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Siloed Perceptions in Pharmaceutical Supply Chain Risk Management: A Brazilian Perspective

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ABSTRACT
This article maps risk perception across the pharmaceutical supply chain (PSC) in Brazil. Our paper employs the method orders-of-magnitude analytic hierarchy process to rank risks as perceived by industry, distributors, hospitals and pharmacies. We show that players have a siloed perception of risk and impact of those risks. While upstream players emphasize cost, downstream players value service; moreover, both prioritize operational risks over strategic risks. We call for further studies in Latin America: although interest in risk is growing, few studies address the PSC and even fewer realities outside the Northern Hemisphere.

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KEYWORDS
Brazil; pharmaceutical supply chain; risk perception; supply chain risk management

RESUMEN
Este artículo esboza la percepción de riesgo en la cadena de abastecimiento farmacéutico (PSC—sigla en inglés para pharmaceutical supply chain) en Brasil. Nuestro documento utilizo el método cuantitativo del proceso de análisis jerárquico (AHP) para clasificar el riesgo percibido por la industria, los distribuidores, hospitales y farmacias. De este modo, demostramos que los participantes tienen una visión compartimentada del riesgo y del impacto de estos riesgos. Mientras los actores principales enfatizan el costo, los secundarios valorizan el servicio. Lo que tienen en común es que ambos enfatizan más los riesgos operacionales que los estratégicos. Destacamos la necesidad de realizar estudios adicionales en Latinoamérica porque, a pesar del creciente interés en el riesgo, existen pocos estudios que aborden el PSC y un número aún menor de realidades fuera del hemisferio norte.

RESUMO
O presente trabalho mapeia a percepção de risco na cadeia de abastecimento farmacêutico (PSC—sigla em inglês para pharmaceutical supply chain) no Brasil. Nosso estudo empregou a metodologia de ordem de dimensão no processo de análise hierárquica para classificar o risco percebido por: indústria, distribuidores, hospitais e farmácias. Demonstamos que os participantes têm uma visão compartimentada do risco, assim como do impacto do risco. Enquanto os players principais enfatizam o custo, os players secundários valorizam...
Introduction

The pharmaceutical supply chain (PSC) is highly complex and key to healthcare. The supply of medicines accounts for 20–30% of medical spending (Narayana, Pati, & Vrat, 2014) and is expected to reach US$1.5 trillion worldwide by 2021 (Associação da Indústria Farmacêutica de Pesquisa [Interfarma], 2017). Additionally, the PSC holds complexity in terms of product variety and complexity, reflected in special maintenance requirements and mandatory quality standards, and involves several different players, from research and development (R&D) companies and big pharmaceutical industries to distributors, hospitals, and drugstores (Chopra & Meindl, 2017; Enyinda, Mbah, & Ogbuehi, 2010). Considering that medicines are essential to the patient’s treatment and life maintenance, the consequences of disruptions in the PSC go beyond financial losses: they pose a threat to the patient’s safety and well-being.

Brazilians have access to medications mainly through the last stage of the supply chain (pharmacies and drugstores), but also through private and public hospitals (Gomes, Pimentel, Lousada, & Pieroni, 2014). Brazil is a developing country of continental dimensions, with a population over 208 million people in 2018 and one of the 10 biggest pharmaceutical markets in the world (Interfarma, 2017). The pharmaceutical sector is heavily regulated across the world and Brazil is no different. Firms in Brazil are predominately dedicated to the production and packaging of final products, with the national laboratories focusing on the manufacturing of generic drugs. Raw materials are mostly imported, and innovation activities are typically carried out abroad (Calixto & Siqueira, 2008; Miguel & Reis, 2014). The result is a large participation of national laboratories in the generic segment and a high dependency on importation. Medicines distribution in Brazil is mainly done by big private distributors which serve drugstores, hospitals and clinics, while pharmacy retail chains usually have their own distribution centers and negotiate directly with the industry (Afonso, Dreszer, Francis, & Ramos, 2015; Fischer, 2017; Gomes et al., 2014; Setem, 2015).

Risk in the PSC is commonly associated with “product discontinuity, product shortages, poor performance, patient safety/dispensing errors,
technological errors, internet pharmacies and counterfeit drugs” (Breen, 2008, p. 195), all of which can result in harm to patient health and safety, erosion of confidence in public health, and thinner profit margins (Enyinda et al., 2010). Managing supply chain risk has a great relevance for this industry, the general public, and governments. Although there is a growing research interest, few studies address risk assessment in the PSC (Bak, 2018; Ho, Zheng, Yildiz, & Talluri, 2015) and fewer are focused on developing countries (Singh, Kumar, & Kumar, 2016), Oliveira, Espindola, & Marins, 2018; Newton, Green, & Fernández, 2010), or the Brazilian reality (Bak, 2018; Oliveira et al., 2018). The literature is dominated by USA and UK (Bak, 2018; Prakash, Soni, & Rathore, 2017) with Asian countries producing increasing numbers of articles (Prakash et al., 2017), even though Brazil is among the top 10 biggest pharmaceutical markets in the world (Interfarma, 2017). Hence, we focus our research on the Brazilian pharmaceutical sector. The Brazilian PSC, as in most countries, is composed of multiple tiers of storage and distribution between the manufacturer and the final user, the patient. Supply chains with multiple tiers, when not integrated, may lead to silos that often focus on different outcomes (Spekman, Kamauff, & Myhr, 1998). Most surprisingly, we found no study clearly comparing and contrasting how different players in the PSC perceive risks, and whether this sector has been able to overcome siloed perceptions across the tiers.

In order to overcome the PSC vulnerabilities, it is paramount to identify, prioritize, mitigate, and monitor the risks so there can exist proper configuration and adaptability in the supply chain. The supply chain risk management (SCRM) process is where partners in the supply chain collaborate to deal with risks and uncertainties, thus allowing companies to monitor hazards and operate more efficiently (Ho et al., 2015). The goal of this paper is to compare and contrast how different players in the Brazilian PSC identify, evaluate, and rank risks. We hence pose the following research question (RQ): “How do the different players identify, evaluate, and rank the risks in the Brazilian PSC?”

We interviewed professionals of the pharmaceutical sector responsible for the management of products and information in the supply chain, and then applied the method orders-of-magnitude Analytic Hierarchy Process (OM-AHP), developed by Saaty and Shang (2011), in order to rank the perceived risks.

Our paper contributes to the field of SCRM by showing that in Brazil the different players assess risk through a silo approach, meaning that players perceive risk differently from each other, and have limited understanding of how risks are affecting other players. This result reinforces the findings of previous research also conducted in developing countries, such
as Iran (Yousefi & Alibabaei, 2015), Morocco (Benazzouz, Echchtabi, & Charkaoui, 2017), and Bangladesh (Moktadir et al., 2018), that revealed that there is little perception of how risks may affect the supply chain as a whole. The study also contributes to risk analysis by decomposing the *impact* dimension in the *cost* and *service* (*time/quality*) dimensions, allowing better understanding of SCRM. The remainder of this paper begins with a literature review on SCRM; the research methodology is then presented, followed by the presentation and discussion of the results. The last section addresses implications, limitations, and suggestions for future research.

**Literature review**

**Supply chain risk management**

A common expression of risk is the function (multiplication) of the probability of occurrence of said risk and its impact severity (Dong & Cooper, 2016; Manuj & Mentzer, 2008). Supply chain-related risks are events that cause disturbance or disruption to the material, information, or financial flow within the supply chain and interrupt operations (Ghadge, Dani, & Kalawsky, 2012; Pfohl, Köhler, & Thomas, 2010; Tummala & Schoenherr, 2011). One can define risk either by discussing its causes or its effects; that is, risk can be understood as an endangerment resulting from a wrong decision (Pfohl et al., 2010). The term ‘risk’ is not necessarily negative and can be seen as an opportunity. Aven (2016, p. 4) elaborates on the definition of risk:

> The possibility of an unfortunate occurrence; the potential for realization of unwanted, negative consequences of an event; exposure to a proposition (e.g., occurrence of a loss) of which one is uncertain; uncertainty about and severity of the consequences of an activity with respect to something that humans value.

