Systematic review: resilience enablers to combat counterfeit medicines

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Abstract

Purpose – The purpose of this paper is to understand the role of resilience enablers in combating counterfeits in the medicine supply chain based on a Systematic Literature Review (SLR). The objective is also to help practitioners and scholars as the review revealed that little research has been conducted on selecting and implementing practices to improve resilience to counterfeiting.

Design/methodology/approach – Based on the literature review, a content analysis was performed for 84 selected papers to explore the potential relationship among resilience enablers and counterfeit anti-measures.

Findings – This paper contributes to Supply Chain Resilience (SCR) research by summarizing the highly fragmented literature concerning how to combat counterfeiting. The SLR indicated reengineering, collaboration, visibility, innovation, SCR culture and trust as six key enablers to combat counterfeit medicines and identified literature gaps. Moreover, the paper discusses other resilience enablers which have been less studied in the literature and shows new avenues of research.

Research limitations/implications – This paper is limited in that it is an exploratory literature review and focuses only on three databases over the past 15 years. Furthermore, counterfeit is a rapidly evolving issue and anti-measure studies require frequent surveillance concerning new discoveries.

Originality/value – The main contribution of this paper is to provide a better understanding of enablers most often associated with counterfeit anti-measures, which, therefore, might help to increase resilience to counterfeit medicines. Moreover, research gaps involving enablers less associated with anti-measures are presented.

Keywords Pharmaceuticals, Counterfeit, Resilience, Intellectual capital, Systematic literature review

Paper type Literature review

1. Introduction

Intellectual property is an intangible and valuable asset used by organizations to leverage business and, therefore, has become a key factor in organization evaluation (Green and Smith, 2002; Staake *et al.*, 2009). However, supply chains have been experiencing a growing emergence of illicit trade within supply chains. This threat has been heightened because of increased global and dispersed networks (Berger *et al.*, 2012), challenging economic conditions and the popularity of the internet and business to consumer (B2C), where control legislations in most countries are not consolidated (Wilcock and Boys, 2014).

The Pharmaceutical Security Institute (PSI) defines three types of crimes related to illicit trade in supply chains: illegal diversion, thefts and counterfeit trade. Illegal diversion happens when a produced and approved genuine product is intercepted and sold in a different region. Thefts are products illegally obtained at any point of the supply chain (PSI, Pharmaceutical Security Institution, 2017). Finally, counterfeit is the trade of products that bear reference to a brand or organization without authorization and could be confused with an original one (Staake *et al.*, 2009). This research focuses on counterfeit crimes, as for each type of illicit trade, there are different actors, capabilities and mitigation mechanisms to be evaluated (Staake *et al.*, 2009). Moreover, the number of counterfeit incidents reported has grown, especially in markets focusing on research, development and innovation (Stevenson and Busby, 2015), and it may be especially critical in environments and chains with strong concerns about consumer safety (Ringsberg, 2014), such as food, electronics and medicines.

Developing countries tend to be more vulnerable to counterfeiting (Cockburn *et al.*, 2005; Lybecker, 2008). However, it is a global issue, as the product flow might be found anywhere and in different markets (Coustasse *et al.*, 2010). For instance, Meraviglia (2015) presents the threats of counterfeits in the fashion industry and analyzes a case in Italy. Cesareo and Stöttinger (2015) propose consumer-oriented anti-measures after conducting interviews with experts from luxury brands in Italy and Hong Kong. Berger *et al.* (2012) surveyed organizations from different industries in Germany, such as mechanical and electrical engineering, chemical and

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pharmaceutical, metal processing and consumer goods, to analyze the relationship between strategies and exposure to risk. In the pharmaceutical industry, counterfeits have been identified in the UK (Coustasse *et al.*, 2010), Brazil (Ames and Souza, 2012), Singapore, Pakistan and many other countries (Ossola, 2015). In the USA, the Food and Drug Administration (FDA) warned health care professionals about batches of cancer counterfeited medicines being delivered to patients (FDA, 2012).

To combat counterfeit threat, fragmented literature on the topic explores a range of anti-measures. The articles may be related to:

- Authentication practices – Almuzaini *et al.* (2013) presented a Systematic Literature Review (SLR) about counterfeit medicines focusing on assessing the quality of studies concerning drug analysis.
- Technologies – Kwok *et al.* (2010), Coustasse *et al.* (2010), Li (2013), Taylor (2014) and Dimase *et al.* (2016) provided technological solutions to address the issue.
- Consumer's role – Cesareo and Stöttinger (2015) developed a survey in the luxury industry to propose anti-measures targeted at consumers. Most articles on this subject do not focus on managerial perspectives of supply chains.

Hoecht and Trott (2014) presented a broad review of such anti-measures, for example, co-opt offenders, educating stakeholders at the source, aggressive advertising and internal and external guanxi (China), but focusing on Chinese scenarios. Lybecker (2008) presented managerial mechanisms specific to the pharmaceutical industry. However, counterfeiting is an ever-evolving threat in the sense that as soon as new strategies are developed, counterfeiters start looking for new ways to mimic products without being detected (Everts, 2010; Dimase *et al.*, 2016).

An alternative way to study measures to combat counterfeits is to see each counterfeiting incident as a disruption in the supply chain. Therefore, Supply Chain Resilience (SCR) may be an effective way to prevent and combat counterfeits. The authors claim that the more resilient the supply chain, the greater the trend of better responding to disturbances (Sheffi, 2005; Brusset and Teller, 2017). Although many researchers have tried to define SCR (Fiksel *et al.*, 2015; Hohenstein *et al.*, 2015; Kamalahmadi and Parast, 2016; Ali *et al.*, 2017), there is no consensus in the literature. For the purpose of this study, SCR represents the supply chain's dynamic capability to prepare and adapt to respond positively to changes and disturbances in operations (Ponomarov and Holcomb, 2009; Kamalahmadi and Parast, 2016; Brusset and Teller, 2017), seek competitive advantage (Hohenstein *et al.*, 2015), learn from facts and evolve to a new operating state (Christopher and Peck, 2004; Fiksel *et al.*, 2015; Ali *et al.*, 2017).

This definition may help future practitioners and academics to guide their research. First, it summarizes the main points mentioned by other authors. Second, it considers disturbances as predictable and unpredictable events. Third, it highlights the importance of resilience enablers, developed to compensate supply chain vulnerabilities (Fiksel *et al.*, 2015) and ensures better responses in case of disruption (Christopher and Peck, 2004; Pereira *et al.*, 2014 and Scavarda *et al.*, 2015). Hence, enablers are attributes to support anticipation and overcoming of disturbances (Pettit *et al.*, 2013; Ali *et al.*, 2017). Fourth, it underscores the importance of proactive and reactive measures to increase resilience.

In recent years, academics have been developing a vast body of literature involving SCR. Essentially, they are related to:

- generic mechanisms or frameworks to increase organizational or supply chain resilience (e.g. theoretical: Ehrenhuber *et al.*, 2015; Hohenstein *et al.*, 2015; Kilubi and Haasis, 2015; Tukamuhabwa *et al.*, 2015; Kamalahmadi and Parast, 2016; Ali *et al.*, 2017; and empirical: Sheffi, 2005; Blackhurst *et al.*, 2011; Pettit *et al.*, 2013; Brusset and Teller, 2017);
- specific enablers (e.g. theoretical: Christopher and Lee, 2004; Sheffi and Rice, 2005; Kache and Seuring, 2014; Chang *et al.*, 2015; and empirical: Christopher and Lee, 2004; Kache and Seuring, 2014; Scholten and Schilder, 2015; Liu *et al.*, 2017);
- organizational functions or processes to increase organizational or supply chain resilience (e.g. empirical: Khan *et al.*, 2012; Pereira *et al.*, 2014; Wang *et al.*, 2015); and
- analysis of specific disturbance scenarios and how resilience could contribute (e.g. empirical: Rashid *et al.*, 2014; Scholten *et al.*, 2014; Stevenson and Busby, 2015).

The literature considering SCR enablers as tools to combat counterfeits is still in its infancy stage (Stevenson and Busby, 2015). Stevenson and Busby (2015) were the first to link counterfeit construct to resilience enablers. They identified four sets of strategies used by counterfeiters to introduce illegitimate products and proposed counter-measures to increase resilience based on the signaling theory and the resource-based view. More studies are needed within this context, as SCR may play an important role in the fight against counterfeits. Green and Smith (2002) and Qian (2014) present evidence that counterfeit anti-measures found to be useful for one product may not work for another (e.g. organizations may choose to increase or decrease the price depending on the product sold). Thus, anti-measures need to be tailored to specific products (Cho *et al.*, 2015). This study focuses on counterfeit medicine because its supply chain is one of the most threatened because of the amount of existing counterfeited medicines, the direct impact on consumer health and the difficulty in identifying counterfeit products (Cockburn *et al.*, 2005; Berger *et al.*, 2012; Stevenson and Busby, 2015).

In this context, aiming at contributing to this field, this research first identifies counterfeit anti-measures in the supply chain based on a systematic literature review. Second, supply chain resilience enablers potentially associated with these anti-measures are characterized. Finally, particularities of resilience enablers' influence on strengthening counterfeit anti-measures in the medicine supply chain is investigated. Based on this systematic review, a content analysis was carried out to explore the potential relationship among enablers and anti-measures. The main contribution of this paper is to provide a better understanding of which key enablers are most often associated with counterfeit anti-measures in the medicine supply chain and, therefore, might better prepare organizations to increase resilience to counterfeits.

The remainder of this paper is structured as follows. Initially, it briefly contextualizes the two main topics in this study – resilience enablers and counterfeit anti-measures. Section 2 summarizes the research method and describes the SLR. Sections 3 and 4 present (respectively) the 16 counterfeit anti-measures and 13 resilience enablers most mentioned in the literature. In Section 5, conclusions are drawn based on the results reached from the association of anti-measures and resilience enablers, and further research opportunities are presented based on two identified sets: stronger and weaker resilience enablers associated to counterfeit anti-measures in medicine supply chains in the existing literature. Section 6 presents the most relevant managerial and theoretical implications and, finally, discusses the limitations of this study.

