the increasing occurrence of disrupting events has led researchers and executives to question this traditional look of risk management, where normally they do not consider risks with low probability of occurrence or uncertainty, or events that cannot be anticipated (JÜTTNER; MAKLAN, 2011; PETTIT et al., 2013; PETTIT et al., 2010). In addition, the strategy to evaluate and develop plans for mitigating each of the potential risks could prove to be expensive and time consuming, often times not taking priority in a day to day corporate schedule (PETTIT et al., 2010).

In this regard, recent research has been devoted to understanding factors that make a supply chain resilient in different situations, in order to cover this gap in traditional research of risk (JÜTTNER; MAKLAN, 2011; PETTIT et al., 2013; PETTIT et al., 2010). Resilience of supply chains is defined as "The adaptive capacity of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function" (PONOMAROV; HOLCOMB, 2009, p. 131). Despite the increase in the number of written works on the topic, understanding the factors that enable or form the resiliency is still in its infancy (BLACKHURST et al., 2011).

Recent work has positioned resilience as a characteristic of the company or supply chain, originated from capabilities (BRANDON-JONES et al., 2014; JÜTTNER; MAKLAN, 2011; PETTIT et al., 2013; PETTIT et al., 2010), formed in an idiosyncratic manner from practices and resources (WU et al., 2010). Also under this vision of capabilities, there are still different views about which are responsible for forming a resilient supply chain, being the most cited collaboration, visibility and agility (CHRISTOPHER; PECK, 2004A; JÜTTNER; MAKLAN, 2011; SCHOLTEN et al., 2014). On the other hand, there are other capabilities in the literature that do not have share consensus among different authors, such as the ability to re-design the supply chain (Christopher & Peck, 2004), velocity (JÜTTNER; MAKLAN, 2011), agility and flexibility (PETTIT et al., 2013b).

However, the capability of flexibility is considered by many authors as fundamental to the formation of resilient chains as it is responsible for creating options for the supply chain and the different nodes involved to deal with problems (JÜTTNER; MARKLAN, 2011; SCHOLTEN et al., 2014; BLACKHURST et al. 2011; TANG; TOMLIN, 2008; PETTIT et al., 2010). On the other hand, as far as has been verified, there are no studies focused on the forms of manifestation of this capability.

This research seeks to answer the following question: how does the capability of flexibility manifest itself contributing for the formation of resilient supply chains?

As context, a healthcare chain that was affected by the H1N1 pandemic that struck Brazil in 2009 was analyzed. The study is based on a single case study of a healthcare supply chain from a well-recognized hospital in the city of São Paulo, that was positioned as the focal company of the supply chain, and other links, such as the Ministry of Health, State Secretary of Health of São Paulo and the pharmaceutical industry responsible for the production and commercialization of the anti-viral medicine used for prophylaxis and the treatment of the disease.

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2. REVIEW OF THE LITERATURE

This section will present the theoretical review related to resilience and the capability of flexibility.

2.1 Resilience in Supply Chains

In recent years, some authors began to argue that traditional models of risk management are not capable of addressing risks of disruption since many of them cannot be anticipated or a specific strategy to mitigate them can be economically unviable (JÜTTNER; MAKLAN, 2011; JÜTTNER et al., 2003; MITROFF; ALPASLAN, 2003; PETTIT et al., 2010). For this reason, another line of research has been deepening in the understanding of resilience in order to understand what allows certain chains to pass through situations of disruption, suffering less impact than others, and rapidly returning their operations to the desired situation.

According to the vision of Jüttner and Maklan (2011) the reduction of the probability of occurrence of risk, although it also may lead to a reduction in vulnerability, does not necessarily have an effect on the increasing of the resilience since, in the event of risk becoming reality, the company can suffer from drastic consequences. Thus, according to these authors, resilience is related to the mitigation of the effects of risk, whether in relationship to its gravity or its recovery time, and not to the reduction of the likelihood of its occurrence.

The essential factor for resiliency of a supply chain is its ability to adapt so that it can return the operations to the desired state (PONOMAROV; HOLCOMB, 2009). In this sense, some works position resilience as a multidimensional capability.

The discussion of the concept of capabilities has been refined in recent years, inserted into the theoretical lens of RBT (Resource Based Theory) (BARNEY 1991; PETERAF 1993) and its evolutions (TEECE et al., 1997; BARNEY 1996, 2001; PETERAF; BARNEY, 2003).

