CEFET/RJ
DIRETORIA DE PESQUISA E PÓS-GRADUAÇÃO

# SUPPLY CHAIN RISK MANAGEMENT IN HEALTHCARE: IDENTIFICATION, ASSESSMENT AND MITIGATION

Pedro Senna Vieira

Tese de Doutorado apresentada ao Programa/Curso de Pós-Graduação *Stricto Sensu* em Engenharia de Produção e Sistemas do Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, CEFET/RJ, como parte dos requisitos necessários à obtenção do título de Doutor.

Orientador: D.Sc. Augusto da Cunha Reis

Rio de Janeiro
Junho de 2019

SUPPLY CHAIN RISK MANAGEMENT IN HEALTHCARE: IDENTIFICATION, ASSESSMENT AND MITIGATION

Exame de qualificação apresentado ao Programa/Curso de Pós-Graduação *Stricto Sensu* em Engenharia de Produção e Sistemas do Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, CEFET/RJ, como parte dos requisitos necessários à obtenção do título de Doutor.

Pedro Senna Vieira

Banca Examinadora:

_____

Presidente, Professor Dr. Augusto da Cunha Reis (Orientador – CEFET/RJ)

_____

Professor Dr. Annibal José Roris Rodriguez Scavarda do Carmo (Unirio)

_____

Professora Dra. Mirian Picinini Méxas (UFF)

_____

Professor Dr. Igor Leão dos Santos (CEFET/RJ)

_____

Professor Dr. Ormeu Coelho da Silva Júnior (CEFET/RJ)

Rio de Janeiro
Junho de 2019

CEFET/RJ – Sistema de Bibliotecas / Biblioteca Central

V658 Vieira, Pedro Senna
Supply chain risk management in healthcare : identification, assessment and mitigation / Pedro Senna Vieira.—2019.
163f. + apêndices: il. color. , grafs. , tabs. ; enc.

Tese (Doutorado) Centro Federal de Educação Tecnológica Celso Suckow da Fonseca , 2019.
Bibliografia : f. 131-163
Orientador : Augusto da Cunha Reis

1. Administração dos serviços de saúde. 2. Cadeia de logística integrada - Avaliação de riscos. 3. Engenharia de produção. I. Reis, Augusto da Cunha (Orient.). II. Título.

CDD 670

Elaborada pela bibliotecária Mariana Oliveira CRB-7/5929

# RESUMO

Gestão de Riscos é um tópico consolidado pela literatura acadêmica e amplamente estudado por companhias de seguros e corretoras de investimentos. Como uma extensão natural do conceito, Riscos que dizem respeito a mais de um elo em uma Cadeia de Suprimentos, formam o conceito de Gestão de Risco em Cadeias de Suprimentos, que vem sendo estudado de forma crescente, principalmente a partir do início dos anos 2000. Artigos da primeira metade desta década, focaram principalmente em conceituar Riscos inerentes às Cadeias de Suprimentos e na construção de arcabouços conceituais baseados em etapas lógicas. Entre os diversos arcabouços propostos, há consenso entre os autores no que diz respeito a três etapas: Identificação de Riscos, Avaliação de Riscos e Mitigação de Riscos. Tão relevante quanto o conceito de Risco é o conceito de Resiliência das Cadeias de Suprimentos, que prega que a construção de uma Cadeia de Suprimentos Resiliente e robusta pavimenta o caminho para a minimização de Riscos. Em termos de estudos empíricos, vários segmentos (incluindo automotivo, têxtil e petrolífero) têm aplicado Gestão de Riscos e Resiliência em Cadeias de Suprimentos com relativo sucesso. Entretanto, esta tese identificou que a aplicação destes conceitos a Cadeias de Suprimentos da saúde constitui uma lacuna importante na literatura. Enquanto em grande parte das indústrias os benefícios são conhecidos, consistindo em tornar Cadeias de Suprimentos menos propensas a erros, perturbações e efeitos em cascata; em organizações de saúde, além destes benefícios, inclui-se a possibilidade de salvar vidas. Neste sentido, esta tese tem como objetivo geral a construção de um arcabouço conceitual que seja capaz de conduzir a geração de Resiliência em Cadeias de Suprimentos através do gerenciamento de Riscos ao longo da cadeia. Como objetivo específico, a tese apresenta aplicação do arcabouço construído incluindo Identificação de riscos, Avaliação de Riscos (via Revisão Sistemática de Literatura para identificação de Indicadores) e Mitigação de Riscos. Como principais resultados, podem ser destacados o arcabouço metodológico construído, a metodologia de Revisão Sistemática de Literatura e a validação com entrevistas realizadas com profissionais da cadeia de suprimentos da saúde.

Palavras - Chave: Supply Chain Risk Management, Supply Chain Resilience, Healthcare Management; Healthcare Supply Chain Risk Management; Supply Chain Risk Management Framework.

# ABSTRACT

Risk Management is a very consolidated topic mostly studied by insurance, financial companies and brokers. As a natural extension of the concept, Risks concerning more than one tier in a Supply Chain, namely Supply Chain Risk Management, have been increasingly studied since the early 2000's. Papers from the first half of this decade focused on Risk conceptualization as well as constructing frameworks built on logical steps. Among the different frameworks proposed, there were consensus regarding three steps: Risk identification, Risk Assessment and Risk Mitigation. As important as Supply Chain Risk Management is Supply Chain Resilience, which preconizes that building a robust and resilient Supply Chain consists in a solid path to minimize Risks. In terms of empirical studies, several different segments (including automotive, clothing and oil industry) have applied Supply Chain Risk Management and Supply Chain Resilience with relative success. Nevertheless, this thesis identified that the application of both concepts in Healthcare Supply Chains consists in a major literature gap. While in most industries the benefits are already recognized, consisting in making a Supply Chain less prone to errors, disturbances and ripple effects, in Healthcare, besides these benefits, can be added the possibility of saving lives. Therefore, this thesis has the general objective of generate a conceptual framework to address resilience to Healthcare Supply Chains through Supply Chain Risk Management. As specific objectives this thesis presents Risk identification, Risk Assessment (using a Systematic Literature Review to identify Key Process Indicators) and Risk Mitigation. As the main results, can be highlighted the methodological framework, the Systematic Literature Review Methodology and the validation with Healthcare Supply Chain Professionals.

Keywords: Supply Chain Risk Management, Supply Chain Resilience, Healthcare Management; Healthcare Supply Chain Risk Management; Supply Chain Risk Management Framework.

# SUMMARY


**Introduction** 13
**General context** 13
**Motivation** 15
**Problem statement** 18
**Objectives** 19
General objective 19
Specific objectives 20
**Thesis contributions** 20
**Research delimitation** 21
**Study organization** 21
**1. Theoretical Background** 22
**1.1. Chapter Abstract** 22
**1.2. Graphical Abstract** 23
**1.3. Prior to "Supply Chain Risk Management"** 24
**1.4. Supply Chain Risk Management (SCRM)** 24
**1.4.1. Stages of SCRM** 27
**1.5. Supply Chain Resilience (SCRes)** 28
**1.5.1. Resilience strategies** 29
**1.6. Healthcare management** 34
**1.7. Healthcare Supply Chains** 35
**1.8. Supply Chain Risk Management in Healthcare** 36
**1.9. Chapter Results** 38
**1.10. Chapter Conclusions** 41
**2. Methodology** 42
**2.1. Data collection** 45
**2.1.1. Data collection procedure for Systematic Literature Review** 45
**2.1.2. Data Collection limitations (SLR)** 46
**2.1.3. Data collection procedure for empirical study** 47
**2.2. Research questions** 48
**3. Results of the Systematic Literature Review** 49
**3.1. Chapter abstract** 49
**3.2. Chapter Introduction** 49
**3.3. Chapter Methodology** 50
**3.3.1. Formulate research question** 54
**3.3.2. Database Selection** 54
**3.3.3. Define search terms** 55
**3.3.4. PRISMA Protocol** 55
**3.4. Results of the Systematic Literature review** 56

**3.4.1. Classify papers** 56
**3.4.2. Analyze papers** 58
**3.4.3. Results and research gaps** 59
**3.5. Discussion, limitations and conclusion of the Chapter** 71
**4. Risk Identification** 73
**4.1. Chapter Abstract** 73
**4.2. Chapter introduction** 73
**4.3. Clinical Engineering** 74
**4.4. High Reliability Organizations** 75
**4.5. Defining Healthcare Supply Chain Risk Management** 77
**4.6. Chapter methodology** 80
**4.7. Formulate research questions** 82
**4.8. HCSC risks identified** 82
**4.9. Qualitative interviews** 83
**4.10. Discussion** 86
**5. Risk Assessment** 91
**5.1. Chapter abstract** 91
**5.2. Introduction** 91
**5.3. Chapter methodology** 92
**5.4. Formulate research question** 93
**5.5. Select database** 94
**5.6. Define search terms** 94
**5.7. Select papers** 94
**5.8. KPI mapping** 95
**5.9. Qualitative interviews – KPI related analysis** 99
**6. Risk Mitigation** 101
**6.1. Chapter abstract** 101
**6.2. Chapter introduction** 101
**6.3. Method** 102
**6.4. Antecedents, Mediators and Consequences of Healthcare Supply Chain Resilience** 106
**6.5. Antecedents of Healthcare Supply Chain Resilience** 107
**6.6. Mediators of Healthcare Supply Chain Resilience** 112
**6.7. Consequences of Healthcare Supply Chain Resilience** 114
**6.8. Framework for Healthcare Supply Chain Management analysis** 116
**6.9. P1 – Healthcare Supply Chain Risk Identification Drivers** 116
**6.10. P2 – Healthcare Supply Chain Risk Assessment Drivers** 117
**6.11. P3 – Healthcare Supply Chain Risk Mitigation Drivers** 118
**6.12. P4 – Healthcare Supply Chain Integration Drivers** 119
**6.13. P5 – Healthcare Supply Chain Resilience Drivers** 120

**6.14. P6 – Healthcare Supply Chain 4.0** 121
**6.15. Qualitative interviews** 121
**6.16. Discussion** 123
**6.17. Conclusions, contributions, limitations and future research** 125
**7. General Discussion, Conclusion and Further Research** 126
**Appendices** 161
**Interview Protocol** 161
**Questionnaire ready to be distributed** 162

# FIGURE INDEX

**Figure 1 –** Private health insurance coverage ..... 16
**Figure 2 -** GDP variation (%) ..... 17
**Figure 3 -** Private health insurance beneficiaries (with or without dental care) ..... 17
**Figure 4 -** Graphical abstract - Chapter 1 ..... 23
**Figure 5 -** Risk Sources ..... 27
**Figure 6 -** Framework for resilience enhancing ..... 33
**Figure 7 –** A Healthcare Supply Chain ..... 36
**Figure 8 -** Conceptual framework ..... 41
**Figure 9** - Thesis Methodology ..... 43
**Figure 10 –** Chapters' structure ..... 44
**Figure 11 -** Mendeley® Software ..... 45
**Figure 12 -** Paper database ..... 46
**Figure 13 -** Research Methodology workflow ..... 52
**Figure 14 –** Data and results generating process ..... 56
**Figure 15 -** Segment distribution (Proportions) ..... 56
**Figure 16 –** Articles distribution ..... 58
**Figure 17 -** Top 10 publishing countries ..... 59
**Figure 18 -** Top 10 countries with more citations ..... 60
**Figure 19 -** Most productive authors ..... 60
**Figure 20 -** Most cited papers ..... 61
**Figure 21 -** Lotka's distribution ..... 64
**Figure 22 -** Bibliographic coupling ..... 65
**Figure 23 -** Bibliographic co-citation ..... 66
**Figure 24 -** Bibliographic collaboration ..... 67
**Figure 25 -** Country collaboration ..... 68
**Figure 26 –** co-words analysis ..... 69
**Figure 27 –** Word Cloud ..... 70
**Figure 28 –** Conceptual map ..... 71
**Figure 29 -** Healthcare Supply Chain Risk Management Constructs ..... 79
**Figure 30 -** Research Methodology workflow ..... 81
**Figure 31 -** The Healthcare Supply Chain studied ..... 84
**Figure 32 -** Systematic literature review of KPI ..... 93
**Figure 33 -** KPI list validation methodology ..... 96
**Figure 34 -** Literature review workflow ..... 105
**Figure 35 -** Healthcare Supply Chain Risk Identification factor ..... 108
**Figure 36 -** Healthcare Supply Chain Risk Assessment factor ..... 109
**Figure 37** – Healthcare Supply Chain Risk Mitigation ..... 110
**Figure 38 -** Healthcare Supply Chain Risk Integration ..... 112
**Figure 39 -** Healthcare Supply Chain Risk Management ..... 113
**Figure 40 -** Healthcare Supply Chain 4.0 ..... 114
**Figure 41 -** Healthcare Supply Chain Performance factor ..... 115
**Figure 42 -** Framework for Healthcare Supply Chain Resilience analysis ..... 116

# TABLE INDEX

**Table 1 -** Risk sources ..... 26
**Table 2 -** Resilience definitions ..... 29
**Table 3 -** Risk mitigation strategies I - Juttner et al. (2003) ..... 30
**Table 4 -** Resilience principles - Christopher and Peck (2004) ..... 30
**Table 5 –** Risk mitigation strategies II - Tang (2006) ..... 31
**Table 6 -** Risk mitigation strategies II - Iakovou et al. (2007) ..... 31
**Table 7 -** Mitigation Strategies ..... 32
**Table 8 -** Analysis brought by review papers ..... 38
**Table 9 -** Literature Summary ..... 39
**Table 10 -** Review papers used to construct the research methodology ..... 51
**Table 11 -** Main indicators brought by review papers ..... 52
**Table 12 -** Publications by journal ..... 61
**Table 13 -** Distribution by segment (with at least two studies found) ..... 57
**Table 14 -** Most used techniques (2 or more outcomes) ..... 57
**Table 15 –** Authors' dominance ranking ..... 62
**Table 16 -** h-index, g-index and m-quotient ..... 62
**Table 17 -** Lotka's law calculations ..... 63
**Table 18 -** Interviwees profile ..... 83
**Table 19 -** Risks corroborated in the interviews ..... 84
**Table 20 -** Search strings ..... 94
**Table 21 -** Questionnaire I – General Questions ..... 96
**Table 22 -** Questionnaire II) Final List of KPI ..... 97

# ACRONYMS LIST

**ABS** - Agent-Based Simulation

**AHP** - Analytic Hierarchy Process

**AMOS** - Analysis of a Moment Structures

**ANOVA** - Analysis of Variance

**ANS** - Agência Nacional de Saúde Suplementar

**BPI** - Business Process Improvement

**CFA** - Confirmatory Factorial Analysis

**CRM** - Clinical Risk Management

**CVaR** - Conditional Value - at - Risk

**DEMATEL** - Decision making trial and evaluation laboratory

**FAHP** - Fuzzy Analytic Hierarchy Process

**FMEA** - Failure Mode and Effect Analysis

**GDP** - Gross Domestic Product

**HC** - Healthcare

**HC** SCRES - Healthcare Supply Chain Resilience

**HC** SCRM - Healthcare Supply Chain Risk Management

**HCSC** - Healthcare Supply Chain

**HIV** - Human Immunodeficiency Virus

**HLM** - Health Lean Management

**IBGE** - Instituto Brasileiro de Geografia e Estatística

**KPI** - Key Process Indicators

**LHCSC** - Lean Healthcare Supply Chain

**MCA** - Multiple Correspondence Analysis

**MS** – Ministério da Saúde

**PRISMA** - Preferred Reporting Items for Systematic Reviews and Meta-Analyzes

**QFD** - Quality Function Deployment

**SC** - Supply Chain

**SCM** - Supply Chain Management

**SCOR** - Supply Chain Operations Reference

**SCR** - Supply Chain Risks

**SCRAMTM** - Supply Chain Resilience Assessment and Management

**SCRES** - Supply Chain Resilience

**SCRM** - Supply Chain Risk Management

**SEM** - Structural Equation Modeling

**SIB** - Sistema de Informações de Beneficiários

**SLR** - Systematic Literature Review

**SPSS** - Statistical Package for Social Sciences

**TQM** - Total Quality Management

**VaR** - Value - at - Risk

**VSM** - Value Stream Mapping

**WoS** - Web of Science

# Introduction

## General context

Today's managers must face a very challenging business arena, which often includes finding new (and greater) income sources and cost reduction while maintaining a premium service level. Considering this scenario, Healthcare managers face an even harder struggle, as they still must pursue these indicators and deal with a very sensitive service that involves a great deal of subjectivity that is providing an affordable quality care in a spiraling cost burden scenario (Chakraborty et al., 2014). Additionally, managers in healthcare industry face intense competition and inability to meet an increasingly growing demand, which makes Healthcare organizations to seek structural and organizational changes to achieve performance improvement (Gomes et al, 2016). In this sense, Healthcare systems are quickly becoming networks of interconnected services, where increasing costs and expectations for high service levels form the required backbone for the birth of Healthcare monitoring activities and the proposition of numerous performance indicators (Antonelli and Bruno, 2015). Regarding global challenges related to cost, most of the increase is due to ageing population, use of expensive technologies and clinical errors (Crema and Verbano, 2016; Kekkonen et al., 2017). Additionally, Healthcare costs rise in a faster rate than the overall costs of other products or services, submitting Healthcare providers to a constant pressure to improve services, patient safety while reducing costs (Costa et al., 2017). Expanding the view about costs source, Goldsmith (2015) shed light upon two different narratives: i) The conservative narrative, in which the patient is the culprit (patients have bad habits such as smoking); ii) The progressive narrative, in which the physician is the culprit (mostly due to target incomes that physicians would have and so motivating treatments and diagnoses that generate more income). Such assumptions can open a pathway to discuss medical treatment approaches, which is not the objective of this thesis. Moreover, going on "witch - hunts" and electing a single culprit seems to be a comfortable solution instead of finding a systemic consistent solution. Crema and Verbano (2017) also highlight the rising Healthcare costs and propose the "Choosing Wisely" (CW) methodology, which is an approach to identify and reduce unnecessary care, such as tests and treatments that do not add value for patients and may even cause harm. Rotter et al. (2017) cite wastes (also

cited by Bentley et al., 2008), Lean culture, empowerment, and heterogeneity of clinical cases (Dundas et al., 2011; Knowles and Barnes, 2013; Vegting et al., 2012; Rajan et al., 2012). Nevertheless, more scientific analyzes are required to establish which are the more burdensome costs for proposing a systemic solution. In addition, Cost-improving methods are also present in the literature, for example, Cho et al. (2018) use multiple linear regression analysis to examine the factors influencing dialysis costs. Thus, organizations will have to adapt to this new reality and find ways to achieve more efficiency with fewer resources.

Within this context, different approaches and improvement strategies that aim to find a systemic approach for cost reduction and service level improvement such as Lean have arisen. Several Lean enablers such as Kanban (Aguilar - Escobar and Garrido -Vega, 2013), Markov models (McClean et al., 2007), Value Stream Mapping (Yu et al., 2015), Lean/Six-Sigma (Bhat et al., 2014) have been noticed, mostly due to a cost reduction emphasis. More recently, Lean have been used to reduce wastes and costs in hands surgery (Van Demark et al., 2018), Measuring and improving pediatric cardiac care (Barach and Kleinman, 2018), turnaround time reduction (Gupta et al., 2018) and even to evaluate waiting times in a Kenyan clinic for treating HIV positive patients (Monroe-Wise et al., 2017). Lean methodologies have become a consolidated set of practices and tools, which aim to improve processes while reducing costs. When applied to Healthcare organizations led researchers to coin the term “Lean Healthcare”. A Healthcare unit is a facility, which provides direct or indirect services to promote or keep individuals’ health condition, such as hospitals and clinics (Gomes et al., 2016).

Although many papers mention the keyword “Lean Healthcare”, there are not many studies discussing Supply Chain level problems of Healthcare organizations. In this thesis, the subject is treated using the term Healthcare Supply Chain (HCSC). As examples of relevant studies concerning this subject there is an application of Leagility (which is Lean plus Agility combined) concept in an Iranian hospital (Rahimnia and Moghadasian, 2010). The study groups the Healthcare services into three pipelines, and then, identifies the decoupling points for the Supply Chain. Leagility and modularity can be applied to Healthcare organizations (Guimarães and Carvalho, 2012; Guven-Uslu et al., 2014). The authors apply decoupling points in crucial processes so Lean and agile philosophies could coexist.

Papers approaching Lean Healthcare applied to Supply chains (LHCSC) are very few, nevertheless, if the search narrows it down to even more specific subjects like

Healthcare Supply Chain Risk Management (HC SCRM), it returns even fewer entries. While academic literature provides great examples of disaster response and preparedness in Supply Chain Management literature, little information is available concerning Healthcare Supply Chain Management (Vanvactor, 2011). To support these assumptions, full systematic literature review results are conducted in Chapter 3.

In this sense, the presented research leads to conclude that there is a significant literature gap concerning how Supply Chain Risks can impact Healthcare services.

**Motivation**

Recently, subjects such as Supply Chain Resilience (SCRes) and Supply Chain Risk Management (SCRM) have been growingly studied. With the urge to offer lean and Just - in - Time services, Supply Chains become vulnerable to natural and man - made disasters (Soni and Jain, 2011). Many different papers are studying the two concepts, approaching dimensions such as Collaboration (Ayuso et al., 2009), Innovation (Gölgeci and Ponomarov, 2013; Gölgeci and Ponomarov, 2015), Supply Chain Risk (SCR) assessment and metrics (Chen et al., 2016; Pournader et al., 2016; Vargas and Gonzalez, 2016; Mohapatra et al., 2015), Review papers (Mandal, 2014; Durach, et al., 2015; Tukamuhabwa et al., 2015; Kamalahmadi and Parast, 2016) among others.

This study focused on the Healthcare sector for three main reasons. First, disruptions in Healthcare sector often mean that patients will receive poorer attendance that can result in surgery delays, lack of medications, which in worst cases can be fatal for patients. Second, with population ageing, Healthcare costs are constantly increasing, making imperative to offer increasingly better services with the same or even lower costs. Third, literature contribution. There are very few studies investigating how SCRM can be applied to Healthcare organizations. Therefore, there is an opportunity of generating technical literature, which would benefit scholars interested in generating further studies.

Furthermore, a strong motivation of this thesis is the opportunity to contribute to Healthcare services in Brazil, more specifically, with public Healthcare services. In this sense, this thesis constructs a framework described by risk identification, risk assessment and risk mitigation. The literature findings were validated by interviews with Healthcare Supply Chain members and serve as start for Healthcare organizations needing to implement risk management. As Figure 1 shows, there are areas with very low private health insurance coverage, which highlights the urge to generate public Healthcare improvements in order to maintain Health access to most of the people.

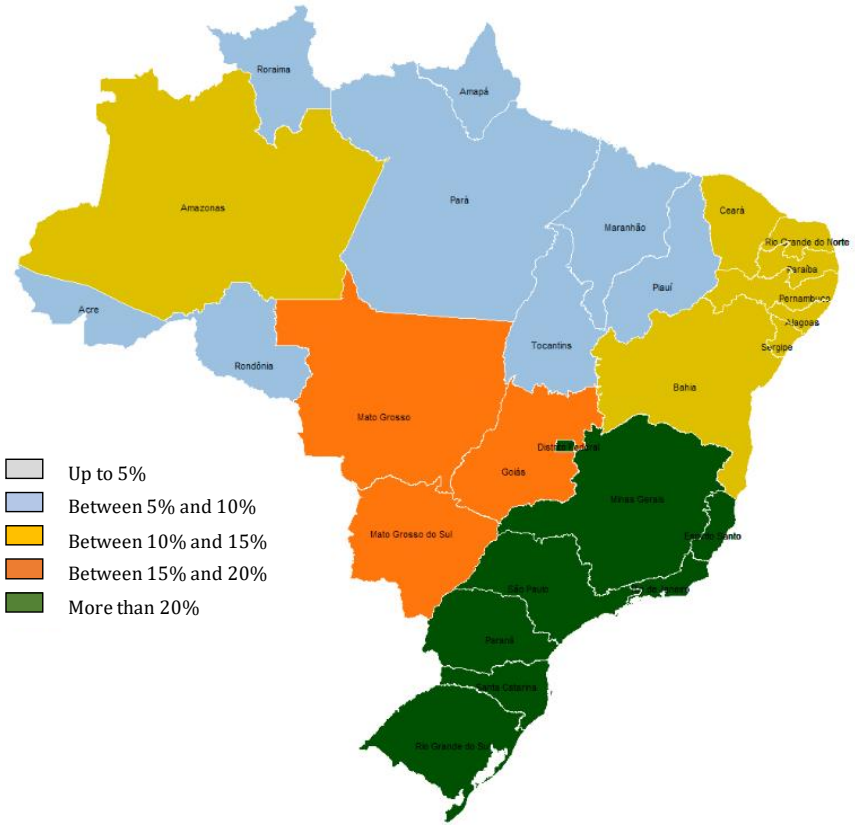



**Figure 1 –** Private health insurance coverage
**Source:** Beneficiaries information systems SIB/ANS/MS – IBGE/DataSus (data updated until May/2018)

Although Brazil is the 9th world economy considering Gross Domestic Product (GDP) (Smith, 2018) families in Brazil live (in average) with a *per capita* income of 1,268.00 BRL, which is about US$ 300.00 (IBGE, 2018). Considering that a private Healthcare insurance average cost is around 2,000.00 BRL for people over 60 years old (Average calculated based on 107 insurances using data provided by: "Planos de Saúde Todos Aqui – 2018") and can cost over 9,000.00 BRL, most of Brazilians depend on public Healthcare. Additionally, since 2015, Brazil is experiencing the worst economic crisis in its history with two consecutive years of GDP decrease (Figure 2), which further depresses purchasing capability of families. Figure 3 shows Brazilian private insurance coverage reduction, which can be considered a consequence of this crisis.