2. Research method

The large amount of information available in recent years resulting from dissemination on the internet and new journals and conferences constantly emerging, as well as the importance of literature reviews as the basis for good scientific work have increased the need for more systematic approaches to understand existing knowledge in more depth (Badger *et al.*, 2000; Fawcett *et al.*, 2014). Taking this into account, SLR was chosen to ensure that no relevant research was overlooked and also to improve the validity of the findings, rigor in research and minimize biases (Tranfield *et al.*, 2003; Denyer and Tranfield, 2009; Tukamuhabwa *et al.*, 2015).

2.1 A systematic review

Following the guidelines drawn up by Denyer and Tranfield (2009) and Colicchia and Strozzi (2012), the present SLR is conducted in three phases and based on three research questions. Clarity, feasibility and alignment with existing theory of research questions are crucial to drive the SLR and support its findings (Jesson *et al.*, 2011). The aim of this study is to understand the role of resilience enablers in combating counterfeits in the medicine supply chain. Literature about counterfeit anti-measures is highly fragmented and few researchers have explored them from a managerial perspective (as discussed in Section 1).

In this context, the SLR of this paper started with two questions from a broader perspective:

Q1. What are the counterfeit anti-measures in the supply chain?

Q2. What are the resilience enablers associated with these anti-measures?

Question 1 provided a wider overview of anti-measures applied by different sectors and supply chains to mitigate counterfeit risks. The literature from specific sectors, such as footwear (Qian and Xie, 2014), fashion (Meraviglia, 2015), construction (Naderpajouh *et al.*, 2015) and electronics (Dimase *et al.*, 2016), were selected as the ones presenting generic anti-measures (Mackey and Liang, 2011; Li, 2013; Qian, 2014; Cho *et al.*, 2015). Theoretical (Kamalahmadi and Parast, 2016) and empirical (Speier *et al.*, 2011) articles from different supply chains were analyzed based on Q2. It supported the map and characterization of resilience enablers and the understanding of how these enablers may be associated with the counterfeit anti-measures raised in Q1. After investigating the first two questions in depth and analyzing insights from different sectors, the SLR focused on articles that deal specifically with the medicine supply chain by addressing Question 3:

Q3. How do resilience enablers help to combat counterfeit medicines in the supply chain?

Question 3 enabled us to analyze peculiarities of the medicine supply chain and suggested new avenues of research.

Phase 1 develops the SLR Protocol aimed at protecting research objectivity by providing an explicit description of activities to be performed (Tranfield *et al.*, 2003). To conduct the SLR from a broader perspective and then focus specifically on the medicines supply chain, we chose first the following words to define constructs, keywords and strings: ("counterfeit*"), ("supply chain*"), ("resilien*"), ("risk*"). Then, a second search was conducted combining these strings with ("medicine*") or ("pill*") or ("drug*"). This option was used to minimize biases and cover a wide range of sources and information, while ensuring that all relevant papers from the medicine supply chain were considered. The Web of Science from Thomson Reuters Institute of Scientific Information and Scopus from Elsevier were chosen because they are regularly updated databases, with a wide breadth of coverage in most scientific subjects (Jacso, 2005; Chadegani *et al.*, 2013). These bases also offer powerful features for conducting and refining results (Jacso, 2005; Boyle and Sherman, 2008). Although they are powerful tools, researchers advocate that combining them may provide better research results (Chadegani *et al.*, 2013). Furthermore, ProQuest ABI/INFORM databases were considered because of their coverage of publications in the management field (Rüling, 2005). The study considered articles published over the past 15 years from 2002 to 2016 as topics regarding counterfeits and resilience have significantly grown in recent years (Lybecker, 2008; Kamalahmadi and Parast, 2016; Linnenluecke, 2017), especially in the medicine supply chain (Lybecker, 2008). Furthermore, anti-measures to combat counterfeiters are changing with technological advances, more access to medicine and new counterfeit techniques (Lybecker, 2008; Staake *et al.*, 2012). Moreover, the review was limited to published peer-reviewed journal articles to ensure the high quality of this paper (Denyer and Tranfield, 2009).

Phase 2 conducts the SLR. Based on the key words, the process returned 3,341 articles, 1,289 duplicated. Then, a two-step screening process was followed to assess the relevance of the remaining papers according to pre-stipulated inclusion and exclusion criteria, as observed in Table I.

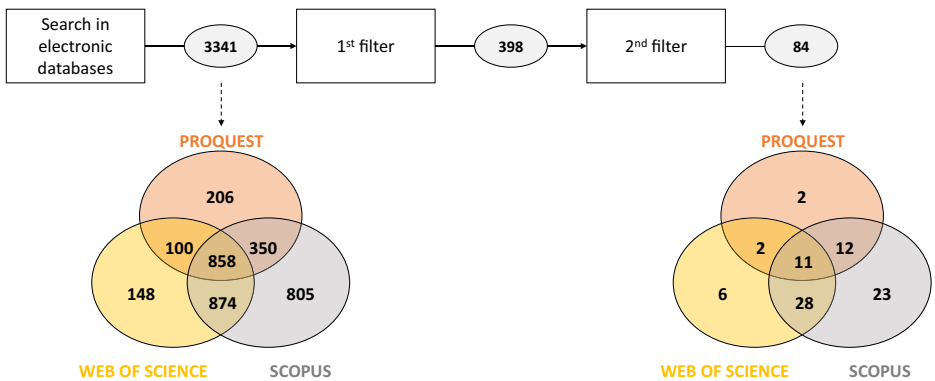
The aim was to ensure that the focus was on resilience enablers and/or counterfeit anti-measures in the context of organizations or supply chains. Articles that meet all inclusion criteria, and consequently violate all exclusion criteria were considered in the SLR so as to ensure quality of the selected materials (Tranfield *et al.*, 2003). It resulted in 84 articles for further analysis, as illustrated in Figure 1.

Table I Inclusion and exclusion criteria of SLR

Criteria	Inclusion	Exclusion
Journal quality	Scientific periodic peer-reviewed	Business magazines, conference, books and notes
Access	Full content written in English or Portuguese	Full content not written in English or Portuguese
Objective alignment	Resilience and/or counterfeit concept within the scope of Operations Management	Resilience and/or counterfeit concept within the scope of other research areas such as materials engineering, pharmacology and medicine
SLR Unit of analysis	Organizations or supply chains	Communities
Focus	Deal directly with resilience enablers in organizations or supply chains and/or with counterfeit anti-measures	Not deal directly with resilience enablers and/or with counterfeit anti-measures under organizations or supply chains perspective
Clarity	Clearly define resilience enablers and/or counterfeit anti-measures	Not define clearly resilience enablers and/or counterfeit anti-measures

Source: Authors

Figure 1 Search summary



Phase 3 represents the analysis, synthesis and communication of results from the three proposed questions. This study applies the content analysis methodology, following Bringer (2006), Johnston (2006) and Krippendorff (2013). It is recommended for facilitating the rigorous exploration of complex issues in the management field (Duriau *et al.*, 2007). Thus, after reading the full texts, the chosen articles were uploaded in QDA Miner for more in-depth investigation (QDA, 2007). First, the study categorized the available data following the basic requirements proposed by Krippendorff (2013), which are mutually exclusive and exhaustive categories. Categorization is crucial to support the identification of relationships and establishment of connections among the different authors studied that write about the same constructs (Gibbs, 2009). QDA Miner enabled us to better understand the frequency and potential clusters and relationships of both resilience enablers and counterfeit anti-measures. Results are presented in a proximity plot graph (Figure 3), as it can be observed better which key enablers are most often associated with counterfeit anti-measures (QDA, 2007). The coefficient of co-occurrence is calculated based on Jaccard's coefficient, which gives equal weight to cases where co-occurrence is identified (a) and cases where one item is found but not the other (b and c). Thus, it is calculated from a fourfold table as a/(a + b + c) (QDA, 2009). Finally, the conclusion summarizes the results and sheds light on recommendations of future research, as well as policies and practices (Denyer and Tranfield, 2009). The next items aim at reporting the findings by answering the SLR questions.

2.2 Literature review – descriptive analysis

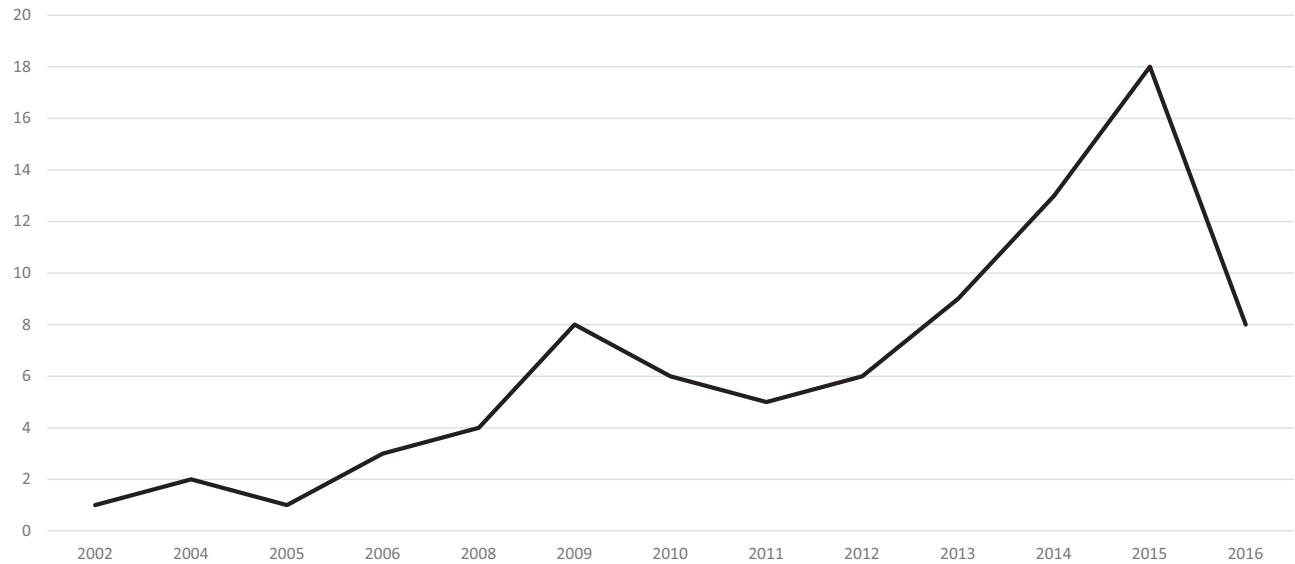
When evaluating the formal characteristics of the collected material, the authors can:

- provide a consistent analysis of the articles; and
- use them to support the content analysis (Seuring and Gold, 2012).