Although there is no consensus about the capabilities that form resilient supply chains, several works consider that flexibility is one of the most essential to its formation (CHRISTOPHER; PECK, 2004; SHEFFI; RICE, 2005; JÜTTNER; MARKLAN, 2011; PETTIT et al., 2013; SCHOLTEN et al., 2014).

2.2 Flexibility

Jüttner and Marklan (2011) define the capability of flexibility as "The ease with which a supply chain can change its range number (i.e. the number of possible "options") and range heterogeneity (i.e. the degree of difference between the "options") in order to cope with a range of market changes/ events while performing comparably well" (p. 251). Skipper and Hanna (2009) discuss that flexibility is usually related to the immediate ability of adapting to new situations. Therefore, the existence of flexibility in disrupting events is important since it offers alternatives for the supply chain to circumventing situations which hamper the implementation of activities that are essential to its operation.

For example, Pettit et al. (2013, p. 49) point out that flexibility in the provision and execution of orders are important to the supply chain. For provisioning, flexibility is defined as the ability of the supply chain or its entities to quickly change its sources or ways of receiving input. Flexibility in the execution of orders is the ability of the chain or its entities to quickly change the outputs or the way it delivers its orders. The authors also describe adaptability, defined as the ability to modify operations, as important to resilience, reinforcing the definition of flexibility presented earlier of Jüttner and Marklan (2011).

In order for flexibility to exist, it is necessary that resources are available and there is ability to coordinate them so they may become options to the situation. The coordination of resources, according to Craighead et al. (2007), can occur before or after the occurrence of the disruptive event, which suggests that flexibility can be planned and have its execution previously operationalized or articulated. In this sense, the existence of contingency plans can increase the level of flexibility of a company, reinforcing its importance in the mitigation phase of disruption (SKIPPER; HANNA, 2009).

The modularization of processes and design of products, for example, is a way to increase the agility and flexibility, to the extent that it can bring alternatives for reassessing the production lines (KLEINDORFER & SAAD, 2005; TANG 2006).

Various practices described by Tang et al. (2006) can increase the flexibility of companies and supply chains, as for example: the postponement of production; the implementation of strategic stocks; the use of a flexible supplier base; the use of the ap-

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proach of make or buy; the planning of transport alternatives; and the active management of revenue and price, directing the consumption to products with greater availability.

The resources used to achieve flexibility in supply chains can be both tangible and intangible. An example presented by Pettit et al. (2013) are financial resources, which are important for the absorption of oscillations in chains.

The use of security stocks is also described in the literature as being important for the formation of flexibility in disruptive situations. One of the strategies for self-protecting from disruptive events described by Bode et al. (2011) is called buffering. This strategy has a built-in view of the focal company, in the creation of self-protection mechanisms for dealing with external events, working as a buffer to absorb shocks. According to the authors, this can be based, for example, in the use of security stocks, flexible production processes, redundant suppliers, and the design of products that are not dependent on just one supplier.

Differently, Sheffi and Rice (2005) believe that the use of emergency stocks do not refer to the construction of flexibility but for redundancy, which they regard as distinct concepts. They argue that, although both have a positive relationship with resilience, flexibility entails lower costs and could become a source of competitive advantage. The argument comes from the vision that flexibility does not involve the need for idle resources, while redundancy does. Some common examples in companies are the use of emergency/security stocks, the use of a multiple base of suppliers, even while causing a higher cost, or the maintaining of slack operations. Similarly, Scholten et al. (2014) distinguishes flexibility of redundancy.

Tang and Tomlin (2008) have already presented that the existence of operational buffer enables flexibility. In this paper, the authors perform simulations to identify the amount of flexibility necessary to deal with risks of supply, demand and of process. In their study, flexibility is positioned as a quantitative variable, relating it to different practices, such as the use of multiple vendors, the use of flexible supply contracts, the use of flexible manufacturing processes, the postponement of products in production lines and the use of flexible pricing politics to influence demand. The result shows that even the existence of small levels of operational buffer is sufficient to increase flexibility. This occurs once the existence of this buffer reveals the interoperability of the operation, i.e. that different processes can be executed in different locations. Jüttner and Marklan (2011) also hold the view that the redundancy "is one of the routes for flexibility."

Christopher and Peck (2004) argue that the definition of supply risk mitigation is not only about the decision to keep multiple vendors within the base, but to understand the implications for the business, since, in some situations, establishing a relationship with a deep bond with the supplier may be the safest strategy (BODE et al., 2011). The possibility of conversion of an operation is also related to flexibility, as in the case of migrating the operation to different locations in case there is a problem with one of them (CHRISTOPHER; PECK, 2004). The authors point out the necessity of structuring supply chains that maintain various open options in case a disruptive event happens. Additionally, they reinforce that the search for efficiency may not be the best decision, but that maintaining redundancy in key processes can be a better alternative.