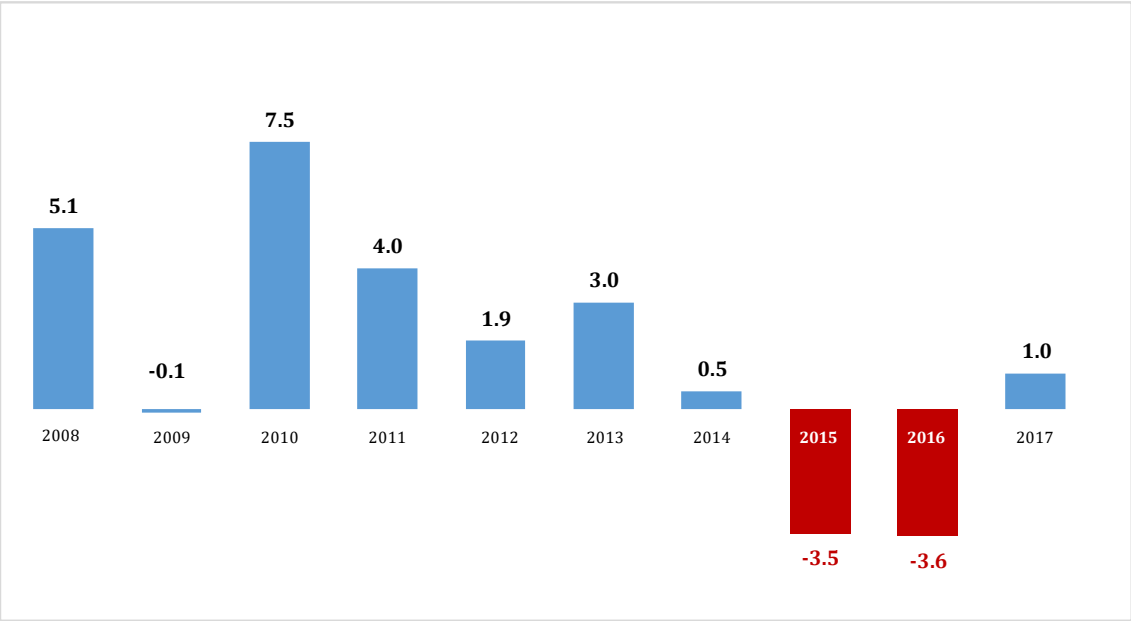



**Figure 2 -** GDP variation (%)
**Source:** IBGE (2018)

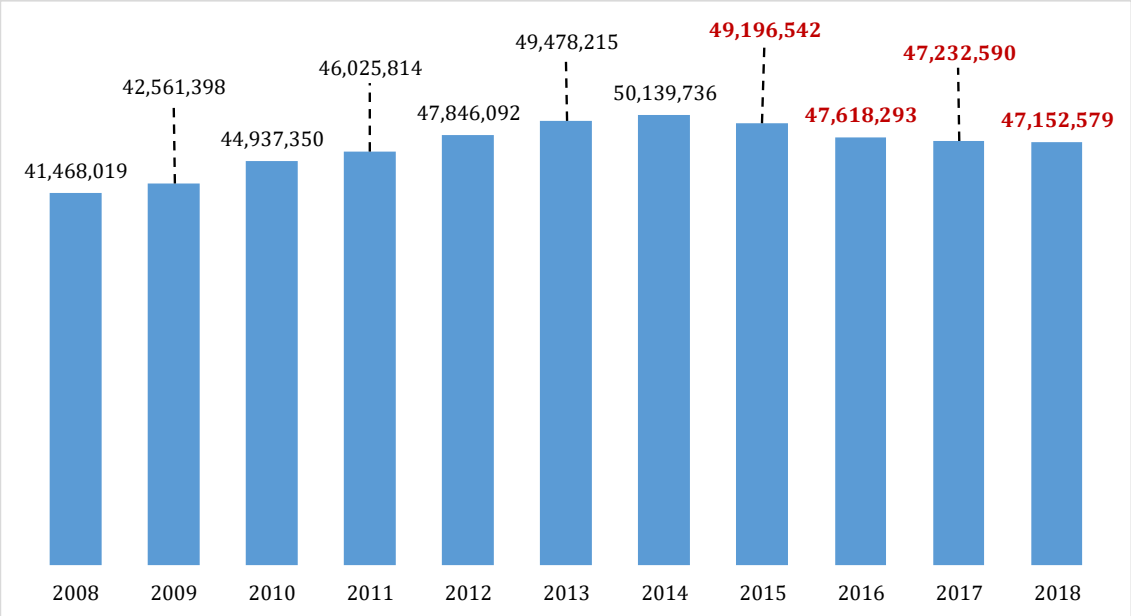



**Figure 3 -** Private health insurance beneficiaries (with or without dental care)
**Source:** Beneficiaries information systems SIB/ANS/MS (data updated until May/2018)

Therefore, the already insufficient public Healthcare must deal with a demand growth that generates surgery queues greater than 6 months depending on the medical specialty and location (see for example: Portal G1 – Patients in Campinas/SP wait an average of 1 year for medical appointments).

In this sense, considering that Brazilian public Healthcare system is already unable to meet an increasingly growing demand; process improvement, cost cutting, and Risk mapping, measuring and mitigation are crucial for survival of Healthcare (HC) organizations as well as their SC.

**Problem statement**

Crisis strike Healthcare organizations of all types, obligating the Supply Chains, which are exposed to multiple high-magnitude Risks (Kouvelis et al., 2011) to maintain a posture of resiliency for crisis mitigation (Vanvactor, 2011). This statement is supported by Khalili et al. (2017), which affirms that Supply chains are increasingly exposed to operational, and disruption Risks threatening their business continuity. In addition, when dealing with HCSC Risks it often means that a medicine or a bandage is missing, or the wrong treatment is applied, or the team was unable to save the patient's life (Khalili et al., 2017). Therefore, literature analysis leads to conclude that it is crucial to identify, assess and mitigate not only Healthcare organizations Risks, but Risks concerning their whole SC as well. The identification of Risk is more than a list of threats, furthermore, the sooner a Risk is managed, the less it will negatively impact an organization (Ojha and Gokhale, 2009). In terms of mitigation, Wieland and Wallenburg (2012) propose two main Risk-mitigating constructs: Robustness (Proactive strategy) and Agility (Reactive strategy). The authors identify antecedents for these constructs and validate their literature-based Risk identification. Grötsch et al. (2013) focus on Proactive SCRM implementation.

Although there are many papers applying means of identifying and confirming Risks to most different Supply chains such as apparel (Chowdhury and Quaddus, 2016), automotive (Grötsch et al., 2013), clothing (Freise and Seuring, 2015), courier (Wang et al., 2015) and papers approaching multiple segments (Ojha and Gokhale, 2009; Wieland and Wallenburg, 2012; Kern et al., 2012; Cantor et al., 2014; Fan et al., 2016; Sreedevi and Saranga, 2017) literature shows a gap in Supply Chain Risks identification related to Healthcare. Concerning Healthcare, Riley et al. (2016) present a study where they test the influence of 3 constructs (Internal integration, Information sharing and Training) in the Operational Performance of Healthcare organizations.

The next logical step after Risk identification would be how to assess/measure these Risks. Performance Management is considered an always challenging issue, in

addition, there are significant adverse outcomes associated with poor use of Performance Management systems in public services, particularly negative effects on staff morale managers (Arnaboldi et al., 2015). Such inadequate use or even the total absence of Performance indicators is responsible for jeopardizing improvement initiatives, as it is almost impossible for managers to improve a process that is not being measured.

In areas such as finance, insurance, crisis management and Healthcare, the importance of considering Risk is already largely acknowledged and well-elaborated concepts and approaches for Risk management have been developed (Heckmann et al., 2015). However, disasters also strike Healthcare organizations of all types, designs, making resiliency actions important for crisis mitigation (Vanvactor, 2011).

Some studies have focused on Key Performance Indicators (KPI) for SCRM (Heckmann et al., 2015; Wu et al., 2010). Literature also presents KPI related to Healthcare, being most of them medical KPI (see Cavalcante et al., 2015) or more general and operational KPI (Habidin et al., 2015; Kanamori et al., 2015). However, this research could not locate papers that systematically mapped KPI to measure Risks concerning Healthcare Supply Chains. To start filling this literature gap, this thesis brings a KPI mapping based on a literature survey, answering questions seen in Vanvactor (2011) such as “What metrics should be employed to evaluate success or failure in healthcare logistics management? “

In this sense, based on extensive literature study, this thesis aims to provide contribution to fill these literature gaps. To do so, three main work fronts are explored: i) Risk identification via literature studies and validation via interviews; ii) Risk assessment via KPI identification based in literature and Interviews; iii) Risk mitigation framework constructed based in literature and interviews.

## Objectives

This section presents the thesis objectives.

### General objective

The general objective of this thesis consists in constructing a conceptual framework that was carefully tailored to address resilience to the Healthcare Supply Chain through Supply Chain Risk Management.

**Specific objectives**

The previously presented general objective can be divided into:

- Present a formal definition of Healthcare Supply Chain Risk Management;
- Propose a framework that is generic enough to apply SCRM to Healthcare Supply Chains;
- Identify Healthcare Supply Chain Risks and validate via interviews. with Healthcare Supply Chain professionals;
- Identify KPIs present in the literature and mentioned by the interviewed professionals;
- Propose a framework to generate resilience in Healthcare Supply Chains and analyze the strategies used by the interviewed professionals.

**Thesis contributions**

This thesis contributions are divided in two major contributions: i) Theoretical and ii) Empirical.

i) In terms of theoretical contribution, this thesis provides definition for Healthcare Supply Chain Risk Management (HC SCRM).

ii) Concerning empirical contributions, and in respect to Risk identification, this thesis also provides a framework to identify and validate Risks empirically. The KPI list is also an important contribution of this thesis. Until the completion of this thesis, there were not found many studies performing systematic SCRM KPI mapping.

Lastly, this thesis constitutes a guide that can be applied to generate real improvements (such as a framework to implement SCRM) concerning Healthcare organizations.

## Research delimitation

This study is, however, subject to limitations. First, the chosen sample (for the empirical studies) is geographically limited to Brazilian Healthcare organizations.

The second limitation is the method chosen to conduct the research. Although this thesis method was a result of a thorough paper analysis and inspired by peer-reviewed papers methodologies, the results obtained in this thesis are a product of the method of choice. Other methods and approaches could provide different results. Limitations of each chapter are discussed accordingly.

## Study organization

This study is organized as follows; this introductory chapter provides an overview of the whole Thesis.

Chapter 1 presents the theoretical background that provides the conceptual backbone and enables the understanding of the results and proposals.

Chapter 2 provides the methodological workflow alongside the explanation of the method, which guides the execution of this Thesis.

Chapter 3 is the Systematic Literature Review results, which enabled trend setting and an overview of the current stage of SCRM research and provided insights for the empirical studies.

Chapter 4 is the first study, which consists in identifying the most relevant Risks concerning HC SCRM.

Chapter 5 is the second study which provides measuring KPI to assess Risks.

Chapter 6 shows Risk mitigation framework.

Chapter 7 closes the Thesis with a general discussion, conclusions and further research opportunities.

# 1. Theoretical Background

## 1.1. Chapter Abstract

The objective of this chapter is to present the theoretical background, which set the knowledge base for the research. This section includes concepts definitions such as Supply Chain Risk Management (SCRM) and Supply Chain Resilience (SCRes). Although the theoretical framework presented in this chapter was based in extensive literature reading using indexed papers, it has limitations. The first limitation is that only papers in English language were considered. The second limitation is that this chapter was not exhaustive or had the pretention of covering all definitions and frameworks presented in literature. As the main results of the chapter are SCRM and SCRes definitions based on extensive literature, and a conceptual generic framework that can further help researchers to conduct similar Healthcare SCRM improvement initiatives.

Chapter keywords: Supply Chain Risk Management; Supply Chain Risk; Quantitative techniques, Qualitative techniques, Healthcare Management.

## 1.2. Graphical Abstract

Figure 4 shows a graphical abstract of the chapter.

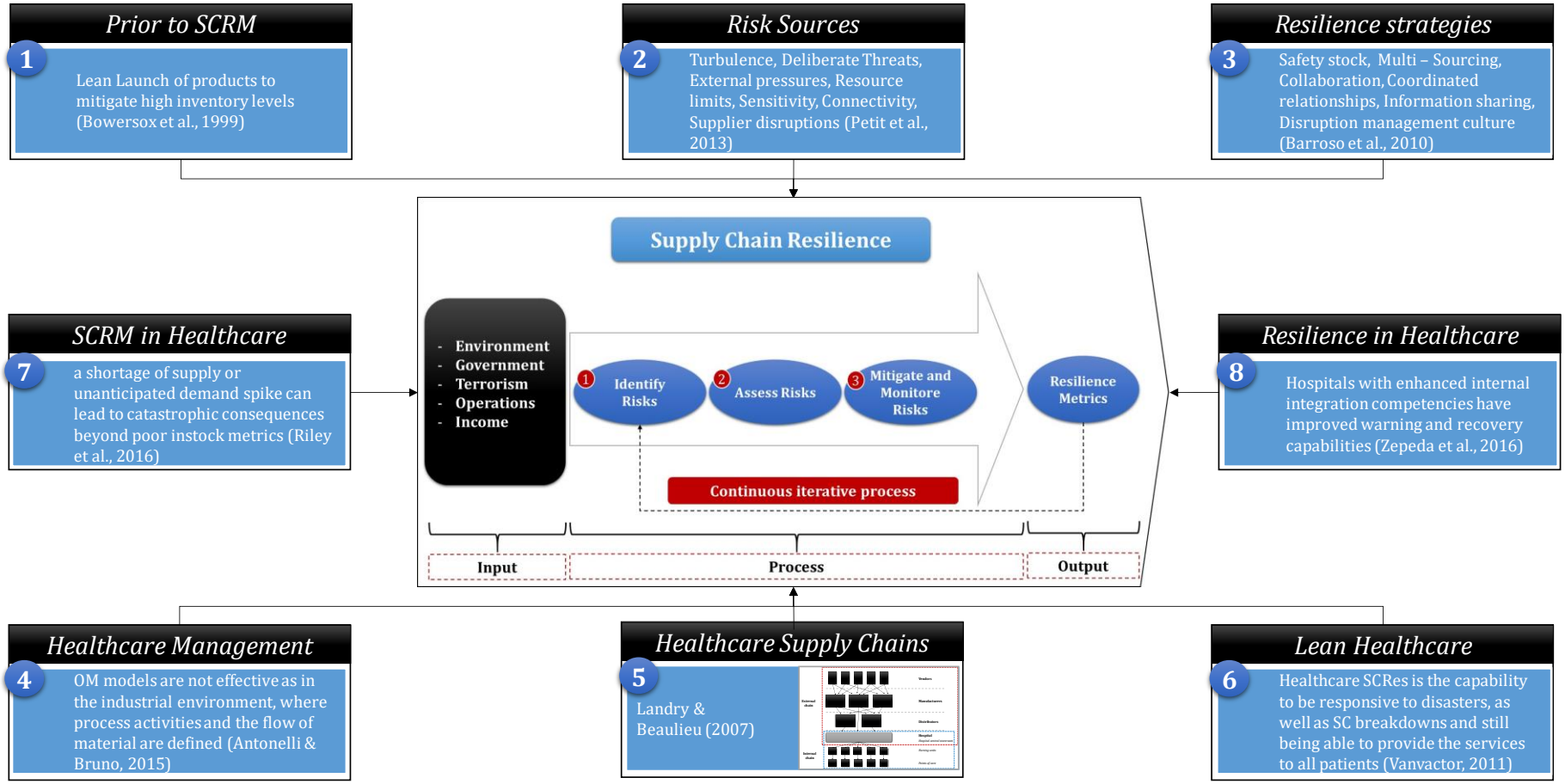



**Figure 4 -** Graphical abstract - Chapter 1

### 1.3. Prior to “Supply Chain Risk Management”

The term “Supply Chain Risk Management” also known as “SCRM” started to be coined in the early 2000’s by papers such as Juttner et al. (2003), Norrman and Jansson (2004), Juttner (2005), Sorensen (2005), Tang (2006), among others. However, even before the concept became popular, the subject was already studied. For example, Bowersox et al. (1999) preconized Lean Launch of products to mitigate the Risks of higher inventory levels that a push strategy would generate. Lonsdale (1999) presented a model for mitigating Risks associated with outsourcing practices. Zsidisin et al. (2000) presented inbound supply Risks such as quality, design, cost, availability, manufacturability, supplier, legal, environmental, health and safety. Hallikas et al. (2002) studied Risks concerning a supplier, a buying company and assesses Risks related to networking. Furthermore, Hallikas et al. (2004) expanded the conceptual analysis brought by Hallikas et al. (2002) presenting methods for Risk management in a complex network environment. They also concluded that Risk management is an important development target in the studied supplier networks.

In this sense, conceptual basis for establishing the building blocks of the SCRM concept were complete, Risks concerning inbound and outbound logistics were studied in a way that already transcended companies’ functional barriers. Therefore, SCRM became a concept that expanded the vision of Risks, highlighting the importance of linking Supply Chain business processes.

### 1.4. Supply Chain Risk Management (SCRM)

Customer demands are constantly increasing and almost all industries face intense competition and globalization effects on business. To become more competitive, companies became to look at process integration, which is corroborated by papers such as Von Brocke (2014) and Kannengiesser et al. (2016). The next stage after internal process integration would be to integrate those processes externally, which is known as Supply Chain integration. Most of the Supply Chain integration studies highlight which were Supply Chain main processes (Croxton et al., 2001), how to model a Supply Chain (Saen et al., 2016; Lehoux et al., 2016; De Meyer et al., 2016) and Key performance indicators concerning a Supply Chain (Coelho et al., 2009; Fang and Deng, 2010; Cai et al., 2009).

Researchers such as Croxton et al. (2001); Cooper et al. (1997); Lambert and Pohlen (2001); Lambert and Cooper (2000) among others, preconize that Supply Chain Management (SCM) is integration and coordination of key Supply Chain business processes going through all suppliers and manufacturers, to end-user providing products, services and information for customers and all stakeholders. Tang (2006) defines SCM as the management of all material, information and financial that flows through an organization network that produces and delivers products or services for the costumers. Coordination and collaboration of processes and activities are key crucial features and include functions such as marketing, sales, production, product design, procurement, logistics, finance, and information.

Lately, with process integration inside and outside companies, theoretical framework for these subjects was complete, and formed the required backbone for Supply Chain Risk Management to emerge. Papers such as Norrman and Jansson (2004), Lavastre et al. (2012); Thun and Hoenig (2011); Pujawan and Geraldin (2009), show that this subject started to be a relevant study field throughout the world. Neiger et al. (2009) show that Supply Chains that are composed by hundreds and sometimes even thousands of companies over several tiers present significant Risks. Companies and Researchers are increasingly giving more attention to SCRM, which is triggered by the frequency and intensity of catastrophes, disasters, and crises that are increasing on a global scale (Coleman, 2006). References such as Juttner et al. (2003), Juttner (2005), Thun and Hoenig (2011) leads to conclude that the first stage concerning Supply Chain Risk Management analysis is to visualize a Supply Chain as a set of cross – functional processes. Additionally, Risk analysis should considerate the whole Supply Chain to provide good results.

To consider the whole process instead of a single activity and to consider a whole Supply Chain process instead of a single enterprise process is one of the main points of the Theory of Constraints (Goldratt, 1990). Papers such as Rahman (2002); Li et al. (2002); Croxton et al. (2005), highlight the urge to consider global optimum instead of local optimum. Juttner et al. (2003) contribute to this vision affirming that the lack of integration between companies within a SC may lead to suboptimal results. Norrman and Jansson (2004) affirm that the focus of SCRM is to understand, and try to avoid, the devastating effects that disasters and disruptions can have in a Supply Chain. Juttner (2005) affirms that, usually, companies implement organization level Risk management and stressed that there was still little evidence of SC level Risk management

implementation.

Tang and Musa (2011) define Risk as a possibility of mismatch between supply and demand generating Supply Chain rupture. Such mismatch may be caused by lack of information, raw materials shortage and unbalanced products flow (Juttner et al., 2003). Moreover, classical approach to Risk in operations management consists in seeing Risk as a result from the product of probability of loss and the potential loss (Ancarani and Di Mauro, 2011). Supply Chain Risks happen due to several reasons like disruptions to material flows, information flows, knowledge flows, and control and coordination flows (Ancarani and Di Mauro, 2011).

There are notable differences between operational Risks and disruption Risks (Jianlin, 2010). Operational Risks are referred to uncertainties such as uncertain customer demand, uncertain supply and uncertain cost, but disruption Risks are concerned with major disruptions influencing the whole chain. Given its importance, SCRM has emerged as a topic within the domain of Supply Chain Resilience (SCRes). Concerning Supply Chain Risk Management, it is relevant to distinguish four basic constructs: Supply Chain Risk sources, Risk consequences, Risk drivers and Risk mitigating strategies (Juttner et al., 2003). Table 1 summarizes the main Risk sources found in literature.

**Table 1 -** Risk sources

| Author | Macro Risk Source | Risk Sources |
|---|---|---|
| Juttner et al. (2003) | Envinronmental | Accidents, Socio-political actions, Acts of god (Natural disasters) |
| | Organizational | Strikes, Machine failure, IT system uncertainty |
| | Network | Lack of ownership, Chaos, Inertia |
| Norman and Jansson (2004) | Do not have a macro source | Increased use of outsourcing of manufacturing and R&D to suppliers |
| | | Globalization of Supply Chains, Reduction of supplier base, More intertwined and integrated processes between companies, Reduced buffers, e.g. inventory and lead time, Increased demand for on-time deliveries in shorter time windows, and shorter lead times, Shorter product life cycles and compressed time-to-market, Fast and heavy ramp-up of demand early in product life cycles, capacity limitation of key components |
| Barroso et al. (2010) | Do not have a macro source | War, Supplier failure, Natural hazards disasters, Terrorism, Man-made disasters, Regulatory/legal, Infrastructure, Supplier insolvency |
| Petit et al. (2013) | Turbulence | Natural disasters, Geopolitical disruptions, unpredictability of demand, Fluctuations in currencies and prices, Pandemic |
| | Deliberate threats | Theft, Terrorism/sabotage, Labor disputes, Espionage, Special interest groups, Product liability |
| | External pressures | Competitive innovation, Social/Culture change, Political/Regulatory change, Price pressures, Corporate responsibility, Environmental change |
| | Resource limits | Supplier, Production and distribution capacity, Raw material and utilities availability, Human resources |

| | | |
|---|---|---|
| | Sensitivity | Complexity, Product purity, Restricted materials, Fragility, Reliability of equipment, Safety hazards, visibility to stakeholders, Symbolic profile of brand, concentration of capacity |
| | Connectivity | Scale of network, Reliance upon information, Degree of outsourcing, Import and export channels, Reliance upon speciality sources, |
| | Supplier/customer disruptions | Supplier reliability, Customer disruptions |

**Source:** Peck et al. (2003); Norman and Jansson (2004); Barroso et al. (2010) and Petit et al. (2013)

Barroso et al. (2010) summarize Risk sources concerning a SC, as it can be seen in the framework shown in Figure 5.

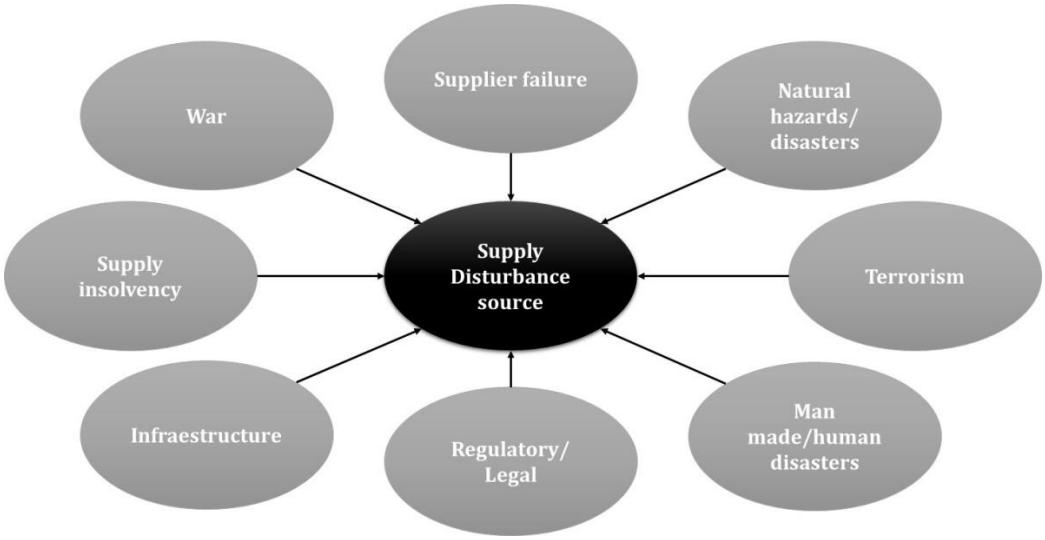



**Figure 5 -** Risk Sources
**Source:** Author based in Barroso et al. (2010)

### 1.4.1. Stages of SCRM

Managing Risks that comprise the whole Supply Chain can become a very difficult task. To make this hard task viable, some authors propose steps and phases that if logically followed result in a promising way of managing Risks. For example, Sinha et al. (2004) identified five steps for mitigating supplier Risks: (1) identify Risks, (2) assess Risks, (3) plan and implement solutions, (4) conduct failure modes and effect analysis, and (5) continuously improve. Based on an extensive literature review, Sodhi et al. (2012) summarized four key sub-processes for managing SCR: (1) Risk identification, (2) Risk assessment, (3) Risk mitigation, and (4) responsiveness to Risk incidents. This stream of research has generated valuable insights on the SCRM process and has offered significant implications for practitioners. Nevertheless, Sodhi et al. (2012) show that the major understanding of SCRM literature consists in approaching SCRM with 3 main elements:

Identification, Assessment and Mitigation. As already shown, some authors bring 4 or even 5 or more elements (Sodhi et al., 2012). Considering the available frameworks, this thesis adopts the major understanding of considering the framework composed by Identification, Assessment and Mitigation, considering that all other steps proposed are embedded within these 3.

### 1.5. Supply Chain Resilience (SCRes)

In the Supply Chain context, a SC must be resilient to disturbances in order to achieve competitiveness (Barroso et al., 2010). Juttner et al. (2003) affirm that Supply Chain disruptions can be financial losses, negative corporate image, or bad reputation eventually accompanied by demand loss, as well as damages in security and health. In this sense, today's globalized, leaner and Just-in-Time Supply Chains are more vulnerable to natural and man - made disasters (Soni and Jain, 2011).

If a manager only emphasizes lower costs and higher efficiency, lacking resilience, it is likely to make the Supply Chain system vulnerable (Shuai et al., 2011). Ponomarov and Holcomb (2009) define resilience as an adaptive capability of the SC to prepare for unexpected events, respond to disruptions, and recover from them maintaining continuity of operations at the desired level of connectedness and control over structure and function. Barroso et al. (2011) and Carvalho et al. (2012) go further, affirming that a Supply Chain resilience is a matter of survival. Additionally, SCRes is concerned with the system's ability to return to its original state or to a new, more desirable one after experiencing a disturbance, and avoiding the failure modes (Carvalho and Cruz Machado, 2007). Resilience was later defined by Barroso et al. (2010) as the ability to react to the negative effects brought by disturbances that occur in a given moment to maintain SC's objectives.

Considering SCRes strategies, Haimes (2006) affirms that there are two ways of improving a system's resilience: (i) to recover the desired values of the states of a system that has been attacked, within an acceptable period and at an acceptable cost; and (ii) to reduce the effectiveness of the threats by changing the level of effectiveness of a threat. Resilience can also be found in emerging interdisciplinary fields such as emergency management, sustainable development and SCRM (Torabi et al. 2015). The concept of resilience is related with the capability of a system to return to a pre - disturbance state after a disruption (Bhamra et al. 2011). Table 2 summarizes SCRes definitions found in

the literature.