Building on the above definitions, we understand supply chain risk as *any event that negatively affects the efficient flow of materials, information, or financial resources across the SC, from the suppliers to the end consumer*.

There has been a growing interest in SCRM for the past years, which can be seen reflected on the increasing number of published studies on the subject (e.g., Bak, 2018; Fahimnia, Tang, Davarzani, & Sarkis, 2015; Ho et al., 2015; Moktadir et al., 2018; Rao & Goldsby, 2009). Although definitions of SCRM vary, they have some key elements in common. First, SCRM is seen as a strategic activity (Narasimham & Talluri, 2009). Several authors point out how SCRM can affect the organization’s performance and reduce the vulnerability of the SC as a whole (Chen, 2018; Ho et al., 2015; Kilubi & Rogers, 2018; Miemczyk & Luzzini, 2019; Rao & Goldsby, 2009; Revilla & Saenz, 2017). Another important factor is that SCRM
supports the decision-making process by providing a structured way to analyze and select the best strategies to mitigate risks and their impacts on the SC (Bak, 2018; Ho et al., 2015; Manuj & Mentzer, 2008; Narasimham & Talluri, 2009; Sharma & Bhat, 2014). This study follows the definition by Ho et al. (2015, p. 6):

An inter-organisational collaborative endeavour utilising quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain.

SCRM entails generic steps and can be considered as a set of strategies and approaches planned in an integrated manner in order to achieve the targeted goals (Bak, 2018; Prakash et al., 2017). For this paper, based on Ho et al. (2015) and Hallikas, Karvonen, Pulkkinen, Virolainen, and Tuominen (2004), the SCRM process includes: risk identification, risk assessment, risk mitigation and contingency and, finally, risk monitoring. However, we will focus on the first two phases.

Risk identification, the first step, is when a firm must conduct a comprehensive and structured search where the focus is on collecting information on risks in order to determine potential and relevant risk sources, along with their potential damage to the company, their partners, and the shareholders (Tummala & Schoenherr, 2011).

The second phase, labeled risk assessment, is the step when the analysis of the identified risks occurs, both in terms of magnitude of their consequences and impact, as well as their likelihood (Ho et al., 2015). The outcome of the risk assessment activities is a classification of all identified risks and risk prioritization (Sharma & Bhat, 2014). There are several intangible aspects (e.g., trust and reputation) that are hard to convert into monetary values when conducting this analysis (Hallikas et al., 2004). Besides, depending on the context and industry, the variables of the analysis may range from a commercial nature (e.g., focus on consequences of stockouts) to life-threatening ones (e.g., floods probabilities) (Dong & Cooper, 2016). The methods applied can be quantitative, semi-quantitative, or qualitative. Frequently used methods include checklists, HAZOP, scenario analysis, risk matrix, AHP, simulations, etc. (Sharma & Bhat, 2014).

**Risk types**

Multidiscipline databases were accessed in April 2019 (EBSCO, Emerald, and Web of Science) and papers that addressed risks in the supply chain were selected; the criterion adopted to select them was that the research should explicitly identify and categorize risks for a supply chain. No filter regarding the method of identification was applied; that is, studies that
used literature reviews, interviews, or case studies, among others, were all selected to compose the list of risks. From this first filter, a list of the risks that were most commonly identified in the literature was developed, resulting in list of 40 risks.

We encountered several different approaches to risk categorization involving different degrees of generalization; and some presented different terminologies but similar definitions and vice-versa (Rangel, Oliveira, & Leite, 2015). In this article, the 43 risks were organized based on the 14 dimensions proposed by Rangel et al. (2015). These authors developed a map of the supply chain risk classifications based on a literature review and, using cluster analysis, proposed 14 dimensions for supply chain risk classification: strategic, inertia, informational, capacity, demand, supply, financial, relational, operational, disruption, customer, legal, environmental, and culture. The strategic risks are the events that affect the business strategy, e.g., strategic planning process. The inertia category comprises risks related to the ability of the company to remain competitive, such as new technologies development. Capacity risks are the events related to capacity management, both over- or underutilization. Demand risks occur due to forecasting issues, seasonality, information distortion, among others. The supply category covers the risks of the supplier not being able to deliver the agreed quantity or quality. The financial risks are related to cash flow problems and changes in the financial market. Relational risks relate to visibility, level of trust, and interaction among supply chain partners. The operational risks are the ones related to the focal company’s production performance. Disruptions are the events that stop the material flow in the production process, e.g., labor strikes. The customer category focuses on events that can change the customer’s choice, such as product obsolescence. The legal risks are the level of exposure to litigations and legal restrictions of the company. The environmental category comprises the risks outside the chain, e.g., natural, governmental, and economic. Informational risks are related to information system failure due to a poor data feed system. The last category, culture, refers to the risks that arise from differences in business cultures among partners and the cultural differences in the countries in which a company operates. Dimensions, risks that compose each dimension, and their authors are presented in Table 1.

Risk assessment

Not all risks affect the supply chain the same way: some are more critical than others and should receive more attention (Manuj & Mentzer, 2008). According to Aven (2016), the way the risk is understood and described influences the way it should be assessed, and, in the supply chain field, the
Table 1. Risks emerging from the literature review.

Authors: Chopra and Sodhi (2004); Tang and Tomlin (2008).

Capacity: caused by the effective capacity of overlapping or underutilization of production.

Demand: changes in the customers’ choice; forecasting issues; seasonality; uncertainties in volume and mix.

Disruption: events that can cause supplier failure that interrupt the production and material flow.

Environmental: risks outside the chain, e.g., natural, governmental, social, and economic; external and uncontrollable events and natural disasters, e.g., terrorism, war, earthquakes, floods, and manmade disasters, macroeconomic uncertainties, and cargo theft.

Financial: uncertainties in investments and cost structures; cash flow problems; changes in the financial market, payment and investment risks, e.g., exchange rates; interest rates; price volatility; unanticipated increases in purchasing costs; uncertainties in investments and cost structures; commodity prices; tax payable change.

Inertia: related to manufacturing capacity and flexibility; flexibility – market changes and new trends that demand some sort of investments in order to follow the novelty and remain inside the network; ability of the company of remaining competitive, such as new technologies development; new product development; process development; technology upgrade; new technologies; R&D capabilities; time to market; organizational capabilities, technological and innovative capabilities, learning and exploitation capabilities.

Infracost: related to how the managers face risk and how they proceed on making decisions; emerges when the process of risk management itself is poorly constructed and becomes a source of risk; outsourcing.

Logistics: product damage in transit; fluctuation in imports arrival; problems in cargo handling, port capacity, and congestion and custom clearance; lack of response of suppliers; cost and level of commitment of the suppliers; supplier performance; transportation scheduling, late deliveries and choice of transport mode; supplier quality and delivery failure; outsourcing logistics; product damage in transit; fluctuation in imports arrival.

Operational: related to the focal company’s production performance; poor quality; events that cause fluctuations in effective capacity and quality; process failure; equipment failure; events that jeopardize the focal company’s internal ability to produce goods and services; inventory control accuracy; obsolescence risk and costs of holding inventory; shortages of spare parts; problems with collectables and supply shortages; unanticipated resource requirements; labor quality; worker skills; availability and quality of raw materials; storage contamination risks.

Operational: any event that affects business strategy, such as lack of strategic planning; short term SC planning; related to how the managers face risk and how they proceed on making decisions; emerges when the process of risk management itself is poorly constructed and becomes a source of risk; outsourcing.

Supply: Uncertainties in delivery of products within the network, from supplier to buyer, in terms of quality and time; problems in cargo handling, port capacity, and congestion and custom clearance; lack of response of suppliers; cost and level of commitment of the suppliers; supplier performance; transportation scheduling, late deliveries and choice of transport mode; supplier quality and delivery failure; outsourcing logistics; product damage in transit; fluctuation in imports arrival.