The SLR considered 84 papers, from which 57 per cent (48 articles) discuss mainly resilience enablers and 42 per cent (35 articles) counterfeit anti-measures. As stated, only one article presents resilience as a solution to mitigate counterfeit disruptions. Moreover, only 18 articles (21 per cent) address the anti-counterfeit measures and/or resilience enablers from a medical perspective. It corroborates with the claim that few articles are concerned with these topics. The articles selected mainly (48 per cent or 40 papers) address the issues from a general perspective, 6 papers (7 per cent) discussed the food and beverage sector, 5 papers (6 per cent) the fashion sector and 15 papers (18 per cent) other industries.

Most of the articles (70 per cent) were published from 2011-2016 which shows the increased attention to topics on resilience and counterfeiting, despite the decrease in articles in 2016. Figure 2 presents the distribution of articles per year.

Figure 2 Distribution of articles per year



Moreover, this paper analyzes the origin of the authors of the 84 papers and which countries or regions the articles focus on. Table II presents an overview of the main findings.

As observed, most of the research (52 per cent) does not focus on any area but analyzes the problem from a global perspective. Moreover, although 77 per cent of the authors come from Europe and North America, Asia is the scenario which has been more studied among the selected papers. The articles were probably influenced by the increasing economic rates in the area and their susceptibility to counterfeiting. Less attention has been paid to Africa, Central and South America and Oceania.

3. Counterfeit anti-measures in supply chains

Sales of counterfeit products do not seem to be decelerating in the near future. On the contrary, advances on the internet provide a wider and global reach of customers at a lower cost and increases the difficulty of tracking and tracing them, as the store's location is virtual (Cesareo and Stöttinger, 2015); globalization has increased counterfeiters' ability to move to low-cost manufacturing locations (Chaudhry *et al.*, 2009); and the price of technology used to manufacture products has substantially reduced, while access is increasingly easier (Chaudhry *et al.*, 2009; Chaudhry and Stumpf, 2013). Therefore, counterfeit anti-measures have aroused the attention of academics and practitioners. To help with studies on the subject, Grossman and Shapiro (1988a, 1988b) present some of these measures and distinguish counterfeit markets. They introduce two types of market for counterfeit products:

1 deceptive, when consumers are unaware that they are not purchasing original products and cannot detect them by inspection or inference from the place of purchase; and
2 non-deceptive, when consumers know or strongly suspect when they purchase non-original products.

Mapping the fragmented literature on the topic, this review identified and characterized the 16 most mentioned anti-measures, described in Table III, which sheds light on a diverse set aimed at both counterfeit markets. Moreover, authors (Green and Smith, 2002; Hoecht and Trott, 2014; Naderpajouh *et al.*, 2015) claim that sometimes the best strategy to be taken is simply to do nothing or withdraw from the market. Although these measures initially cause a certain discomfort, they may be an intelligent solution when:

- the costs are higher than the expected benefits (Hoecht and Trott, 2014);
- in non-deceptive markets where an organization faces many difficulties in terms of authority cooperation (Green and Smith, 2002); or
- when the risks are too high (Sharma and Bhat, 2014; Cesareo and Stöttinger, 2015).

The SLR raised a set of anti-measures and this study proposes dividing them into four groups to make it easier to understand:

1 inter-organizational processes and policies, which are anti-measures and require coordination among supply chain links;
2 intra-organizational processes and policies, which are anti-measures applied only inside the organizations;
3 behavioral, which are anti-measures that influence the behavior of supply chain stakeholders; and
4 technology, which includes cientific and technical knowledge and application of technological tools to avoid counterfeiters.

Table II Studied regions and origin of authors

Region	Regions researched	Origin of authors
General	44	–
Africa	2	1
Asia	15	18
Europe	11	39
North America	8	46
Central America	1	1
South America	2	1
Oceania	1	5

Source: Authors

Table III Definition of counterfeit anti-measures identified in the present literature review

Counterfeit anti-measures	Definition	Authors
Inter-organizational processes and policies		
Strict government requirements	Develop laws, regulations and requirements to help countries to monitor and control counterfeiting and to penalize counterfeiters appropriately	Chaudhry *et al.* (2009), Urciuoli (2010), Chaudhry and Stumpf (2013), Hoecht and Trott (2014)
Enforcement of intellectual property rights	Ensure the application of enforcement actions enabling right-owners from copyrights and related rights to impose their rights and facilitate the grant of rights to others to be resisted	Chaudhry *et al.* (2009), Urciuoli (2010), Fernandes (2013), Hoecht and Trott (2014), Qian (2014)
Enhance national and international cooperation	Develop practices to enable collaboration among national and international entities (e.g. NGOs, WHO, QBPC), government, regulatory authorities, police, judiciaries and companies	Lybecker (2008), Jameson *et al.* (2009), Coustasse et al (2010), Almuzaini *et al.* (2013), Qian (2014)
Monitor supply chain members	Establish a system of surveillance, supervision, control and auditing of other supply chain members to protect the network, as well as detect and expose counterfeiters	Kumar *et al.* (2009), Urciuoli (2010), Hoecht and Trott (2014), Cho *et al.* (2015), Dimase *et al.* (2016)
Intra-organizational processes and policies		
Improve quality	Offer customers better quality products to enhance the brand's value perception by adding features, improving product's testability and offering complementary services	Urciuoli (2010), Qian (2014), Cesareo and Stöttinger (2015), Cho *et al.* (2015), Meraviglia (2015), Stevenson and Busby (2015)
Price strategies	Use strategies to increase or decrease prices of products to combat counterfeiters	Stumpf and Chaudhry (2010), Qian (2014), Cho *et al.* (2015)
R&D strategies	Develop R&D strategies regarding products, processes and infrastructure to mitigate counterfeit risks	Green and Smith (2002), Berger *et al.* (2012), Hoecht and Trott (2014), Qian (2014), Stevenson and Busby (2015)
Supply/partner strategies	Review relationship strategies with suppliers and other partners by analyzing potential long-term damage to intellectual property and counterfeiting risks, creating partnerships to combat it	Hoecht and Trott (2014), Qian (2014), Meraviglia (2015), Stevenson and Busby (2015), Wilson *et al.* (2016)
Create an internal structure	Develop a structure within the organization responsible for mitigating and/or combatting counterfeit risks	Green and Smith (2002), Lybecker (2008), Chaudhry *et al.* (2009), Meraviglia (2015), Wilson *et al.* (2016)
Behavioral		
Enhance risk awareness	Raise general awareness of risk involving counterfeit activities and seriousness of the problem, from customers, organizations, supply chains and government perspectives	Chaudhry *et al.* (2009), Chaudhry and Stumpf (2013), Cesareo and Stöttinger (2015), Cho *et al.* (2015), Stevenson and Busby (2015), Wilson *et al.* (2016)
Train members to identify fakes	Communicate about how to differentiate between counterfeit and genuine products	Chaudhry and Stumpf (2013), Hoecht and Trott (2014), Cesareo and Stöttinger (2015)
Enhance brand reputation	Develop mechanisms to strengthen the brand's image and reputation to diminish the counterfeiter¨s urge to imitate and emphasize positive experiences from buying originals	Green and Smith (2002), Berger *et al.* (2012), Cesareo and Stöttinger (2015), Stevenson and Busby (2015)
Standardize and train practices and processes	Define practices and processes and train supply chain personnel to handle counterfeit issues	Chaudhry *et al.* (2009), Jameson *et al.* (2009), Berger *et al.* (2012), Naderpajouh *et al.* (2015), Dimase *et al.* (2016), Wilson *et al.* (2016)
Technology		
Authentication technologies	Overt and covert technologies, developed to facilitate original product verification and counterfeit recognition by providing solutions difficult to duplicate without being easily detected	Green and Smith (2002), Lybecker (2008), Kwok *et al.* (2010), Li (2013), Taylor (2014), Wilson *et al.* (2016)
Traceability	Track and trace history, apply or locate what is under consideration to show the chain of custody, ensure pedigree to manufacturers and certify product authenticity	Wyld (2008), Jameson *et al.* (2009), Coustasse *et al.* (2010), Kwok *et al.* (2010), Dimase *et al.* (2016)
Big data and analytics	Application of sophisticated mathematical and statistical models to manage, process and analyze big data ("5Vs") to support decision-making in counterfeit issues	Kwok *et al.* (2010), Urciuoli (2010), Meraviglia (2015), Papadopoulos *et al.* (2016)

Source: Authors

3.1 Inter-organizational processes and policies

Aline Plançon, an Interpol police officer, states that "counterfeiters can make more money than hard-drug traffickers, and they have less chances of going to prison [. . .]. The attractive revenues don't come with heavy enough consequences" (Everts, 2010, p. 27). Thus, stricter government laws/regulations are essential tools to make it difficult for counterfeiters to enter the market and fight against them. For this purpose, a legal framework to specifically address falsification is needed (Cohn *et al.*, 2012). Although the literature normally criticizes mild laws in regions such as Asia and developing countries, developed countries such as France and Norway also do not have really severe laws (Nayyar *et al.*, 2015). Stricter legislations are also necessary concerning legitimate supplies. For example, although some pharmaceutical companies in the USA were willingly implementing traceability systems, this massive implementation just initiated when its regulatory agency pushed them (Kumar *et al.*, 2009; Coustasse *et al.*, 2010).