**Table 2 -** Resilience definitions

| Author | Definition |
|---|---|
| Holling (1973) | Resilience determines the ability of systems to absorb changes, and stability is the capacity of systems to return to an equilibrium state after a temporary disturbance. The faster a system returns to equilibrium, the greater its stability |
| Weick et al. (1999) | Supply Chain Resilience is the capacity to adjust and maintain desirable functions under challenging or straining conditions. |
| Gunderson (2000) | The magnitude of disturbance that a system can absorb before its structure is redefined by changing the variables and processes that control behavior. |
| Carpenter et al. (2001) | The Magnitude of disturbance that a system can tolerate before it transitions into a different state that is controlled by a set of processes. |
| Rice and Caniato (2003) | The authors focus resilience on redundancy and flexibility, recommending leaders to develop a "flexibility DNA" through communications, distributed authority, passion for the mission, deferring to experience, and conditioning for disruptions. |
| Hamel and Valikangas (2003) | The authors stress that Resilience is not just concerned with recovery, flexibility, or crisis preparedness but also a distinct source of sustainable competitive advantage. |
| Christopher and Peck (2004) | Supply Chain resilience addresses the Supply Chain's ability to cope with the consequences of unavoidable Risk events or disruptions, such as the loss of a critical supplier, a major fire at a manufacturing plant, or an act of terrorism, to return to its original operations or move to a new and more desirable state after being disturbed. |
| Fiksel (2006) | Capacity for an enterprise to survive, adapt, and grow in the face of turbulent change |
| Ponomarov and Holcomb (2009) | SC resilience is related to the development of SC capabilities that incorporate event readiness, provide an efficient and effective response that supports quick recovery to the desired state of the system that has been disturbed. |
| Azevedo et al. (2010) | Resilience is referred to as the SC ability to cope with unexpected disturbances. |
| Schmitt and Singh (2012) | Resilience refers to the ability of a system or component to bounce back from a setback whereas reliability is the ability of a system or component to perform its required functions under stated conditions for a specified period, or even resist failure. |
| Ivanov and Sokolov (2012) | Resilience is also termed as an intersection of robustness, flexibility and adaptation. |
| Carvalho et al. (2012) | SC resilience is concerned with the system's ability to return to its original state or to a new, more desirable, one, after experiencing a disturbance, and avoiding the occurrence of failure modes. The goal of SC resilience analysis and management is to prevent movement to undesirable states, i.e., the ones where failure modes could occur. |
| Petit et al. (2013) | The ability to survive, adapt, and grow in the face of turbulent change. |

### 1.5.1. Resilience strategies

Although Risk identification and assessment are the foundations of SCRM, Risk mitigation is an invaluable practice that all organizations should implement in order to reinforce their resilience. Knowing the actions that should be taken can mitigate Risks or even prevent their materialization. Literature provides some examples of Risk mitigation

strategies. The first example is the one seen in Juttner et al. (2003) presenting the mitigation strategies in Table 3:

**Table 3 -** Risk mitigation strategies I - Juttner et al. (2003)

| Strategy | Examples |
|---|---|
| **Avoidance** | - Dropping specific products/geographical markets/ supplier and/or customer organizations |
| **Control** | - Vertical Integration<br>- Increased stockpile and the use of buffer inventory<br>- Maintaining excess capacity in productions, storage, handling and/or transport<br>- Imposing contractual obligations on suppliers |
| **Cooperation** | - Joint efforts to improve Supply Chain visibility and understanding<br>- Joint efforts to share Risk-related information |
| **Flexibility** | - Postponement<br>- Multiple sourcing<br>- Localized sourcing |

**Source:** Juttner et al. (2003)

Nevertheless, not all the authors that dedicate to research mitigation strategies follow the same exact framework. For example, Christopher and Peck (2004) propose the following principles to design resilient SCs as shown by Table 4:

**Table 4 -** Resilience principles - Christopher and Peck (2004)

| Principle | Detail |
|---|---|
| **Strategies that keep several options open** | Strategy that is based around centralization of distribution facilities may be the lowest cost option, but it could also shut down other options and hence increase vulnerabilities. |
| **Efficiency vs. redundancy trade - off** | Conventionally surplus capacity and inventory have been seen only as 'waste' and are therefore undesirable. However, the strategic disposition of additional capacity and/or inventory at potential 'pinch points' can be extremely beneficial in the creation of resilience within the Supply Chain. |
| **Supply Chain collaboration** | A high level of collaborative working across Supply Chains can significantly help mitigate Risk. The underlying principle of collaborative working in the Supply Chain is that the exchange of information can reduce uncertainty. |
| **Supply Chain Agility** | Supply chain agility can be defined as the ability to respond rapidly to unpredictable changes in demand or supply. Many organizations are at Risk because their response times to demand changes or supply disruption are too long. |
| **Supply Chain Visibility** | Supply Chain visibility is the ability to see from one end of the pipeline to the other. The achievement of Supply Chain visibility is based upon close collaboration with customers and suppliers as well as internal integration within the business. |
| **SCRM Culture** | There is a requirement to create a Risk management culture within the business. This culture of Risk management should extend beyond the boundaries of corporate Risk and business continuity management to become 'Supply Chain continuity management'. |

**Source:** Christopher and Peck (2004)

Tang (2006) proposes robust strategies for mitigating operational and disruption Risks. The author affirms that a robust strategy must have efficiency (the strategy would enable a firm to manage operational Risks efficiently regardless of major disruptions) and resiliency (the strategy would enable a firm to sustain its operation during a major disruption and recover quickly after a major disruption). Table 5 summarizes the strategies.

**Table 5 –** Risk mitigation strategies II - Tang (2006)

| Strategy | Description |
|---|---|
| **Supply management strategies** | - Supply network design (Strategic)<br>- Supplier selection, supplier order allocation, and supply contracts (Tactical**)** |
| **Demand Management strategies** | - Shift demand across products time and markets (Strategic)<br>- Product rollovers and pricing (Tactical) |
| **Product Management strategies** | - Product variety (Strategic)<br>- Postponement and process sequencing Information (Tactical) |
| **Information management strategies** | - Supply Chain visibility (Strategic)<br>- Information sharing, vendor managed inventory, and collaborative planning, forecasting and replenishment (Tactical) |

**Source:** Tang (2006)

Iakovou et al. (2007) refer to two categories of resilience interventions, Interventions to improve security that include initiatives for preventing security breaches, inspections, information protection, compliance to international standards and Interventions to improve Supply Chain resilience. Table 6 summarizes the strategies.

**Table 6 -** Risk mitigation strategies II - Iakovou et al. (2007)

| Strategy | Description |
|---|---|
| **Flexible sourcing** | The dependency on one-vendor solely could prove highly risky for a Supply Chain |
| **Demand-based management** | The ability to influence dynamically customer choices can be very effective in times of crises. The customer guidance can be accomplished through promotions and discounts |
| **Strategic emergency stock** | Just-in-time's lean inventories make Supply Chains vulnerable to sudden demand spikes. Companies must differentiate regular business uncertainties from the Risks associated with a terrorism-related event for example, using on one hand safety stocks to absorb normal business fluctuations, and on the other hand, a strategic emergency stock. |
| **Total Supply Chain visibility** | Two of the most efficient practices of Supply Chain management are Supply Chain visibility and collaboration among Supply Chain partners |
| **Process and knowledge back-up** | Global companies realize their dependence upon their information system and thus they have created database, software and hardware backups |

**Source:** Iakovou et al. (2007)

Barroso et al. (2010) also summarize the main mitigation strategies found in the literature as well as classifies them as Reactive/Proactive (R/P); Buffer strategy/Improvement Process (B/I). A proactive strategy preconizes preventive actions to avoid specific challenges or prevent their occurrence as much as possible (Barroso et al., 2010). For unavoidable challenges, the emphasis is to mitigate their negative consequences and transform them into business opportunities (Barroso et al., 2010). Table 7 brings the complete findings of Barroso et al. (2010).

**Table 7 -** Mitigation Strategies

| **Mitigation strategy** | **Reference** | **Classifications** | |
|---|---|---|---|
| **Safety Stock** | Baker (2007); Zsidisin et al. (2000) | R | B |
| **Multi-Sourcing** | Baker (2007); Zsidisin et al. (2000); Svensson (2003) | R | B |
| **Collaboration with Supplier** | Zsidisin et al. (2000); Christopher and Peck (2004) | P | I |
| **Coordinate relationships in SC** | Giunipero and Eltantawy (2004) | P | I |
| **Increase Information sharing** | Giunipero and Eltantawy (2004); Li et al. (2006) | P | I |
| **Supplier selection process** | Levary (2007); Micheli et al. (2008) | P | I |
| **Well stocked pipeline** | Zsidisin et al. (2000) | P | I |
| **SC reengineering** | Christopher and Peck (2004) | P | I |
| **Create SC disruptions management culture** | Christopher and Peck (2004) | P | I |

**Source:** Barroso et al. (2010)

Some strategies like safety stocks can either be a mitigation strategy or a Risk source depending on the safety stock amount. This vision finds support in Barroso et al. (2010) which affirm that building redundant inventory in the SC will function as a buffer to maintain continuous operations, as well as it may also drive up costs and lead to lower efficiency.

Soni and Jain (2011) propose a framework for enhancing resilience, mostly based on pillars such as flexibility, adaptability, collaboration, visibility and sustainability, as seen in Figure 6.

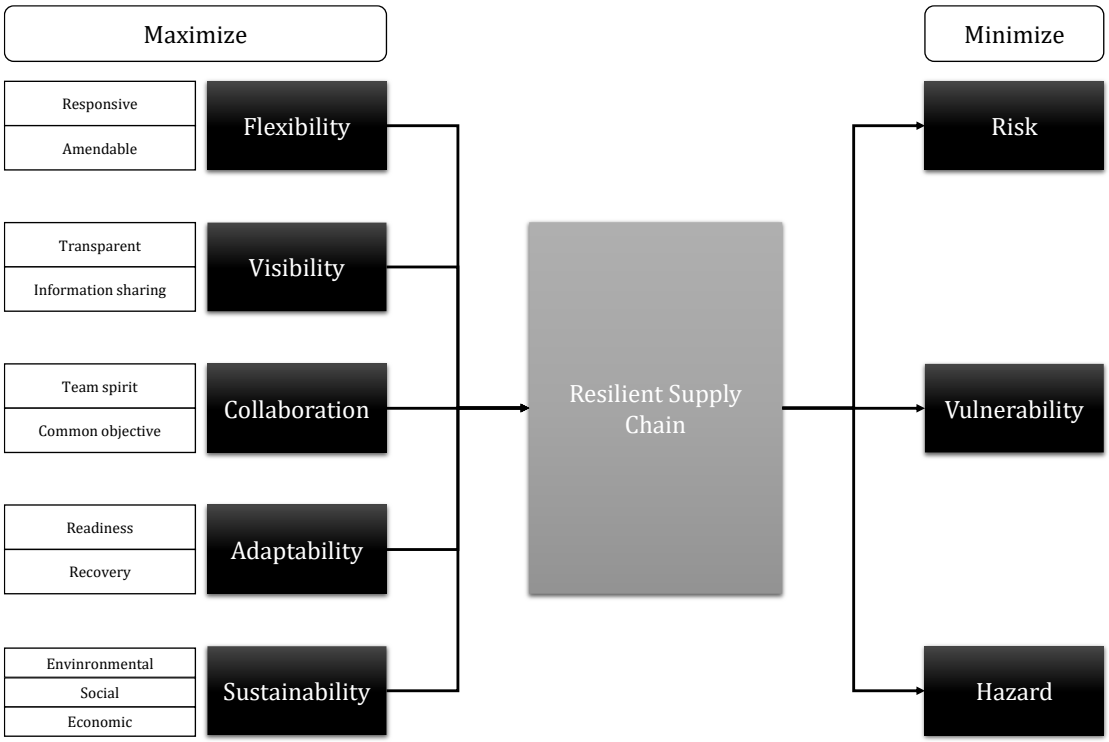



**Figure 6 -** Framework for resilience enhancing
**Source:** Soni and Jain (2011)

The authors also affirm that these are intangible dynamic Supply Chain capabilities (i.e. capabilities that require constant update) that can hold Supply Chain disruptions as well as generate competitive advantage. Each of these boxes are defined by Soni and Jain (2011):

- Flexibility is responsible for ensuring that changes caused by the Risk event can be absorbed by the SC through effective response.

- Supply Chain Visibility addresses information about entities and events regarding end-to-end orders, inventory, transportation and distribution as well as any events in the environment.

- Collaboration is related to visibility in the sense that it includes the parties' keenness Risks in general.

- While Flexibility is responsible for a quick response capability, Adaptability is the capacity to change due to a market requirement or a will to improve.

- Sustainability is important in an economic perspective, where stakeholders are keener to sustainable companies, and to prevent environment related Risks.

Resilience is also hard to be obtained due to specificities of each Supply Chain and the uncertainty environment in which they operate, making difficult to determine the most appropriate strategy to mitigate the negative effects of a disturbance.

### 1.6. Healthcare management

A Healthcare unit can be considered a facility that provides direct or indirect services to promote or keep individuals health condition (Gomes et al., 2016). Healthcare quality can be defined as a degree to which health services for individuals and populations increase the likelihood of desired health outcomes and care consistent with current professional knowledge (Gomes et al., 2016). The analysis of Healthcare network using operations management models is not effective as in the industrial environment, where the process activities and the flow of material are defined (Antonelli and Bruno, 2015). The production is substituted by care pathway that is far less deterministic. Products are substituted by patients that are free to move along the process flow at their will (Antonelli and Bruno, 2015).

Lean manufacturing is a management philosophy focusing on waste reduction and focuses on delivering the highest quality product on time and at the lowest cost (Dias et al., 2018). The seven waste categories of the Toyota Production System are adapted to Healthcare by Costa and Godinho Filho (2016): waiting (for an appointment), motion (searching for drugs), transportation (transferring patients to new rooms), overproduction (unnecessary treatment), defect (inspecting work already done for errors), over processing (unnecessary forms) and inventory (overstocked or understocked drugs), as well as including an eighth category, talent (failure to train emergency technicians and doctors in new diagnostic techniques).

Lean methodologies have become a consolidated set of practices and tools, which aim to improve processes while reducing costs. Recently, Lean practices are being applied to Healthcare organizations. Such practices led many researchers to coin the term “Lean Healthcare” (Gomes et al., 2016).

Lean offers a huge set of tools which can help Healthcare organizations to deal with the pressure of an environment with limited resources and a growing patient

population (Yu et al., 2015). Clinical processes could be analyzed through Health Lean Management (HLM) principles, tools and practices, redesigning and managing them in a scientific and systematic way and contributing to clinical errors reduction (Crema and Verbano, 2016).

Lean/Six-Sigma approach was also used, as an example, can be highlighted a study where the objective was to improve a medical records department (Bhat et al., 2014). In fact, Lean and Six-Sigma combined are mentioned by several papers such as Al Owad et al. (2013); Bhat et al. (2014); Bahensky et al. (2005); Bonilla et al. (2008); Carboneau et al. (2010); D'Andreamatteo et al. (2015).

The study found in Li et al. (2015) highlight the lack of a Healthcare standardized framework for implementing Lean Healthcare tools. The paper proposes a method for standardizing lean management approach in Healthcare and Yu et al. (2015) use Value Stream Mapping to redesign inefficient processes in an oncologic clinic. For more applications of VSM in healthcare organizations see Grove et al. (2010); Crema and Verbano (2015) and Cheng et al. (2015). Nevertheless, further research is still needed to understand how to Lean a Healthcare process, without making it prone to errors, and to measure HLM effects on patient safety (Pawlicki and Mundt, 2007; Holden, 2011). Curatolo et al. (2014) affirm that for Lean to be adopted and implemented by hospital practitioners a structured robust method should be provided. After this research, it can be affirmed that Leaning a Healthcare process without the proper training and consultancy can elevate Risks not only for the Healthcare organization but for all the Healthcare Supply Chain. Nevertheless, can also be affirmed that "not Leaning" a process may cause other Risks such as too much inventory, too much costs and other Risks which may result in the bankruptcy of the Healthcare organization and so, defining a hard to balance trade-off.

### 1.7. Healthcare Supply Chains

The main difference from HCSC to most segments is that the main objective is to save lives (Abdulsalam et al., 2015; Rakovska and Stratieva, 2017). A hospital is more than a simple link in a complex Supply Chain (Landry and Beaulieu, 2007). Hospitals are constituted by clinical departments such as emergency, intensive care, oncology, cardiology or coronary care, the catheterization laboratory and surgery (Landry and Beaulieu, 2007). A Healthcare Supply Chain model is described by Landry and Beaulieu

(2007) with the following tiers as shown by Figure 7:

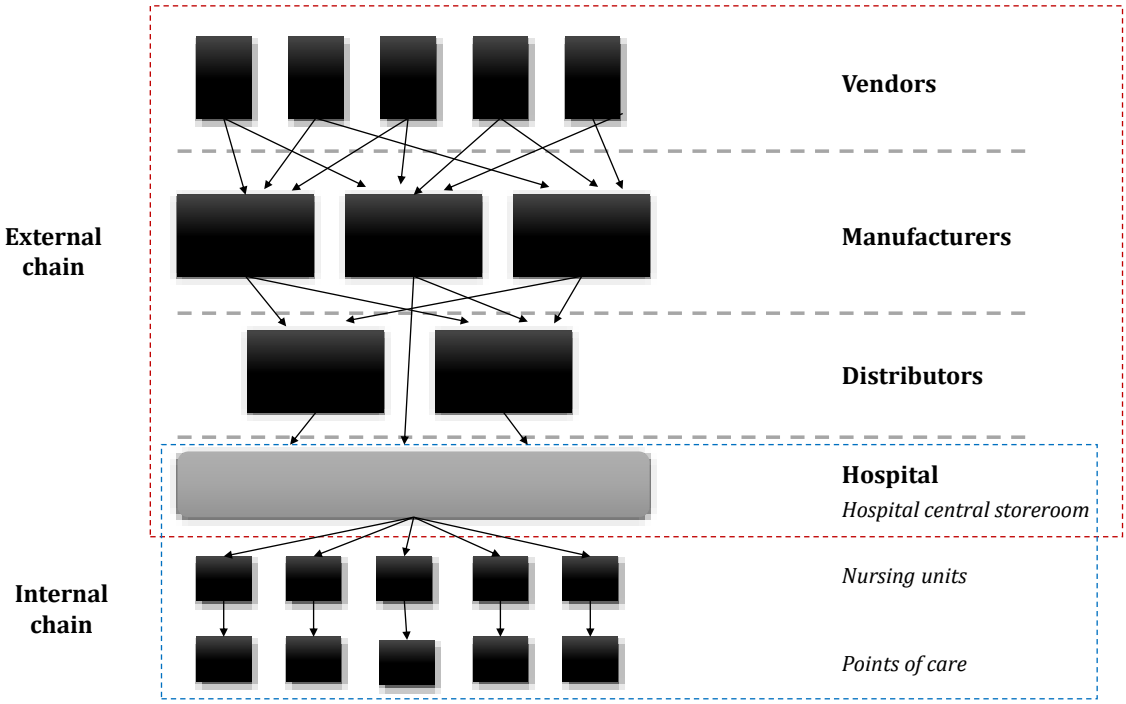



**Figure 7 –** A Healthcare Supply Chain
**Source:** Author based on Landry and Beaulieu (2007)

Vendors supply raw materials to medical devices and pharmaceuticals manufacturers which supplies wholesalers and/or distributors that are responsible for supplying hospitals and clinics (Rakovska and Stratieva, 2017). Chandra and Kachhal (2004) also include stakeholders such as insurance companies, government agencies, government regulators and users of Healthcare services. However, Rakovska and Stratieva (2017) affirm that it is not uncommon that manufacturers direct supply the hospitals. Nevertheless, distributors are important most because of scale economies in logistics activities.

### 1.8. Supply Chain Risk Management in Healthcare

Literature on Risks presents a great variety of techniques, nonetheless, they have considered to be scarcely adapted to the needs of Supply Chain management and even more scarcely considering Healthcare Supply Chains (Khan and Burnes, 2007). SCRM have been largely studied with many different approaches and applications, however, when a search is conducted to find specific HC SCRM applications, just a few papers are

found. These few papers can be sorted into two types, papers that explicitly say it analyzes SCRM applied to HC organizations and papers which eventually discuss solutions to problems that consist in major Risks and may cause rupture to one or more SC tiers. Concerning papers that clearly approach HC SCRM can be cited Vanvactor (2011) which highlights the importance of disaster mitigation to prevent SC breakdown and draws attention to crisis mitigation concepts. Thus, based on Vanvactor (2011) Healthcare Supply Chain Resilience (HC SCRes) can be defined as a capability to be responsive to disasters, as well as SC breakdowns and still being able to provide a full continuum of services to all patients arriving at a facility for care. Study seen in Zepeda et al. (2016) highlights the Risks concerning mismatch between supply and demand and discusses Risks of higher inventory costs.

Other articles bring forth issues that may indirectly contribute to measure and mitigate Risks, as is the case of Eiro and Torres-Junior (2015), which bring cases of Healthcare organizations that implemented Total Quality Management (TQM) and Lean through the implementation of tools like Value Stream Map (VSM) and Failure Mode and Effect Analysis (FMEA). Such tools, techniques and concepts are process improvers and generate KPI that helps measuring undesired effects.

Up to this point, prior to a thorough analysis presented in chapter 3, research reveals that there are only a little number of papers that deals with SCRM specifically in Healthcare. Nevertheless, there are papers mentioning Healthcare Supply Chain Risks, although not in a systematic way. For example, Rakovska and Stratieva (2017) mention that pharmaceuticals and medical devices are of special interest because they must meet specific requirements of several clinical departments and therefore, present great Risks of stockout. Other papers, for example Mandal and Jha (2017); Niemsakul et al. (2018) analyze the role of collaboration considering hospital-supplier, which helps mitigate Risks related to demand changes. Syahrir et al. (2015) highlights how a Healthcare Supply Chain plays a major role in natural disasters mitigation. Explicitly mentioning Healthcare Supply Chain Resilience (HC SCRes), Mandal (2017) uses Structural Equation Modeling (SEM) to empirically confirm the hypothesis that develop, group and rational cultures contributes positively to HC SCRes while hierarchical culture inhibits it. Still limited systematic research has been conducted to identify practices and strategies for improving hospital Supply Chain performance (Zepeda et al., 2016). Lack of proper studies concerning Risks in Healthcare are specific hazardous. According to Riley et al. (2016) for hospitals, a shortage of supply or unanticipated demand spike can lead to catastrophic

consequences beyond poor instock metrics. When a hospital experiences an unanticipated demand spike or supply shortage, supply managers must have the means to alter and/or reconfigure the Supply Chain (Riley et al., 2016). The authors conclude that by developing SCRM capabilities organizations can better address an array of Supply Chain Risks.

Zepeda et al. (2016) presents a study where they assess effects of horizontal inter-organizational arrangements on inventory costs for hospitals. More specifically, they deal with two conditions: i) logistics services infrastructure where the hospital is located; ii) demand uncertainty for clinical requirements that a hospital experiences.

## 1.9. Chapter Results

Regarding Healthcare organizations, there are still few papers that bring SCRM applied to Healthcare organizations and Supply Chains. Furthermore, literature still lacks proper definition of SCRM applied to Healthcare, which this thesis will refer to as HC SCRM. Considering analysis proposed by the review papers, Table 8 was built and summarizes the main analysis brought by review papers that based this chapter.

**Table 8 -** Analysis brought by review papers

| | **SCRM Approaches** | **Resilience Approaches** | **Risk /Resilience definitions** | **Risk Categories/ classification** | **Risk/ Resilience Strategies** |
|---|---|---|---|---|---|
| Heckmann et al. (2015) | ✓ | | ✓ | ✓ | ✓ |
| Ho et al. (2015) | | | | ✓ | |
| Fahimnia et al. (2015) | | | | | |
| Hohenstein et al. (2015) | | ✓ | ✓ | | |
| Kamalahmadi and Parast (2016) | | ✓ | ✓ | | ✓ |
| Bandaly, et al. (2013) | ✓ | | ✓ | ✓ | |
| Kilubi and Haasis (2015) | | | ✓ | ✓ | |
| Hamdi et al. (2015) | ✓ | | | ✓ | |
| Kilubi (2016a) | | | ✓ | | |
| Kilubi (2016b) | | | ✓ | ✓ | ✓ |

**Source:** Author

Note that were also considered review papers more focused on SCRes, which is the case of Kamalahmadi and Parast (2016) and Hohenstein et al. (2015), mostly because SCRes is a complementary subject to SCRM. Concerning Table 8, different papers had different visions for these concepts most of the time. For example, Heckmann et al. (2015) consider “Explicit Supply Chain Risk definition” and “No Explicit Supply Chain Risk definition” as SCRM approaches. In this thesis, this understanding of SCRM was

broadened and considered also what Hamdi et al. (2015) define as “Risk attitudes”, which classify whether a company is more or less willing to assume Risks looking for more profit. SCRes approaches are the pillars needed in order to build a resilient Supply Chain. Hohenstein et al. (2015) define “Readiness”, “Response”, “Recovery” and “Growth” as SCRes building blocks. Risk and Resilience definitions consist in summarize definitions found in literature regarding both concepts. Concerning the field “Risk categories/classification” it regards the factors that generate Risks, which can be fire, terrorism, natural disasters and more business-related ones like supply shortage, short product life cycles etc. By “Risk/Resilience strategies” are considered the macro strategies as well as the core processes which are strategy enablers. In this sense, Kilubi (2016b) presents 8 main strategies to deal with Supply Chain Risks, which are “Visibility and transparency”, “Flexibility”, “Relationships/Partnerships”, “Postponement”, “Multiple Sourcing”, “Redundancy”, “Collaboration” and “Joint planning and coordination”. Some of these strategies are also found in papers that more specifically approach SCRes which is the case of Kamalahmadi and Parast (2016). The authors bring SCRes principles such as “Collaboration”, “Redundancy”, “Agility”, “SCRM culture” and “SC Reengineering”. Note that the similarity of these factors shows the complementarity of both concepts being SCRM a way of creating solid SCRes.

Table 9 shows the summary of the main literature that composed this chapter.