Disruption: Events that can cause supplier failure that interrupt the production and material flow – e.g., strikes.

Authors: Manuj and Mentzer (2008); Breen (2008); Arruda (2011); Jaberidoost et al. (2015); Dong and Cooper (2016); Huq et al. (2016).

Relational: visibility, level of trust, and interaction among supply chain partners; occurs due to interactions between companies within the supply chain, e.g., mistrust, lack of responsiveness, and distorted information; good-will; related to the level of visibility and control in the supply chain, which can result in trust issues among partners and low confidence within the supply chain; low supplier integration; intellectual property – protecting internal knowledge and potential counterfeit; occur when there are processes being outsourced to manufacturers that are also used by competitors; network and partnership capabilities.

Authors: Chopra and Sodhi (2004); Breen (2008); Reis and Perini (2008); Tang and Tomlin (2008); Arruda (2011); Jaberidoost et al. (2015); Yousefi and Alibabaei (2015); Almeida, Marins, Salgado, Santos, and Silva (2016).
concept of risk needs further development. In general, risk assessment refers to the analysis of the identified risks, both in terms of the magnitude of their consequences as well as their likelihood (Aven, 2016; Ho et al., 2015). While risk consequences are related to the extent to which an adverse event affects resources (Tummala & Schoenherr, 2011), including financial losses, reputation damage, interruption of service level, cost overruns, poor process performance, or safety issues (Tummala & Schoenherr, 2011), the likelihood of a risk, on the other hand, is related to the uncertainties and frequency of occurrence (Aven, 2016; Tummala & Schoenherr, 2011).

Risk assessment helps to establish priorities, serving as a starting point for selecting the appropriate risk mitigation techniques according to the situation of the company and its network (Falkner & Hiebl, 2015; Gardner & Colwill, 2018; Hallikas et al., 2004). An important aspect of the risk assessment is that, as the number of risks being evaluated increases, the potential to have less-consistent judgments increases concomitantly, because it becomes difficult to simultaneously compare variations in both probability and impact on a large number of variables (Dong & Cooper, 2016).

To address this challenge, a great number of risk assessment methods have emerged in the past years (Ho et al., 2015). One line of researchers chose to focus their analysis on a single type of risk, such as demand-volatility risks, inventory-management problems, operations risks, product-quality risks, and financial risks (e.g., exchange rate risks) (Ho et al., 2015). Out of this group, most of these studies are focused on supply-related risks (e.g., supplier selection, poor quality, supplier failure, uncertain capacity, geographical dispersion of suppliers) (Fahimnia et al., 2015; Ho et al., 2015; Prakash et al., 2017). Another group of researchers focused on evaluating

Legal: level of exposure to litigations and legal restrictions of the company; related to government’s policies, legislation and regulations; compliance to regulations; broken contract; contract and agreements; risk of litigation.

Authors: Manuj and Mentzer (2008); Breen (2008); Tang and Tomlin (2008); Tummala and Schoenherr (2011); Arruda (2011); Asamoah et al. (2011); Kamath et al. (2012); Jaberidoost et al. (2015); Dong and Cooper (2016); Enyinda (2018).

Cultural: risks that arise from differences in business cultures among partners and the cultural differences in the countries a company operate; foreign production.

Authors: Tang and Tomlin (2008); Huq et al. (2016); Kurniawan, Zailani, Iranmanesh, and Rajagopal (2017); Majid and Bapuji (2018).

Informational: results of information system failure due to poor data feed system; potential failures on the information technology infrastructure; distortions in information; distorted information; information accuracy and security; viruses.

Authors: Chopra and Sodhi (2004); Tang and Nurmaya Musa (2011); Tummala and Schoenherr (2011); Quabouch and Amri (2013); Colicchia et al. (2019).

Source: Based on Rangel et al. (2015).
generic supply chain risks, presenting a broader view and creating a comprehensive risk index (Ho et al., 2015).

The methods used can be quantitative, semi-quantitative, or qualitative. Some of the frequently used methods are checklists, HAZOP, scenario analysis, risk matrix, AHP, simulations, among others (Sharma & Bhat, 2014).

**SCRM in the pharmaceutical sector**

Manufacturing companies, especially those in the automotive sector, are still the preferred field of SCRM studies (Ho et al., 2015; Prakash et al., 2017), while many sectors, such as banking and healthcare, are underrepresented (Ho et al., 2015). SCRM in the PSC is still little-explored (Ho et al., 2015; Prakash et al., 2017). We conducted a literature review in April 2019, including accessing multidiscipline databases (BVS, EBSCO, Emerald, ProQuest, Science Direct, and Web of Science), which resulted in our finding few papers defining supply chain risk in the PSC (Table 2).

Different methodologies were used to analyze PSC risk, both qualitative and quantitative. Some focus on risk identification, and others focus on risk assessment and mitigation. Furthermore, while the most papers focused on the traditional flow, two studies looked at reverse flow, mainly related to recalls (Kumar, Dieveney, & Dieveney, 2009; Narayana, Elias, & Pati, 2014).

Regarding method, one of the selected studies used a literature review to analyze the risks (Iyengar, Hedman, Forte, & Hill, 2016); two used simulation (Shah, 2004; Zamora, Adarme, & Arango, 2013); one used an Ishikawa

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**Table 2. Map of the literature on SCRM in the pharmaceutical industry.**

<table>
<thead>
<tr>
<th>Author (Year)</th>
<th>Type of Study</th>
<th>Methodology</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breen (2008)</td>
<td>Mixed</td>
<td>Focus Group / Survey</td>
<td>UK</td>
</tr>
<tr>
<td>Kumar et al. (2009)</td>
<td>Qualitative</td>
<td>Cause and Effect, Diagram/Situation, Analysis/FMEA</td>
<td>–</td>
</tr>
<tr>
<td>Enyinda et al. (2010)</td>
<td>Quantitative</td>
<td>AHP</td>
<td>Ghana</td>
</tr>
<tr>
<td>Arruda (2011)</td>
<td>Quantitative</td>
<td>Survey</td>
<td>Brazil</td>
</tr>
<tr>
<td>Kamath et al. (2012)</td>
<td>Quantitative</td>
<td>AHP</td>
<td>India</td>
</tr>
<tr>
<td>Zamora et al. (2013)</td>
<td>Quantitative</td>
<td>Simulation</td>
<td>Colombia</td>
</tr>
<tr>
<td>Ouabouch and Amri (2013)</td>
<td>Quantitative</td>
<td>Survey</td>
<td>Morocco</td>
</tr>
<tr>
<td>Narayana, Elias, et al. (2014)</td>
<td>Qualitative</td>
<td>Casual Loop Development</td>
<td>USA</td>
</tr>
<tr>
<td>Elleuch et al. (2014)</td>
<td>Mixed</td>
<td>AHP</td>
<td>Tunisia</td>
</tr>
<tr>
<td>Jaberidoost et al. (2015)</td>
<td>Mixed</td>
<td>Interviews / AHP</td>
<td>Iran</td>
</tr>
<tr>
<td>Huq et al. (2016)</td>
<td>Mixed</td>
<td>Focus Group / Survey</td>
<td>Global</td>
</tr>
<tr>
<td>Iyengar et al. (2016)</td>
<td>Qualitative</td>
<td>Literature Review</td>
<td>Global</td>
</tr>
<tr>
<td>Mokrini, Dafaoui, et al. (2016)</td>
<td>Quantitative</td>
<td>MCDA – ELECTRE TRI</td>
<td>France</td>
</tr>
<tr>
<td>Mokrini, Kafa, Dafaoui, El Mhamedi, and Berrado (2016)</td>
<td>Quantitative</td>
<td>Fuzzi AHP, PROMETHEE</td>
<td>France</td>
</tr>
<tr>
<td>Md et al. (2018)</td>
<td>Mixed</td>
<td>Delphi method and AHP</td>
<td>Bangladesh</td>
</tr>
<tr>
<td>Enyinda (2018)</td>
<td>Quantitative</td>
<td>AHP</td>
<td>Global</td>
</tr>
</tbody>
</table>
diagram (Kumar et al., 2009); three made use of surveys (Arruda, 2011; Huq, Pawar, & Rogers, 2016; Ouabouch & Amri, 2013); one applied Elimination and Choice Translating algorithm (ELECTRE – TRI) (Mokrini, Dafaoui, Berrado, & El Mhamedi, 2016); one used a casual loop model (Narayana, Elias, et al., 2014); one conducted a workshop with PSC stakeholders (Breen, 2008); and seven applied AHP (Elleuch, Hachicha, & Chabchoub, 2014; Enyinda, 2018; Enyinda et al., 2010; Jaberidoost et al., 2015; Kamath, Kamatha, Azaruddin, Subrahmanyam, & Shabharaya, 2012; Mokrini, Dafaoui, et al., 2016; Moktadir et al., 2018).