At the individual level, Weick (1993) shows that the ability of improvisation is important so that an organization can go through stressful situations, as will be the case of a disruption. Improvisation involves the ability to recombine available resources for a specific task. In this vision of improvisation, the author also includes creativity, defining it as the ability to use what you already know in different situations. In this way, creativity and, consequently, improvisation, are related to flexibility, to the extent that they are responsible for the increase in available options for dealing with a given situation.

Sheffi and Rice (2005) argue that risk perception as well as collaboration, play an important part in flexibility, since you usually cannot recover from a disruptive situation without the involvement of different areas of the business and entities of the supply chain, no matter how close one is to the direct effects that affect it.

In addition to the points described related to the construction of flexibility, there are others that can difficult its existence, such as strict internal and external regulations, as well as the complexity and requirements of materials that make the amount of available options limited (BLACKHURST et al., 2011).

3. METHODOLOGY

The study on resilience in supply chains is still in its infancy (BLACKHURST et al., 2011), therefore,

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there is still a great deal of disagreement about the concept and what composes the theme. This empirical research was carried out by a single case study of a healthcare chain in Brazil. Single case studies, despite having a smaller external validity, allow the researcher to go deeper into the case (SIGGELKOW, 2007). In addition, single cases are especially relevant when they are regarded as critical, extreme and revelatory of the question posed by the research (MILES et al., 2013; YIN 2014).

For this research, the unit of analysis considered was the service supply chain. The service supply chain chosen for this research is embedded in the context of health management and refers specifically to a hospital chain. As the main objective of this chain is to provide care for patients, the hospital is positioned as the focal company, considered as the service provider (BALTACIOGLU et al., 2007). Additionally, the context in which the unit of analysis is embedded is the pandemic of the H1N1 virus that struck Brazil in 2009.

The links that were selected were chosen in order to represent the entities most affected or that influenced by actions the H1N1 outbreak in 2009. The entities selected were validated based on preliminary interviews with health professionals involved in H1N1 pandemic in 2009.

Hospital: the focal company to be studied from the chain. Responsible for the care of patients, the hospital is the last link in the supply chain, since problems that occurred in previous links have the potential to impact patient care and, consequently, their goal of treating them.

Doctors: responsible for the diagnosis and medication of patients. Along with the nurses, they are on the front line of care and have to deal with the day-to-day situations.

Nurses: responsible for the treatments of the patient, focused on their physical, social and mental well-being.

In this context, doctors and nurses are being considered as links in the chain and not only as hospital staff workers, since in many situations these professionals provide services to more than one entity.

Pharmaceutical Industry: responsible for the supply of medicines for the treatment of patients. In the case of this study, interviews were conducted with industry professionals responsible for the supply of Oseltamivir Phosphate, the main antiviral used for the treatment of the H1N1 virus.

Secretary of Epidemiological Surveillance of the Ministry of Health: responsible for the management of the National System of Epidemiological Surveillance and Environment in Health. There are attributes of this body that should be highlighted: the national coordination of epidemiological actions and disease control; technical assistance to the states; provision of diagnostic kits; management of epidemiological information systems, including the consolidation of data from the states and the dissemination of information and epidemiological analyses; monitoring, supervision and control of the implementation of the actions related to epidemiology including the evaluation of the epidemiological surveillance systems of the states (CONASS 2003).

State Secretary of Health of São Paulo (SES-SP)/ Center for Epidemiological Surveillance: the state body that sets state health policies, in accordance with the guidelines defined by the Unified Health System (Sistema Único de Saúde – SUS) (CONASS 2003). The SES-SP has eight company departments, including the Coordination of Disease Control (CCD), whose mission is to "Coordinate the state response to disease, aggravations and existing or potential risks, within the framework of public health, with emphasis on planning, monitoring, evaluation, production and the dissemination of knowledge, for the promotion, prevention and the control of the health conditions of the population, in line with regional characteristics and the principles and guidelines of SUS" (CONASS , 2003, p. 2). Within this organization, you find the Epidemiological Surveillance Center.

3.1 Sample Selection

Unlike quantitative analysis for the case studies, the selection of the sample should not be random, as in the case of quantitative research, but instead in a theoretical way (EISENHARDT, 1989; YIN, 2014). The choice of the object is related to the possibility of the case contributing to the research question (STUART et al., 2002), whereas the generalization sought with the findings obtained through case studies is not statistic, as in the case of quantitative research, but analytical (YIN, 2014).