**Table 9 -** Literature Summary

| ***Concept*** | ***Representative literature*** | ***Major Contribution*** |
|---|---|---|
| ***Prior to SCRM concept*** | Bowersox et al. (1999) | Lean Launch - Mitigates excessive inventory costs Risk |
| | Lonsdale (1999) | Addresses the Risks related to outsourcing |
| | Zsidisin et al. (2000) | Presented inbound supply Risks such as quality, design, cost, availability, manufacturability, supplier, legal, environmental, health and safety |
| | Hallikas et al. (2002) | Presented methods for Risk management in a complex network environment |
| | Hallikas et al. (2004) | |
| ***SCRM*** | Juttner et al. (2003) | Distinguish four basic constructs: Supply Chain Risk sources, Risk consequences, Risk drivers and Risk mitigating strategies |
| | Norrman and Jansson (2004) | Real case study relating the applied mitigating practices |
| | Juttner (2005) | The paper contributes to the knowledge on SCRM by presenting the business requirements from a practitioner perspective |
| | Pujawan and Geraldin (2009) | Authors bring a framework called house of Risk, which is a tool that combines QFD and FMEA |
| | Neiger et al. (2009) | Authors propose a novel value-focused process engineering methodology for process-based Supply Chain Risk identification |
| | Thun and Hoenig (2011) | Empirical study which reveals that companies with a high implementation degree of SCRM show a better Supply Chain performance |
| | Tang and Musa (2011) | Identified research gaps and brought important SCRM definitions |
| | Lavastre et al. (2012) | Empirical study that demonstrates that SCRM must be an interorganizational management function in order to be effective |
| | Petit et al. (2013) | research develops a measurement tool titled the Supply Chain Resilience Assessment and Management (SCRAMTM) |
| | Sodhi et al. (2012) | Show that literature summarizes SCRM approach into three main elements (Identification, Assessment and Mitigation). The authors even add a fourth element which is "responsiveness to Risk incidents". |

| | | |
|---|---|---|
| ***SCRes*** | Haimes (2006) | Two major ways of obtaining resilience: to recover the desired values of the states of a system that has been attacked, within an acceptable period and at an acceptable cost; and (ii) to reduce the effectiveness of the threats by changing the level of effectiveness of a threat. |
| | Ponomarov and Holcomb (2009) | Extensive literature review aiming to define SCRes |
| | Carvalho et al. (2012) | Quantitative simulation study using SCOR framework |
| | Torabi et al. (2015) | Improves resilience through stochastic optimization |
| ***Resilience Strategies*** | Juttner et al. (2003) | Provide strategies for Resilience and Risk mitigation |
| | Christopher and Peck (2004) | Propose principles that design resilient Supply Chains |
| | Tang (2006) | Brings Resilience strategies |
| | Iakovou et al. (2007) | Highlight features that increase resilience |
| | Barroso et al. (2010) | Resilience strategies |
| | Soni and Jain (2011) | Framework to enhance resilience |
| ***Healthcare Management*** | Antonelli and Bruno (2015) | Apply process mining in order to obtain a lean Healthcare network |
| | Bahensky et al. (2005) | Sucessfully applied Kaizen in a hospital |
| | Pawlicki and Mundt (2007) | Application of Lean/Six Sigma in a radiation oncology department |
| | Bonilla et al. (2008) | Authors apply Quality Function Deployment in a Oncology clinic |
| | Carboneau et al. (2010) | Authors present a study where Lean/Six Sigma is applied and, as a result, Hygiene enhancements led to a 51% infections reduction |
| | Grove et al. (2010) | Identify barriers for Lean implementation |
| | Holden (2011) | The implementation of Lean thinking in na Emergency department there were improvements in patient care |
| | Bhat et al. (2014) | Authors obtain considerable improvements applying Lean/Six Sigma in a registration process of a hospital |
| | D'Andreamatteo et al. (2015) | A literature review is presented and as the main findings can be highlighted the fact that hospital's emergency and surgery are the pioneer clinics applying lean. |
| | Li et al. (2015) | The paper then proposes a new approach for supplier selection based on selection criteria and agent-based simulation (ABS) |
| | Yu et al. (2015) | A VSM is presented a framework to implement Lean |
| | Cheng et al. (2015) | Information quality was reported by authors to be the most urgent problem in this Healthcare organization |
| | Crema and Verbano (2016) | study how to implement Health Lean Management (HLM) projects with benefits of Clinical Risk Management (CRM) |
| | Costa and Godinho Filho (2016) | Extensive literature review. The highlights include an analogy of the 8 toyota wastes adapted to Healthcare context, and frequently applied tools |
| | Curatolo et al. (2014) | the paper suggests a meta model for a high-methodological maturity-level Lean method based on the characteristic activities of Business Process Improvement (BPI) |
| **Healthcare Supply Chain** | Landry and Beaulieu (2007) | Modelled a generic Healthcare Supply Chain |
| **Healthcare Supply Chain Risk Management** | Vanvactor (2011) | The paper brings deadlines in Healthcare Supply Chain management involvement in disaster readiness |
| | Zepeda et al. (2016) | Results suggest that while affiliation with local, regional, and national systems has mitigating effects under weak logistics services infrastructure, the mitigating effect is greatest for affiliation in local systems |
| | Riley et al. (2016) | The results indicate that internal integration and training positively affect organizations' warning and recovery capabilities |

**Source:** Author

Figure 8 summarizes the main result of this chapter. This result consists in a comprehensive framework that summarizes the macroprocess of generating resilience and minimizing Risks through 3 main steps that are proposed for the rest of this thesis.

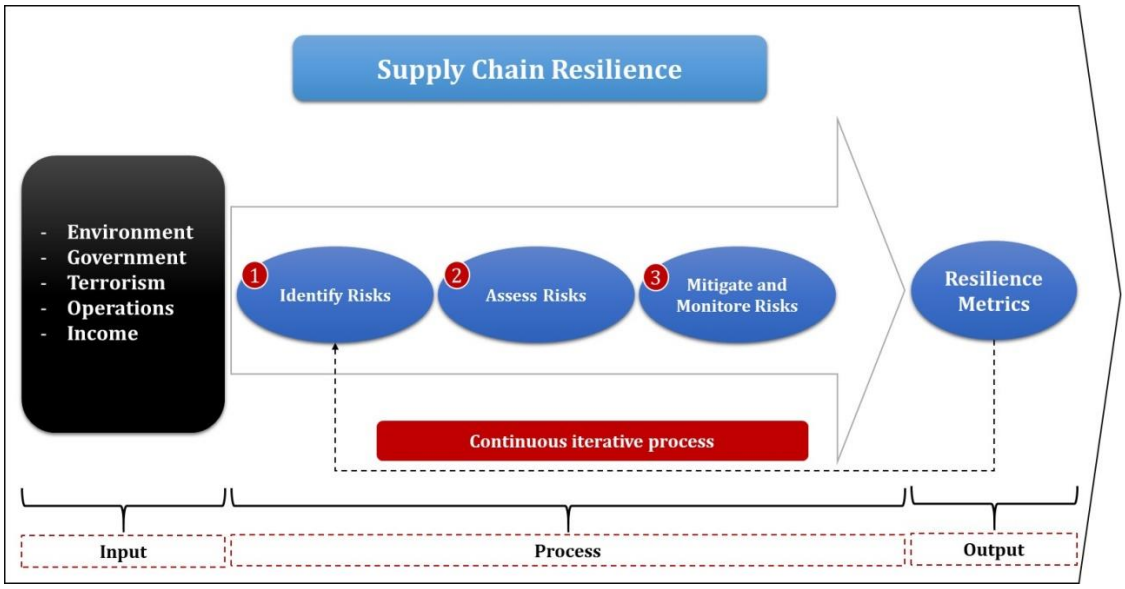



**Figure 8 -** Conceptual framework
**Source:** Author

## 1.10. Chapter Conclusions

This chapter discussed the main concepts used in the further chapters of this thesis. As direct results of this chapter can be cited Table 9 - Literature Summary and Figure 8 - Conceptual framework. Table 9 brings a summary of the main authors and approaches that provide the backbone needed for technique selection. The studied literature also provided resources for generating the framework seen in Figure 8. There was a clear option in this thesis to offer a solution considering Healthcare Supply Chain Risk Management through Risk identification, Risk Assessment and Risk Mitigation, although this chapter have shown that there were authors that preconize other steps such as Risk monitoring for example. Nevertheless, these 3 steps are consensus in consulted literature, therefore, they are chosen to compose the framework, which in the final conclusions of the thesis is submitted to critic scrutiny where a full assessment is carried out for evaluating the need of further steps. Chapter 2 shows the research methodology of the thesis.

# 2. Methodology

The main objective of this Thesis consists in constructing a conceptual framework that was carefully tailored to address resilience to the Healthcare Supply Chain through Supply Chain Risk Management. To do so, a thorough methodology is needed for providing robustness and consistency to the research.

The methodology was constructed based on an extensive paper reading and study along the doctorate course. Nevertheless, each chapter has its own objectives and methodology, which contribute to the main objective of this Thesis. The framework showed by Figure 9 summarizes the methodology.

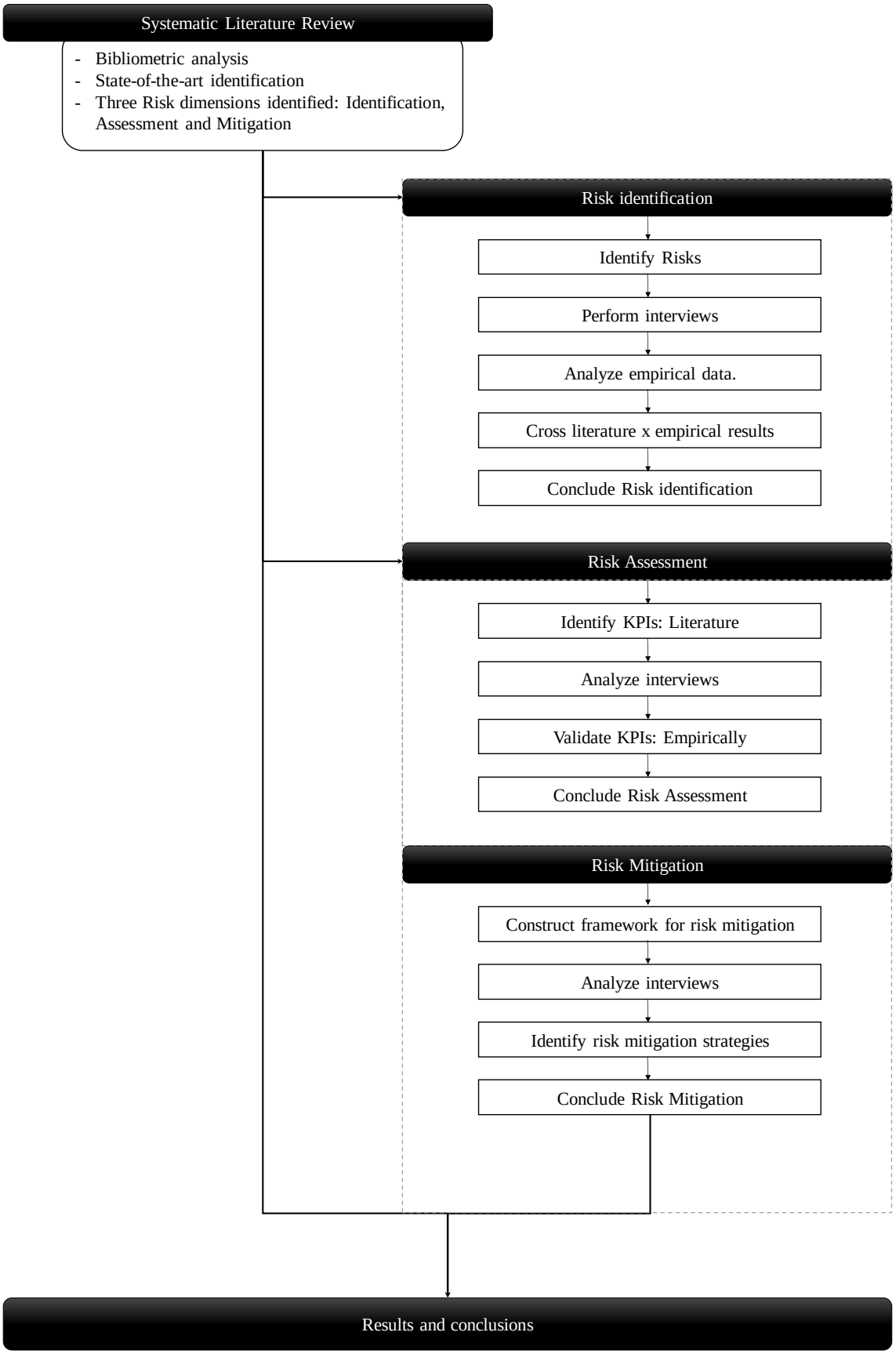



**Figure 9** - Thesis Methodology
**Source**: Author

|The Systematic Literature Review (SLR) was based on the search for “Supply

Chain Risk Management" and "Supply Chain Resilience, which showed that among the many segments contemplated by the survey, studies concerning Healthcare sector are lacking. The full SLR methodology and bibliometric analysis is presented in Chapter 3.

Complementary, Figure 10 summarizes the chapters structure proposed in order to fulfill this thesis methodology.

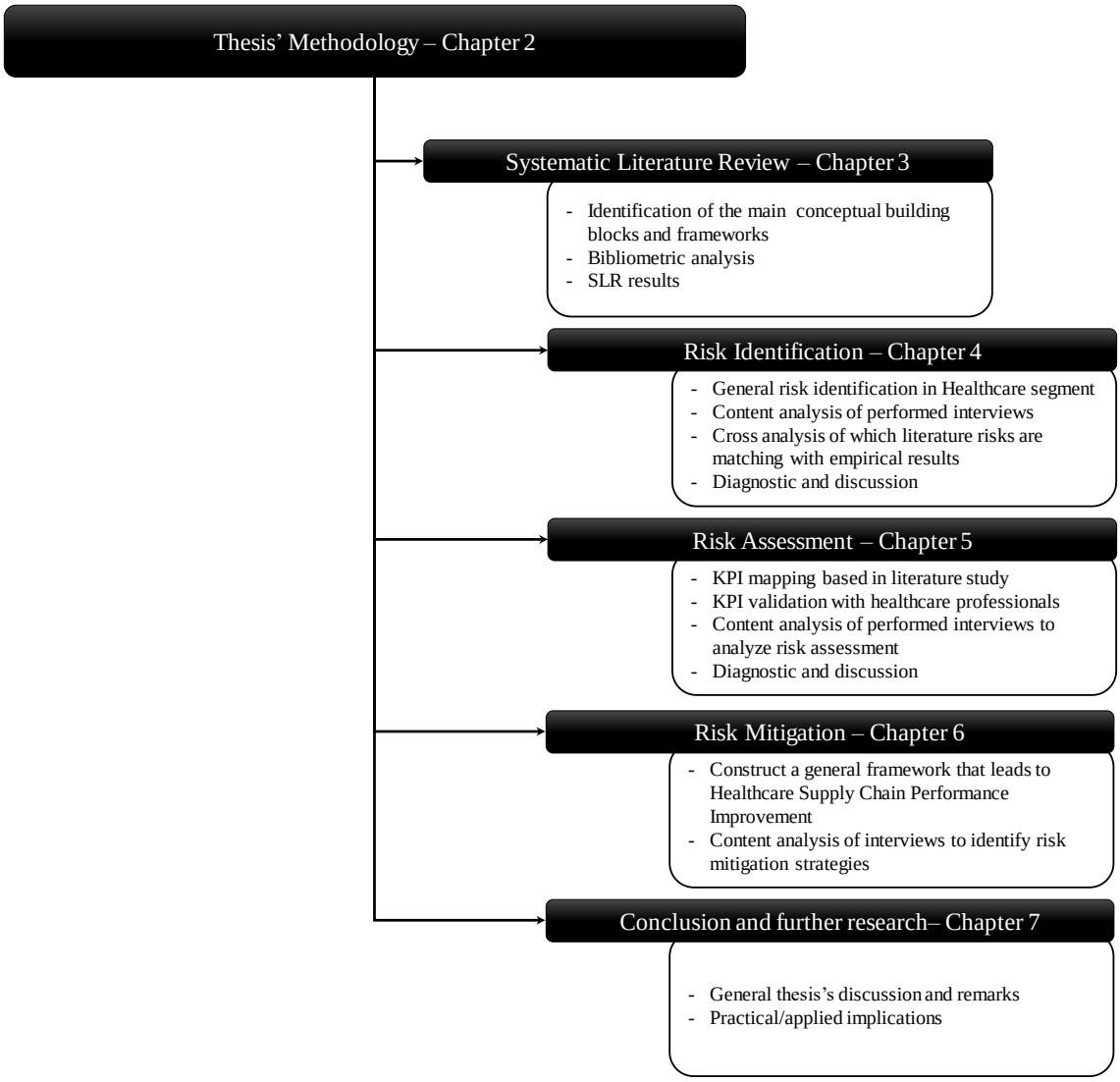



**Figure 10 –** Chapters' structure
**Source:** Author

SLR revealed the literature gap of SCRM frameworks and techniques applied to the Healthcare sector. Since there was only 2 studies that approached SCRM applied to Healthcare (Zepeda et al., 2016; Riley et al., 2016) the conclusion is that it is a very unexplored and promising research field.

## 2.1. Data collection

Data collection was carried out by two different methods. The first method consisted in collecting papers that were used for literature review and bibliometric study that based the further chapters. The databases chosen were Scopus and ISI Web of Science (WoS). The second, consisted in collecting empirical data from semi - structured Questionnaires answered by Healthcare Supply Chain professionals.

### 2.1.1. Data collection procedure for Systematic Literature Review

SLR review was based on research using Scopus and WoS database. The "data" in this case are the papers found in the research. For organizing the papers two softwares were used. The first software was Mendeley®, which is mainly a software that organizes all references, making it easier to remove duplicates and cite papers, as it automatic generates references in the desired format. Figure 11 shows a sample of the selected papers in Mendeley®.

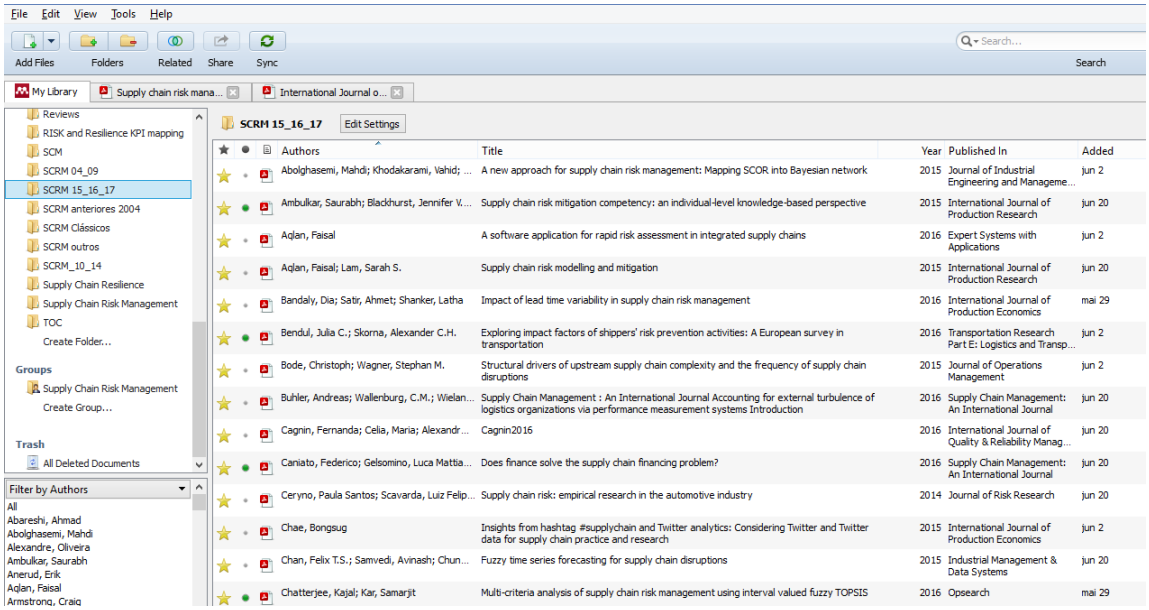
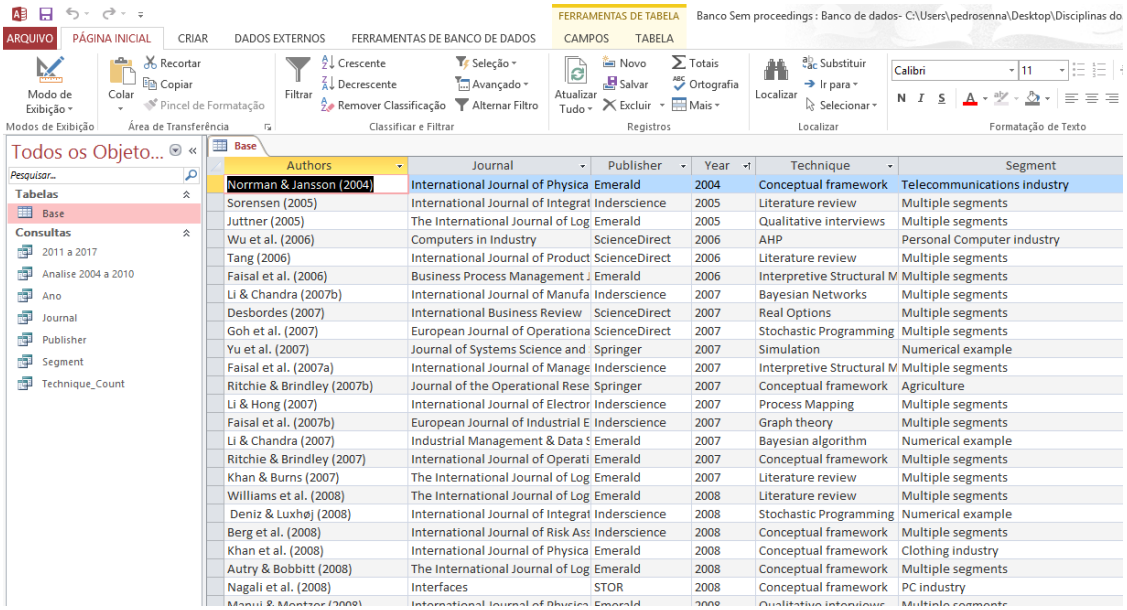



**Figure 11 -** Mendeley® Software
**Source:** Author

Scopus and WoS database can provide some important bibliometric analysis such as Publications per Year, Publications per author and others. Both bases also provide a segment analysis, which did not fit to the requirements for being too generic. Therefore, all papers were manually compiled into a more detailed database and stored in MS Access®. As Figure 12 shows, other important fields such as the specific segment and the predominant paper technique were identified and manually registered for further analysis.



| Authors | Journal | Publisher | Year | Technique | Segment |
|---|---|---|---|---|---|
| Norrman & Jansson (2004) | International Journal of Physica | Emerald | 2004 | Conceptual framework | Telecommunications industry |
| Sorensen (2005) | International Journal of Integrat | Inderscience | 2005 | Literature review | Multiple segments |
| Juttner (2005) | The International Journal of Log | Emerald | 2005 | Qualitative interviews | Multiple segments |
| Wu et al. (2006) | Computers in Industry | ScienceDirect | 2006 | AHP | Personal Computer industry |
| Tang (2006) | International Journal of Product | ScienceDirect | 2006 | Literature review | Multiple segments |
| Faisal et al. (2006) | Business Process Management J | Emerald | 2006 | Interpretive Structural M | Multiple segments |
| Li & Chandra (2007b) | International Journal of Manufa | Inderscience | 2007 | Bayesian Networks | Multiple segments |
| Desbordes (2007) | International Business Review | ScienceDirect | 2007 | Real Options | Multiple segments |
| Goh et al. (2007) | European Journal of Operationa | ScienceDirect | 2007 | Stochastic Programming | Multiple segments |
| Yu et al. (2007) | Journal of Systems Science and | Springer | 2007 | Simulation | Numerical example |
| Faisal et al. (2007a) | International Journal of Manage | Inderscience | 2007 | Interpretive Structural M | Multiple segments |
| Ritchie & Brindley (2007b) | Journal of the Operational Rese | Springer | 2007 | Conceptual framework | Agriculture |
| Li & Hong (2007) | International Journal of Electror | Inderscience | 2007 | Process Mapping | Multiple segments |
| Faisal et al. (2007b) | European Journal of Industrial E | Inderscience | 2007 | Graph theory | Multiple segments |
| Li & Chandra (2007) | Industrial Management & Data S | Emerald | 2007 | Bayesian algorithm | Numerical example |
| Ritchie & Brindley (2007) | International Journal of Operati | Emerald | 2007 | Conceptual framework | Multiple segments |
| Khan & Burns (2007) | The International Journal of Log | Emerald | 2007 | Literature review | Multiple segments |
| Williams et al. (2008) | The International Journal of Log | Emerald | 2008 | Literature review | Multiple segments |
| Deniz & Luxhøj (2008) | International Journal of Integrat | Inderscience | 2008 | Stochastic Programming | Numerical example |
| Berg et al. (2008) | International Journal of Risk Ass | Inderscience | 2008 | Conceptual framework | Multiple segments |
| Khan et al. (2008) | International Journal of Physica | Emerald | 2008 | Conceptual framework | Clothing industry |
| Autry & Bobbitt (2008) | The International Journal of Log | Emerald | 2008 | Conceptual framework | Multiple segments |
| Nagali et al. (2008) | Interfaces | STOR | 2008 | Conceptual framework | PC industry |

**Figure 12 -** Paper database
**Source:** Author

Analysis provided by SLR were conducted by MS Access® queries, graphics and maps conducted using MS Excel®.

### 2.1.2. Data Collection limitations (SLR)

The search was conducted using two search engines; Scopus and ISI Web of Science. Elsevier's Scopus is the largest database of peer-reviewed literature and recovers journals from all major databases such as Emerald, Taylor & Francis, Science Direct, PubMed, among others. Scopus database is the largest searchable citation and abstract source (Chadegani et al., 2013). WoS from Thomson Reuters (ISI) was the only citation database and publication that covers all domains of science for many years (Chadegani et al., 2013). The advantage of one database over another one depends on what explicitly will be analyzed, the scientific field and period of analysis (Chadegani et al., 2013). WoS is the oldest citation database, therefore it has strong coverage with citation data and bibliographic data going back to 1900 (Boyle and Sherman, 2006). Study of Vieira and Gomes (2009) reveals that 2/3 of the studies can be found in both databases and 1/3 only in one database. Another considerable advantage is that both databases provide ". bib" files providing full search data (such as references, article authors, etc.) that can be further analyzed in bibliometric packages. Nevertheless, even conducting the research in both

databases it would not be possible to guarantee that all relevant literature was covered and so, it can be considered a limitation. The second limitation is that only papers in English language were considered. This decision was taken based in: i) Most review articles (and all review articles in this thesis) use this criterion, therefore, it has literature methodological support, ii) English is the main language used to communicate scientific research, iii) To guarantee that any researcher can understand any paper selected for this bibliometric study. Nevertheless, this procedure may disregard relevant studies published in other idioms. The third limitation is that this chapter was not exhaustive or had the pretention of covering all definitions and frameworks presented in literature. This limitation is a direct consequence of the first two. However, definitions and frameworks analyzed to compose the one presented, and this chapter are based in quality literature provenient from both cited databases.

### 2.1.3. Data collection procedure for empirical study

The empirical data was formed by the content analysis carried on from the performed semi-structured interviews. This approach provides a open format, but is still focused on specific questions, allowing the researcher to guide the interviewee through the areas of interest (Fan and Stevensson, 2018). The results were analyzed through three chapters that covered Risk identification, Risk Assessment and Risk Mitigation. The questionnaire was based in Gaudenzi et al. (2017); Fan and Stevensson (2018). In this thesis the interest was to understand professionals' experiences of SCR identification, assessment and mitigation their upstream relationships with suppliers and buyers. The methodology was adapted from previously cited authors and followed the criteria: i) Organizations should be based in Brazil, ii) Organizations should be part of a Healthcare Supply Chain. The Interviewees had the option of being interviewed in loco, via telephone, video telephone or answering the questions in the spreadsheets. The objective of giving so many options consisted in having the possibility of collecting at least some information even if the interviewee did not have any dates available. A total of three interviews were carried in loco and 8 were carried via spreadsheet. In loco interviews were a better way of collecting data because it still allows the non-verbal behavior of participants to be observed. Interviews were audio-recorded. In opposition of Fan and Stevensson (2018) the interview questions were not sent in advance. In addition, in their

paper, Fan and Stevensson (2018) interviewed two professionals per company, while in this thesis were not imposed this constraint aiming to get at least one vision of a given organization. There were no access to use corporate reports either. The specific content of the interviews was treated according to the theme of each chapter.

## 2.2. Research questions

In this section are presented the research questions that the Thesis aims to answer.