Severe regulations to punish counterfeiters and assure supply chain security are necessary. However, they are pointless without appropriate enforcement (Hoecht and Trott, 2014). In many cases, encouraging the government to enforce existing laws is more effective than lobbying for new ones (Chaudhry *et al.*, 2009). The most mentioned enforcement tools are raids (Chaudhry *et al.*, 2009; Everts, 2010; Fernandes, 2013), arrests (Wyld, 2008; Chaudhry *et al.*, 2009) and increased border inspection (Fernandes, 2013). Licenses or certifications are also mentioned, which are provided by local governments, independent organizations or the company itself (to its partners or suppliers), and to obtain them organizations have to comply with anti-counterfeit criteria (Urciuoli, 2010).

Organizations can also help by making efforts to register, establish a renovation process, monitor trademarks and patents (Chaudhry *et al.*, 2009) and promote self-enforcement (Qian, 2014). These efforts facilitate public-private partnerships developed to detect and seize counterfeit products (Mackey and Liang, 2011). A more comprehensive outcome of these initiatives is achieved when there is cooperation among national and international entities involved in counterfeit combat. International organizations may contribute by promoting joint initiatives, such as Interpol and World Customs Organization, who have been working together with national police forces to combat illicit trade in medicines (Almuzaini *et al.*, 2013).

Another anti-measure to reduce supply chain vulnerability can be achieved through constant monitoring. Blackhurst *et al.* (2011) discovered through an empirical study in the automotive sector that organizations consider it important to have a system to monitor supply chains in real time to help make strategic decisions to avoid disruption and to predict them. More specifically, Cho *et al.* (2015) state that monitoring systems should focus on identifying members who are selling counterfeits, facilitating seizure and punishing counterfeiters and their intermediates. Inside organizations, monitoring controls may include closed circuit television systems, perimeter alarms, physical barriers and high value storage areas (Urciuoli, 2010).

3.2 Intra-organizational processes and policies

Reviewing the literature concerning counterfeit anti-measures, the two practices of quality and price are widely discussed and controversial when associated with counterfeits. Cho *et al.* (2015) developed a theoretical model and evaluated the effectiveness of quality and price, marketing, enforcement and technology strategies against deceptive and non-deceptive markets. Qian (2014) presents a framework to find the equilibrium level of prices, quality and purchase decisions. In this context, quality strategies involve upgrading the quality of the product, making it more durable, adding features, improving the product's testability or offering complementary services to distinguish the legitimate product from counterfeits. By increasing the brand's value to the consumer, they become less tempted to purchase illegal products (Fernandes, 2013; Cho *et al.*, 2015) and the widened quality gap hampers the counterfeiters' ability to fool consumers (Qian, 2014). Wilcock and Boys (2014) studied the integration of anti-counterfeits and standard quality management plans and stated that they should, at least, be aligned to proactively prepare organizations for counterfeit issue. However, the authors claim that quality strategies are not always effective because high quality products may increase counterfeit interest (Green and Smith, 2002); and time is needed for changes to take place; therefore, they might not be applied when the counterfeit problem is urgent and requires immediate actions. In this case, organizations might opt for price adjustment responses (Cho *et al.*, 2015; Meraviglia, 2015).

Setting low prices, entry level products make originals more accessible to consumers, by lessening the savings associated with buying a counterfeit, without alienating more the affluent who can afford pricier product lines (Stumpf and Chaudhry, 2010; Cesareo and Stöttinger, 2015). It increases the perceived importance of the original product (Fernandes, 2013), improves access, increases sales volume (Li, 2013), drives counterfeiters out of the market (Lybecker, 2008; Li, 2013) and helps to connect customers to the original manufacturer, who apparently understands their needs (Cesareo and Stöttinger, 2015). On the other hand, authors such as Qian (2014) and Cho *et al.* (2015) also discuss raising price strategy to discourage the licit distributor from taking the risk of selling counterfeits (and losing their current large margin) and distinguishing the brand from counterfeiters.

Creating a moving target is constantly mentioned as a counterfeit anti-measure, which is linked to R&D capacity of developing new characteristics difficult to copy (Green and Smith, 2002). Thus, R&D strategies, such as creating effective labelling and featured packaging (Cesareo and Stöttinger, 2015), redesigning products and increasing the product's complexity (Cho *et al.*, 2015) discourage illegal imitators from copying. A survey conducted by Berger *et al.* (2012) shows the negative relationship of R&D intensity and patent infringement. In addition, the intelligence gained from efforts to detect counterfeit incidents should be reverted to the product design so that improvements can be planned and ensure that the manufacturer is a step ahead.

Furthermore, it is critical that organizations analyze sourcing from a strategic perspective. Although relationships with suppliers and partners may differ depending on a set of characteristics, organizations should provide internal guidance on how to make and implement strict contractual agreements. This includes detailing penalties for non-conformance, rights to audits and quality assurance (Wilson *et al.*, 2016) and

incentives to increase risk (Chaudhry *et al.*, 2009; Hoecht and Trott, 2014). Organizations may proactively create internal teams to monitor if partners stick to the agreement settled to enhance brand-protection (Chaudhry *et al.*, 2009; Wilson *et al.*, 2016) and/or to analyze counterfeiter activities and perform initial investigations (Green and Smith, 2002; Lybecker, 2008; Meraviglia, 2015).

3.3 Behavioral

In complex environments, if knowledge is limited and good governance practices do not exist, then the potential for counterfeits will be high (Enyinda and Tolliver, 2009). Thus, counterfeit anti-measures should focus on modifying stakeholders' behavior to make them more active counterfeit fighters. The most mentioned anti-measure in the behavioral group is also one of the most challenging for organizations (Meraviglia, 2015): raising general awareness of risk involving counterfeiting and the seriousness of the problem.

From a customer perspective, organizations should tailor solutions to stymie demand for counterfeit products (Cesareo and Stöttinger, 2015). This means:

- fighting the perception that counterfeiters are as good as the genuine product;
- combatting anti-big business sentiments;
- enhancing awareness concerning legal impacts of consuming counterfeits (Chaudhry *et al.*, 2009; Fernandes, 2013; Meraviglia, 2015);
- reinforcing the potential use of illegal/child labor (Wilcock and Boys, 2014; Cesareo and Stöttinger, 2015; Meraviglia, 2015);
- challenging the view that purchasing counterfeits is a victimless crime (Meraviglia, 2015);
- explaining disadvantages for countries and society (Cesareo and Stöttinger, 2015); and
- emphasizing positive experiences from buying legitimate rather than counterfeits and reinforcing the value of the genuine product (Wilcock and Boys, 2014).

Programs should be tailored addressing specific beliefs and ethical norms within regions/countries (Wilcock and Boys, 2014) and looking for incentives to strengthen the bond with consumers (Cesareo and Stöttinger, 2015 and Wilcock and Boys, 2014).

To be effective, behavioral anti-measures should be associated with training consumers to identify illegitimate products. This can be achieved through constant communication about how to validate a real product (e.g. packaging, label and appearance) (Chaudhry and Stumpf, 2013; Hoecht and Trott, 2014) and about the authorized retailers (Cesareo and Stöttinger, 2015). Notwithstanding, advertising on how to identify counterfeits may be difficult to implement (Lybecker, 2008) and have only a limited effect (Green and Smith, 2002). The disparities on the success of implementation might explain the significant variation in perspectives of executives from different countries, as observed in the survey conducted by Stumpf and Chaudhry (2010).

Furthermore, organizations, governments and policymakers should also inform and educate their own employees about risks associated with counterfeits in supply chains (Jameson *et al.*, 2009; Stumpf and Chaudhry, 2010) and enhance risk awareness. Sources (Wilson *et al.*, 2016) have emphasized the need for aligning brand-protection values with performance objectives to help understand risk culture and increase counterfeiting risk awareness. Its operationalization may be achieved through inter and intra-organization communication programs, guidelines and training (Naderpajouh *et al.*, 2015), attending conferences and seminars and benchmarking other players (Wilson *et al.*, 2016). The organization's level of risk awareness usually reflects on its practices and processes. Naderpajouh *et al.* (2015) conducted a survey in the construction industry and reported that a lack of awareness implied a lack of assessment and mitigation strategies. Furthermore, recovery and knowledge-sharing plans need to be formulated and distributed (Gould *et al.*, 2010). Absence of standardized practices and processes and/or training generates a knowledge gap and may harm a firm's capability to respond to a counterfeit incident. Therefore, a multi-pronged action plan aimed at employees and supply chain members is necessary (Chaudhry *et al.*, 2009).

3.4 Technologies

From the articles reviewed that focus on specific counterfeit anti-measures, most of them are related to technologies (Coustasse *et al.*, 2010; Everts, 2010; Kwok *et al.*, 2010; Li, 2013; Taylor, 2014; Nayyar *et al.*, 2015; Dimase *et al.*, 2016). Anti-counterfeit technologies are developed to ensure products' authentication and security. Thus, they should be difficult to imitate, easy to identify, hard to reuse and easy to notice when tampered with (Li, 2013).

Authentication technologies aim at facilitating original products' verification and counterfeit recognition by providing solutions that are difficult to duplicate without being easily detected by counterfeiters. In a survey conducted across five countries by Stumpf and Chaudhry (2010) to understand executives' opinions of counterfeit problems, special packaging/labeling (e.g. hologram) appears as the most valuable counter measure overall. Authentication technologies may be divided into two categories. The first category is the overt technologies, which are visible to the naked eye and authenticated by human inspection, such as holograms, color-shifting ink and watermarks. They tend to be easy to identify and not so expensive. On the other hand, they may require training and be easier to falsify (Kwok *et al.*, 2010; Li, 2013; Wilson *et al.*, 2016). The second category is covert technologies, which require special reading devices for authentication, including security inks, digital watermarks, chemical fingerprints and invisible printing (Chaudhry *et al.*, 2009; Kwok *et al.*, 2010; Li, 2013; Wilson *et al.*, 2016). In this case, experts usually conduct authentication analysis from basic physical exams to sophisticated statistical algorithms (Everts, 2010). They tend to be harder to copy and regulatory approval is usually not necessary. However, it is harder for users to identify illegal products, because special devices are needed (Kwok *et al.*, 2010; Li, 2013).