A hospital in São Paulo, considered to be highly complex, was chosen for this work. This hospital is considered to be one of the main Brazilian centers of the dissemination of techno-scientific information, known for being a center of excellence and reference

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in the field of teaching, research and service. It has more than 2,000 beds and 15,000 professionals in different areas of expertise. According to the social reaction related to the H1N1 virus, this and other high complexity hospitals were widely sought after by a large volume of people for diagnosis and treatment of the disease, raising the risk of disruptions in the chain and becoming a relevant context to the study.

The health professionals who provide services to the hospital were selected after interviews with the administration team, so that professionals indicated had a relevant participation in the defined context.

As in the hospital, so in the other links, the interviewed professionals were protagonists with relevant roles in the preparation of mitigation plans or during the pandemic of 2009. The specific positions are not described in order to ensure the confidentiality of the respondents, but all possessed roles as directors, managers or supervisors of areas related to the event. In total, sixteen semi-structured interviews were conducted.

One concern that existed in the conception of this study was the fact that the H1N1 pandemic studied took place almost five years ago, which could lead to inaccuracies in the data collected. To mitigate these problems, we used a large number of interviews, apart from the information collected from different links allowing triangulation of information. The completion of the analysis with secondary information also contributed to minimizing this problem.

3.2 Data Collection

In order to answer the research questions, the collection of data was conducted through semi-structured interviews. The interviews lasted from 30 to 120 minutes, and on average, they were 75 minutes long. All the interviews were conducted in person and recorded with previous authorization and subsequently transcribed for use as sources of analysis. There was only one exception that was not recorded due to technical problems. In this case, a memo was written right after the interview in order to reduce the probability of losing content.

The transcripts were produced as close as possible to the actual interviews by outsourced capable professionals. That allowed the analysis to happen in parallel with the other interviews (Eisenhardt & Graebner, 2007; Miles et al., 2013; Yin 2014).

The interview protocol was based on the theoretical review performed. The goal of the protocol was to guide the interview, with the objective of assisting the researcher in covering the relevant issues.

The research protocol was previously validated with academics of operations management as well as health professionals in order to ensure that it was adherent to the theme and context studied (YIN, 2014). All of the information was analyzed with the support of the Atlas TI software, version 7 for Mac.

Table 1 summarizes the information pertaining to persons who were interviewed, describing to which link they belonged, the relationship they had with the entity in 2009, as well as the name that will be used during the analysis to identify the information presented.

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Table 1: Relationships of the Interviewees

Responsibility	Name	Relationship this 2009 H1N1 outbreake
Hospital		
Crisis management committee	HP_CGC_1	Related to hospital infection control and member of the crisis management committee
	HP_CGC_2	Related to hospital infection control and member of the crisis management committee
Administration	HP_ADM	Related to departments responsible for security, cleaning and supplies
	HP_SPR	Related to supply management, including purchases and internal logistics
	HP_EMG	Related to emergential purchases
Infectologist pysician	HP_UTI	Related to infectious diseases ICU - Intensive Care Unit
	HP_DMI	Related to infectious disease care
ER	HP_PSC	Related to ER management
Nurses	HP_ENF	Related to the nursing team management
Supplier		
Pharmaceutical industry	IF_MED	Related to antiviral product management
	IF_GOV	Related to government relationship
Governo		
Health Ministry	MS_VEP_1	Related to federal epidemiological surveillance group
	MS_VEP_2	Related to federal epidemiological surveillance group
	MS_VEP_3	Related to federal epidemiological surveillance group
Health Secretary of the State of São Paulo	SE_VEP_1	Related to state epidemiological surveillance group
	SE_VEP_2	Related to state epidemiological surveillance group

Source: Original Compilation

3.3 Data Analysis

The data analysis protocol was adapted from Scholten et al. (2014), which in turn, was derived from Miles et al. (2013). This approach is based on the reduction and analysis of data in a process called encoding.