RQ1 – Which techniques have been employed by authors in the literature to perform SCRM?

RQ2 – Which market segments are being approached by authors in the SCRM literature?

RQ3 – What are the research gaps/unexplored opportunities respective to applying SCRM in Healthcare organizations?

RQ4 – What is the definition of Healthcare Supply Chain Risk Management?

RQ5 – What are the more relevant Risks to the Healthcare Supply Chains?

RQ6 – Which metrics and indicators can be used to measure Healthcare Supply Chain Risks?

RQ7 – Which techniques can be used to mitigate SC Risks in Healthcare?

# 3. Results of the Systematic Literature Review

## 3.1. Chapter abstract

Since SCRM was firstly formalized as a concept (in the early 2000's), many quantitative/qualitative techniques and frameworks have been applied to most different Supply Chains (SC). However, when a systematic search for papers studying Healthcare organizations is conducted an important gap in literature is revealed. Given this scenario, as a primary objective, the chapter aims to present a Systematic Literature Review of SCRM literature to map this research field and set trends. As a secondary goal, were analyzed how many studies concerning SCRM applied to Healthcare sector can be found in literature and which opportunities for improvements are being missed. The research revealed that Healthcare segment is still a very promising field, therefore, Healthcare literature could benefit from SCRM conceptual frameworks and techniques for cost reduction and improvement of service quality.

Chapter keywords: Supply Chain Risk Management; Supply Chain Risk; Quantitative techniques, Qualitative techniques, Healthcare Management

## 3.2. Chapter Introduction

Since Supply Chain Risk Management emerged formally as a concept in the early 2000's significant literature has emerged with many different studies. One of the first papers bringing SCRM definition is Norrman and Jansson (2004) where the authors thoroughly describe a real case study and respective measures for Risk identification and mitigation. Among the most studied segments are the automotive (Elangovan et al., 2010; Colicchia et al., 2011; Thun et al., 2011; Grötsch et al., 2013; Abolghasemi et al., 2015; de Oliveira et al., 2017), Food industry (Taylor et al., 2010; Robinson et al., 2012; Song and Zhuang, 2017) and Electronics industry (Kumar and Harrison, 2012; Chatterjee and Kar, 2016; Rajesh, 2017). As the main approaches can be highlighted Simulation (Keramydas et al., 2015; Hong et al., 2015; Zeng and Yen, 2017), Fuzzy Logic (Tipmontian et al., 2012; Dolatabadi et al., 2015; Mostafaeipour et al., 2017), Structural Equation Modeling (Riley et al., 2016; Chowdhury and Quaddus, 2016; Fan et al., 2017) and Confirmatory Factorial Analysis (Bendul and Skorna, 2016; Kauppi et al., 2016; Wiengarten et al., 2016).

As a first analysis, article database reveals that there are very few papers that apply

concepts of SCRM to Healthcare organizations. Modern management techniques applied to Healthcare segment are even more relevant regarding global population growth and aging, therefore, drastically increasing the need of higher investments. Based on this assumption, it becomes increasingly crucial to apply SCRM techniques for additional cost reduction and service level improvement. To further investigate the literature concerning SCRM, a SLR was conducted through an already well-consolidated methodology known as Bibliometrics, which consists in using quantitative statistical analysis in order to describe patterns of publications, i.e. a general picture of the literature (Kilubi, 2016a). Therefore, the objectives of this chapter are threefold: (1) Set a complete picture of SCRM research field; (2) Identify which segments and techniques are more approached and which are less studied, in order to set research trends and help researchers to explore new research fields; (3) More specifically, this chapter aims to identify if there are a relevant number of studies in Healthcare segment and what are the conclusions.

This chapter is composed by 5 sections (including the abstract and this introductory one). Section 3.3 brings methodology of this chapter, Section 3.4 brings the results of the bibliometric results and Section 3.5 discusses the results and closes the chapter with conclusions and further research opportunities.

## 3.3. Chapter Methodology

Among the papers found in this research, we identified review papers (in the last five years) to construct the methodology. To do so, the most cited papers in last 5 years were chosen. There are more classic review papers with even more citations, nevertheless, to set new trends, were considered more relevant to build a methodology based on more recent articles. Table 10 shows authors and citations in Scopus and WoS database.

**Table 10** - Review papers used to construct the research methodology

| Authors | Citations Scopus | Citations WoS |
|---|---|---|
| Heckmann et al. (2015) | 142 | 109 |
| Ho et al. (2015) | 89 | 62 |
| Fahimnia et al. (2015) | 65 | 47 |
| Hohenstein et al. (2015) | 53 | 44 |
| Kamalahmadi and Parast (2016) | 36 | 30 |
| Bandaly et al. (2013) | 9 | 10 |
| Kilubi (2016a) | 7 | 5 |
| Hamdi et al. (2015) | 4 | 3 |
| Kilubi (2016b) | 2 | 2 |
| Kilubi and Haasis (2015) | 2 | - |

**Source:** Authors

The first step consisted in analyzing the research methodology of papers cited in Table 10 which resulted in the workflow presented in Figure 13.

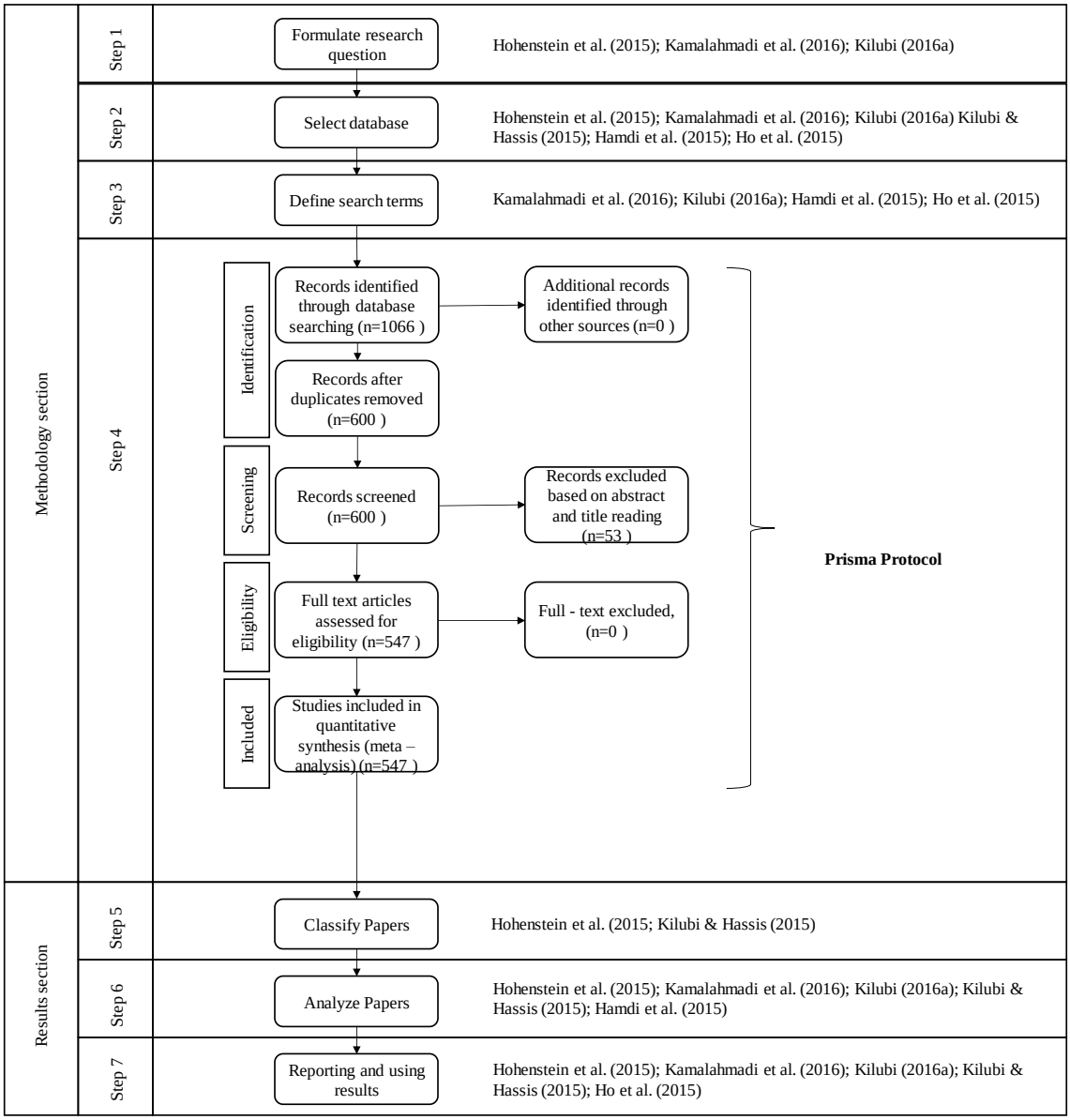


**Figure 13 -** Research Methodology workflow
**Source:** Authors

Table 11 shows quantitative analysis brought by these review papers.

**Table 11 -** Main indicators brought by review papers

| | Publications/ year | Publications/ Journal | Publications/ author | Publications/ Country | Segment analysis | Techniques applied |
|---|---|---|---|---|---|---|
| Heckmann et al. (2015) | ✓ | | | | | ✓ |
| Ho et al. (2015) | ✓ | | | | ✓ | ✓ |
| Fahimnia et al. (2015) | ✓ | ✓ | ✓ | ✓ | | ✓ |
| Hohenstein et al. (2015) | | ✓ | | | | |
| Kamalahmadi and Parast (2016) | ✓ | ✓ | | ✓ | | ✓ |
| Bandaly, et al. (2013) | | | | | | ✓ |
| Kilubi and Haasis (2015) | ✓ | ✓ | | | | |
| Hamdi et al. (2015) | ✓ | | | | | ✓ |
| Kilubi (2016a) | | ✓ | ✓ | | | |
| Kilubi (2016b) | ✓ | ✓ | | | | ✓ |

**Source:** Authors

The amount of publications per year, per journal, per author and country are straightforward indicators and mean the quantity of papers published considering each of these filters. Segment analysis mean the amount of publications by a specific segment, for example automotive industry. Techniques applied means the quantity of publications which use a given technique. By this point, it is crucial to highlight that to sort the papers techniques, it was chosen the predominant technique of the paper declared by the paper's authors, not considering possible techniques idiosyncrasies in a first moment. Mostly, this mean that all papers that use many different variations of Simulations are all sorted as "Simulation". This simplification is needed to set big areas of research which can be further detailed depending on researcher's interest. Furthermore, this Research Methodology aims to provide the necessary backbone for a broader view of Supply Chain Risk Management literature.

Steps 1 to 4 of the research methodology are the foundations of this chapter's methodology, so, they are presented and further detailed in this section, while steps 5 to 7 (which are direct consequences of first 4 steps) are discussed in section 4 and are

focused on results.

### 3.3.1. Formulate research question

In the first step, is important to make sure that the research scope is in adherence to the objectives and the underlying study questions are defined (Kilubi, 2016a). Therefore, the research questions of this chapter are:

RQ1 – Which techniques have been employed by authors in the literature to perform SCRM?
RQ2 – Which market segments are being approached by authors in the SCRM literature?
RQ3 – What are the research gaps/unexplored opportunities respective to applying SCRM in Healthcare organizations?

As exposed by the three research questions, the general objective of this paper is to analyze the current scenario of SCRM providing inputs for academics and researchers to develop new studies. As a more specific objective, the goal is to thoroughly analyze those specific papers which apply SCRM in Healthcare organizations and discover with trends can be set in this area.

### 3.3.2. Database Selection

The database chosen for searching the research strings were Scopus, which is the largest database of peer-reviewed literature, and ISI Web of Science which is not as large as Scopus but can recover papers from a greater year range. Moreover, using Scopus and ISI as search engines, allows locating papers of Science Direct, Taylor & Francis, Emerald, Springer, and other important bases used by the Systematic Literature Review. While this research carefully examined extensive SCRM literature, it has limitations. As the main limitations, can be cited the fact that were reviewed international journal articles (published in the english language), excluding conference papers, master and doctoral dissertations, textbooks, book chapters, unpublished articles and notes.

In terms of selection criteria, Kilubi and Haasis (2015); Kamalahmadi and Parast (2016) used ABS (associationofbusinessschools.org) ranking and limited to journals with 3 or 4 grade. Kilubi (2016b) considered in her paper peer-reviewed journals with a VHB

ranking (vhb.online.org/startseite) of A+, A, B or C. Nevertheless, this thesis did not imposed any journal restriction on the list to ensure that all relevant study were captured, which is consonant with the vision of Ho et al. (2015). Additionally, this thesis chose not to use this ranking because a broader scope was needed and since the papers related to Healthcare are few (premise confirmed by the bibliometrics), adding too many constraints could reduce to none the amount of papers related to Healthcare

### 3.3.3. Define search terms

The search term chosen was ("Supply Chain Risk Management" OR "SCRM") OR ("Supply Chain Resilience" OR "SCRES") in article title, keywords and abstract. These strings were chosen because they included consolidated terms when papers mean to approach Risks in a SC, additionally, the main goal was to see the evolution of the concept.

### 3.3.4. PRISMA Protocol

Moher et al. (2009) came up with the Preferred Reporting Items for Systematic Reviews and Meta-Analyzes (PRISMA) method. This protocol is mostly used in Healthcare SLR and Meta – analysis, nevertheless, it is also used in industrial engineering segments (see Muhs et al., 2018). PRISMA protocol was developed after a three – day meeting in Ottawa, Canada, in June 2005 with 29 participants including review authors, methodologists among other Healthcare professionals (Moher et al. 2009). Due to the notoriety and importance of the PRISMA protocol it was incorporated in the step 4 of this SLR methodology workflow. The search was conducted in both Scopus and ISI databases. A ". bib" file was generated for each search and analyzed in R software where a single database file was generated with duplicates removed to generate the complete bibliometric analysis presented in this study. Nevertheless, R software could not conduct all important analyzes, for example, identifying whether the paper was conceptual or analytical, the segment applied and other classifications that needed a more "artisanal" approach. The complete set of statistics and analyzes are shown in the following sections. The flowchart in Figure 14 summarizes the steps conducted in the analyzes.

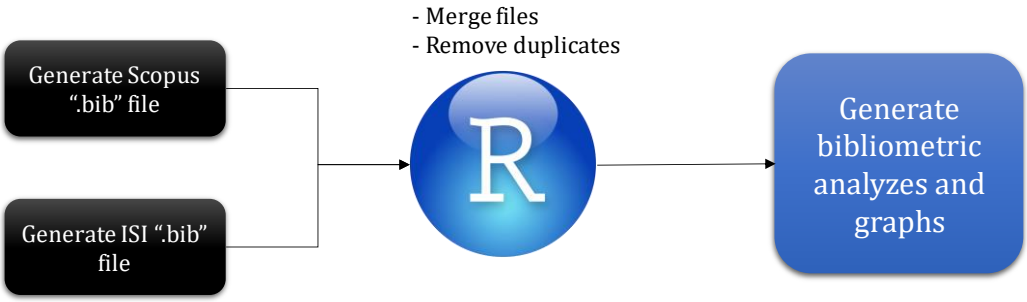



**Figure 14 –** Data and results generating process

## 3.4. Results of the Systematic Literature review

### 3.4.1. Classify papers

This section shows the paper classification. There is a vast number of papers (more than one hundred) that are numerical examples, and do not approach any segment. The paper classification by segment is shown by Figure 15:

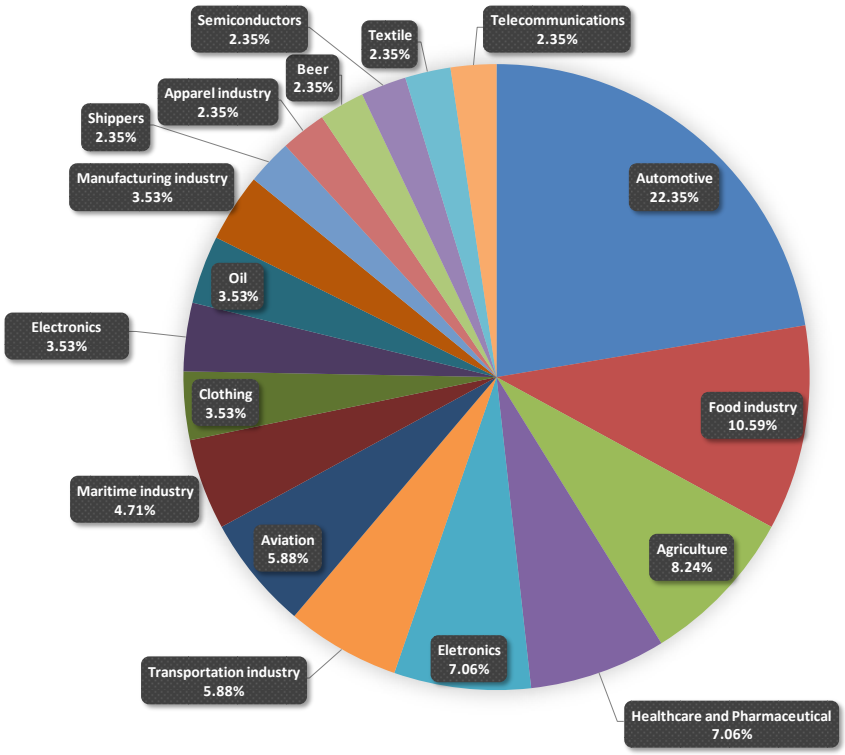



**Figure 15 -** Segment distribution (Proportions)

Among the applied papers the distribution by segment summarized by Table 12. It is noted that Automotive and Food sectors outstand with 19 and 9 outcomes respectively.

**Table 12 –** Segment distribution (absolute numbers with at least two studies found)

| Category | Quantity |
|---|---|
| Automotive | 19 |
| Food industry | 9 |
| Agriculture | 7 |
| Healthcare and Pharmaceutical | 6 |
| Electronics | 6 |
| Transportation industry | 5 |
| Aviation | 5 |
| Maritime industry | 4 |
| Clothing | 3 |
| Electronics | 3 |
| Oil | 3 |
| Manufacturing industry | 3 |
| Shippers | 2 |
| Apparel industry | 2 |
| Beer | 2 |
| Semiconductors | 2 |
| Textile | 2 |
| Telecommunications | 2 |

Concerning Table 12, it is important to highlight that there is not a category called Healthcare Supply Chain Risk Management, therefore, Pharmaceutical and Healthcare studies were joined in a single category which would also include distributors and OEM Suppliers (if these categories were found). Healthcare and Pharmaceutical together appear with 6 studies (Table 13).

**Table 13 -** Healthcare and Pharmaceutical studies

| Authors | Segment | Approach |
|---|---|---|
| Jaberidoost et al. (2013) | Pharmaceutical | Literature review |
| Jaberidoost et al. (2015) | Pharmaceutical | Analytic Hierarchy Process |
| Elleuch et al. (2013) | Pharmaceutical | Filure Modes and Effects Analysis |
| Aguas et al. (2013) | Healthcare | Mathematical Programming |
| Zepeda et al. (2016) | Healthcare | Econometric methods |
| Riley et al. (2016) | Healthcare | Structural Equation Modeling |

Table 14 shows the most used techniques.

**Table 14 -** Most used techniques (2 or more outcomes)

| Technique | Articles |
|---|---|
| Mathematical Programming | 35 |
| Simulation | 25 |
| Structural Equation Modeling | 24 |
| Fuzzy | 18 |

| | |
|---|---|
| Survey analysis | 17 |
| Statistical analysis | 17 |
| Analytic Hierarchy Process | 6 |
| Decision making trial and evaluation laboratory | 5 |
| Failure Modes and Effect Analysis | 2 |
| Behavioral study | 2 |

**Source:** Authors

### 3.4.2. Analyze papers

Figure 16 shows the articles distribution along the years. The search was conducted during 2018 and totalized 547 papers.

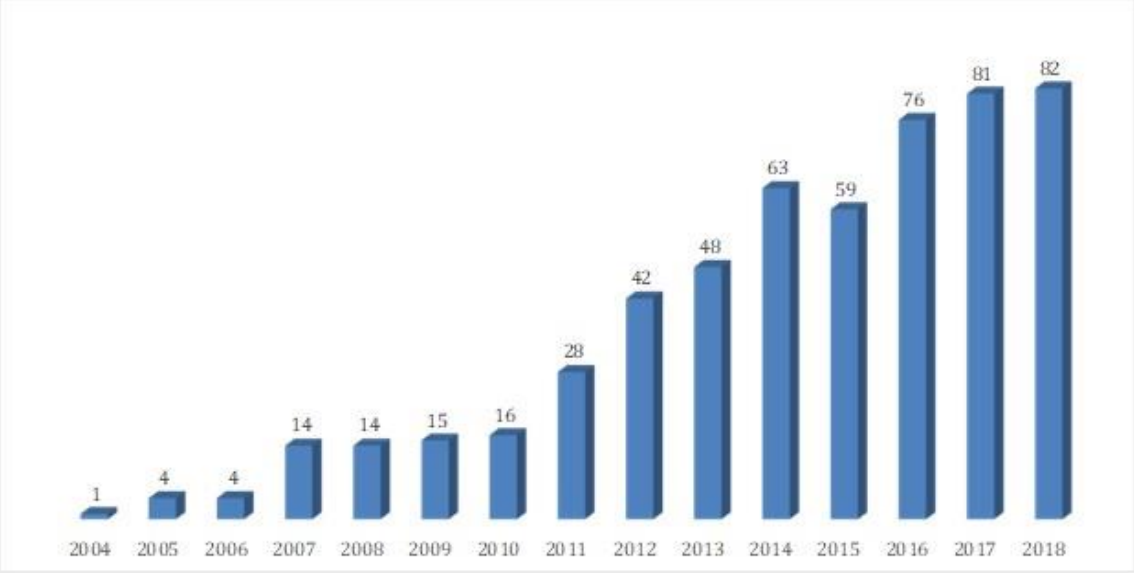



**Figure 16 –** Articles distribution

Figure 16 shows that the concept is being increasingly recognized by academy which is supported by the growing number of publications. Considering the "Supply Chain Risk Management" and "Supply Chain Resilience" strings, this search returned results in 2004 – 2018 range. Considering the first half of the period (2004 – 2010) was detected a "conceptual phase" where the concept needed to be constructed and standardized. As examples of literature review papers in the period can be cited Olson and Wu (2010), Tang (2006), Shashank and Goldsby (2009), Williams et al. (2008) among others. In this period were detected 68 papers where 15 (22.1%) are conceptual frameworks, 26 (38.2%) are analytical, being 5 (7.4%) empirical and 22 (32.3%) applied.

Considering the second half of the analyzed period (2011 – 2018) can be noted an

explosive increase of publications with a total of 479 papers. Among them, 46 (9.6%) are conceptual papers, 201 (42.0%) analytical, being 49 (10.2%) empirical and 183 (38.2%) applied. The results show how the SCRM discipline developed over the years with a phase of establishing the concept and a second phase where the conceptual papers are still present, but a higher number of applications is noted.

### 3.4.3. Results and research gaps

In this section it is shown all numerical results found in the bibliometric analysis. The first graph shown by

Figure 17 shows the top 10 publishing countries. USA is the leader with 54 papers, representing 9.9% of total.

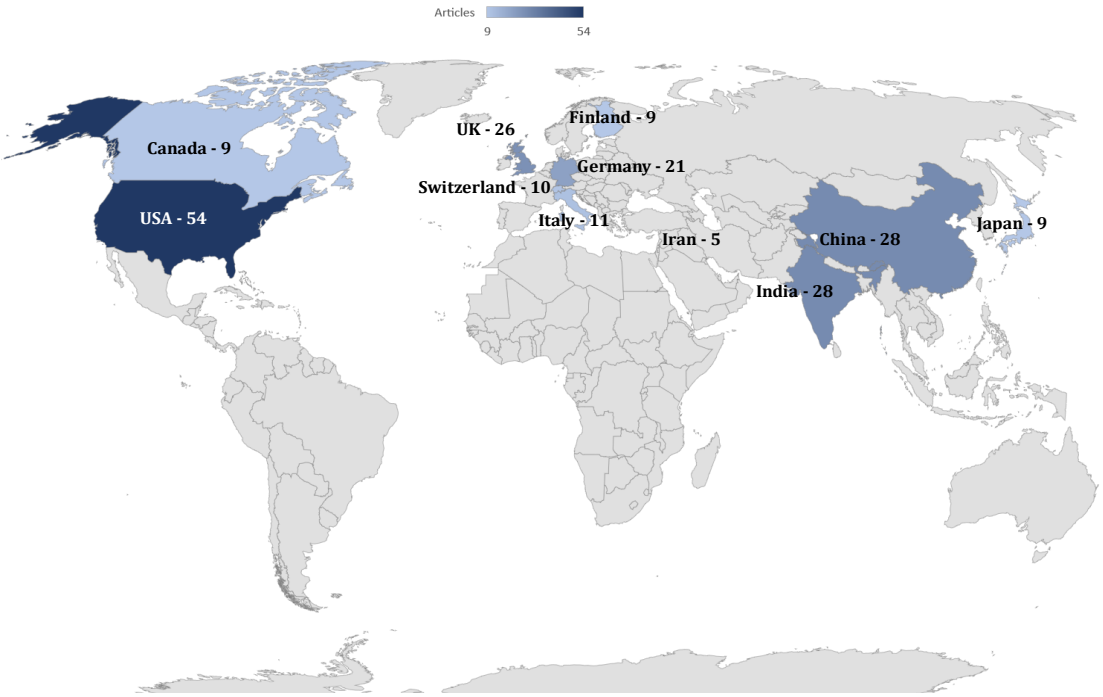



**Figure 17 -** Top 10 publishing countries

Although USA continues to be the leader in terms of total citations, there is some changes in other positions. For example, Italy does not appear in top 10 publishing countries but outcomes Ukraine, Finland and Indonesia in terms of citations as shown by Figure 18.

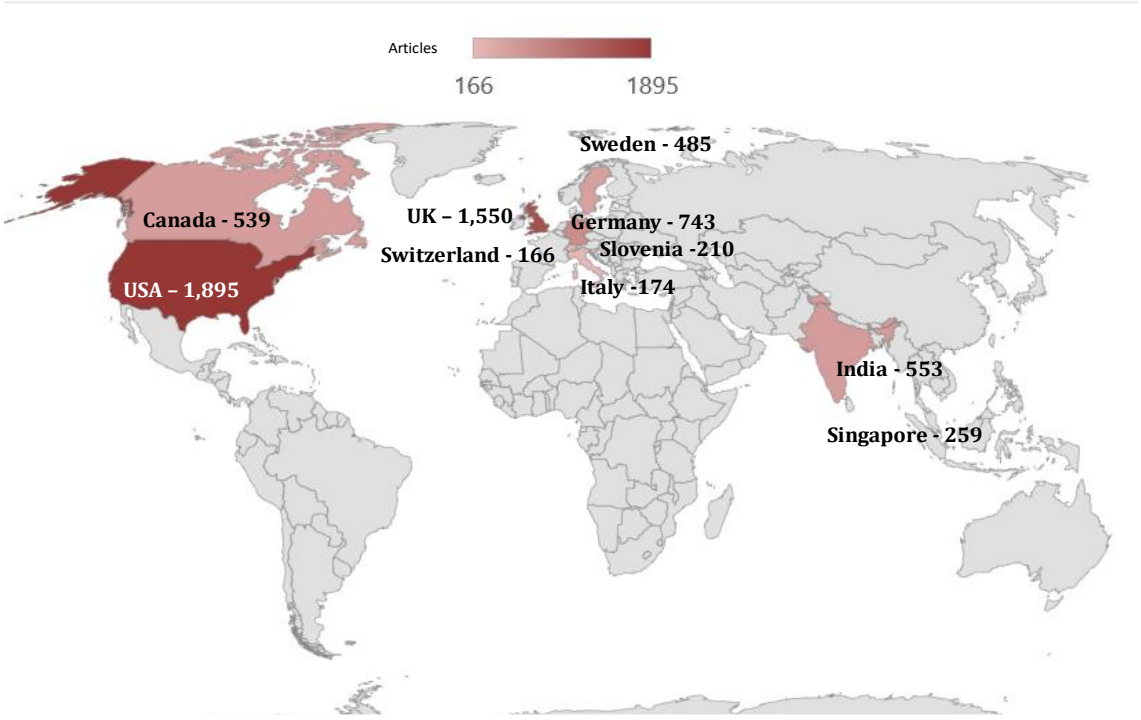



**Figure 18 -** Top 10 countries with more citations

Figure 19 shows the top 10 most productive authors during the researched period. In this category Santanu Mandal and Jennifer Blackhurst outstand with 9 publications.