Moktadir et al. (2018) applied the Delphi method and AHP to select the relevant risks associated to PSC in Bangladesh. They interviewed 10 experts from the pharmaceutical industry to select the relevant risks associated to PSCs. Mokrini, Dafaoui, et al. (2016) applied AHP to evaluate the outsourcing of risks in the pharmaceutical supply chain. Jaberidoost et al. (2015) applied AHP and Simple Additive Weighting (SAW) to rank the 86 risks identified in the Iranian PSC through a literature review and interviews with PSC professionals. They assessed risks by interviewing 15 experts, adopting as criteria the probability of the risk, the hazard of the risk, and the importance of the supply chain function. Elleuch et al. (2014) applied AHP, interviewing six experts in order to evaluate risks management scenarios in Tunisia. Kamath et al. (2012) used AHP methodology in the Indian PSC, aiming to identify which risks were the most important to manage (inventory risk, regulatory risk, financial risk, and counterfeit risk) and what were the best mitigation strategies to address them (risk reduction, risk acceptance, risk avoidance, and risk transferring), according to the perspectives of manufacturers, intermediaries, and dispensing pharmacists. Enyinda et al. (2010) also applied AHP in a PSC, followed by a sensitivity analysis to identify risks in Ghana. The questionnaires were completed by two experts who work for the major Ghanaian pharmaceutical companies. In another study, Enyinda (2018) applied AHP and sensitivity analysis in PSC to investigate risk management in pharmaceutical global supply chain outsourcing, identifying risk sources, priorities, and alternative policy options. The sample was composed of four PSC managers.

Some of the studies adopted a global perspective (Enyinda, 2018; Huq et al., 2016; Iyengar et al., 2016), while others focused on local contexts (Arruda, 2011; Breen, 2008; Enyinda et al., 2010; Jaberidoost et al., 2015; Kamath et al., 2012; Moktadir et al., 2018; Narayana, Elias, et al., 2014; Ouabouch & Amri, 2013; Zamora et al., 2013). From this review, it is possible to observe that some studies were conducted in developing countries (Arruda, 2011; Elleuch et al., 2014; Enyinda et al., 2010; Jaberidoost et al., 2015; Kamath et al., 2012; Moktadir et al., 2018; Ouabouch & Amri, 2013;
Zamora et al., 2013), indicating an increasing interest in understanding the threats to the flow of medicines in poorer regions. Only one study was conducted in Brazil (Arruda, 2011); the objective was to assess the probability of 51 risks in the perception of SC professionals from 22 pharmaceutical companies that were classified based on their revenues. In this sense, many studies that focused on the assessment phase consider the perspective of only one player in the network when analyzing the risks for the supply chain. Many studies consider only the industry’s perspective (usually the biggest player) and assume their perspective to point out the greatest threats to the supply chain. Therefore, it is not surprising to see a lack of discussion regarding whether different participants of the PSC share similar perceptions or think in silos, in a sector that requires the participation of different stakeholders, such as pharmaceutical manufacturers, wholesalers, distributors, retailers, customers, among others (Singh et al., 2016). Overcoming indifference to different perceptions across the supply chain is crucial to achieve co-operation and partnering to maximize the overall effectiveness of the supply chain (Spekman et al., 1998).

Unlike previous studies, we map the perceptions from different players in order to understand the extent to which PSC risks are perceived differently across industry, distributors, retailers, and buyers. Also, different from the articles mentioned, in this research we investigate the risk consequences considering two dimensions: service, which refers to the quality and availability of the products; and cost, which refers to the monetary impact of the risk to the supply chain.

**Research methodology**

This research was designed in two stages: (1) *Exploratory stage*—interviews with Brazilian experts and risk selection; (2) *Assessment stage*—assessment of the risks selected in the previous stage, applying OM-AHP.

**Exploratory stage—interviews with experts and risk selection**

In this first stage, we interviewed three experienced professionals of the PSC in Brazil in order to evaluate the SC risks that emerged from the literature review in terms of the Brazilian context and to make a pre-selection of risks that could be applied to the Brazilian reality. The goal was also to identify potential risks that did not appear in the literature review and to validate the standardization of the vocabulary. We selected the three experts based on their having worked for many years in different managerial positions in the PSC during their careers. One expert had three years of experience and had worked with production, logistics, and importation; the
other, had 23 years of experience and had worked with marketing, production, and sales; the third expert had six years of experience in the sector and had worked with operations, research, and planning.

The interviews consisted of open-ended questions lasting from 45–60 minutes; interviewees were asked to point out the risks they perceived in the Brazilian PSC and to discuss those identified in the literature. We adopted a lower degree of aggregation of the risks present in the literature review, resulting in a list of 40 risks to be evaluated by the interviewees. Also, a new risk—price regulations—emerged from the interviews and was added due to its status vis-à-vis the Brazilian reality in which drug prices are strongly monitored by The Brazilian Health Regulatory Agency (ANVISA) and The Drug Market Regulation Chamber (CMED). In total, 41 risks composed the final list.

Tummala and Schoenherr (2011) propose each risk should be assessed considering two dimensions—consequences and probability. Other authors claim that risk is a combination of probability and impact (Aven, 2016; Dong & Cooper, 2016; Manuj & Mentzer, 2008). Probability refers to the likelihood of a potential risk to happen and impact refers to the ensuing loss in case of the event occurrence (Dong & Cooper, 2016; Tummala & Schoenherr, 2011). Therefore, these are the two criteria used to assess risk in this research.

Adapting this methodology, all professionals analyzed the list of 41 risks in terms of the probability of occurrence, and the consequences in relation to service and cost. Considering that the concept and understanding of risk in the supply chain needs further development (Aven, 2016), we listened to the experts to understand impact in the Brazilian PSC context. It turned out that these two kinds of impacts emerged from the interviews as very relevant in the case of the Brazilian PSC: service is essential, since medicines should be available at the correct time, in the correct quantity, and in perfect conditions to preserve the patient’s treatment, safety, and health; and costs—the monetary impact—is especially relevant in this sector because of product expiration dates, possible contractual penalties, and sector competitiveness. The service index refers to the level of impact the event has on the chain considering the availability of the products and the quality dimension, that is, the level of defective products that reach the final user. The cost index refers to the monetary impact of the risk to the supply chain.

Each risk was classified in “High,” “Medium,” or “Low,” according to the professionals’ expertise, resulting in a final score for each risk, calculated as follows (Table 3):

\[
\text{Risk Total Index} = \text{Index}_{\text{Probab.}} \times \text{Index}_{\text{time/quality}} \times \text{Index}_{\text{Cost}}
\]
Considering that as the number of risks being evaluated increases, the potential to have less consistent judgments increases (Dong & Cooper, 2016), the ten most significant risks were selected to compose the model used in the next stage of the research (Table 4).