As described in Miles et al. (2013), codes are assigned to the descriptive or inferred information during a study, which are represented symbolically as a phrase or word that refers to the original idea. In the words of the authors, "the code is a construct generated by the researcher that symbolizes and assigns the meaning interpreted for each individual piece of data for future purposes of detection of patterns, categorizations, generation of theory and other analytical processes" (MILES et al 2013). The data to be classified can vary from words, sentences, paragraphs, even entire pages. According to the authors, the encoding is an activity of data condensation, and is part of the process of analysis, which they recommend performing in two steps:

The first coding cycle deals with the raw data, and has the main function of reducing the information so they can be later sorted in the second cycle. Three of the most common strategies described by Miles et al. (2013) are: a) descriptive encoding, where the aim is to summarize the topic in question with a word (usually a noun) or short sentence; b) encoding in vivo, which uses literal words or phrases used by respondents who reflect their own language, and; c) encoding processes, where typically gerunds are used to describe actions observed in the data or the interaction with time, showing trends or issues which are emerging, for example.

Miles et al. (2013), suggests two approaches for the first cycle of coding, the inductive and deductive, that could happen at the same time. In the deductive approach, the researcher starts with an initial list of codes that may have been based on an initial conceptual model, a list of research questions, hypotheses or variables that the researcher brings to the study.

The second cycle of encoding usually deals with the generated code in the first cycle, in order to group them in a smaller amount and more parsimonious categories that symbolize themes and constructs (Miles et al., 2013; Scholten et al., 2014). The identification of these patterns allow the researcher to condense a large volume of data (Miles et al., 2013).

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The analysis process followed the steps detailed in Table 2.

Tabel 2: Analysis protocol

Literature Review: based on a review of the literature, the main capabilities responsible for forming the resilience have been identified. Codes have been created for each of these items in the Atlas TI software.
Coding based on Literature: the data was coded using the codes created based on the literature (item 1)
Inductive Coding: throughout the process of analysis and understanding of the case, additional codes were created that were relative to the observed events, such as: protection stock, organizational structure, lack of preparation, support from senior management, etc.
Grouping of the Codes: the codes created in item 3 were grouped according to the objective of the research,
Linking with the capability of flexibility: the codes created in the groups of item 4 were linked with the capability of flexibility,
Consistency with the literature: the result of the analyses was contrasted with the literature to ensure its consistency.

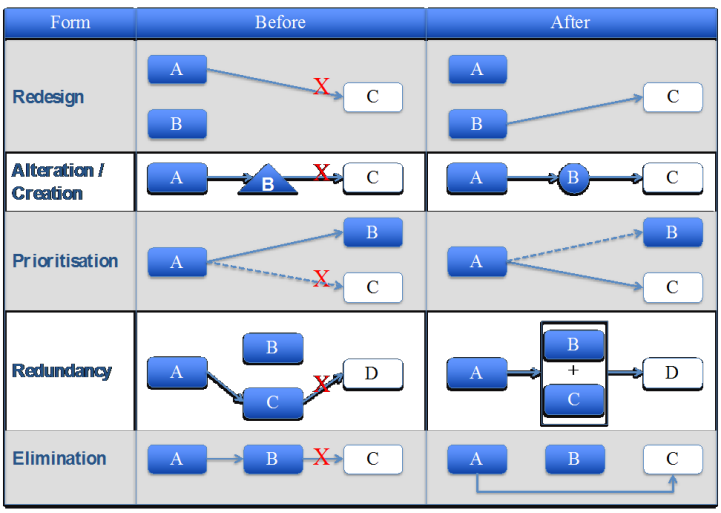
Source: Original compilation

4. DISCUSSION

During the 2009 pandemic, the chain had to deal with various situations where their usual processes and resources were not prepared to deal with the new context. So, it was necessary to create options.

Through the process of analysis, various forms of manifestation of flexibility were identified, where the prior existence of resources was a common element (TANG, 2006). The various forms identified are summarized in Figure 1.

Figure 1: Manifested forms of flexibility



Source: Original compilation

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The letters in Figure 1 could refer to entities, processes or activities, depending on the situation. To simplify the explanation of the forms of manifestation (Table 3), the letters will be simply referred as resources, with the proper explanation already made. The letters that are in the white square refer to the objective to be achieved, and the "X" shows the path that is not feasible in the particular context. Table 3 presents the 5 forms of manifestation of flexibility identified in the analysis and examples presented during the interviews