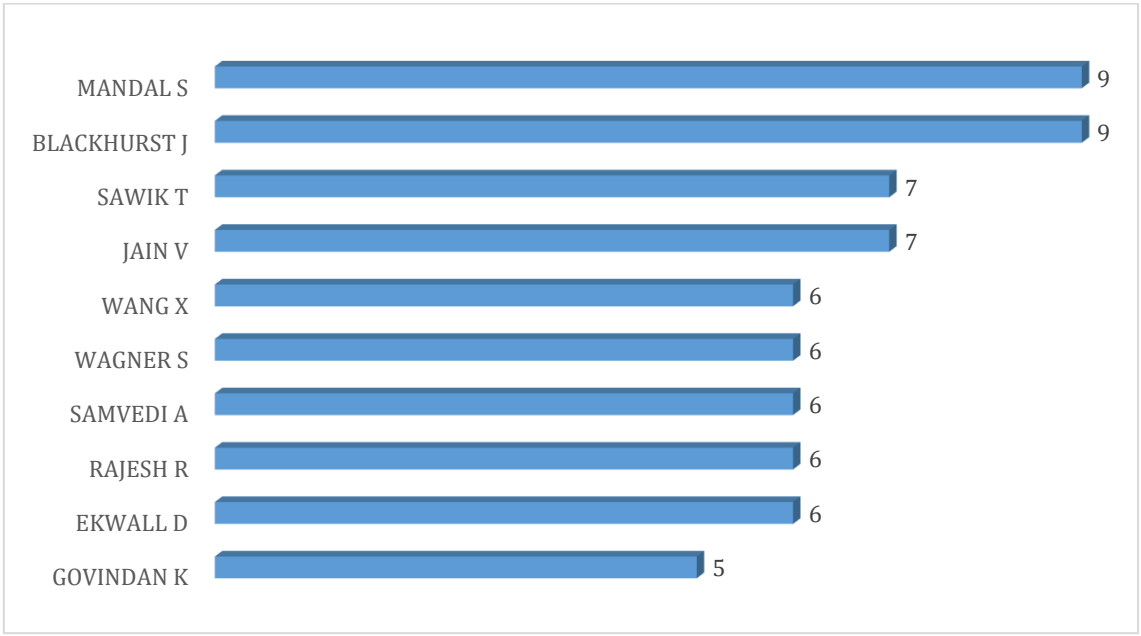



**Figure 19 -** Most productive authors

Figure 20 shows the most cited papers. Note that the top 5 most cited papers are

all prior to 2010.

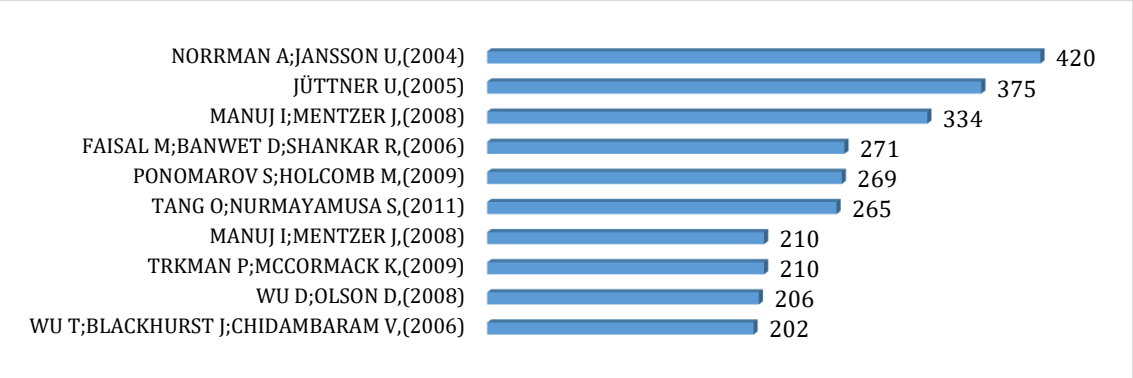



**Figure 20** - Most cited papers

The titles of the papers are: 1 - Ericsson's proactive supply chain risk management approach after a serious sub supplier accident; 2 - Supply chain risk management: Understanding the business requirements from a practitioner perspective; 3 - Global Supply Chain risk management strategies; 4 - Supply chain risk mitigation: modeling the enablers; 5 - Understand the concept of Supply Chain resilience; 6 - Identifying risk issues and research advancements in Supply Chain risk management; 7- Supply Chain risk in turbulent environments - A conceptual model for managing; 8- Global Supply Chain Risk Management; 9 - Supply Chain Risk, Simulation, and Vendor Selection; 10 - A model for inbound supply risk analysis.

The most relevant journals are International Journal of Production Research with 44 results; International Journal of Production Research – 33 results and Supply Chain Management: An International Journal – 19 results. The top 10 most relevant journals are summarized by Table 15.

**Table 15** - Publications by journal

| **Journal** | **Quantity** |
|---|---|
| International Journal of Production Research | 44 |
| International Journal of Production Economics | 33 |
| Supply Chain Management | 19 |
| International Journal of Logistics Management | 14 |
| Crosstalk | 10 |
| International Journal of Physical Distribution and Logistics Management | 10 |
| International Journal of Logistics Research and Applications | 9 |
| International Journal of Operations and Production Management | 9 |
| Computers and Industrial Engineering | 8 |
| International Journal of Logistics Systems and Management | 7 |
| International Journal of Supply Chain Management | 7 |

**Source:** Authors

The dominance function calculates the authors' dominance ranking as seen in

Kumar and Kumar (2008). DF is the Dominance Factor and is calculated considering a proportion of multiauthored papers of an author as first author (*Nmf*) to total number of multi authored papers of the author (*Nmt*). Equation (1) shows dominance calculation and Table 16 shows the most dominant authors.

$$\boldsymbol{DF = \frac{Nmf}{Nmt}} \quad (1)$$

**Table 16 –** Authors' dominance ranking

| Author | Dominance Factor | Multi Authored (Nmt) | First Authored (Nmf) | Rank by Articles | Rank by DF |
|---|---|---|---|---|---|
| Ekwall, D. | 0.67 | 6 | 4 | 4 | 1 |
| Samvedi, A. | 0.67 | 6 | 4 | 6 | 2 |
| Wang, X. | 0.67 | 6 | 4 | 8 | 3 |
| Govindan, K. | 0.60 | 5 | 3 | 10 | 4 |
| Rajesh, R. | 0.50 | 6 | 3 | 5 | 5 |
| Wagner, S. | 0.50 | 6 | 3 | 7 | 6 |
| Chen, H. | 0.40 | 5 | 2 | 9 | 7 |
| Mandal, S. | 0.33 | 9 | 3 | 2 | 8 |
| Jain, V. | 0.14 | 7 | 1 | 3 | 9 |
| Blackhurst, J. | 0.11 | 9 | 1 | 1 | 10 |

**Source:** Authors

The $h$ - index of an author shows how productive is the author. An author would have index $h$ if $h$ of his or her $N_p$ papers have at least $h$ citations each and the other ($N_p$ - $h$) papers have $\leq$ $h$ citations each (Hirsch 2005). The $g$ – index is such that given a set of articles ranked in decreasing order of the number of citations that they received, the $g$ - index is the unique largest number such that the top g articles received together at least $g^2$ citations (Egghe, 2006). General formulation is $g^2 \leq \sum_{i \leq g} C_i$ (where $C_i$ are the citations of a given author *i*). The $m$ – quotient is the $h$ - index divided by the number of years since the first published paper of the author (Hirsch 2005; Copes et al. 2012) . Table 17 shows h-index, g-index and m-quotient.

**Table 17 -** h-index, g-index and m-quotient

| Author | h_index | g_index | m_quotient | TC | NP |
|---|---|---|---|---|---|
| Blackhurst, J. | 6 | 9 | 0.46 | 279 | 9 |
| Sawik, T. | 6 | 7 | 0.75 | 129 | 7 |
| Samvedi, A. | 6 | 6 | 1.00 | 148 | 6 |
| Jain, V. | 5 | 7 | 0.83 | 166 | 7 |
| Wagner, S. | 5 | 6 | 0.71 | 138 | 6 |
| Ekwall, D. | 4 | 6 | 0.40 | 46 | 6 |
| Rajesh, R. | 4 | 6 | 1.00 | 56 | 6 |
| Mandal, S. | 2 | 3 | 0.33 | 10 | 9 |
| Wang, X. | 2 | 2 | 0.29 | 8 | 6 |

| | | | | | |
|---|---|---|---|---|---|
| Chen, H. | 2 | 5 | 0.40 | 42 | 5 |

**Source:** Authors

Lotka's law describes the frequency of publication by authors in any given field as an inverse square law, where the number of authors publishing a certain number of articles is a fixed ratio to the number of authors publishing a single article (Aria and Cuccurullo, 2017). Lotka's law dealt with author publishing and the number of papers published. It is regarded as one of the classical laws of bibliometrics (Sudhier, 2013). Equation (2) shows the mathematical formulation.

$$p(n) = \frac{k}{n^2} \tag{2}$$

Where $p$ is the number of authors producing $n$ papers and $k$ is constant characteristic of a particular subject area of study.

Table 18 shows the number of authors with 1 to 8 publications.

**Table 18 -** Lotka's law calculations

| N.Articles | N.Authors | Freq |
|---|---|---|
| 1 | 853 | 0.821 |
| 2 | 126 | 0.121 |
| 3 | 32 | 0.031 |
| 4 | 15 | 0.014 |
| 5 | 8 | 0.007 |
| 6 | 3 | 0.002 |
| 8 | 1 | 0.001 |

**Source:** Authors

The estimated Beta coefficient is 3.20 with a goodness of fit ($R^2$) equal to 0.99. The constant $k = 1.00$. Kolmogorov-Smirnov two sample test provides a $p$-value of 0.209 that means there is not a significant difference between the observed and the theoretical Lotka distributions. Figure 21 shows the graphics for theoretical and observed Lotka's law.

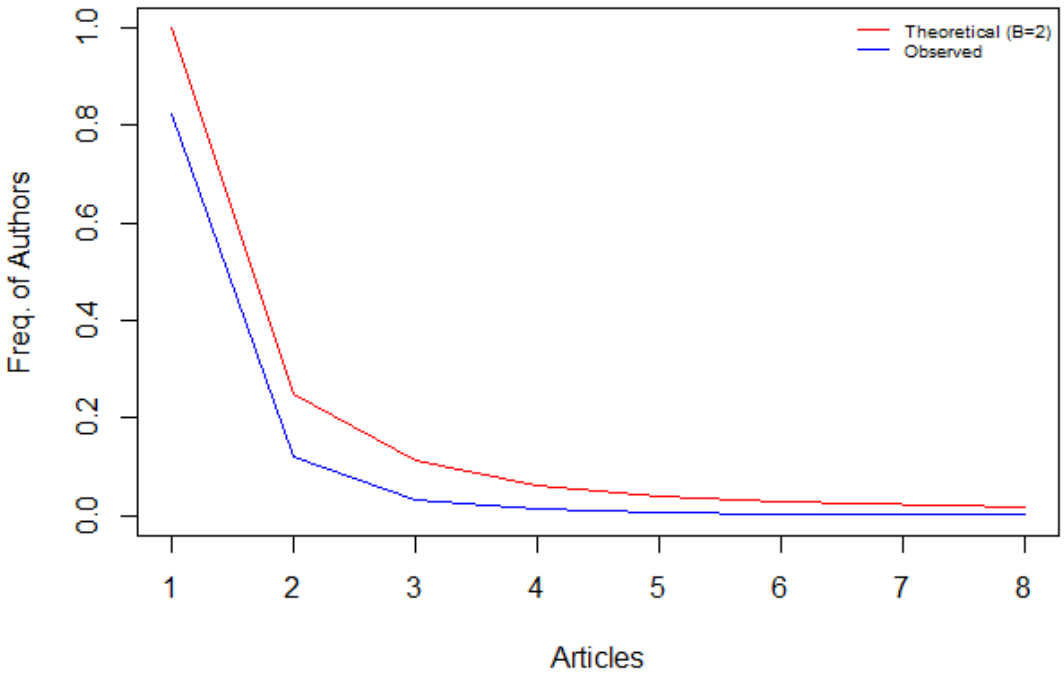



**Figure 21 -** Lotka's distribution

Attributes of a specific paper are connected to each other, for example, through the manuscript itself: author(s) to journal, keywords to publication date, etc. Such connections of different attributes generate networks that are represented as rectangular matrices Manuscripts x Attributes (Aria and Cuccurullo 2017). Furthermore, scientific publications usually references other scientific works, generating networks that can be either co-citation or coupling networks (Aria and Cuccurullo 2017). These networks are analyzed to capture meaningful properties of the underlying research system, and in particular to determine the influence of bibliometric attributes such as scholars and journals (Aria and Cuccurullo 2017). A unit of coupling was defined by Kessler (1963) as any single item of reference that is used by two papers. Two documents are bibliographically coupled if at least one cited source appears in the bibliographies or reference lists of both articles (Kessler 1963). For example, $A$ is a *Document x Cited reference Matrix* and $B_{coup} = A \text{ X } A^T$. The strength of the coupling of two articles, $i$ and $j$ is defined simply by the number of references that the articles have in common, as given by the element $b_{ij}$ of matrix B. Articles with only a few references, would tend to be weaker bibliographically coupled, if coupling strength is measured simply according to the number of references that articles contain in common (Aria and

Cuccurullo 2017). Figure 22 shows the generated graph.

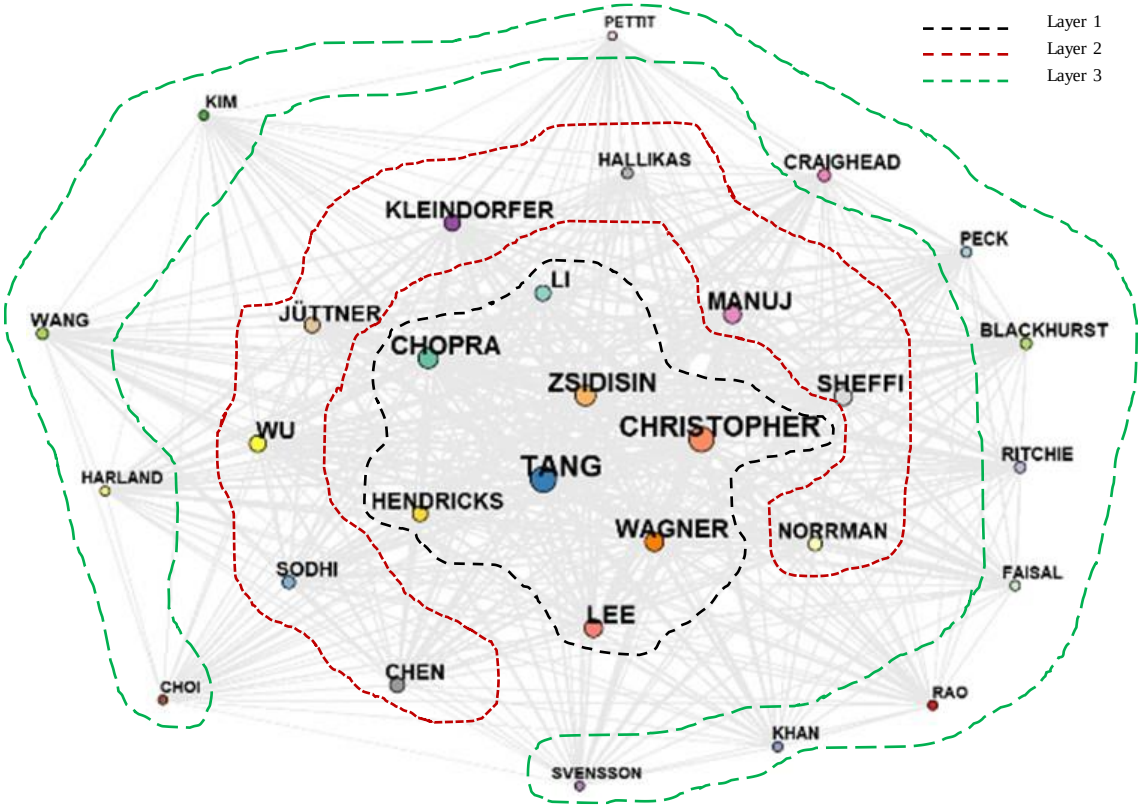



**Figure 22 -** Bibliographic coupling

The network shown by Figure 22 shows that these papers share a great number of references, therefore, composing a very connected network. It is noted that the network can be divided into 3 layers according to its centrality. In the Layer 1 there are the authors that are cited by most papers and started defining SCRM. The Layer 2 shows authors that are very cited, although not as much as the first layer and contributed with definitions and case studies. Layer 3 shows very relevant authors with newer papers in most cases, for example Jennifer Blackhurst appeared in the bibliometrics with a total of 9 papers, including papers from 2018, which are new and therefore not as much cited as authors in Layer 1.

Co-citation is defined by Small (1973) as new form of coupling and analyzes the frequency with which two documents are cited together. In general co-citation analysis is performed for mapping older papers and bibliographic coupling is used to map a current research front (Aria and Cuccurullo 2017). Co-citation analysis is a method for linking cited documents, is highly applied in literature because that the more frequently

two articles are jointly cited, the more likely that they embody a complementary or similar intellectual stream (Verbeek et al. 2002; Kilubi 2016a). Co-citation of two articles occurs when both are cited in a third article (Aria and Cuccurullo 2017). Therefore, two publications are considered to be co-cited if they appear together in the reference lists of other documents (Fahimnia et al. 2015). The co-citations matrix is given by $B_{cocit} = A \text{ X } A^T$. Element $b_{ij}$ indicates how many co-citations exist between documents *i* and *j*. Figure 23 shows the co-citation network.

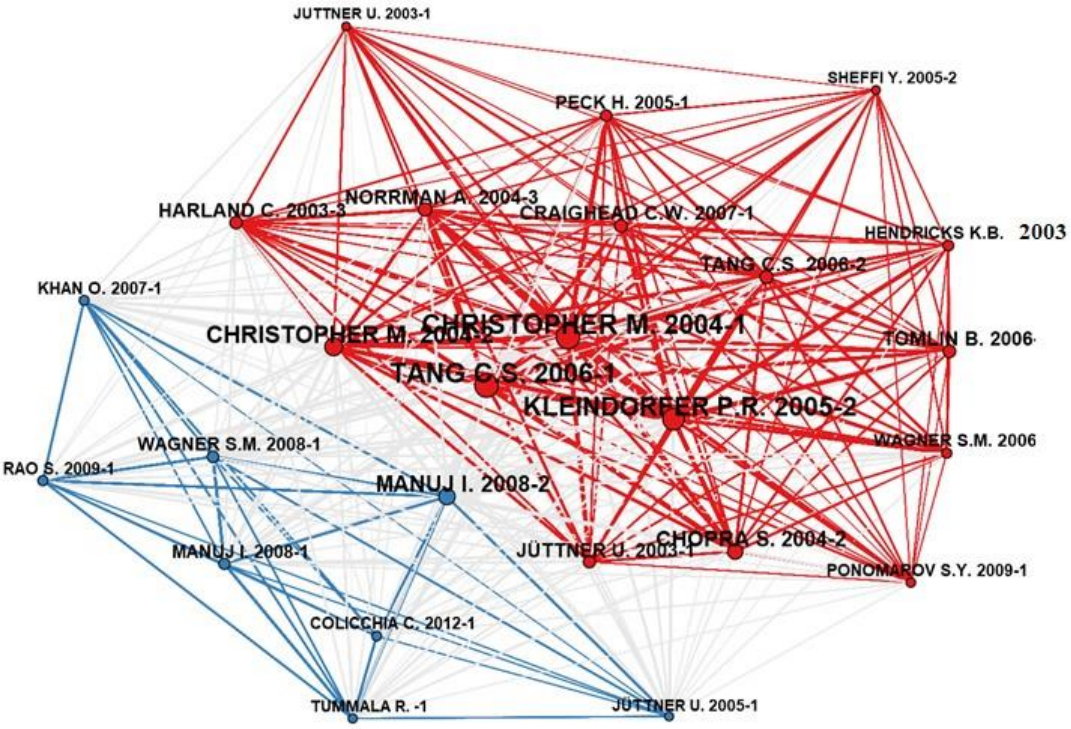



**Figure 23 -** Bibliographic co-citation

The size of a circle means the number of citations the paper has received. Journals that are closer to each other (in terms of publication theme) tend to be more strongly related, based on co-citations, than journals that are located far away from each other.

Scientific collaboration network is a network where nodes are authors and links are co-authorships. It consists in one of the most well documented forms of scientific collaboration analysis (Glänzel and Schubert, 2004). An author collaboration network can be obtained using the general formulation $B_{coll} = A \text{ X } A^T$ where A is a Document X Author matrix and $b_{ij}$ indicates how many collaborations exist between authors *i* and *j*.

The graph is shown by Figure 24.

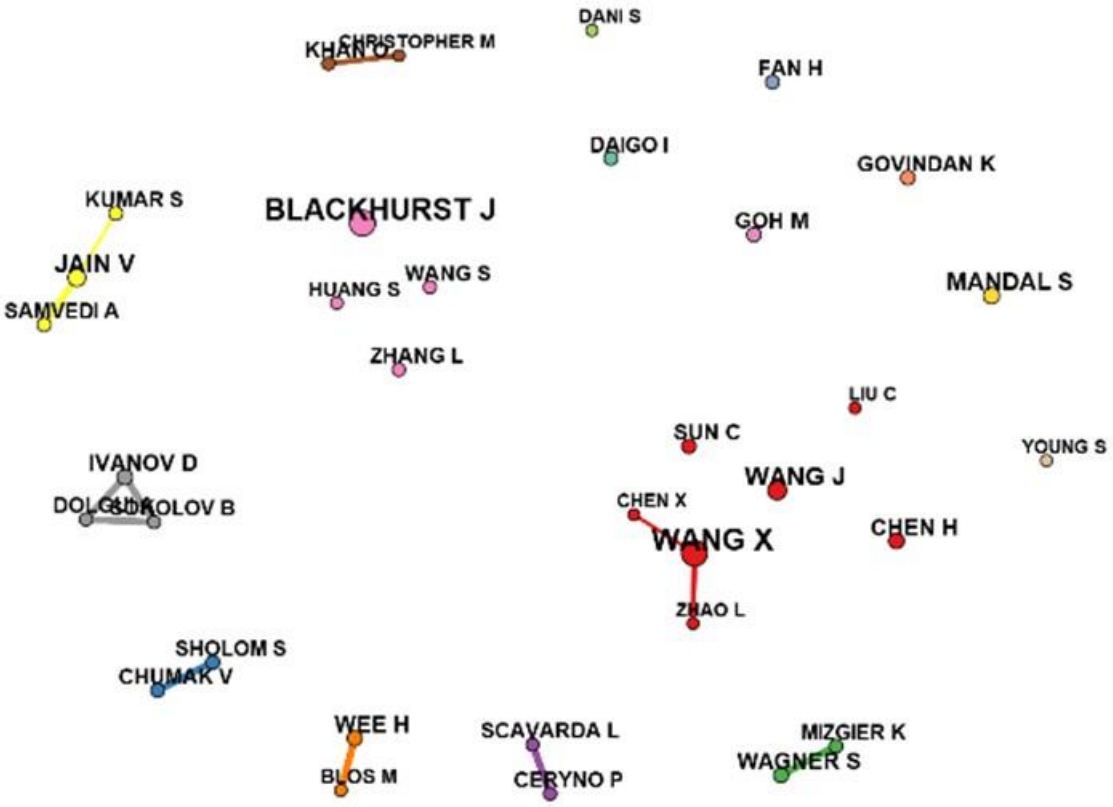



**Figure 24 -** Bibliographic collaboration

The collaboration network works can also be generated in terms of countries and is shown by Figure 25.

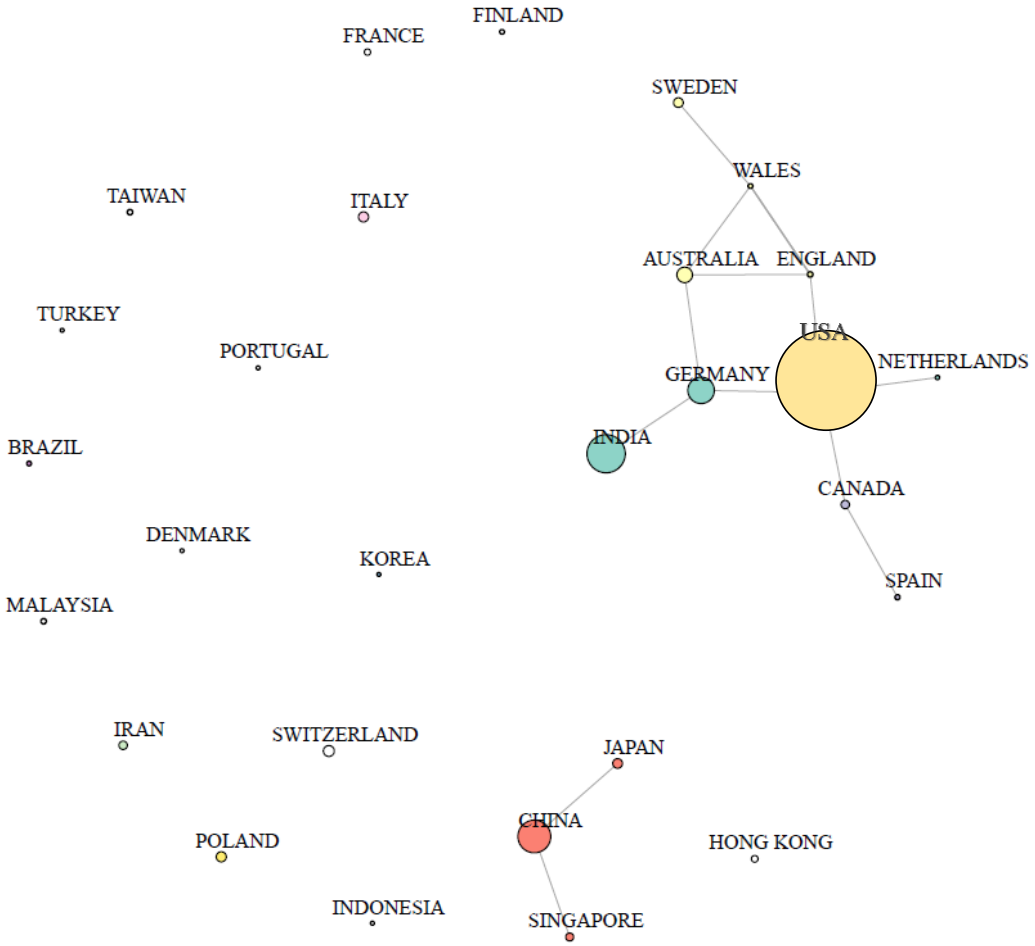



**Figure 25 -** Country collaboration

Co-word analysis aims to build a co-occurrence network to map terms extracted from keywords, titles, or abstracts in a bibliographic collection (Aria and Cuccurullo, 2017). The general formula is $B_{coc} = A \text{ X } A^T$ where A is a Document X Word matrix and $b_{ij}$ indicates how many co-occurrences exist between words *i* and *j*. The graph is shown by Figure 26.