Certification of product authenticity may also be achieved by traceability system implementation (Coustasse *et al.*, 2010), which enables track and trace products across the supply chain, ensuring pedigree to manufacturers and guaranteeing the product flow to the consumer (Dimase *et al.*, 2016). It includes different technologies, such as bar

codes and RFID (Everts, 2010). Many authors present traceability as a solution to address counterfeit prevention and claim that it is essential in ensuring supply chain safety (Kwok *et al.*, 2010). This is because traceability allows rapid identification and reports of suspected products and it also enables greater warehouse and inventory efficiency and control (COUSTASSE *et al.*, 2010), providing real time information (Enyinda and Tolliver, 2009), speeding-up inspection operations (Urciuoli, 2010) and increasing control in reverse logistics (Kumar *et al.*, 2009).

Another possible benefit of traceability is supporting risk-informed decision making (Dimase *et al.*, 2016). However, organizations are still struggling in terms of how to analyze all the information gathered and how to use it as a tool for counterfeiting detection (Kwok *et al.*, 2010). For this purpose, regarding information collected from traceability systems or other sources, they need to develop big data analytics solutions, intelligent systems created to analyze the enormous amount of information gathered. In this context, Kwok *et al.* (2010) designed a system architecture to enable automatic acquisition and effective sharing of information in supply chains. Big data analytics may help, for example, to detect changes in sales and supply chain flow patterns, which indicate counterfeit evidence. Furthermore, it can consider disaster management and analyze how people respond to disasters to take appropriate measures and devise policies (Papadopoulos *et al.*, 2016). In fact, big data and analytics may support the development of social and natural capital during the preparedness phase, alleviate and help recover from disturbances and cope with the future (Papadopoulos *et al.*, 2016).

4. Resilience enablers associated with counterfeit anti-measures

Resilience is built on enablers, organizations' practices and resources created to strategically help decision-making processes after disruptions and to support organizations to reach an improved performance and gain competitive advantage (Ponomarov and Holcomb, 2009). First, it is worth mentioning the inconsistent body of terminologies and wording in the literature. These SCR practices and resources are referred to in the literature as capabilities, enablers, elements, antecedents, competencies or activities (Pereira *et al.*, 2014; Hohenstein *et al.*, 2015; Kilubi and Haasis, 2015). Taking into account Kilubi and Haasis (2015) suggestion and the fact that capability terms have various definitions in the literature, this study remains neutral and uses the term "enablers". From the most recent studies, this literature review mapped and conceptualized the 13 enablers most mentioned in the literature, presented in Table IV.

It is worth mentioning that not all resilience enablers were cited with the same frequency and/or considering the same amount of papers. Collaboration, visibility and flexibility appeared in SLR as the most cited enablers and in most of the articles analyzed. On the other hand, sensing and information security are the resilience enablers less often identified in the papers studied, as observed in Table V.

Resilience enablers are powerful tools for companies to prepare and adapt to respond positively to disruptions in operations (Kamalahmadi and Parast, 2016). One of these risk sources is related to intellectual property, more specifically, to counterfeits (Donadoni *et al.*, 2016). The medicine supply chain is one of the most affected by counterfeits because counterfeit medicines might harm or be inefficient to the patient's health and brand image is a crucial issue (Cockburn *et al.*, 2005; Everts, 2010). The next item explores how resilience enablers might help to combat this challenge.

5. The role of resilience enablers in combating counterfeits in the medicine supply chain

To combat counterfeit medicines in the supply chain, organizations must develop strategies which reduce vulnerabilities to this disturbance (Cockburn *et al.*, 2005; Lybecker, 2008) and prepare them to deal with disruptive events. Thus, based on what has been discussed so far about resilience enablers and counterfeit anti-measures, this study proposes that strengthening resilience enablers helps to combat counterfeiting in the medicine supply chain. To better explore this statement, this study followed the approach proposed by Bringer (2006), Johnston (2006) and Krippendorff (2013): categorization based on dimensions and categories identified in advance and revised during the codification process. Thereafter, a co-occurrence analysis with QDA Miner was conducted (QDA, 2007).

The aim of this analysis is to understand the potential relationship among the counterfeit anti-measures and resilience enablers. To understand the similarities between cases based on coding patterns, QDA (2007) suggests using proximity plot graphs, because it visually shows the proximity of codes. This type of graph more accurately represents the true proximity of codes because it visually shows which resilience enabler is most often associated with counterfeit anti-measures (QDA, 2007). In Figure 3, the coefficients of co-occurrence (Axis X) of all anti-measures are summed up, as observed in the stacked bar graph for each resilience enabler (Axis Y). Thus, the resilience enablers that are most often associated with counterfeit anti-measures present higher coefficients of co-occurrence.

It can be observed in the proximity plot graph (Figure 3) that there are six resilience enablers most often associated with counterfeit anti-measures, considered as the ones with more than five points of coefficient of co-occurrence: collaboration, reengineering, trust, visibility, SCR culture and innovation. This indicates that they are more likely to have relevant influence on combating counterfeit threats. For these six resilience enablers, Item 5.1 discusses what their roles are to increase resilience to counterfeiting by adapting the existing literature and investigating the literature gaps that could be further analyzed considering counterfeit vulnerabilities.

Moreover, Krippendorff (2013) suggests that further analysis concerning the information provided by content analysis indices is required. He argues that analysts have to distinguish between quantifications that lead to testing a statistical hypothesis and quantifications that indicate something other than what is measured. In light of this suggestion, the research approach adopts two bases defined by Ketokivi and Choi (2014). First, a quantitative portion to examine concepts in terms of frequency and second, a qualitative portion in terms of their meaning and interpretation in specific contexts of inquiry. Thus, the frequency of co-occurrence represents the strength of

Table IV Definition of resilience enablers identified in the present literature review

Enablers	Definition	Authors
Flexibility	The ability of a firm and supply chain to sense threats and react and adapt to changing requirements with minimum time, effort, cost and performance drop	Rashid *et al.* (2014), Soni *et al.* (2015), Tukamuhabwa *et al.* (2015), Wang *et al.* (2015)
Redundancy	Replication/Addition of capacity and/or resources that can be invoked during a disturbance to replace the loss of capacity and/or resources during a disturbance	Sheffi and Rice (2005), Chang *et al*. (2015), Kilubi and Haasis (2015), Tukamuhabwa *et al.* (2015), Soni *et al.* (2015)
Collaboration	The ability to join efforts and work effectively within an organization or with other supply chain entities for mutual benefit. In the context of resilience, it reinforces the importance of internal and external communication	Scholten *et al.* (2014), Ehrenhuber *et al.* (2015), Scholten and Schilder (2015), Soni *et al.* (2015), Tukamuhabwa *et al.* (2015), Zhang *et al.* (2016)
Trust	Relationship of trust among supply chain members, a critical component in building successful long-term relationships: goodwill trust (expectation that partners will not act in an opportunistic way) and/or competence trust (belief of the ability to perform as expected)	Dekker *et al.* (2013), Kamalahmadi and Parast (2016), Papadopoulos *et al.* (2016)
Information sharing	Share important, and possibly proprietary information among supply chain members and inside organizations	Dekker *et al.* (2013), Papadopoulos *et al.* (2016), Riley *et al.* (2016)
Information security	Secure information communicated inside the firm with supply chain partners and other stakeholders against deliberate intrusion or attacks	Rajesh and Ravi (2015)
Agility	The ability to react and adapt quickly to changes and potential or actual unpredictable events	Christopher and Peck (2004), Tukamuhabwa *et al.* (2015), Scholten *et al.* (2014)
Visibility	The ability to transparently see through all supply chain links to reduce the information asymmetry, quickly identify needs and disruptions and be able to implement changes effectively	Christopher and Peck (2004), Glickman and White (2006), Tukamuhabwa *et al.* (2015), Ehrenhuber *et al.* (2015)
Sensing	The ability of discerning processes ahead of time and anticipating potential future events or situations	Pettit *et al.* (2013), Ehrenhuber *et al.* (2015)
SCR culture	Infusing a culture of resilience and risk awareness to make it the concern of everyone	Christopher and Peck (2004)
Leadership	Commitment and support of top managers to implement and maintain SCR	Speier *et al.* (2011), Wilcock and Boys (2014), Kamalahmadi and Parast (2016), Manning and Soon (2016)
Innovation	Reach beyond the organization's boundaries and strive to continuously transform knowledge and ideas into new products, processes and systems for the benefit of the supply chain	Golgeci and Ponomarov (2013), Ehrenhuber *et al.* (2015), Wang *et al.* (2015)
Reengineering	Redesigning the supply chain considering certain characteristics to build resilience, reduce risk exposure and overcome disruptions	Christopher and Peck (2004), Scholten *et al.* (2014)

Source: Authors

Table V Frequency and quantity of cases of each resilience enabler

Resilience enabler	Count	Cases (total of 87)
Collaboration	177	59
Visibility	139	48
Flexibility	115	39
Agility	88	32
Redundancy	68	25
Reengineering	61	28
Information sharing	60	29
Trust	58	28
SCR Culture	51	24
Innovation	41	23
Leadership	17	20
Sensing	16	13
Information security	5	5