Table 3: Forms of manifestation of flexibility and examples

Form of Manifestation	Example
Redesign: the ability of the supply chain to adapt by changing the resource that is obstructing its operation. In the figure, this is illustrated by the exchange of the resource A for the resource B. An example is the use of a different supplier to provide specific input.	*Whomever said that they wouldn't be able to attend the demand, went looking for partners. - HP_ADM* *The alternative that we have left are the emergency purchases, which are acquired though the Foundation funds. What is verified is the possibility of acquiring this material from a second or third party vendor. - HP_SUPR*
Alteration /Creation: In this case, for example, a resource B is adapted, turning this resource into a resource more appropriate than the original one. An example of this is the training of professionals to carry out additional activities not foreseen initially. The composition of different resources can also lead to creation of a new one.	*Disposable masks were used by different professionals including the doormen, who were the first [people] to come in contact with [suspected patients]. […] at that time, they [doormen] had also been trained on what to ask, how to act when a sick person arrived... They were lay people. They didn't have this ability to investigate and it wasn't even their role. - HP_ENF* *[…]then we processed in the [Hospital] in a weekend 2000 bottles. We got the antiviral powder and made the medication for the children. - SE_VEP_1* *We said that we were playing MacGyver here in the Hospital. - HP_UTI*
Prioritization: In this situation, a resource C is prioritized at the expense of resource B, since it was more important at that moment, as was the case with the prioritization of ICU beds in the Hospital for H1N1 patients.	*[…] at the time, everybody, regardless if you were ICU of Cardiology, ICU of Pneumology, ICU of Surgery, when they had a bed, the first thing they do was to call me. "Someone needs ICU?" We would transfer someone there in order to receive other patients. - HP_UTI* *The [laboratory] […] practically stopped all other functions. All was geared for just H1N1 analysis […] We worked through the weekend - SE_VEP_1*
Redundancy: in this case, existing resources have buffer or the ability to bear a greater load, enabling the resource D.	*[…]We had enough stock to get going. We will use it and later replenish it. You have to keep an eye on the stock so it doesn't zero out. - HP_ADM* *So what we did, basically, all States had emergency stocks, so you used it, you replaced it later. Whenever ran out of the product. - MS_VEP_2* *They were asking for people to put in extra On-Calls "Contribute by giving an extra On-Call". - HP_CGC_2*
Elimination: The elimination of an intermediate resource B can be the solution for enabling a determined option C that was not initially available.	*[…] when the pandemic started, we had some blisters available in the States that were close to reach their expiration date. Then ANVISA did the revalidation. We performed tests and validated it. - MS_VEP_3*

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In the next few sessions, these categories related to the forms of manifestation of flexibility identified from the analysis of the data will be explored in depth.

4.1 Redesign

The possibility of changing the design of the chain is a factor that allows the entities impacted to increase the amount of options available at the time of crisis (Christopher and Peck, 2004a).

The most usual way, as identified within the literature, is the possibility of changing the suppliers (CHRISTOPHER; PECK, 2004; PETTIT et al., 2013; PETTIT et al., 2010). This was also identified during the research at the healthcare chain.

According to the bidding law, contracts which are performed between the Hospital and its suppliers possess a very hard character. In this way, the replacement of suppliers could prove complex, even though there was evidence of redesign of the chain at the level of suppliers.

On the other hand, the importance of processes that enable this redesign when necessary were also identified. In the case of the Hospital, there is the possibility that certain purchases with a nature of emergency will be carried out using the funds of the Foundation its is linked to. In this context, the purchases are not made through bidding law, which would give more flexibility.

Through the use of the Foundation, a resource that the Hospital has (BARNEY, 1996; WU et al., 2010), it was possible that the redesign of the chain could happen in order to create a new option for the situation.

4.2 Alteration and Creation of Resources

Within the analysis of the case, situations were encountered in which a given resource was not available, or the way that it was available was not adequate to deal with a particular situation.

In these situations, there is a possibility that these resources could be altered or recombined in a way that will carry a new function creating options for the supply chain or its entities to deal with disruptive situations, increasing their resilience. Pettit et al. (2010), for example, refers to the adaptability of processes and Christopher and Peck (2004) to conversion.

These situations usually involve a certain degree of courage and pioneering spirit on the part of its employees, since often times, the alternatives created had not been previously tested, in particular when these alternatives are experimented during the crisis.

One of the main factors for the resilience of the Hospital during the pandemic was the accomplishment of the tests internally for verifying the infection of patients by the H1N1, as it was the critical path for several other decisions concerning movements, hospitalizations and treatment of patients

The network of laboratories set up by the Government had no capacity to deal with the volume of tests needed to support the health units of the State. The Hospital adapted its available resources, such as the existing laboratory and its professionals to perform the tests internally. This decision was considered one of the key elements to reduce operational impacts. In addition to the physical location and the technical expertise of the professionals involved, there was a resource, a relationship between the CDC (Centers for Disease Control and Prevention, in Atlanta, USA) and the Hospital laboratory professionals (DYER; SINGH, 1998), which made it possible to access the specific knowledge needed to prepare the exams (HARDY et al., 2003).