**Assessment stage—assessment of risks selected in the previous stage, applying OM-AHP**

**The method**

The evaluation of risks in the SC is an example of a multi-criteria decision making (MCDM) problem in which multiple evaluation criteria are available for the decision maker to choose (Enyinda et al., 2010). Several techniques exist in the literature; one of them is AHP, a technique which helps in complex decision making involving multiple scenarios and criteria and incorporating decision-makers preferences (Enyinda et al., 2010; Jaberidoost et al., 2015). AHP is usually considered superior to other decision making tools due to its wide acceptance and applicability, lower dependence on pairwise comparisons, and simplicity of use. Another advantage is that the input for the AHP can be a subjective assessment, such as a review, interview, or preference (Moktadir et al., 2018).

Typically, a decision situation is presented; then, several alternatives are assessed relative to each other with respect to multiple criteria that, in turn, are assessed relative to each other with respect to an overall goal (Kull & Talluri, 2008). This process creates a hierarchy of assessments and portrays the relationships between the overall goal, criteria, sub-criteria, and alternatives (Enyinda, 2018). When using this method, one must maintain consistency, where consistency means that in the case of a basic set of data, all other data can be logically deduced from this set. For example, if Activity A is four times more important than Activity C and two times more important than Activity B, one can conclude that Activity B is two times more important than Activity C (Saaty, 1991). Many comparisons often

<table>
<thead>
<tr>
<th>Probability</th>
<th>Impact (Time / Quality)</th>
<th>Cost</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Yearly occurrences, i.e., multiple occurrences within a range of time of 1 year.</td>
<td>Cost and monetary lost to the supply chain is high – over 40% of revenues.</td>
<td>3</td>
</tr>
<tr>
<td>Medium</td>
<td>Occurrences within a established range of time (1−2 years)</td>
<td>Cost and monetary lost to the supply chain is moderate – 10 to 40% of revenues.</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>Probability of occurrence superior to 2 years</td>
<td>Cost and monetary lost to the supply chain is small – up to 10% of revenues.</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability</th>
<th>Impact (Time / Quality)</th>
<th>Cost</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medium</td>
<td>Impact on operations and service levels is moderate with little difficulty to recover.</td>
<td>Cost and monetary lost to the supply chain is moderate – 10 to 40% of revenues.</td>
<td>2</td>
</tr>
<tr>
<td>Low</td>
<td>Little to no impact on operations and/or service level. Quickly recoverable and small stakeholders concern</td>
<td>Cost and monetary lost to the supply chain is small – up to 10% of revenues.</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability</th>
<th>Impact (Time / Quality)</th>
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<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High impact on the strategy and/or operations. It is a big concern to stakeholders.</td>
<td>Cost and monetary lost to the supply chain is high – over 40% of revenues.</td>
<td>3</td>
</tr>
<tr>
<td>Medium</td>
<td>Impact on operations and service levels is moderate with little difficulty to recover.</td>
<td>Cost and monetary lost to the supply chain is moderate – 10 to 40% of revenues.</td>
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<td>1</td>
</tr>
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</table>

**Table 3. Analysis criteria.**
create inconsistencies (Kull & Talluri, 2008), but there is a limit to the level of inconsistency a judgement can have to still be considered reliable (Dong & Cooper, 2016; Kull & Talluri, 2008; Saaty, 1991).

Saaty and Shang (2011) point out that it is difficult to avoid increasing the overall inconsistency of the judgments when one compares more than seven elements at once. In order to overcome this limitation, these authors proposed a new AHP approach by introducing a “pivot” element and organizing the several elements being evaluated in clusters that are connected by this pivot. They called this method orders-of-magnitude AHP (OM-AHP). The method adopts the same assumptions as the original AHP, the difference is that there is an adjustment of the priority weights in each cluster according to the pivot element. Elements within a cluster will be evaluated and compared using a 1–9 scale and calculating the eigenvector to find the local priorities, as in the traditional AHP; however, the measure of the pivot element of one cluster is used in a second cluster, linking the two. The measures of the elements of the second cluster will be then adjusted according to the first cluster pivot’s measure, so both clusters can be compared and the scale can be extended as far as needed (Saaty &

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**Table 4. Selected risks.**

<table>
<thead>
<tr>
<th>Risk</th>
<th>Description</th>
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<tbody>
<tr>
<td>Quality</td>
<td>Events in which some aspect of the manufactured medicines that flow within the chain is compromised and it reaches the end of the chain, or events in which some players in the supply chain struggle to attend the demanded quality standards jeopardizing the flows’ efficiency. Examples: API concentration problems, recalls, lot suspension</td>
</tr>
<tr>
<td>Government’s Policy</td>
<td>Potential changes in the current government policy that can impact the performance of the sector Examples: policies, mandatory insurance coverage, taxes</td>
</tr>
<tr>
<td>Exchange Rates</td>
<td>Potential strong depreciation of the Brazilian Real against other currencies. Examples: US dollar</td>
</tr>
<tr>
<td>Intellectual Property</td>
<td>Events that threaten the level of security, confidentiality and protection offered to operations in Brazil regarding intellectual capital Examples: patent breaking, patent recognition process, counterfeit</td>
</tr>
<tr>
<td>Inventory Management</td>
<td>Potential negative events resulted of poor management of the inventory levels along the chain. Examples: expired products, misplaced products, stockouts and surplus simultaneously</td>
</tr>
<tr>
<td>Regulation</td>
<td>Potential creation of new regulations or changes in the existing ones that can impact the performance of the supply chain. Examples: mandatory safety tests, mandatory drug tracking</td>
</tr>
<tr>
<td>Operations/Process Failure</td>
<td>Losses that occur due to problems in operations or due to non-standardized or well-designed processes Examples: machine break down, re-work</td>
</tr>
<tr>
<td>R&amp;D Capabilities</td>
<td>Events that impact negatively the process of new drugs manufacturing, distribution and marketing process. Examples: lack of specialized work force, insufficient production capacity, technological obsolescence</td>
</tr>
<tr>
<td>Price Regulation</td>
<td>Problems related to the drugs precification policy adopted in Brazil Examples: changes in price mechanism</td>
</tr>
<tr>
<td>Theft</td>
<td>The diversion of medicines from the legal distribution channels due to robbery Examples: cargo theft, pharmacies robbery</td>
</tr>
</tbody>
</table>
According to Dong and Cooper (2016), by using clusters and pivot elements, the number of comparisons needed to analyze the elements is less than with the traditional AHP, while still ensuring enough redundancy to provide high confidence levels. They also point out that OM-AHP has a particular application in risk management where there are large variations in the probability and thus severity of risk.

Due to its advantages when assessing risks, this research employs the OM-AHP to assess risk in the Brazilian Pharmaceutical Supply Chain. The goal is to identify the risks that are most critical to the performance of the Brazilian PSC, so managers can later turn to the monitoring and mitigation phases (Dong & Cooper, 2016). Risks were assessed using the same evaluation criteria applied in the first stage of this research, that is, probability and impact in terms of service and cost. The problem to be solved was decomposed in a hierarchy, where the highest level had the goal of the research, the evaluation criteria were on the lower levels, and the 10 identified risks, obtained in the previous stage, were at the lowest level (Figure 1).

As prescribed by Saaty and Shang (2011), the 10 identified risks were divided into two clusters, according to their score on the first stage of this research (cluster “low” and cluster “medium/high”). As can be seen in Table 5, each cluster had five elements.

A questionnaire was developed—risks were compared pairwise using a 9-point scale that converts human preferences into alternatives (Kull & Talluri, 2008). The value attributed to element $i$ compared to $j$ is organized in a matrix $a_{ij}$, where $i = j$, $a_{ij} = 1/a_{ji}$ and $a_{ij} = 1$ when $i = j$. The priority vector (the eigenvector corresponding to the maximum eigenvalue) of each matrix represents the relative weight of a given activity or factor of the matrix.