Source: Authors

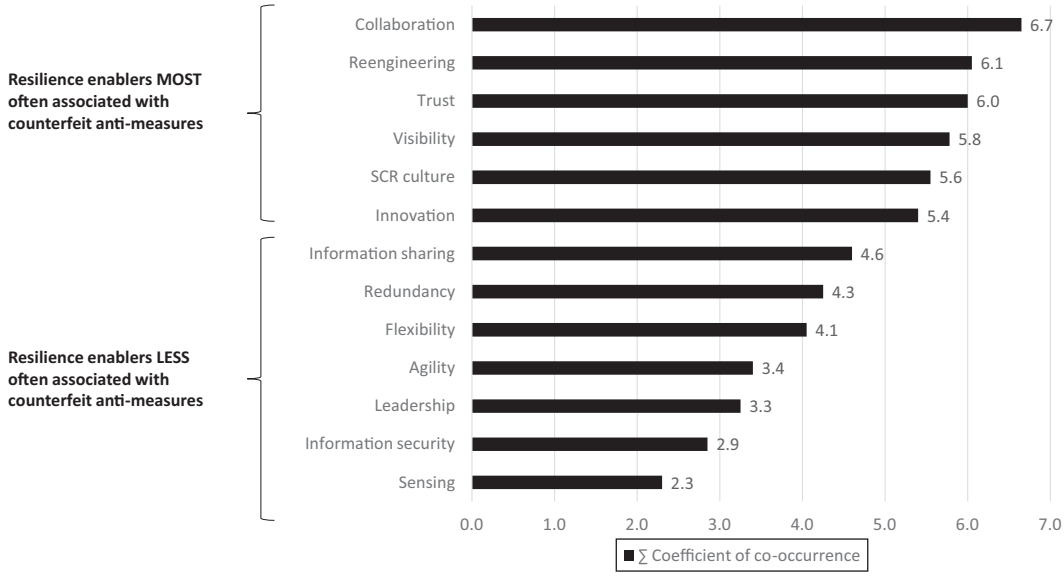
associations between resilience enablers and counterfeit anti-measures in the selected texts. Furthermore, its absence (or weaker association) does not necessarily mean that they do not have an important role to increase resilience to counterfeiting, but that further studies are required to evaluate their role. Thus, Item 5.2 sheds light on resilience enablers less associated with anti-measures and proposes new avenues of research.

5.1 Resilience enablers most often associated with counterfeit anti-measures

5.1.1 Collaboration

Collaboration across supply chains may significantly help mitigate risks (Christopher and Peck, 2004). Despite the existence of many studies to understand its relevance to SCR (Scholten *et al.*, 2014) and performance (Kache and Seuring, 2014; Rashid *et al.*, 2014), little has been researched about the role of collaboration to increase resilience to counterfeiting. Most studies about collaborative relationships aim to establish

Figure 3 Proximity plot – resilience enablers most often associated with counterfeit anti-measures



incentive alignment and joint coordination (Dekker *et al.*, 2013). The challenge raised by Christopher and Peck (2004) to develop a set of practices in which collaborative working is possible still shows a gap in the current literature (Dekker *et al.*, 2013). Dekker *et al.* (2013) conducted a survey with Japanese manufacturers to address this gap.

Coustasse *et al.* (2010) analyzed the severity of counterfeit medicine incidents and stated that in order to reduce this threat, governments need to be willing to promote cooperation among agents to establish effective laws and increase control of the legal supply chain. Scholten *et al.* (2014) showed how the lack of collaboration between entities during a disruption led to problems to meet clients' urgent needs and make efforts in the necessary regions. Jameson *et al.* (2009) evaluated the joint anti-counterfeiting efforts by the USA and China to strengthen enforcement of intellectual property in healthcare. The authors state that governments and organizations such as the US Patent and Trademark Office provide training and technical assistance activities to foster respect for intellectual property and encourage best practices in the enforcement of rights. Organizations might help the government to identify and seize counterfeits by developing internal teams to provide information and report incidents (Green and Smith, 2002). Johnson & Johnson and Pfizer pharmaceutical departments have added this anti-measure to its structure (Lybecker, 2008).

Collaboration can also be considered as a way to increase medicine supply chain costs for counterfeiters, by establishing licenses or certifications to their distributors so that local pharmacists would not collaborate with counterfeiters (Lybecker, 2008); and/or increase monitoring of supply chain partners (Mackey and Liang, 2011). It includes active and real time surveillance of licit and illicit medicine supply chain actors, using enhanced labeling, packaging security measures and supply chain security systems (Mackey and Liang, 2011). Because counterfeit medicine can enter the supply chain at any one of its links due to the large number of intermediaries, Lybecker (2008) states that organizations should partner up with other medicine supply chain links to overcome the challenges. Developing relationships is essential for sharing information (Kache and Seuring, 2014).

Moreover, organizations might share information with consumers and encourage them to collaborate with the fight against counterfeiters in the medicine supply chain (Cesareo and Stöttinger, 2015). Resilience literature advocates that organizations can treat disruption as an opportunity to have more in-depth relationships with customers (Sheffi and Rice, 2005). Thus, organizations may use two-way communication channels to engage consumers more actively by reporting suspected products, inquiring about the product';s authenticity or asking about purchases from authorized sellers (Cesareo and Stöttinger, 2015). By doing so, they tend to increase risk awareness and enhance brand reputation. Thus, collaboration requires network thinking, which is achieved through alignment and engineering among supply chain agents (Christopher and Peck, 2004).

5.1.2 Reengineering

There are certain features that may be engineered into a supply chain to improve its resilience. For instance, by evaluating sourcing criteria or design decisions – such as efficiency versus redundancy – from a supply chain resilience perspective, one may mitigate vulnerabilities (Christopher and Peck, 2004 and Kamalahmadi and Parast, 2016). Thus, they may be used to enhance supply chain resilience to counterfeiting. Christopher and Peck (2004) show the importance of supply chain understanding, design principles for engineering resilience and supply base strategy.

The first step is to map the critical path and main vulnerabilities. The complexity in the medicine supply chain is triggered by the high number of core decision points (Enyinda and Tolliver, 2009) and the high number of secondary wholesalers (Chaudhry and Stumpf, 2013). Moreover, Taylor (2014) discussed the extensive networks of US medicines, which can involve several distributors from different countries.

In this context, Chaudhry *et al.* (2009) state that it is important to analyze intellectual property environments (regulations and

enforcement) before deciding on new investments. Organizations must be aware about law requirements and the possible punishments for counterfeiters and evaluate the risk and probability of counterfeit incidents. Moreover, important reengineering decisions are related to facilities and partner locations, as well as make-or-buy tradeoffs. Kamalahmadi and Parast (2016) state that the likelihood of disruption in supply chains increases when operating in risk-prone areas. In the literature on counterfeiting, this means moving critical functions to ensure overall effectiveness against pro-copying (Berger *et al.*, 2012 and Hoecht and Trott, 2014) and minimizing global sourcing vulnerability (Rashid *et al.*, 2014). Meraviglia (2015) observed that offshoring has made it easier for manufacturers to imitate production processes. Stecke and Kumar (2009) mention the difficulties of a US pharmaceutical company during a port strike in India. Wilson *et al.* (2016) argue that vertical integration of supply chain processes provide the most direct control, surveillance and communication for minimizing counterfeiting risks. Thus, decisions about supply chain design should consider counterfeiting risks.

Moreover, studies on the importance of considering the risk of counterfeits when deciding the R&D process are needed, such as decisions concerning the location of investments (Berger *et al.*, 2012) and integration of suppliers in product development (Stevenson and Busby, 2015). Khan *et al.* (2012), for instance, investigated how alignment between product design and the supply chain influence resilience in the fashion industry. Regarding the suppliers' selection, Enyinda and Tolliver (2009) argue that a high number of intermediates increase counterfeiting vulnerability in the medicine supply chain. Moreover, in Green and Smith (2002) case study, the authors state that maintaining importers and distributors exclusive is an effective strategy to reduce counterfeiters and mitigate counterfeit risks. On the other hand, Cohn *et al.* (2012) examine a real medicine disruption and reinforce the importance of having back-up or substituting suppliers in such events. Academics who study resilience in the supply chain tend to believe that while maintaining a single supplier may have some benefits; it can decrease resilience by undermining disturbance response (Christopher and Peck, 2004). Authors advocate that while it may be interesting to have a lead supplier, wherever possible, alternative sources should be available and there may be limits to pursue supplier base reduction (Christopher and Peck, 2004).

5.1.3 Trust

First, organizations should develop a relationship of confidence with their customers. Customers tend to trust products of reputable brands and offer loyalty in return (Green and Smith, 2002). More than that, if consumers recognize that counterfeiting is less likely, then they will have more confidence in the product (Lybecker, 2008 and Cesareo and Stöttinger, 2015). This is especially true in the medicine supply chain, as patients expect that the right drug is available when they need it to help them feel better (Kumar *et al.*, 2009). Thus, organizations and regulatory agencies in the medicine supply chain are paying more attention to communicating with their customers about the different ways to identify counterfeit products. For example, the FDA launched a campaign to educate consumers about the risks involving online medicine purchase (Chaudhry and Stumpf, 2013). Cohn *et al.* (2012) discusses the importance of working together after a falsification incident of medicines to mitigate the risk of decreased confidence in the healthcare system.

At the same time, the opposite is also true: when consumers are aware of potential counterfeits in the medicine supply chain, the reputation of the brand may erode (Kwok *et al.*, 2010). Thus, to protect the network, organizations in the medicine supply chain are avoiding suspicious wholesalers and eliminating redundant tiers (Lybecker, 2008 and Speier *et al.*, 2011) and increasing surveillance (Lybecker, 2008). Eckerd and Abbott Laboratories are making efforts to increase trust among members of the medicine supply chain and CVS Corporation and Johnson & Johnson are eliminating tiers that trade in secondary markets (Lybecker, 2008). These anti-measures seem particularly effective, as an assessment by Almuzaini *et al.* (2013) identified that the prevalence of counterfeit medicines was significantly higher in unlicensed outlets. Speier *et al.* (2011) observed that the pharmaceutical companies surveyed were concerned about having trusting relationships with suppliers. Trust in the supply chain is affected when its members do not believe in process reliability. This lack of trust may lead to individual actions that collectively increase risk exposure (Christopher and Lee, 2004). On the other hand, when positively applied, trust works as an antecedent of collaboration (Dekker *et al.*, 2013 and Kamalahmadi and Parast, 2016) by, for example, encouraging consumers to report incidents and illegal activities related to counterfeiting (Chaudhry *et al.*, 2009).