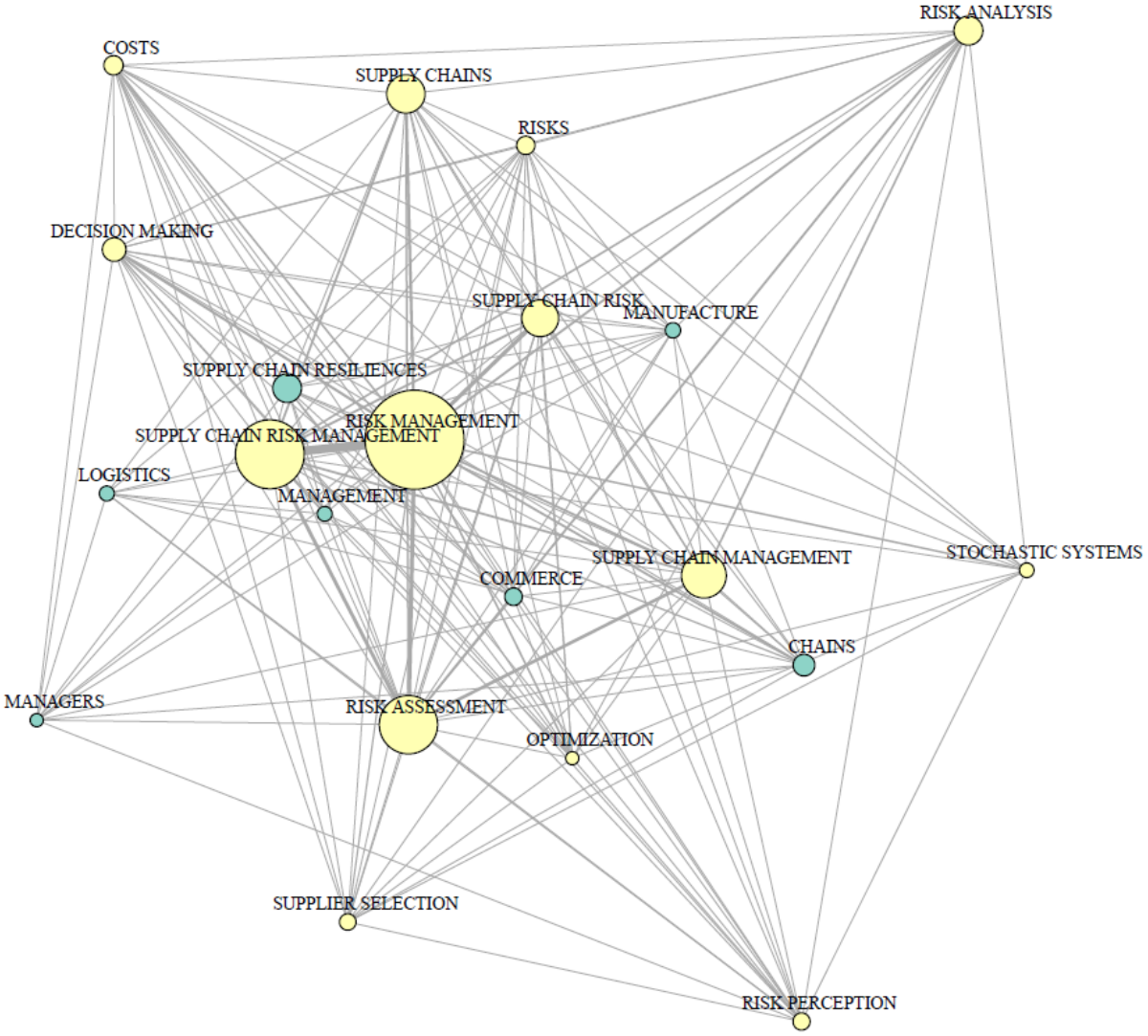



**Figure 26 –** co-words analysis

As expected, the more central keywords are those which relate risks and supply chains. It is worth noting, though, that keywords such as stochastic systems and optimization are more peripheric, since these techniques offer a wide portfolio of mathematical methods to deal with risks.

Figure 27 shows the Word Cloud.




**Figure 27 –** Word Cloud

Multiple correspondence analysis (MCA) is used to draw a conceptual structure of the field and k-means clustering to identify clusters of documents that express common concepts, additionally, MCA consists in a multivariate technique for categorical data (Aria and Cuccurullo 2017). The more similar the words are in distribution, the closer they are represented in the map in Figure 28.

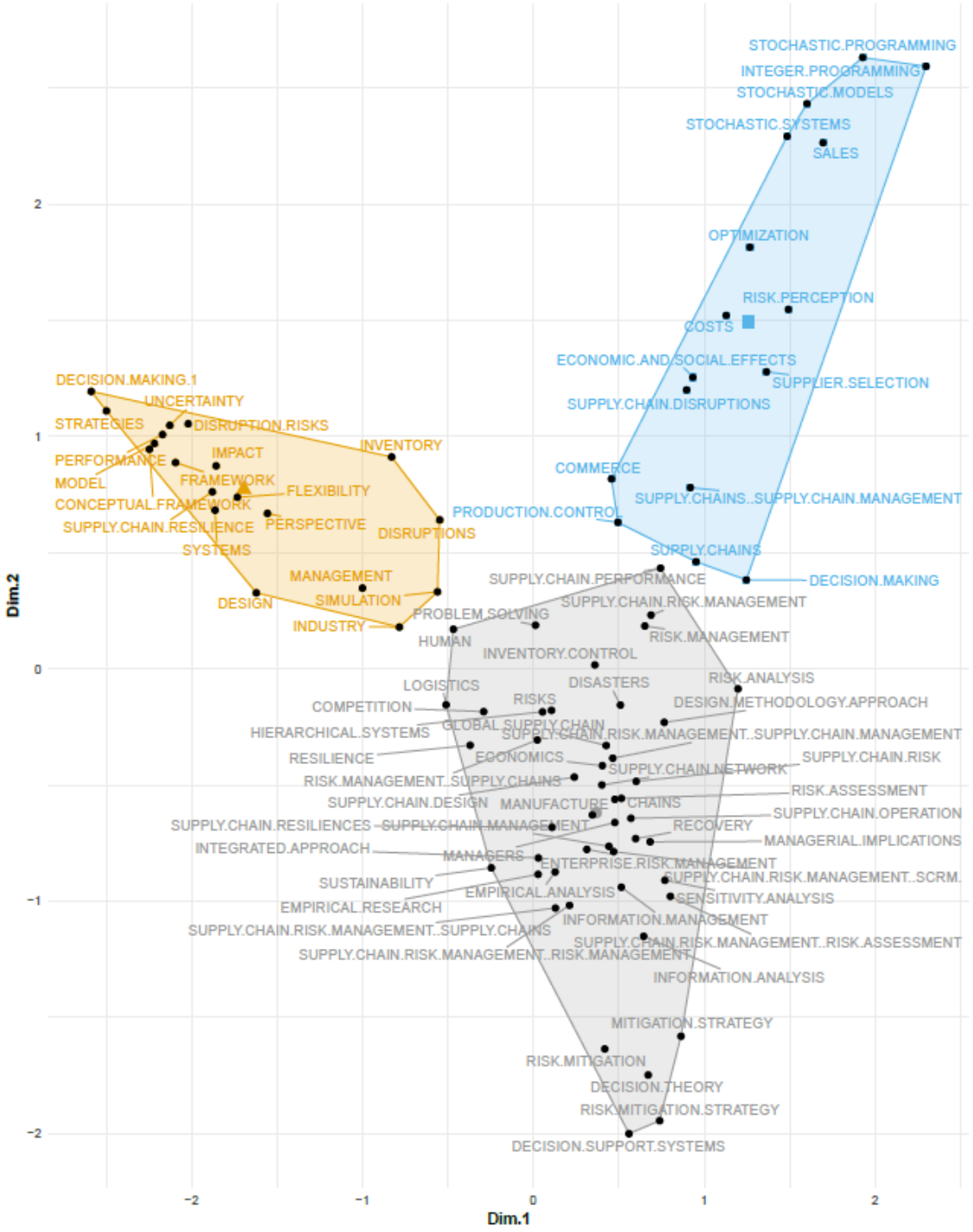



**Figure 28 –** Conceptual map

## 3.5. Discussion, limitations and conclusion of the Chapter

The main objective of the paper was to conduct a Systematic Literature review to set trends concerning SCRM. To achieve this goal, were proposed three research questions: (i) Which techniques have been employed by authors in the literature to

perform SCRM? (ii) Which market segments are being approached by authors in the SCRM literature? (iii) What are the research gaps/unexplored opportunities respective to applying SCRM in Healthcare organizations? Therefore, this chapter conducted a bibliometric analysis resulted from a SLR to approach all three questions

In terms of techniques, Mathematical Programming stands out as the most applied technique (in this case, Mathematical Programming is a broad expression including Integer Programming, Stochastic Programming, Heuristics, among other mathematical optimization techniques), although real case studies are lacking, as there are many numerical examples of conceptual problems. In terms of segments, it is noted that the Healthcare sector is indeed still very unexplored, having 6 studies found by this research. Although this SLR have revealed segments that are even less studied than Healthcare SC segment, this is a field with many opportunities for researchers and hospital managers to explore for reducing costs and improving service quality. The co-word analysis did not show “Healthcare” or any health-related keyword, which is substantial evidence that this field of research is poorly approached. Even though a SLR was conducted (analyzing 547 papers) this research has limitations. First limitation is that only published journal articles were analyzed, for example, conference papers could possibly have showed more studies concerning Healthcare segment. Scopus database and ISI Web of Knowledge were selected as the search engines; therefore, it is possible that not all the papers that could fit in this research were assessed. As another limitation, were analyzed only papers that were written in the English language. The expectation is that this research helps scholars in future research and investigation. For example, techniques largely used in other segments, such as Simulation, Fuzzy, could be applied in Healthcare segment challenges.

# 4. Risk Identification

## 4.1. Chapter Abstract

Supply Chain Risk Management is being increasingly studied since the early 2000's and many quantitative/qualitative techniques and frameworks have been applied to most different Supply Chains (SC). However, some specific segments in SCRM are still somehow neglected. In this sense, as main contributions, of the chapter, can be highlighted: i) a Formal definition of Healthcare Supply Chain Risk Management based upon 5 pillars - Supply Chain Management, Supply Chain Risk Management, Supply Chain Resilience, Clinical Engineering and High Reliability Organizations; ii) an extensive list of Healthcare Supply Chain Risks based on literature survey; iii) Analysis of interviews made with Healthcare Supply Chain Professionals.
Keywords: Healthcare Supply Chain Risk Identification, Systematic Literature Review, Semi – Structured Interviews.

## 4.2. Chapter introduction

This chapter has the objective of approaching Healthcare Supply Chain Risk Identification. In this chapter a specific literature survey was conducted, broadening the scope of the previous SLR in order to identify risks that may harm an entire HCSC. For example, when conducting search for papers studying SCRM in the supply chains of Healthcare organizations, only six papers were found in literature (Jaberidoost et al., 2013; Jaberidoost et al., 2015; Elleuch et al., 2013; Aguas et al., 2013; Zepeda et al., 2016; Riley et al., 2016). Thus, an important gap in the literature is revealed, indicating that the Healthcare sector is a very promising sector for applying SCRM. Medical devices can be over 5000 different types used in all aspects of healthcare (for example tongue depressors and pacemakers) representing a difficult management challenge (Dhillon, 2000). The Healthcare literature could benefit, for instance, from SCRM conceptual frameworks and techniques for cost reduction and quality of service improvement. Thus, as the objective, this chapter aims to present a Systematic Literature Review based on the PRISMA protocol and concerning SCRM applied to the Healthcare sector specifically and which opportunities for improvements are being missed in this

sector.

### 4.3. Clinical Engineering

A Clinical Engineer can be defined as a Biomedical Engineer with broader responsibilities such as financial or budgetary management, service contract management and maintenance tasks in healthcare organizations (Cruz and Guarín, 2017). Clinical engineers are technology specialists who can help Healthcare-related professionals to deal with, use, evaluate, acquire, manage, and adequately maintain and secure biomedical equipment (Del Solar et al., 2017). Clinical Engineering began in the United States of America in the 70's, having as main task the management of hospital's equipment (Calil and Ramírez, 2000). Clinical Engineering is a branch of engineering applied to clinical care. The term clinical engineering is used to denote engineering applied in the hospital setting (van der Putten, 2010). The role of the Clinical Engineer is more than only maintenance, since this professional is responsible to bridge the gap between managers, and physicians to optimize costs and equipment utilization.

Healthcare Technology Management presents itself as a crucial tool to support Clinical Engineers keeping up to the revolutionary changes that Healthcare services are being delivered (Walker, 2012). Healthcare IT (HIT) systems became a core infrastructural technology in Healthcare and have the potential of mitigating patients' risks. However, this also means that a failure in such systems has the potential of leading to patient harm (Habli et al., 2018). Medical devices are increasingly necessary for diagnosis and disease management, nowadays, medical procedures rely on not only the physician medical but also on the performance of medical devices (Kramer et al., 2012). In this sense Risk-based prioritization methods are used to identify the critical medical devices subject to rigorous maintenance program (Mahfoud et al., 2016). An important alternative from purchasing the device is Medical Equipment Loan Services (MELS), which exist to improve availability of equipment for both patients and clinical users, managing and reducing clinical risk, reducing equipment diversity, improving equipment management and reducing the overall cost of equipment provision (Keay et al., 2015). Therefore, Clinical Engineers play a strategic role in Healthcare organizations since they are able to lower an organization's errors increasing its reliability.

## 4.4. High Reliability Organizations

High Reliability Organizations (HRO) can be considered systems which perform their operations in a nearly error-free basis even belonging to risky environments (Roberts, 1990). An HRO is any high-hazard organization that thrives despite the persistent threat of failure (Høyland et al., 2018). HRO research studies complex types of organizations that, despite operating in environments where the potential for errors is always present, seem to maintain high levels of safety performance, for example nuclear power plants, air traffic control, nuclear-powered aircraft carriers, among others (Milch and Laumann, 2018). These HROs have specific characteristics and practices that enable them to achieve sustained reliable safety performance and demonstrate unique and consistent characteristics, including operational sensitivity and control, situational awareness, hyperacute use of technology and data, and actionable process transformation. (Davenport et al., 2018; Milch and Laumann, 2018). In an HRO, safety and quality are organizational priorities, and all workforce members are continuously learning and improving their work (Aboumatar et al., 2017). HRO literature has identified safety concepts and principles for achieving and maintaining safety at an organizational level (Høyland et al., 2018). Table 19 shows HRO safety concepts and principles.

**Table 19 -** HRO safety concepts and principles

| HRO Safety Concepts | HRO Safety principles |
|---|---|
| **Latent errors and Mindfullness** | Sensitivity to operations (SO) |
| | Reluctance to simplify (RS) |
| | Preoccupation with failure (PF) |
| | Commitment to resilience (CR) |
| | Deference to expertise (DE) |
| **Organizational Resilience** | Robustness (Rb) |
| | Redundancy (Rd) |
| | Resourcefulness (Rs) |
| | Rapidity (Rp) |

Latent errors as events, activities, or conditions that deviate from expectations (Ramanujam and Goodman, 2003; Høyland et al., 2018). Høyland et al. (2018) define the mindfulness construct as composed by: i) Sensitivity to operations: management and staff comprehend their processes, how they might go wrong and are aware of how the systems are performing; ii) Reluctance to simplify: When failure occurs, HROs refuse

simple explanations for the failure, instead, they pursue and understand each failed system; iii) Preoccupation with failure: HROs maintain a constant pursuit of perfection; iv) Deference to expertise: Leaders listen and respond to the insights of the front line, regardless of rank or title. Humans and systems always make mistakes and things will probably go wrong, therefore, Organizational Resilience in HROs mean that companies can quickly identify an adverse event to rapidly contain and mitigate the error. Høyland et al. (2018) define the construct upon the following pillars: i) Robustness is, for example, a team are designed to keep functioning despite suffering stresses and demands; ii) Redundancy is any technical or human extra resources that can be used due to demanding tasks/operations; iii) Resourcefulness is an organization's ability to identify problems, establish priorities, and mobilize resources to handle disruptions, and achieve goals; iv) Rapidity can be seen in an organization capable of achieving various goals in an effective and timely manner. Nevertheless, Milosevic et al. (2015) affirm that Previous knowledge is not always enough considering that the dynamism in HROs create nonroutine problems, in this sense, leadership becomes essential, mostly because of its potential of keeping an operation safe by collective priority (Martinez-Córcoles, 2018).

Interorganizational networks are defined as a group of three or more organizations connected in ways that facilitate achievement of a common goal (Berthod et al., 2016). Berthod et al. (2016) define three types of governance that describe how this network will relate: i) Shared Governance, implies an absence of central governance structure among participating organizations, ii) Lead-Organization Governance, lead organization implies the coordination of the network by one participant and iii) Network Administrative Organization based governance implies a separate, neutral administrative body, set up to function as a central broker to coordinate the activities of the whole network. Therefore Berthod et al. (2016) define High Reliability Networks (HRN) as interorganizational networks that must function with dual, uninterrupted attention to both the anticipation and the containment of incidents and peaks in activities.

Concerning Healthcare Organizations, literature mentions The High Reliability Health Care Maturity (HRHCM) model, a model for helping healthcare organizations to achieve high reliability, which incorporates three major domains: Leadership, Safety Culture, and Robust Process Improvement (Sullivan et al., 2016).

## 4.5. Defining Healthcare Supply Chain Risk Management

This thesis already shown (Chapter 3) that SCRM applied to Healthcare Supply Chains lacks empirical studies. One reason can be the lack of formal definition of what is SCRM applied to Healthcare, is it only a straightforward concept merging or does it have particularities that require further definition in order to be effectively studied? Nevertheless, Healthcare management must include other elements considering they form a SC that in a later analysis should care more to life saving than profit itself. Table 20 shows the main definition elements.

**Tabela 20 -** Definition Construction

| Definition element | Text | Reference |
|---|---|---|
| **SCRM Stages** | The Process of identify, Assess, Mitigate, Monitor Supply Chain Risks | Fan and stevenson (2018), Nabelsi (2011) |
| **Objectives** | Aiming to provide the best quality of care | Kokilam et al. (2016); Mishra et al. (2018) |
| **Pathway to SCRM** | through SC processes integration, with sustainable profit avoiding supply shortage, HC professionals unhapiness | Borelli et al. (2015); AbuKhousa et al. (2014); Mustaffa and Potter (2009); Breen and Crawford (2005); Iannone et al. (2014); Balcázar-Camacho et al. (2016); Mishra et al. (2018) |
| **Generating reliability** | Having in consideration that local actions may generate hazards to all HCSC | Author |
| **Human resources** | Valuing HC professionals, as well as clinic engineers | Chen et al. (2018) |
| **Generating resilience** | In that way generating SCREs and High Reliability Healthcare Network (HRHCN) | Author |

Therefore, the definition for Healthcare Supply Chain Risk Management is:

“The Process of identify, Assess, Mitigate and Monitor Supply Chain Risks Aiming to provide the best quality of care through SC processes integration, with sustainable profit avoiding supply shortage, Valuing HC and Clinical Engineering professionals, having in consideration that local actions may generate hazards to all HCSC generating SCREs and HRHCN. “

The proposed definition sought to contemplate the main building blocks responsible to mitigate supply chain risks and generate supply chain resilience. In

addition, the definition comprises often neglected concepts such as clinical engineering and features essential to build a high reliability organization that is part of a high reliability network. Supply chains that are often studied (such as automotive and food) are businesses where there is a well-defined product, with well-defined outcomes and KPIs can be comprised by SCRM definitions that are already fairly discussed in literature. Nevertheless, healthcare supply chains have particularities: i) their main objective is to save lives providing the best quality of care; ii) it is a SC that still needs to profit in order to survive. Considering this idiosyncratic SC and the lack of HC SCRM studies, it is essential to supplement the theory with clinical e engineering and HRN concepts.

Therefore, HC SCRM is constructed by SCRM, SCRes (concepts within SCM domain) and supplemented by Clinical Engineering and HRO. Figure 29 graphically represents the proposed framework.

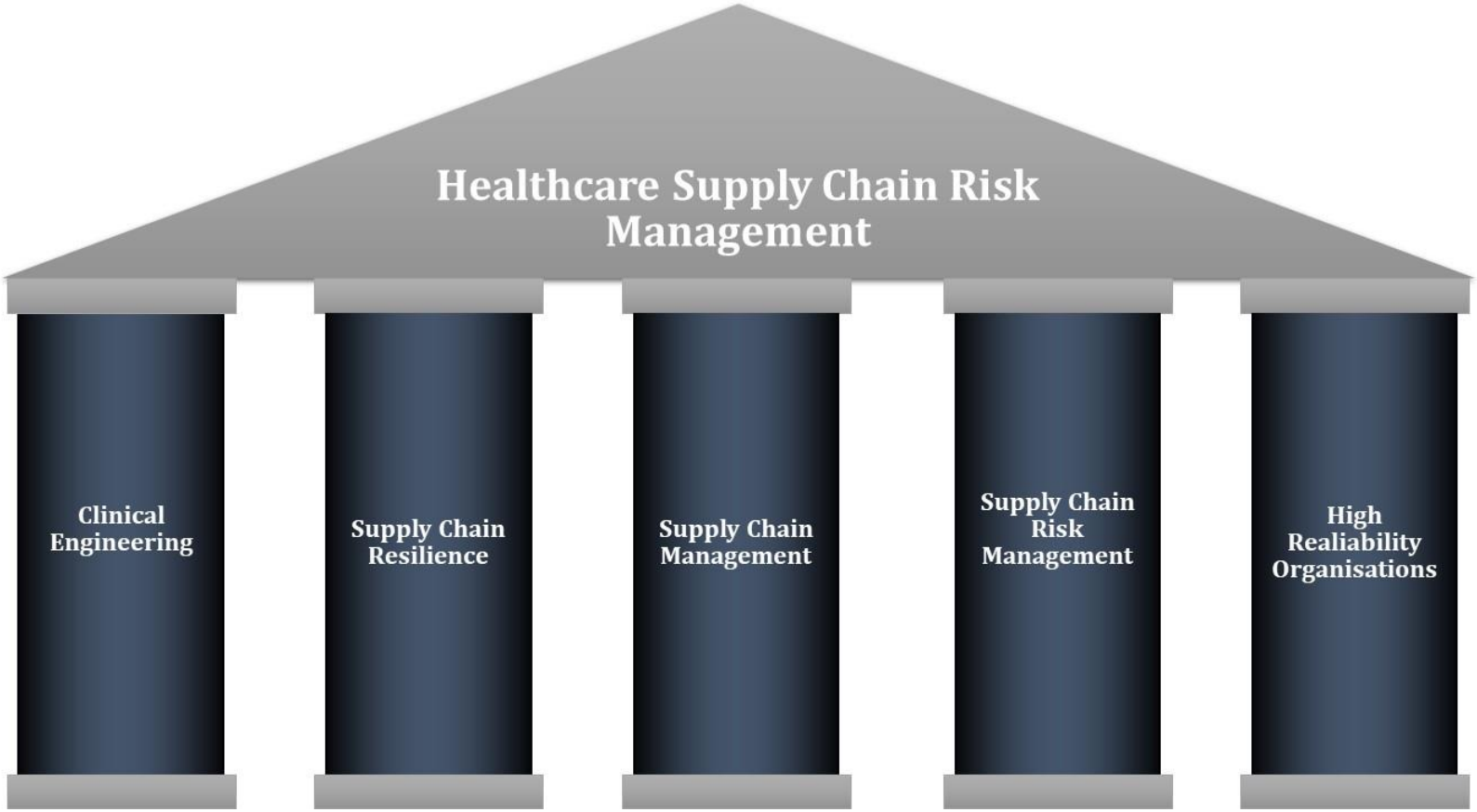



**Figure 29 -** Healthcare Supply Chain Risk Management Constructs

## 4.6. Chapter methodology

The full research methodology of the chapter is presented in the workflow seen in Figure 13.