According to the risk definition adopted for this study, probability and impact have the same importance when assessing risk. Nevertheless, the two dimensions that compose impact, service and cost, have different relative weights depending on what the PSC professionals perceive as
The final score of each risk was obtained according to Equation 2.

\[ R_i = P_i \times (w \times C_i + g \times K_i) \]  

(2)

\( R_i \): Global Priority of Risk; \( P_i \): Local priority of Risk in relation to criterion Probability; \( C_i \): Local priority of Risk in relation to criterion Time/Quality; \( K_i \): Local priority of Risk in relation to criterion Cost; \( w \): Priority of criterion Time/Quality in relation to Impact; \( g \): Priority of criterion Cost in relation to Impact.

**Data collection and analysis**

According to the traditional AHP method, in order to assign meaningful numbers when comparing activities, the evaluator must have a thorough understanding of both activities and how relevant they are to the criterion being considered (Saaty & Khouja, 1976). Informants must be experienced people who know how the evaluated activities interact and understand their impact on the objectives. Therefore, for the data collection, it was established that the interviewed experts had to have at least five years of experience in the PSC; it was also decided that they had to occupy managerial positions and directly and frequently interact with other players in the supply chain. It was also sought to select professionals from the different stages of the supply chain (i.e., representatives from the industry, distributors, retail, and institutional buyers), from the leading companies in their segment in Brazil.

In total, ten professionals of the PSC in Brazil were contacted to participate in the research; of these, six agreed to participate. Despite the limited number of interviews, AHP is a subjective methodology in which it is not necessary to involve large samples. Also, for this method, a high number of inputs may result in very high degrees of inconsistency, rendering it impractical for use in large surveys (Wong & Li, 2008).
Before the interviews, a pilot study was conducted with one professional in order to identify points of improvement and reorganize the questionnaire. The validated questionnaire was then administered in the interviews with the six professionals who had agreed to participate. Each interview lasted between 40 and 60 minutes. In the interviewed expert group there were industry, distributor, retail, and institutional buyer representatives, as set out in Table 6.

The many pairwise comparisons often create inconsistencies (Kull & Talluri, 2008) and to assess such inconsistencies, the consistency index (C.I.) and the consistency ratio (C.R.) were used (Enyinda, 2018). The C.I. for each matrix order \( n \) is determined by the maximum eigenvalue (\( \lambda_{\text{max}} \)) as follows (Saaty, 1991). The C.R., in turn, is obtained by the ratio between the C.I. and the random index (R.I.), proposed by Saaty (1991), based on simulations he conducted for matrixes of different orders, as presented in Table 7.

\[
C.\ I. = \frac{(\lambda_{\text{max}} - n)}{(n-1)}
\]

In order to have an acceptable set of judgments, the C.R. should be below 0.10 (Dong & Cooper, 2016; Kull & Talluri, 2008; Saaty, 1991). The results of the interviews were assessed using the C.R. and, based on this filter, two questionnaires had to be returned and re-evaluated. Only one of the returned questionnaires obtained the C.R. inferior to 0.10 after re-evaluation. For this study, due to agenda constrains, the experts had to be interviewed separately; therefore, following Saaty (1991), the geometric means was adopted to combine the scales of judgments. In order to calculate the eigenvectors and eigenvalues, the software adopted was RStudio, a free open-source environment for R language, which uses the LAPACK package, developed by University of Tennessee, University of California, University of Colorado Denver, and NAG Ltd, to solve eigenvalue problems.

<table>
<thead>
<tr>
<th>Table 6. Expert group profile.</th>
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<tbody>
<tr>
<td>Average Years of Experience*</td>
</tr>
<tr>
<td>Industry</td>
</tr>
<tr>
<td>Distributor</td>
</tr>
<tr>
<td>Retail</td>
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<tr>
<td>Institutional Buyer</td>
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*The years do not consider the time they worked in other stages of the PSC

<table>
<thead>
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<th>Table 7. Random index.</th>
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<tr>
<td>1</td>
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<tr>
<td>0</td>
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Results and discussion

The priorities are presented from a PSC point of view and analyzed individually by player. Considering the PSC perspective, the risks global priorities are, in this order: inventory management; operations/process failure; quality; R&D; theft; government’s policy; exchange rates; price regulation; intellectual property; regulation. However, when comparing players’ perspectives, some interesting results are apparent. The first is related to the lack of a holistic view of the PSC. The players tend to prioritize risks that affect their specific tier, therefore perceptions are siloed, as identified in previous studies conducted in developing countries (Benazzouz et al., 2017; Moktadir et al., 2018; Reis & Perini, 2008; Yousefi & Alibabaei, 2015). Figure 2 presents detailed assessment of risks and the impact/frequency graphs for each player in the Brazilian PSC.

Inventory Management is among the top 4 risks for all players, aligned with previous studies conducted in developing countries, such as Iran (Jaberidoost et al., 2015), India (Kamath et al., 2012), and Colombia (Zamora et al., 2013), and also with the literature review conducted by Singh et al. (2016). Poor inventory management can result in delayed treatments and higher costs due to the necessity of acquiring substitute and more expensive drugs (Zamora et al., 2013). In Brazil, according to the Institute of Logistics and Supply Chain (Institute of Logistics and Supply Chain (ILOS), 2017), inventory represents 39% and 43% of logistics costs for Industry and Distributors, respectively, representing the greatest logistics cost. This scenario is reflected on the risk rank, since both players present similar relative weights of priority to this risk (position 3 and 4, respectively), but Industry considers this risk the most frequent among those analyzed. For the Institutional Buyer, this is the most concerning risk, considering the complexity and criticality of medicines for hospitals, as previously identified by Singh et al. (2016). As pointed out earlier, for the hospital sphere, problems in inventory translate into delayed procedures, longer hospital stays, threats to patient safety, and higher costs when alternative options, usually more expensive, are taken in order to overcome inventory issues (e.g., emergency purchasing). For the Retail Pharmacies, because the consumer has a variety of interchangeable medicines at their disposal (e.g., generic and other brands), not having one product of a particular brand in stock was not considered critical because they can offer alternatives to the client.

Operations/Process Failure is another big issue for the Brazilian PSC because it compromises the flow of products and delays operations. This result is in line with previous studies conducted in Europe and in developing countries (Huq et al., 2016; Singh et al., 2016), and also in Brazil (Arruda, 2011). However, the analysis of each player individually reveals
that Retailers and Institutional Buyers are more concerned with this risk than the other two players analyzed. From the Retailers’ perspective, this risk has the highest impact and frequency and is related to the fact that most pharmacies in Brazil are computerized and use some sort of information system. As such, they need solid IT systems and well-defined processes to operate properly to avoid financial losses. On the other hand, Institutional Buyers are concerned about internal process failures, that is, the hospital pharmacy processes designed to ensure the safe and effective use of medicines.
Quality is another risk that is perceived as potentially harmful to the Brazilian PSC. This result is consistent with (1) the research of Arruda (2011), who concluded that, for more than 54% of the companies investigated in Brazil, product counterfeiting is considered as very likely; and (2) the findings of Newton et al. (2010), who analyzed the impact of poor-quality medicines in Africa, parts of Asia, and parts of Latin America, and concluded that in these regions more than 30% of the medicines offered for sale may be counterfeit (i.e., deliberately adulterated drugs, fake packaging, or lack of active ingredients) or substandard (i.e., genuine products that do not meet quality specifications). Also, this result is in line with previous studies that highlighted quality issues in developing countries (Singh et al., 2016) and in Europe (Huq et al., 2016). However, the present study adds to the literature by identifying how each player assesses this risk in the Brazilian PSC.