Papadopoulos *et al.* (2016) state that relationships built on trust should be supported by exchanging reliable information. Thus, organizations in the medicine supply chain have invested in integrated systems with a number of anti-counterfeit technologies, such as traceability (Enyinda and Tolliver, 2009; Li, 2013; Dimase *et al.*, 2016) authentication (Li, 2013) and systems for rapid data analysis. Despite the advances in technology, it is hard to ensure quality and performance when products leave the authorized supply chain. Moreover, identifying counterfeit medicines may be especially difficult and costly (Nayyar *et al.*, 2015). Therefore, trusted sources should monitor and control supply chain material flow to ensure visibility of the supply chain and product authenticity (Dimase *et al.*, 2016).

5.1.4 Visibility

Visibility is one of the most important enablers for SCR, as discovered in theoretical and empirical studies conducted by Kilubi and Haasis (2015) and Blackhurst *et al.* (2011). Managing a supply chain with limited visibility is challenging (Blackhurst *et al.*, 2011) because managers rely on good information systems and connectivity throughout the supply chain for decision-making (Glickman and White, 2006). However, in the literature on counterfeiting, this is a sensitive subject, because organizations are afraid of the negative impacts on brand perception (Chaudhry *et al.*, 2009; Cesareo and Stöttinger, 2015) and competitors use of counterfeit incidents to gain competitive advantage.

Nonetheless, the recent increase in the number of counterfeit medicine and their criticality in patients' lives has led pharmaceutical companies to find new anti-counterfeit

strategies (Lybecker, 2008) by adopting innovative ways to detect anomalies and provide real-time information to take decisions (Gould *et al.*, 2010). End-to-end medicine supply chain visibility helps organizations to increase the level of control over partners and other supply chain members (Enyinda and Tolliver, 2009) and also monitor critical ways to improve threat awareness and better prepare for disturbances (Rashid *et al.*, 2014; Tukamuhabwa *et al.*, 2015). In a study carried out by Wilson *et al.* (2016), they identified that all surveyed firms use physical and virtual market monitoring against counterfeiters. However, companies are struggling to monitor virtual environments and might be lacking important information. In the medicine supply chain Interpol, the World Customs Organizations, the World Health Organization and national police forces are working together to combat illicit trade online (Almuzaini *et al.*, 2013).

Another opportunity is the development of traceability systems (Speier *et al.*, 2011; Taylor, 2014), as it helps to protect consumers, prevent and respond to adverse disruptions (Enyinda and Tolliver, 2009; Coustasse *et al.*, 2010; Taylor, 2014). Traceability in healthcare has been used in emergency rooms, for surgeries and hospital supply management (Coustasse *et al.*, 2010; Taylor, 2014) and has been broadly discussed in the medicine supply chain (Wyld, 2008 and Kwok *et al.*, 2010). For instance, Pfizer, Purdue-Pharma and GlaxoSmithKline (GSK) have announced developments regarding RFID tagging of its most popular and vulnerable prescription medicines (Wyld, 2008). Ideally, traceability should be applied as early as possible in the medicine supply chain to increase transparency and enable data collection even before medicine production. Despite advances in the subject and the current enforcement of medicine traceability regulations worldwide, there is no standardized system to identify and code pharmaceutical products. Thus, many countries are developing their own serialization patterns, creating a complex and fragmented system, which further hinders the visibility of the supply chain. The increase in transparency, accountability and responsibility enabled by visibility inhibits illegal behavior because it is easier to link it back to the organization.

Furthermore, visibility can promote collaboration by sharing sensitive information among supply chain agents (Christopher and Lee, 2004 and Soni *et al.*, 2015). Thus, more than having available information, organizations need to develop decision structures (Gould *et al.*, 2010) and eliminate functional decisions that do not consider "the big picture" (Christopher and Peck, 2004), which means developing well-defined communication protocols (Blos *et al.*, 2009 and Blackhurst *et al.*, 2011), as well as big data and analytics solutions. However, changing information in the medicine supply chain may be challenging because of the high number of intermediates and low degree of collaboration (Taylor, 2014). Complementary to these measures, Cohn *et al.* (2012) highlight the importance of communicating with civil society. To do this, Wilcock and Boys (2014) suggest:

- co-ordination among chain members' databases, sharing intellectual property information and counterfeit incidents; and
- actively disseminating information about counterfeiters and their products.

However, although reports of counterfeit medicines are improving, global databases are mostly voluntary, and few countries fully report incidents to these databases, which makes it difficult to understand the whole problem (Nayyar *et al.*, 2015).

5.1.5 SCR culture

Many authors have discussed the importance of introducing SCR culture (Christopher and Peck, 2004 and Kamalahmadi and Parast, 2016). They argue that implementing a culture of resilience may help to mitigate specific vulnerabilities. Counterfeiting threat is one of them. Developing anti-measures to influence behavior is crucial to diminish counterfeiting. A SCR culture supports the development of all resilience enablers (Christopher and Peck, 2004; Scholten *et al.*, 2014; Dimase *et al.*, 2016) at all levels (Christopher and Peck, 2004). Moreover, plans should be developed, aimed at employees, partners, local law enforcement and other relevant organizations focusing on preserving intellectual property and disseminating SCR culture (Chaudhry *et al.*, 2009).

Naderpajouh *et al.* (2015), in their empirical study on the construction industry, highlight the negative impact of lack of awareness in counterfeit practices. Moreover, Cohn *et al.* (2012) report the increase of counterfeit risk awareness and problems' visibility as the most important anti-measures after a big incident of falsified medicines. Enyinda and Tolliver (2009) argue that if the knowledge of governance practices are limited, the potential for medicine counterfeiting may be high. Thus, it seems important for researchers to explore SCR culture enablers and develop empirical studies to evaluate barriers and best practices to implement governance of counterfeit risks within the medicine supply chain. Complementarily, Christopher and Peck (2004) encourage including risk awareness as a selection criterion. Rashid *et al.* (2014) analyze business practices in Malaysia's electronics industry and suggest rewarding excellent performer suppliers and demand a countermeasure plan for poor performer level suppliers. Their performance may be linked to avoiding counterfeits (Wilson *et al.*, 2016). From the consumer's perspective, SCR culture supports the increase of general awareness of counterfeit risks (Cesareo and Stöttinger, 2015), as direct communication with customers may reduce the counterfeit market (Hoecht and Trott, 2014) and help them to learn more about counterfeits, and even monitoring and reporting suspicious events (Cho *et al.*, 2015). In the medicine supply chain, countries are studying the availability of implementing solutions to empower consumers to identify and report counterfeit products.

5.1.6 Innovation

Innovation helps organizations to provide agile responses to disruptions, withstand impacts and support organizational restructuring (Golgeci and Ponomarov, 2013). Thus, organizations should continuously innovate to achieve SCR (Ehrenhuber *et al.*, 2015). However, few have discussed its role in increasing SCR (Golgeci and Ponomarov, 2013 and Wang *et al.*, 2015) and no empirical paper has been found which discusses its role in increasing resilience to counterfeiting. In the literature on counterfeiting, Qian (2014) suggests through empirical analysis that organizations which did not innovate were more susceptible to counterfeiters. Furthermore, Lybecker (2008) argue that pharmaceutical companies that

invest a large amount in innovation have more expertise to combat counterfeiters.

Innovation may help to enhance the quality of products (Meraviglia, 2015) and support different price strategies by introducing new materials, processes and ideas into the supply chain. Although it may be applied to any supply chain process and link, it is of the utmost importance in R&D and authentication technology. It directly affects R&D intensity, mitigates the likelihood of imitation and creates barriers for counterfeiters (Berger *et al.*, 2012). R&D teams should also analyze and address supply chain vulnerabilities (Christopher and Peck, 2004). One option used by organizations is to look for suppliers and national or international organizations to help develop solutions to combat and mitigate the risks (Li, 2013) and to induce them into collaboration (Hoecht and Trott, 2014). The medicine supply chain has been looking for suppliers to develop authentication technologies (Everts, 2010; Chaudhry and Stumpf, 2013). Although these technologies are important, counterfeiters reproduce mimics a few months after a new feature development (Dimase *et al.*, 2016). Therefore, it must be associated with agility and innovation, so that the organization is always one step ahead of counterfeiters. Pfizer maintains a queue of new technologies to replace the ones that have already been copied (Everts, 2010). Nayyar *et al.* (2015) presented new techniques for medicine sampling and authentication. Furthermore, literature about counterfeited medicines often address the necessity and challenges to implement serialization and traceability systems, as it enables real-time surveillance and the monitor of the whole supply chain (Coustasse *et al.*, 2010).

5.2 Resilience enablers less often associated with counterfeit anti-measures

Redundancy, agility, flexibility, information sharing, leadership, information security and sensing are the resilience enablers identified in SLR with weaker coefficient of co-occurrence (Figure 3). Although at first glance, it may seem that they are not all relevant to increase resilience to counterfeiting in the medicine supply chain, this study suggests that more in-depth analysis is required to understand their roles to increase SCR and then include counterfeit perspectives.

Sensing and information security, for example, are enablers still little explored in the literature on resilience (Table V). Sensing represents the ability of discerning processes ahead of time and anticipating potential future events or situations (Pettit *et al.*, 2013 and Ehrenhuber *et al.*, 2015). Thus, a hypothesis that sensing influences resilience to counterfeiting should be put forward. Ehrenhuber *et al.* (2015) highlight its importance in anticipating disruptions. This ability may be achieved through specific functional structures within organizations (Blos *et al.*, 2009), the development and dissemination of standardizing processes (Blackhurst *et al.*, 2011) and investments in information sharing and monitoring performance (Kamalahmadi and Parast, 2016). Furthermore, in counterfeiting, it could be highly associated with big data and analytics opportunities, which the potential should not be underestimated. Despite its popularity, little is known about its application in supply chains (Papadopoulos *et al.*, 2016). Increasing sensing in the medical supply chain could, for example, increase the ability to analyze information generated by customers anywhere, identify problems and define actions.