Some resources, such as human resources, presented itself possessing a high degree of adaptability to different situations and roles. During the 2009 pandemic, the preparation of professionals to perform functions which they were not initially prepared was an important factor that increased the amount of options available to deal with the events. Two cases that exemplify this statement were: training the doormen to perform screenings of patients at the entrance of the Hospital, since they were the first people to come in contact with them; and the training of nurses in the emergency room to conduct sample collection of materials for examination through the use of a swab in patients suspected of infection with H1N1.

With regards to improvisation, as pointed out by Weick (1993) its existence proved to be relevant to the construction of flexibility in the case analyzed. The improvisation implicitly contains the concept of creativity, which is related to the ability to adapt previous knowledge to new situations (WEICK, 1993). For this reason, improvisation is an element capable of providing new options in situations of disruptions, thereby increasing the flexibility and consequently, resilience.

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An event that exemplifies the use of improvisation during the 2009 pandemic was the need for defining the dosages of the drug Oseltamivir to be administered to patients in specific situations, for example, with renal failure, since the knowledge was not available in the literature. In order to define this dosage, a medical board was formed to discuss the issue and, in this way, make the decision based on knowledge available at that point.

Several professionals at the Hospital that were interviewed described the necessity to improvise on a daily basis and not just during disruptive events. Therefore, the prior existence of the ability to improvise was accessed during the 2009 pandemic, proving its importance in that situation.

4.3 Prioritization

In the study, there were situations where necessary resources existed, but were allocated to other functions or activities. This allocation, at the time of the disruption, can be of minor importance and, in this way, may be replaced by another of greater relevance (CRAIGHEAD et al., 2007).

During the 2009 pandemic, for example, the ICU beds in the different departments of the Hospital were prioritized for the infectious diseases department. This way, if there were any beds available in other departments, they would be provided as a priority to patients infected with the H1N1 virus.

Activities that often trigger prioritization cause adverse effects in activities for which the resources were originally allocated. Often times, these resources belong to other areas or even entities within the chain. In this way, the existence of a chain of command proved to be important so that decisions can be executed (CHRISTOPHER; PECK, 2004; CRAIGHEAD et al., 2007).

Another example within the supply chain was the prioritization given to performing tests in the main laboratory of the government. Craighead et al. (2007) reinforces the importance of the coordination of resources for building resilient supply chains. Flexibility through prioritization proved possible by the existence of resources and by the existence of decision-making mechanisms, thusly proving to be an important way of making feasible alternatives during the 2009 pandemic.

4.4 Redundancy, Availability and Robustness

Although authors like Sheffi and Rice (2005) argue that there is a difference between flexibility and redundancy, empirically, these concepts proved to be difficult to separate. Several authors have argued that the existence of very lean processes increase risk (BLACKHURST et al., 2011; CRAIGHEAD et al., 2007; PETTIT et al., 2013; PETTIT et al., 2010), as they diminish the possibilities of maneuverability. The evidence of the case studied show that the existence of idle resources, even in a small degree, is an important factor for resilience.

The most common example in the literature (BODE et al., 2011; SHEFFI; RICE, 2005) also identified in the case analyzed was the existence of emergency stocks, which allowed, especially in the case of the Hospital, to get past the disruptive situation with little impact related from the lack of supplies. In general, the professionals interviewed stressed that there was no lack of supplies to treat patients, such as the personal protection equipment (PPE), during the pandemic, despite many problems that the suppliers were facing to deal with the demand.

Despite the suppliers having an important role of ensuring that the Hospital had the needed supplies available, the existence of emergency stock was important in allowing time for adaptation. In addition to the existence of stockpiles in the central warehouse of the Hospital, it was possible to use materials from others departments´ warehouses.

In the case of the distribution of medicines between the Ministry of Health and State Secretaries, the existence of stocks also proved to be an important factor by giving time for the supply chain to adjust.

The availability of materials from suppliers or distributors can also be considered as an element of redundancy or availability of resources (SHEFFIE; RICE, 2005). This availability of resources from other entities was also used as an alternative by the government when the decision was made to withdraw the drugs available in drug stores so that they could be distributed by the Health Ministry. The existence of these drugs was a key factor so that the Ministry could meet the demand allocating it according to the necessity in the early months of the pandemic in the country, since the process of distributing the medicine powder was not yet ready.