For the Industry, quality ranked as the second most important risk; moreover, during the interviews, it was mentioned not only as posing a risk to patients’ health, but also as harming the image of the industry and consequently leading to expensive lawsuits and market share erosion. This result is consistent with the findings of Arruda (2011), who interviewed 22 pharmaceuticals companies in Brazil. Another reason why quality is a serious issue for Institutional Buyers relates to the impact it has on the services they provide; thus quality ranks third in terms of priority for this player. In contrast, quality risk is not considered so important to Distributors and Retailers. For the Distributors, quality in the PSC is more related to weak purchasing practices and poor infrastructure and is perceived as the seventh priority by the Distributors interviewed. For Retailers, the main problem poor quality poses is related to product maintenance, such as damaged packaging and short-dated products from suppliers. Suppliers claim that adulterated products seldom reach the pharmacies, as the distributor is usually responsible for solving the issue before the product reaches the shelves. By analyzing each players’ perspective of the quality as risk, we have identified that the main concern for the interviewees is with the maintenance of the medicines’ characteristics through the supply chain but little was mentioned about the issue of counterfeit drugs entering the SC. Such results differ from previous studies where counterfeit is widely discussed and appears as one of the most important risks for the PSC (Enyinda et al., 2010; Huq et al., 2016, among others; Kamath et al., 2012).

R&D risks are considered by the Industry as the most concerning and as having the greatest impact, since R&D, from the Industry standpoint, is fundamental to the entire chain. Industry invests significant amounts of money in the release and promotion of a new drug in order to ensure a healthy pipeline, as identified by Singh et al. (2016). The Retailers also
showed high concern with this risk—ranking as the number two priority, with a high frequency and impact. The concern of Industry, however, is not only related to the drug development processes, but also with the people involved. In their perspective, there are potentially serious problems with the quality and efficiency of the human capital involved in the PSC process in Brazil, including pharmacists, doctors, and other healthcare professionals. This shortage of skilled professionals was also pointed out as one of the main hurdles in the development of the Brazilian PSC by Afonso et al. (2015) and converges to the top ten global health SC issues, as proposed by Privett and Gonsalvez (2014). However, a shortage of skilled professionals was not identified as a major threat for the European PSC in the study conducted by Huq et al. (2016). In turn, for Distributors and the Institutional Buyers, R&D does not post a major risk to the PSC and ranks ninth and eighth place, respectively, for these players. For both Distributors and Institutional Buyers, R&D is a particular concern of the industry that does not impact the other players of the PSC as much.

The interviewees also rated Theft as among the top risks for the PSC, albeit with different priorities for the players in the PSC. In another study conducted in Brazil (Arruda, 2011), PI executives rated cargo theft as having a high risk. Cargo robberies during road transportation is a serious problem in Brazil and has been growing since 2011, generating a loss of US$423 million in 2016 and US$453 million in 2017 (FIRJAN, 2017; Transported Asset Protection Association [TAPA], 2018). Cargo robbery is one channel through which drugs enter the black market and later re-enter the PSC through secondary or illegal distribution channels. Once such channel is the clandestine markets (camelōs), where medicines are sold without a prescription or the monitoring of regulatory agencies. Product theft occurs in all stages of the supply chain, including inside facilities (e.g., factories, warehouses, hospitals, and drug stores) and during transportation. However, theft is most likely in the distribution phase, hitting the distributors hardest. In this study, Distributors pointed to Theft as the main threat to the PSC performance, perceiving it as the most frequent and a threat to the final consumer. Retailers also ranked Theft as a high priority (position 3), although they were most concerned with robbery inside their facilities. Indeed, violence in pharmaceutical retailers has been increasing, and now represents one of the segments with the highest demand for insurance services (Instituto de Ciência, Tecnologia e Qualidade [ICTQ], 2018). For Industry, this risk is still considered as controlled and the use of insurance and other security measures can keep the problem at acceptable levels. However, interviewees pointed out that cargo theft incidents have been increasing in recent years and looking forward, insurance rates might become prohibitive. Under such a scenario, this risk could become more
relevant to Institutional Buyers, who are also subject to theft inside their units, albeit on a much smaller scale. For Institutional Buyers, theft events in the distribution phase are not a critical problem because they can acquire medicines from multiple suppliers; therefore, flow is not interrupted. For Distributors and Institutional Buyers, the risk theft ranked in sixth and seventh, respectively.

Government’s Policy is not a high priority for any of the players investigated. For all of them, the main issue is irregular Government support for the development of a solid national industry. The lack of long-term policies and interruptions of existing programs is one of the biggest hurdles to the growth of the pharmaceutical sector in Brazil, according to Calixto and Siqueira (2008).

Concerning Exchange Rates, Brazil imports most of its active pharmaceutical ingredients (APIs), as well as some finished medicines used in the health system, and this causes major deficits on the trade balance of the sector (Calixto & Siqueira, 2008). Currency devaluation can, therefore, create hurdles in the importation process, increase costs, and ultimately threaten the efficient supply of specific medicines. Consequently, the Institutional Buyer and the Industry ranked this risk in fourth and fifth place, respectively, while Distributor and Retail ranked Exchange Rate last. Both argue that exchange rates are primarily a concern for the industry and do not perceive it as a risk for the PSC, ranking Exchange Rate tenth among the analyzed risks. This result is consistent with the findings of Arruda (2011), who identified that this is not a major risk in terms of the sector as a whole. However, the present study contributes to the literature by revealing the different perspectives among the players of the PSC.

Because in Brazil prices are regulated by ANVISA and CMED, as previously mentioned, there negotiations among the PSC players may be fraught (Gomes et al., 2014). In this context, Price Regulation is a high risk (position 3) from the standpoint of Distributors, who suffer pressure from both Industry and Retailers and must (re)negotiate prices and margins. For Industry and Retailers, prices are directly related to margins and the financial viability of drugs commercialization and distribution. In terms of chance of occurrence, all the players agreed that, given the model of pricing and annual readjustments provided by law, price increases are expected, allowing for advance planning. Price regulation and its impact on operations was also emphasized by the professionals in the Indian PSC, who listed it as a source of market flooding, where innovative but unnecessary drugs are encouraged to be produced so as not to be subject to price controls (Narayana, Elias, et al., 2014).

Intellectual Property risks—related to patents and intellectual property rights—were considered relevant in previous research conducted in Europe,
China, and India (Huq et al., 2016), while in Brazil this risk was considered “unlikely” for 54% of the PI researched by Arruda (2011). Similarly, in the present study, Intellectual Property risk was not a major concern for the PSC professionals. This can be explained by the fact that, although the Industry player invests large amounts of money to develop new drugs and register new patents, in the case of the Brazilian market, most multinational laboratories operate in the generic sector and little research is performed locally. For the Distributor, this risk is important in relation to profits, and ranked fourth in terms of priority and as having the greatest impact, despite being considered the least frequent. According to Distributors, compulsory licenses and patent expiration have a significant impact on their margins, reducing their revenues and interest in marketing certain drugs. Although in terms of the population’s access to medication this is a positive situation, for Distributors, it is financially negative. On the other hand, for both Retailers and Institutional Buyers, patent infringement or patents expiration are perceived as positive events: for the Institutional Buyer, it means an increase in the offer of a previously patented drug, which means they have more supply options in the market; for the Retailer, although the branded products have higher margins, generic drugs are the ones that have greater sales volume and guarantee higher revenues. Both players recognize that this is an issue for the Industry in terms of return on investment, but in their view, the benefits overcome the potential negatives effects for the SC.

Regarding Regulation all players pointed out that changes are usually gradual and that they have enough time to adjust to them; therefore, the chances of real negative impacts on the PSC are considered low, a view consistent with Fischer (2017) regarding the Brazilian market. Arruda (2011) also found that regulation was the highest risk that Brazilian companies face at the time of that study.

However, differently from the present study, the research conducted by Kamath et al. (2012) in India showed that the risk related to regulations is considered the most significant to the PSC. India is similar to Brazil in terms of regulation, where both countries possess a central regulatory agency, embrace universal health coverage, and explore the exceptions allowed in the international treaties related to medicine production. Also, the research conducted by Enyinda (2018) indicated that SC executives from the US attach great importance to regulation/legislation. For them, non-compliance with regulatory guidelines has severe consequences and is the greatest risk facing organizations.