Moreover, little is known about the relevance of information security to increase SCR or specifically resilience to counterfeiting in the medicine supply chain. SLR identified five authors that mention it as a resilience enabler. However, the information that an organization communicates with its supply chain partners is among the most critical of its assets (Faisal *et al.*, 2006) and may help to prevent intentional man-made incidents (Stecke and Kumar, 2009), such as counterfeiting. In the medicine supply chain, assuring information security is a prerequisite for information sharing and visibility, as it involves sensitive data about patients' lives.

6. Conclusion

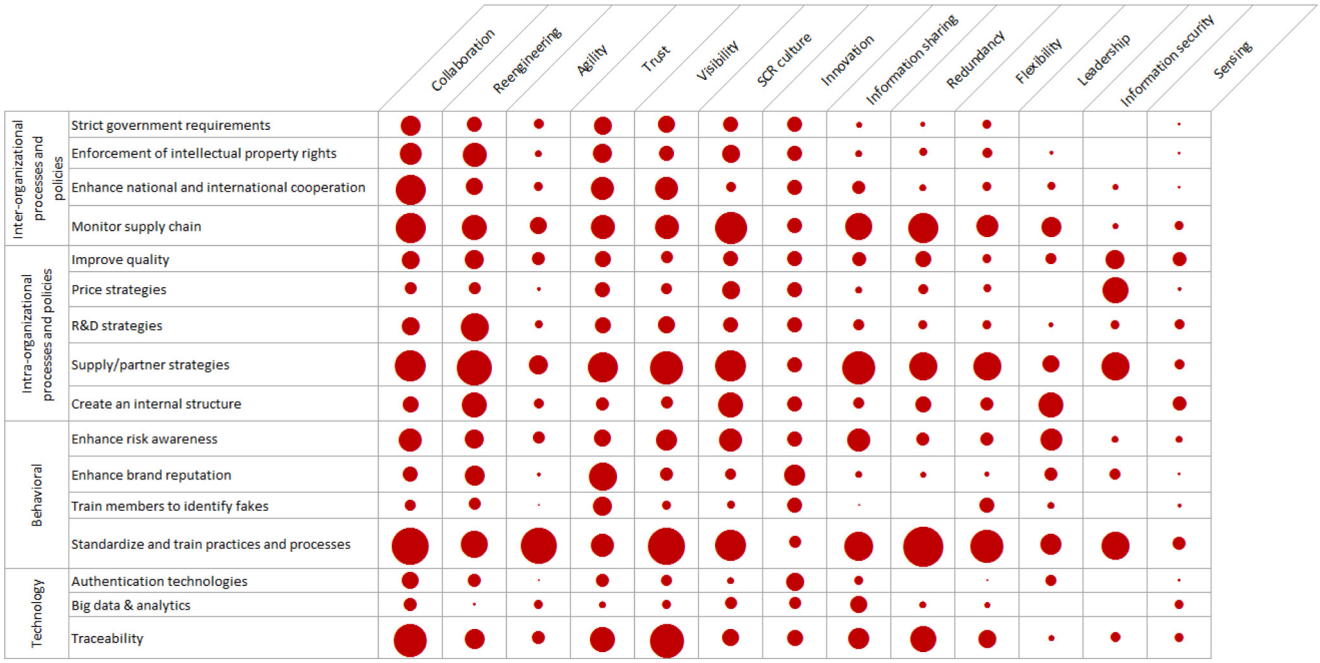
The findings of this research contribute to the ongoing investigations concerning SCR and counterfeit literature by shedding light on how resilience enablers can strengthen anti-measures to counterfeiting in the medicine supply chain. Although resilience reports have addressed counterfeiting as a vulnerability (Donadoni *et al.*, 2016), little research has been conducted on how to address counterfeiting threats by increasing resilience.

6.1 Managerial and theoretical implications

Counterfeiting in the medicine supply chain has been growing, because of free trade agreements, lack of severe regulations, globalization, an increase in emerging markets, the internet, lack of protection in intellectual property and advances in counterfeiting technologies (Chaudhry and Stumpf, 2013). Despite the potential danger for society (Wilcock and Boys, 2014; Quadri, 2017) and the escalating medicine counterfeit market (Almuzaini *et al.*, 2013), just in recent years academics, practitioners and governments have drawn their attention to the issue. Thus, little has been researched on how to address counterfeit threats (Wilson *et al.*, 2016). In this context, this article proposes that disturbances caused by counterfeit medicines could be mitigated by more resilient supply chains and points out some directions in terms of enablers. The findings show that there is potential for future research in this emerging topic with relevant impacts on different agents of the medicine supply chain. Figure 4 represents the association between the resilience enablers and each counterfeit anti-measure. The bigger the bubble, the higher the coefficient of co-occurrence (the coefficient is extracted based on from the QDA Miner software through the same co-occurrence analysis explained in Section 2.1).

From a managerial perspective, our findings show the importance for practitioners to increase SCR to prepare for, respond to, recover and grow successfully (Scholten *et al.*, 2014; Ehrenhuber *et al.*, 2015; Hohenstein *et al.*, 2015) from disruptions caused by counterfeiting. Moreover, our results indicate the outcomes of strengthening resilience enablers. As previously discussed, collaboration, reengineering, trust, visibility, SCR culture and innovation were the resilience enablers most often associated with counterfeit anti-measures. Moreover, monitoring the supply chain, developing strategies for partners and suppliers and standardizing and training practices and processes are the counterfeit anti-measures most

Figure 4 Framework of resilience enablers' influence on counterfeit anti-measure in the medicine supply chain



often associated with resilience enablers. For instance, this study presents how collaboration among supply chain links and share of best practices may help organizations to define standardized practices and processes to mitigate counterfeiting risks and, thus, promote more properly and quickly enforcement; and how considering counterfeit threat during supply chain (re)engineering may mitigate vulnerabilities related to facility locations and questionable suppliers and partners. Moreover, raising awareness about resilience might help organizations to monitor supply chains by transforming their customers into "auditors". To do so, customers might be supported by innovative solutions, which help them to connect fast with their brands.

This study also contributes to SCR and anti-counterfeiting literature. This paper is unique, as it provides an in-depth analysis of the literature in both fields. By analyzing the associations drawn in Figure 4, our findings present new insights that have not been mentioned in existing studies about the relevance of resilience. Further studies are necessary to determine the role of each resilience enabler in promoting resilience to counterfeiting, and the study also contributes by suggesting new avenues of research that could be better explored in future studies. The main conclusion is the need for more studies into how resilience enablers may mitigate counterfeit risks. The role of collaboration, trust and reengineering, for example, has been little explored in the literature. Stevenson and Busby (2015) illustrate this gap by stating that although the literature on resilience regarding supplier selection considers trust, flexibility and redundancy, little is known about the risk of passing-off products under the original trademark. In addition, identifying the role (or not) of enablers less associated with counterfeit anti-measures, such as the importance of big data and analytics in sensing threats as counterfeit, would contribute to a field in constant growth. The SLR also suggests the need of understanding the effectiveness of such resilience practices. A few authors (Liu *et al.*, 2017; Mandal, 2017) have drawn conclusions in this sense by investigating the impact of SCR in performance; however, more studies are needed. For instance, despite the increased academic anti-measures aimed at consumers (Fernandes, 2013), practitioners and academics doubt their effectiveness and efficiency (Chaudhry *et al.*, 2009). Although a few authors (Stumpf and Chaudhry, 2010) have evaluated consumer and manager perception, to the best of our knowledge, no empirical studies have explored the effectiveness of such anti-measures.

Moreover, authors may investigate trade-offs between current findings in SCR literature and the findings here explored about how to increase resilience to counterfeit. For instance, while counterfeiting literature advocates that offshoring and outsourcing may have potential long-term damage (Hoecht and Trott, 2014; Meraviglia, 2015), resilience literature affirms that a rapid response involves using standard processes and having multiple locations with built-in interoperability (Sheffi and Rice, 2005) and dual sourcing (Lücker and Seifert, 2017). Furthermore, while academics who study counterfeiting claim that companies should increase technological complexity of their products and make it harder to imitate (Cho *et al.*, 2015), literature on resilience states that the complexity of products increases the risk of the supply chain, making it difficult to recover in the event of a disruption (Blackhurst *et al.*, 2011 and Khan *et al.*, 2012). Thus, this paper reinforces that understanding these tradeoffs and proposing equilibrium is necessary.

This study also suggests that new trends in the medicine supply chain, as the increase in online pharmacies and the existence of many intermediates before consumers' consumption, require more studies on how to address these new exposures once, as stated by Dimase *et al.* (2016), Quadri (2017), if one link is susceptible to counterfeiters, then the whole chain is. Moreover, this study encourages researchers to conduct empirical studies in

vulnerable areas still little explored, such as Africa and South America.

Finally, the counterfeit issue is also a threat in other supply chains, and many similarities may be observed. For instance, the criticality of counterfeit products for consumers' safety and health may also be identified in other sectors, such as food, beverage and aviation parts. Moreover, complex and extensive networks are also not restricted to medicines. Cash, for example, presents innumerous opportunities for counterfeiters to introduce illegal banknotes. Luxury, fashion and cigars sectors are also constantly threatened by counterfeiters. Thus, this study urges researchers to investigate similarities and differences on how to increase resilience to counterfeiting in other industries.

6.2 Limitations

Even though efforts were made to maintain the rigor of the research, limitations associated with it need to be addressed for future implications. Our research is not free from limitations. First, as aforementioned, counterfeiting is rapidly evolving and, therefore, anti-measures require constant monitoring and updating. Studies on the subject may shift dramatically over time. Second, although the search strings were carefully formulated, and relevant databases were carefully selected, potentially relevant articles that do not explicitly use any of these terms or that have not been published in one of the three databases searched may not have been identified. Moreover, this study does not address the literature concerning other relevant types of trade crimes. Third, the opportunities provided by the literature gaps have not been empirically tested, which should be done in different contexts and markets to assure their validity. Our findings are exploratory rather than definitive but indicate areas of interest for practitioners and academics to explore in future studies.

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Further reading

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