The use of available time from human resources also contributed to the resiliency during the 2009 pandemic. Two examples, the increasing workload of

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professionals through overtime or alternative forms of work, and the use of physical resources in times that are idle. In respect to the time of the professionals, it was common in the Hospital to offer overtime in order to meet the increased demand for attending patients. On-Call shifts by phone were transformed into in-person shifts in order to increase the number of people working at the hospital.

Another point that does not have consensus in the literature, are the differences between resilience and robustness (BRANDON-JONES et al., 2014; CHRISTOPHER; PECK, 2004A; WIELAND; WALLENBURG, 2013). The evidence identified in the research suggests that the existence of robust processes can be a viable factor of resilience, once robust processes allow to increase the load on them, such as including new activities.

An example is the prior existence of a structure for emergency purchases in the Hospital. This structure was essential in enabling the purchase of materials for the institution in order to meet the sudden increase in demand. Another example was the use of existing logistics processes in the Ministry of Health to distribute the drugs to the States.

In this way, these processes can be considered as available options and can be framed in the definition of capability of flexibility.

4.5 Elimination

The ability to eliminate existing processes also presented itself as a way to create flexibility, to the extent that it enabled options that initially were not available.

Blackhurst et al. (2011) reinforces that the existence of regulations and rigid processes work against resilience. In this way, it is possible to conclude that the elimination of these factors could increase resilience. In the case study, an example that corroborates with this statement was the elimination of bureaucratic barriers, such as the one that occurred by the government when it worked together with Anvisa, to validate lots of drugs that were close to their expiration date.

This enabled a considerable volume of medicine, which was suitable for use, to be made available to the service network, at a time when there was a shortage.

5. CONCLUSION

The capability of flexibility has a main function of generating new options for the chain and its entities in order to deal with situations of disruption, and thus plays an important role for resilience (JÜTTNER; MARKLAN, 2011; SCHOLTEN ET AL., 2014). In this research, the importance of the capability of flexibility for the formation of resilience in service chains was verified, as well as the different forms of manifestation in disruptive situations.

The redesign allows the entity or the supply chain to access other options by exchanging one resource for another one available (CHRISTOPHER; PECK, 2004). An example that represents this manifestation is the use of another supplier when there are problems with the original.

The change and creation of resources is achieved from knowledge and skills present in the members of the chains or its entities (FAISAL et al., 2006). The ease with which resources can be modified and the ability of the members to improvise were important alternatives in the case analyzed.

Prioritization became apparent in the case analyzed when a resource that was allocated to a given function could be allocated to another more relevant function during the disruptive event. As there may be a trade off, because this change could lead to negative effects to the original function, the importance of decision-making mechanisms proved to be important in the case studied, corroborating with Christopher and Peck (2004).

Redundancy, availability and robustness also proved important for the formation of flexibility. The existence of buffers, which can be evidenced, for example, by the existence of emergency stocks, is an important option for the entities of the supply chain studied. The possibility of using resources beyond the original planned, as the allocation of extra time by the professionals or the existence of robust processes that allow scalability are also important for the formation of flexibility (JÜTTNER; MARKLAN, 2011). In this way, this work also argues that mechanisms for redundancy and robustness are important for the formation of resilience, positioning them as part of the capability of flexibility and not as unrelated concepts.

Finally it was found that the flexibility is also favored by the possibility of the elimination of processes, resources or activities that impede the objective, such as the elimination of rules or bureaucracy.

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As was shown, there are several categories with potential to contribute to the formation of flexibility. The common factor is the previous existence of resources for it to manifest. A proposition which can be made in this regard is that, the choice or construction a priori of resources is important for the formation of flexibility, just as is the recruitment of qualified professionals.

6. LIMITATIONS AND FUTURE RESEARCH

In spite of the care given to methodology, as is in all research, this also presents some limitations that need to be considered.

A first limitation refers to the elapsed time since the occurrence of the event that took place approximately 5 years ago. In addition to the difficulty of identifying professionals from the different entities that were in the functions of interest in this period, at various times it was noted the difficulty of these informants to remember with accuracy the dates and events. To mitigate these effects, interviews were conducted with various people involved in order to triangulate the data. The use of some documentary sources also assisted in this matter, since the event was deeply covered by the media. It is important to consider that there might be inaccuracies related to the data collected.

The second limitation relates to the single case study. Several authors reinforce the limitations involved in only one case study (EISENHARDT, 1989; MILES et al., 2013; YIN, 2014), since the conclusions may reduce the external validity of the survey. Nevertheless, it is worth mentioning that some entities are analyzed only in relation to the context in question, such as, for example, the Health Ministry, the pharmaceutical industry, and the Secretary of State, as in the case of São Paulo.

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