In brief, there is evidence of a siloed mentality where one player often considers a major concern of other members of the supply chain as “someone else’s problem” (Spekman et al., 1998). To confirm this
perspective we calculated the weights given by each player in the PSC, as well as the combination of all perspectives through the geometric mean of results (Figure 3).

Figure 3 shows that, at the PSC aggregation, the cost dimension and the service [time/quality] dimension have similar weights. However, when each player’s perception is analyzed separately, it is possible to see that the industry and the distributors attribute greater importance to cost, while retail and institutional buyers assign greater relative importance to service. These results provide further evidence of the siloed perception we refer to throughout this article.

The Industry player is facing reduced R&D productivity, shortening of patent lives, several available substitute products (e.g., generics), and pressure from healthcare providers to control prices (Hunt, Manson, & Morgan, 2011; Shah, 2004), thus increasing their concerns as to cost base. In turn, Distributors have a similar perspective to the Industry, as they also make large investments in fixed assets, have the smallest margins in the SC, and are pressured both by the industry and by retailer—both of whom wield bargaining power (Fischer, 2017). This scenario of reduced margins and high fixed costs supports the relatively high concern this player has with costs over service. On the other hand, the Institutional Buyer—hospitals and health insurance companies—is mainly concerned with service—which is related to the immediate impact of drug shortages in patient care, as observed by Reis and Perini (2008). The interviewees pointed out that although costs are a concern, problems with quality can have immediate and severe non-monetary impacts, which may subsequently translate into financial ones. Similarly, Retailers also attribute more importance to service over cost. Indeed, service level and customer retention are a major concern, considering the high level of competition in the sector in Brazil, a point also made by Gomes et al. (2014) and Afonso et al. (2015).
Conclusion

Theoretical implications

Our study contributes to SCRM in a number of ways. First, we show that participants of the Brazilian PSC have a siloed perception of risks and priorities, in other words, a self-centered conception of risk and hence limited vision of what truly jeopardizes the performance of the whole PSC. Reis and Perini (2008) highlighted the importance of integration. However, thus far, no article had mapped the varying risk perceptions in the PSC in Brazil. Arruda (2011) analyzed risk solely from the industry perspective. Latin America has received little attention from researchers in this topic (Zamora et al., 2013). The present study contributes to deepen the knowledge on the subject in Brazil and in Latin America. In short, this study incorporated of the voices of the various PSC players, providing a more comprehensive view on what is understood as risk and highlighting the silo mentality in the PSC.

Second, this study identified the ten main risks in the Brazilian PSC: three operational (inventory management, operations/process failure and quality); two environmental (cargo theft and government policy); one inertial (R&D); one financial (exchange rates); one relational (intellectual property); and one legal (regulation). A new risk—price regulation—emerged from the interviews. As such, this research unveiled a new type of risk, complementing the extant literature and the classification proposed by Rangel et al. (2015) insofar as this risk can be added to the environmental dimension. Also, our results demonstrate a higher concern with operational risks over other types.

Additionally, we found a lack of concern with the risk posed by counterfeit drugs. Contrary to the intense scrutiny with this type of risk in the literature as a whole (Enyinda et al., 2010; Huq et al., 2016; Narayana, Elias, et al., 2014), in our study, counterfeiting was not considered a threat and although acknowledged, the interviewees considered the threat as low in the Brazilian context.

As SCRM is a relatively new field when compared to SCM, there is still a lack of industry-oriented research, with most papers focusing on theory building over theory verification (Prakash et al., 2017). In terms of its empirical focus, SCRM has been dominated by USA, UK, and Germany, and by growing numbers of Asian countries (Prakash et al., 2017). There is a dearth of studies focused in Brazil and in Latin America, as revealed by Oliveira et al. (2018), who conducted a systematic literature review of SCRM in five databases and identified that Brazil ranks ninth (out of 20 countries) in terms of the number of articles published in SCRM and is the only Latin American country on the list. In another systematic literature review, conducted by Bak (2018), there was no article produced in Brazil or indeed in Latin America.
Another contribution of our study to the field is to decompose the *impact* dimension when discussing risk analysis in the *cost* and *service* dimensions, thus improving our understanding of the motivations of the different players when managing risk.

Finally, our study also contributes to the literature by applying AHP to investigate the subject. Although AHP has already been applied in several studies conducted in Africa and Europe (Enyinda, 2018, among others; Kamath et al., 2012; Mokrini, Dafaoui, et al., 2016; Moktadir et al., 2018), it has, to the best of our knowledge, never been applied in Brazil or in Latin America.

**Managerial implications**

From a managerial perspective, we provide orientation to managers about which are the most important risks in the Brazilian PSC. The results show that operational problems, such as inventory management and quality management, are still an important issue; hence those should be starting points for improving the system.

By ranking the risks, we can discern the main issues in each stage of the supply chain and act on them, allocating the resources in a more structured and logical way. Once the risks are identified, further studies can be developed so mitigation strategies can be put in place.

This study calls the attention of managers in Latin America to two key issues in the PSC. First, to acknowledge that research grounded on empirical evidence from Northern countries may misdirect managerial decision-making or simply lack empathy with the Latin American context. Developing countries face operational and regulatory challenges, while risks associated to strategy are more associated to Northern countries.

Second, our findings in Brazil may resonate in other Latin American contexts, where lack of integration is still prevalent and specific economic, cultural, and political issues shape managerial decision-making and perception of risks in the PSC. This siloed perception is antagonistic with the overall performance of the PSC. In particular, we highlight the mismatch between upstream players who favor cost over service against downstream players who emphasize service over cost. This mismatch may hinder collaborative efforts. PSC actors should first engage in a search for strategic alignment in order to allow collaboration to prosper.

**Limitations**

Three limitations should be discussed. The first is related to the chosen method of analysis, the OM-AHP. This method was proposed as an evolution of the traditional AHP, and although it overcomes some of the
limitations of the original approach (e.g., the ability to evaluate greater numbers of elements in the same hierarchy with fewer comparisons and without losing consistency), it shares some of its limitations. Both methods rely on the expert’s knowledge and experience, a simplification that makes adoption of the method easier and more intuitive, especially when there is little or unreliable data on the assessed risks. However, neither method takes into account the uncertainty connected with the perception of the decision makers who generate the inputs to the analysis (Radivojević & Gajović, 2014). This aspect of the method makes the results sensitive to the reality and past experiences of the interviewed professionals.

A second limitation is related to the generalization of the results. OM-AHP tends to underperform with a large number of respondents, due to an increase in the risk of arbitrary answers being delivered and hence increasing overall inconsistency (Wong & Li, 2008). As a result, generalizations of the findings should be carefully considered.

One final important constraint for this study is related to group decision-making. When more than one person is involved in decision making, aggregating individual judgements into a single representative judgement (Saaty, 2008) can pose a challenge. For this study, due to scheduling and time constrains, the experts had to be interviewed separately. Therefore, following Saaty (1991) recommendation for such a scenario, in which individuals cannot discuss among themselves to reach consensus, the geometric means is adopted to combine the scales of judgements. Ideally, the experts should be able to discuss among themselves to reach consensus when assessing the risks.

**Future research**

Future studies could apply the SCRM process in the public PSC in Brazil. The Brazilian public health system is a significant part of the national healthcare system and presents its own particularities. As such, analyzing the risks for this system can provide several insights to mitigate supply chain disruption. Another suggestion is to expand the profile of the players involved in the risk assessment phase. This study involved representatives from the industry, distributors, retailers, and institutional buyer; however, for a broader view of the supply chain, it would be interesting to include the perspective of regulatory agencies, cooperatives, and independent pharmacies (i.e., drug stores that are not part of a large retail chain).

Future studies could also look at risk management in the reverse flow of drugs in the supply chain, i.e., recalls. Considering the concern of international institutions with counterfeit or altered drugs entering the market,
as well as environmental concerns with disposal, the risks to the upstream flow of medicines must also be assessed so that plans to reduce recall costs or avoid the diversion of drugs could be developed.

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References