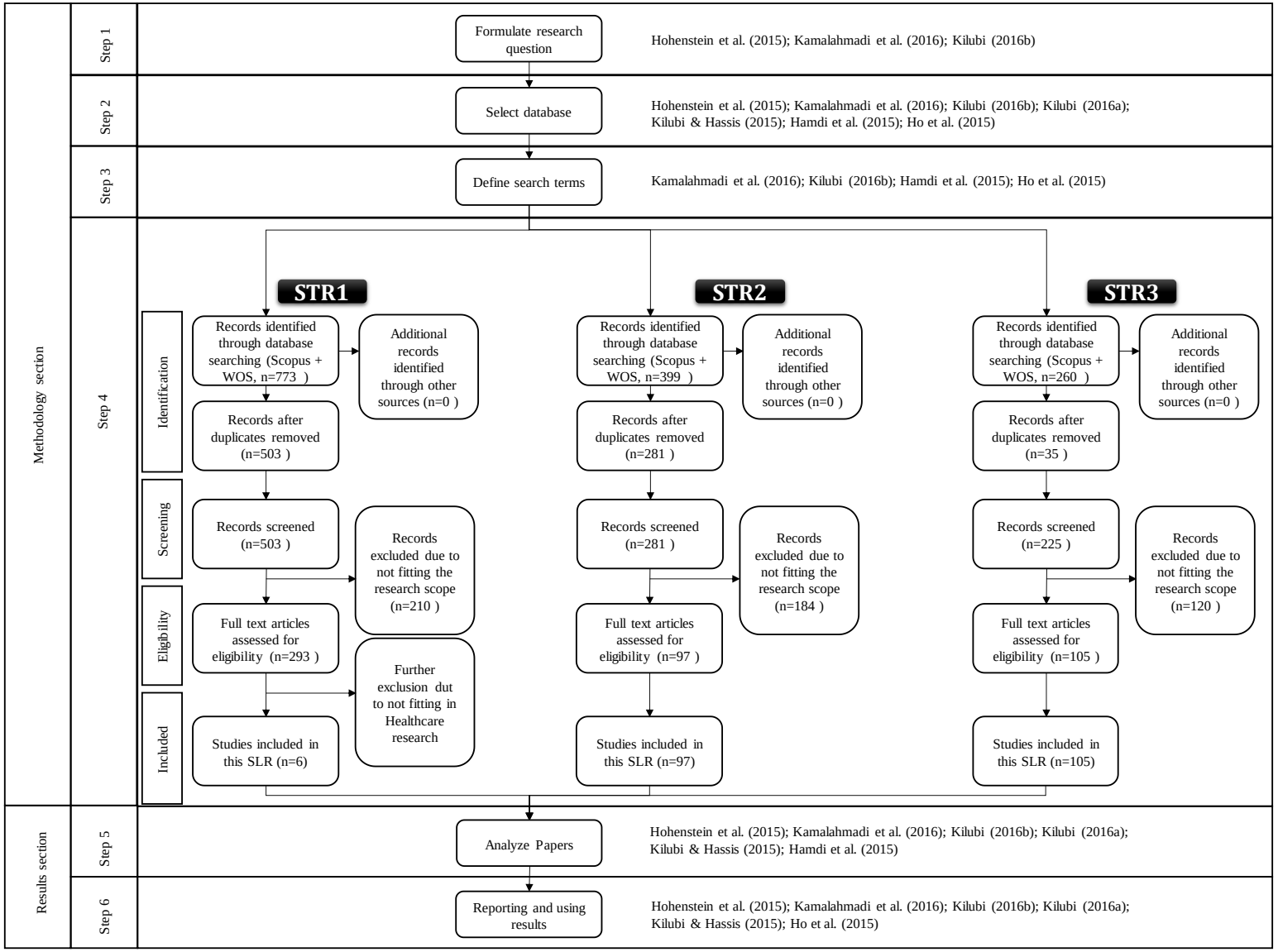



**Figure 30 -** Research Methodology workflow

## 4.7. Formulate research questions

In this section are presented the Research questions that are answered by this chapter.

RQ4 – Which is the definition of Healthcare Supply Chain Risk Management?

RQ5 – What are the more relevant Risks to the Healthcare Supply Chains?

## 4.8. HCSC risks identified

SCRM literature already has a significant amount of studies identifying risks, as is the case of Juttner et al. (2003), Norman and Jansson (2004), Barroso et al. (2010) and Petit et al. (2013). Merging risk categories of Juttner et al. (2003) and Petit et al. (2013) a list of risks was constructed as it is shown by Table 21.

**Table 21 -** HCSC risk list

| Risk Category | Risks | Reference |
|---|---|---|
| **Envinronmental** | Disasters | Vanvactor (2016) |
| | Environmental risks | Chiarini et al. (2017), Vatovec et al. (2013), Viani et a. (2016) |
| | Flood | Farley et al. (2017) |
| | Government risks | Chandra (2008) |
| | Hazardrous wastes risks | Viani et al. (2016) |
| | Legal risks, | Mudyarabikwa and Regmi (2016), Askfors and Fornstedt (2018) |
| | Sustainability risks | Gelderman et al. (2017) |
| **Deliberate threats** | Corruption | Cavalieri et al. (2017) |
| **External pressures** | Purchasing cost higher than expected, | Lin and Ho (2014) |
| | Insufficient e-government services | Katsaliaki and Mustafee (2010) |
| | Lack of Health service supply chain design | Helo (2016) |
| | Lack of macro-ergonomics conditions in HCSC | Azadeh et al. (2016) |
| | Procurement risks | Lingg et al. (2016), Meehan et al. (2017), Nollet and Beaulieu (2003) |
| | Technology risks | Mandal (2017) |
| **Organizational/ Resource limits** | Blood wastage | Arvan et al. (2015) |
| | capability | Meehan et al. (2017) |
| | costs | Campling et al. (2017), Arshoff et al. (2012), Callea et al. (2017), Venkateswaran et al. (2013), Ghannouchi et al. (2010), Mudyarabikwa et al. (2017), Wilkinson and Drummond (2014) |
| | Culture risks | Mandal (2017), Campling et al. (2017), |
| | Drug recalls management | Bevilacqua et al. (2015) |
| | Excess of packaging material | Kumar et al. (2008) |
| | financial risks | Mudyarabikwa et al. (2017) |
| | No comprehensive e-procurement system, | Lin and Ho (2014) |
| | Institutional pressures (coercive, mimetic, and normative, endogenous pressures) | Bhakoo and Choi (2013) |
| | Internal conflicts, | Ancarani et al. (2016) |

| | | |
|---|---|---|
| | IT risks | Afshan and Sindhuja (2015), Ghannouchi et al. (2010), Chong et al. (2015), Borelli et al. (2015) |
| | lack of efficiency, | Mudyarabikwa et al. (2017) |
| | lack of executive support; | McKone-Sweet et al. (2005) |
| | lack of expertise | McKone-Sweet et al. (2005), Campling et al. (2017) |
| | lack of product rotation | Hall (2016) |
| | lacking provision of dressings to nurses | Jenkins (2014) |
| | Long waiting times, | Kumar et al. (2009) |
| | Misalignment of priorities, | Ancarani et al. (2016) |
| | Prescription errors | Awofisayo et al. (2011) |
| | Time waste (from non-value added activities) | Bendavid et al. (2010) |
| | turnover | Ancarani et al. (2016) |
| **Sensitivity** | Expired drug management | Bevilacqua et al. (2015) |
| | Huge variety of drugs, | Lin and Ho (2014) |
| | Management of product expiration date, | Kastanioti et al. (2013) |
| | performance measurement risks | McKone-Sweet et al. (2005), Nabelsi (2011) |
| **Network** | communication risks | Askfors and Fornstedt (2018), Grudinschi et al. (2014) |
| | Credibility risks | Kumar et al. (2005), Kokilam et al. (2016), Afshan and Sindhuja (2015), Meehan et al. (2017), Guy et al. (2007) |
| | Data management risks | Hall (2016), Jannot et al. (2017), Harris et al. (2014), Puttergill et al. (2018), Essa et al. (2018), McKone-Sweet et al. (2005) |
| | No integrated and unified information system between hospital and its suppliers, | Lin and Ho (2014) |
| | No information-sharing between hospital and its suppliers, | Lin and Ho (2014) |
| | No collaboration | Lin and Ho (2014) |
| | Information risks | Parsa et al. (2017), Breen and Crawford (2005), Khangura et al. (2014), Mudyarabikwa and Regmi (2016), Ghannouchi et al. (2010), Hall (2016), Chong et al. (2015), Jannot et al. (2017), Harris et al. (2014), Chandra (2008), Iannone et al. (2014), Kumar et al. (2009) |
| | picking risks | Piccinini et al. (2013) |
| | Relationship risks | McKone-Sweet et al. (2005), Knight et al. (2017), Grudinschi et al. (2014) |
| | warehouse management risks | Cagliano et al. (2016), Spisak et al. (2016), Meehan et al. (2017) |
| **Supplier/customer disruptions** | Demand risk | Balcázar-Camacho et al. (2016), Turhan and Vayvay (2012), Kokilam et al. (2016) |
| | Distribution risks | Kumar et al. (2005), Afshan and Sindhuja (2015), Spisak et al. (2016), Arvan et al. (2015), Mustaffa and Porter (2009) |
| | hospital–supplier integration - mitigators; | Afshan and Sindhuja (2015) |
| | Quality risks | Kastanioti et al. (2013), Kumar et al. (2005), Mudyarabikwa et al. (2017) |
| | Supply risks | Campling et al. (2017), Kritchanchai and Meesamut (2015), Turhan and Vayvay (2012), Prada (2016), Chandra (2008), Spisak et al. (2016), Puttergill et al. (2018), Kastanioti et al. (2013), Iannone et al. (2014), Chandra (2008) |

## 4.9. Qualitative interviews

This section shows the data colected from the qualitative interviews concerning HCSC risk identification. Table 22 show the interviewees profile.

**Table 22 -** Interviewees profile

| Professional | Job description/Formation | Supply Chain tier |
|---|---|---|
| **PROF A** | National Logistics Manager of private Hospital chain (PrHC) - Logistics Degree | Hospitals, warehouses (Supply, Procurement) |
| **PROF A.1** | Logistics analist of PrHC - Industrial Engineer | Hospitals |
| **PROF A.2** | Logistics analist of PrHC - Industrial Engineer/Pharmacist | Hospitals |
| **PROF B** | Supply Manager of Public Federal Hospital (PuFH) - Administrator | Hospital |

| | | |
|---|---|---|
| **PROF B.1** | Nurse at PuFH - Nurse | Hospital |
| **PROF C.1** | 1st Lieutanant Pharmacist - Airborne - Pharmacist | Hospital |
| **PROF D.1** | 1st Lieutanant Pharmacist - Navy - Pharmacist | Hospital |
| **PROF E.1** | Production and Planning Control analist - Industrial Engineer - Private OEM (PrMOEM1) | OEM |
| **PROF F.1** | Production and Planning Control Analist - Industrial Engineer (PrMOEM2) | OEM |
| **PROF G.1** | Logistics Analist - Nurse/ Industrial Engineer | Distributor of Pharmaceutical products |
| **PROF H.1** | Terapist in Public Clinic (PuCL) - Psychologist | Clinic |

The professionals interviewed compose the following supply chain (Figure 31).

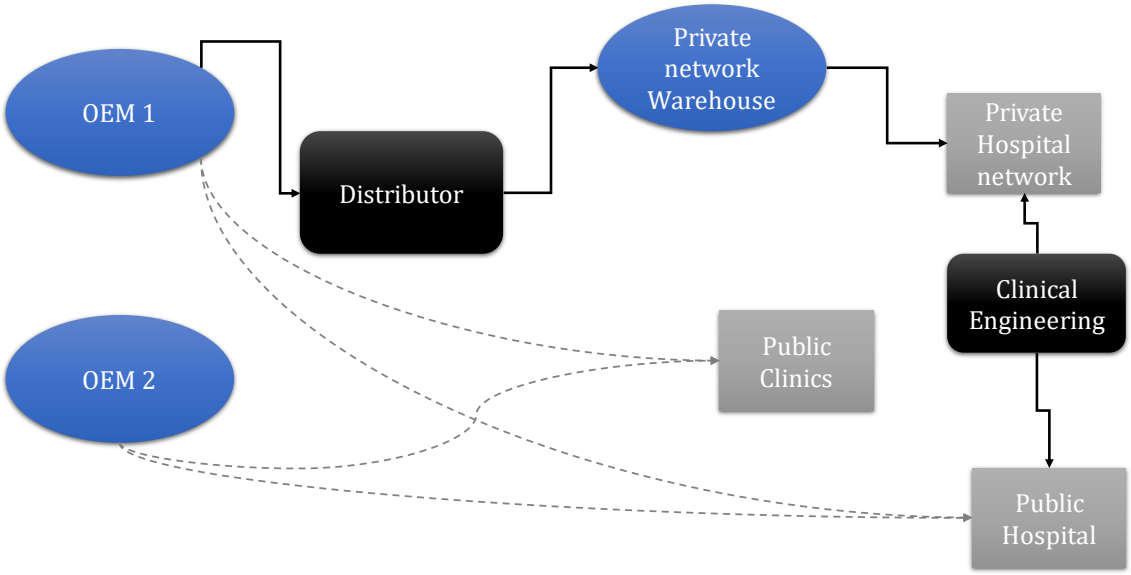



**Figure 31 -** The Healthcare Supply Chain studied

Table 23 - Risks corroborated in the interviewsShows which risks were validated by HCSC professionals

**Table 23 -** Risks corroborated in the interviews

| **Risk Category** | **Risks** | **Professionals** |
|---|---|---|
| **Environmental** | Disasters | |
| | Environmental risks | |
| | Flood | |
| | Government risks | PROF B, PROF B.1, PROF A.2 |
| | Hazardrous wastes risks | PROF A, PROF A.1, PROF B, PROF B.1 |
| | Legal risks, | PROF B |
| | Sustainability risks | PROF A, PROF A.1, PROF B, PROF B.1, PROF E.1 |
| **Deliberate threats** | Corruption | PROF B |
| **External pressures** | Purchasing cost higher than expected, | PROF B, PROF B.1 |
| | Insufficient e-government services | PROF B |
| | Lack of Health service supply chain design | PROF B |
| | Lack of macro-ergonomics conditions in HCSC | |

| | | |
|---|---|---|
| | Procurement risks | PROF B, PROF B.1, PROF C.1 |
| | Technology risks | PROF A.1, PROF B |
| **Organizational/Resource limits** | Blood wastage | |
| | capability | |
| | costs | PROF A.1, PROF B, PROF E.1 |
| | Culture risks | PROF B |
| | Drug recalls management | |
| | Excess of packaging material | PROF A, PROF B |
| | financial risks | PROF E.1, PROF A.2 |
| | No comprehensive e-procurement system, | |
| | Institutional pressures (coercive, mimetic, and normative, endogenous pressures) | PROF B |
| | Internal conflicts, | PROF B |
| | IT risks | PROF A.1, PROF B, PROF E.1, PROF F.1 |
| | lack of efficiency, | PROF A, PROF A.1, PROF B |
| | lack of executive support; | |
| | lack of expertise | |
| | lack of product rotation | PROF A, PROF A.1, PROF B |
| | lacking provision of dressings to nurses | |
| | Long waiting times, | |
| | Misalignment of priorities, | |
| | Prescription errors | PROF A, PROF A.1, PROF B |
| | Time waste (from non value-added activities) | |
| | turnover | |
| **Sensitivity** | Expired drug management | PROF A, PROF A.1, PROF B |
| | Huge variety of drugs, | |
| | Management of product expiration date, | PROF A, PROF A.1, PROF B |
| | performance measurement risks | PROF A, PROF A.1, PROF B |
| **Network** | communication risks | PROF A, PROF A.1, PROF B |
| | Credibility risks | PROF B, PROF B.1 |
| | Data management risks | PROF A.1, PROF B |
| | No integrated and unified information system between hospital and its suppliers, | PROF A.1, PROF B |
| | No information-sharing between hospital and its suppliers, | PROF A.1, PROF B, PROF E.1 - |
| | No collaboration | PROF A.1, PROF B, PROF E.1, PROF F.1 |
| | Information risks | |
| | picking risks | PROF A.1 |
| | Relationship risks | PROF B, PROF F.1, PROF E.1 |
| | warehouse management risks | |
| **Supplier/customer disruptions** | Demand risk | PROF A, PROF A.1, PROF E.1 |
| | Distribution risks | PROF A, PROF A.1, PROF B, PROF B.1, PROF D.1, PROF E.1, PROF A.2, PROF F.1, PROF G.1 |
| | hospital–supplier integration - mitigators; | |
| | Quality risks | PROF B, PROF B.1, PROF D.1, PROF E.1, PROF A.2, PROF F.1, PROF G.1 |
| | Supply risks | PROF A, PROF A.1, PROF B, PROF C.1, PROF D.1, PROF E.1, PROF F.1, PROF B.1 |

In a list of 54 risks there are 35 risks corroborated by the professionals (about 64.8%). Although this study is not quantitative, it is notable that the most part of risks

identified in the literature are also mentioned by HCSC professionals.

Some of the professionals also showed detailed visions of the risks. Sustainability risks were detailed by the interviewees as cardboard boxes, chemicals, overdue products and medicine, prostheses and and Orthoses. In terms of Procurement risks, PROF C.1 affirms that even if the company have a bad reputation (bad delivery, quality issues, etc.) public procurement cannot prohibit the company to take part in the procurement process and if the company has the lowest price, answers to all specifications and presents all documents the company will win the bidding. In terms of financial risks, only PROF E.1 and PROF A.2 highlighted this as an issue, mentioning for example changes in currency rates (imported raw materials for example). Concerning lack of efficiency, PROF A, PROF A.1 and PROF B.1 highlight how manual are the processes. Both private and public Healthcare professionals highlighted the lack of process automation. In terms of lack of product rotation, there are problems concerning inventory checking. For example imagine that a bin have a 1,000 medicine ampoules with different due dates. The employee checking the ampoules must store them using a FIFO (First-in First-out) logic. The risk "No information-sharing between hospital and its suppliers" was also mentioned by the OEM (talking about the OEM's suppliers). Thus, the hospitals and clinics complain about the lack of communication between them and the suppliers and the OEM also highlight the urge for better communication with their suppliers. In terms of Demand risks, PROF E.1 highlight the existance of meetings to determinate whether there are risks of real demand overcomes the forecast and avoid backorders. Concerning distribution risks, PROF B.1 highlights that a major risk consists in delays in deliveries. PROF D.1 affirms that other issues that affect a SC are the excessive ammount of documents (bureaucracy, slow processes, etc.) and lack of management, inventory planning.

## 4.10. Discussion

This chapter presented a systematic mapping of HCSC risks. The risks were consolidated in table 22 and then validated by HCSC professionals via qualitative interviews. The table is a product of a systematic literature review where the risks were identified. There was a detailed work of analyzing the risks to conclude which categories they should be in and which risks although presented differently could mean the same

risk. This risk table can also be detailed as much to answer to specific needs of further studies. Concerning the 5 constructs presented in figure 29 there are 5 pilars. Supply Chain Management is a well-consolidated concept that was taylored by professionals and scholars in the last three decades and is the basis for all SC analysis. SCRM and SCRes are two concepts that have been studied and defined in the last 15 years, therefore, there is still some divergence in the literature, although many convergences. First, is important to highlight that SCRM involves an understanding that a SC is a set of processes and local risks may generate risks for the entire SC, therefore, risk identification, risk assessment, mitigation and monitoring are the essencial stages to compode SCRM. SCRes is the capability that a SC has to endure crisis and arise at the same level of performance or even better, so is a set of capabilities that should be forged in any SC. Clinical Engineering plays a major role in HCSC. Clinical engineers have a great potential to give consultancy and generate savings in the SC. CE is a SC tier that is responsible for approving a 100,000 USD equipment ou diagnose that the same equipment can be repaired for half the cost, therefore is a company that is also responsible to bridge the gap between management and giving patients better quality of care. HRO and HRN provide principles that converge to the generation of SCRes and the generation of Resilience in HCSC.

Deepening the discussion concerning HCSC risk identification, PROF A highights that there is no formal risk identification method, the manager affirms though, that there is an assessment of the resupply policy in order to avoid rupture. The inventory control planning is not integrated, there are several different local spreadsheets and inventory conference depends on the analist hability. Supply delays are registered in a list which generates an alert. Then, there will be an investigation to discover which order did not arrive. This information will also go to a technical sector which will assess wheter there is or not the possibility of substituting the product. In case the disruption is confirmed (i.e. the order is already delayed) the planning sector contacts the supplier and asks if he will deliver. The supplier then, may deliver (with delay) or not deliver at all (he may be experiencing severe ruptures as well such as fires, strikes, etc.). In case there is already a substitute homologated, the product is replaced. The document containing these informations shows what is delayed and a critical list shows which orders are in imminent rupture. The manager reinforces the criticity of a reliable Clinical

Engineering department. There is a a corporate procurement department the buy stockable products for CE, and the CE department is responsible for buying the more technical equipments such as tomographs. CE is also responsible for managing the equipments being responsible for depreciation and equipments exchange. These items are considered non-stockables. The PrHN do not have a facilities department, and so each hospital execute maintenance via its building maintenance department.

Other PrHN have to deal with risks related to Health insurance as is the case of the D'Or network of hospitals. the network litigated with one of the main Health insurance companies in Rio de Janeiro (AMIL). AMIL argues that D'Or network is overcharging the procedures, therefore, they could not reach an agreement (Portal G1 – 27/04/2019).

PROF A.1 highlights that other major risk is the lack of inventory accuracy. PROF A.1 is an analyst that already worked in retailer warehouse and affirms that the inventory accuracy in PrHN is considerably lower than the average retailer inventory accuracy. To preserve the companies the number cannot be disclosed. The analyst discusses that HC is a very normative sector, needing a thorough medicine due date control. In most of retailers, inventory is conducted at about three times a year while in HC the inventory is continuously checked. Inventory checking is also very challenging because after the confference, the analists often do not restore the medicine in a FIFO (First – in – First – Out) due date logic. The company do not have an appropriated inventory system, it cannot eletronically check a bar code. Instead, the system prints a list and the employee does a mannual check and then compiles (mannually) into the system. In an emergency, lack of inventory accuracy may result in not having an important medicine in stock. PROF A.1 also mentions culture problems. In general, is very challenging to convince HC professionals that they also play a major role in logistics. There are issues concerning doctors that only use one determined kind of medicine (even if there are equivalent substitutes). Keeping a minimal stock is also very challenging because of the huge variety of medicines.

PROF B highlights that in a PuHN the lack of standard demand flows at municipality level. Each Hospital have a demand in a different time span. At the federal level hospitals have systems and is easier to consolidate demands, in opposition of municipality level where which hospital has their spreadsheets. Private pharmaceutical

companies also have dificulties with the government that often delays payments, generating considerable struggle for companies to fullfill de public hospitals orders. There are also private pharmaceutical companies with still a strong family culture, lacking business-orientation and often loosing deadlines and accumulating backorders. There are many quality issues, for example suture wires that depending on the quality may result in patients death. In PuHN quality is mostly means complying with the laws. Wire sutures can be considered an A product (Considering a price ABC classification) and is a very complex purchase. Diapers (mostly in B or C category) are considerably cheaper, having a great volume, nevertheless, if the quality is too poor it may result in using more product, resulting in a hard to balance trade-off.

Suppliers use to deliver a lot of of non-conforming products. Considering the law 8,666, there is a clause that gives the possibility of provisionally receiving the order, which give managers some time to execute quality control. Concerning technology change, there may be a cost-benefit analysis. There is a CE company contracted to cary on this analysis. The companies do materials and equipments mapping and inspect companies that do equipment maintenance. The recent cargo theft (mostly in Rio the Janeiro) are responsible for an increase in suppliers prices. The reverse logistic process of prostheses and ortheses are also very costly as they must be incinerated. A mitigation strategy for this problem consists in reselling silver components that most hospital equipments have, therefore, managers can negotiate a discount in future purchases if the suppliers can receive these silver components

PROF B.1 also highlights the problems of quality that often prejudice patients recovery. For example, poor quality bandages can lead to non-healing of an injury, increasing patient discomfort, increasing infection risks, aggravating their clinical condition. This situation aldo leads to a cost increase for the hospital as the patient eventually will have a longer stay, generating a bed deficit. Another major problem is when a poor quality sterile procedure glove is purchased. The gloves can rip during a procedure generating risks to both HC professional and the patient.

PROF H.1 is a terapist professional with experience in treating schizophrenia, bipolarity, among other severe mind ilnesses. The professional cites how important would be for the patients and the treatment team to choose toghether which vegetables and fruits they want in what the professional call assemblies. The assemblies join all

patient treatment stakeholders (family, friends, neighbors, etc.) and they discuss actions. Thinking in the own food gradually makes the patient used to make decisions, assigning responsibilities and play a major role in the treatment. The heavy drugs that psychic patients have to consume most of the times generate other health problems such as obesity, cholesterol, diabetis, which reinforces the need of a healthy food supply, whch often does not occur.

Hotel sector also should not be “too standard”. White sheets and white beds compose a context that is similar to asylums, therefore, the service do the opposite, having colored furniture, sheets and other furniture that relieves this stigma. In this sense, a simple solution would be to integrate this network of clinics in a system and consolidate the needs, in this way it would be possible to keep the individuals choices and still have scale gains, since the needs from clinic to clinic would not be so different. PROF E.1 (PrPI) highlights that raw materials delivery may cause severe impact in Planning and Production Scheduling and hence, in product availability. Therefore, for the OEM, tha major risks are fail to delivery the orders and production capacity constraints that may generate backorders. The most critical suppliers are raw materials and packing. Raw material suppliers are even more critic because may impact the hospital patients. The suppliers and the OEM do not have a good integration, mostly because they are from other Brazilian states or even other countries and cannot evaluate how a wrongly emmited invoice may impact or delay a delivery. In the analysis of PROF E.1 is a relationship that still have to be developed and improved.

PROF F.1 highlights the lack of documented procedures, for example, when a procurement professional leaves the company he usually carries away all the technical knowledge about that specific purchase. The professional also highlights that they work in almost a Make-to-Order logic and do not have an increased safety stock.

PROF G.1 points out the vision of the distributor and highlights supplier quality problems, which generate fail to fullfill orders they receive and cause impact in competitive pricing. These risks could be mitigated if there were more involvement of the supplier in understanding their needs.

In this sense, professionals present a empirical understanding of the risks, although they do not map these risks systemtically, nevertheless, after identifying risks is crucial to measure them via KPIs.

# 5. Risk Assessment

## 5.1. Chapter abstract

The objective of this chapter is to identify KPIs in literature that can be used to improve risk assessment in Healthcare Supply chains. We conducted a Systematic Literature Review to find the papers and categorize the most relevant to the study. As the main findings, it is highlighted an extensive list of 66 KPI identified from a shortlist of 81 papers and specialists' interviews. The secondary goal is to broaden the discussion concerning SCRM, Supply Chain Resilience and contribute to the literature offering risk measurement options, which is the first step for risk mitigation. A few Healthcare KPI studies can be found, nevertheless, the conducted search did not find any study aiming to map risk and resilience KPI in Healthcare Supply Chain context.

Keywords: KPI, Healthcare supply chain risk management, Healthcare KPI, Supply chain.

## 5.2. Introduction

The academic literature provides many examples of risks that led to disasters, on the other hand, little information is available concerning Healthcare Supply Chain Management (VanVactor, 2011). Supply Chains (SC) are often vulnerable to multiple high-magnitude risks (Kouvelis et al., 2011). Furthermore, supply chains are increasingly exposed to operational and disruption risks that threaten their business continuity. When these risks are in a HCSC context, it often means that a medicine or a bandage is missing, the wrong treatment is applied or even the team was unable to save the patient's life (Khalili et al., 2016). Therefore, it is crucial to identify, measure and mitigate not only Healthcare organizations risks, but risks concerning their SC as well. In this sense, Performance Management becomes a crucial feature for risk mitigation. Performance Management systems are usually introduced to monitor goal achievement (Franceschini et al., 2014) and is considered a challenge frequently confronted by public service managers (Arnaboldi et al., 2015). In addition, there are dreadful outcomes associated with poor use of Performance Management systems in public services, including negative effects on staff morale. The implementations of indicators can even generate behavior

change (Franceschini et al., 2014). The lack of quick answers and solutions to improve Performance Management makes this task complex and critical for public service managers (Arnaboldi et al., 2015). Mostly of the poor Performance Management in Healthcare organizations is aggravated due to the lack of good KPI, since managers become unaware of which tasks should be prioritized. In areas such as finance, insurance, crisis management and Healthcare, the importance of considering risk is largely acknowledged, creating an environment where heterogeneous concepts and approaches for risk management are developed (Heckmann et al., 2015). Healthcare disasters strikes Healthcare organizations of all types, designs, making resiliency actions crucial for crisis mitigation (VanVactor, 2011).

Several studies have focused on Supply Chain Risk Management KPI, including Heckmann et al., 2015; Wu et al., 2010 which present indicators such as standard deviation, VaR (Value – at - Risk) and CVaR (Conditional Value – at – Risk). Literature also provides KPI related to Healthcare, being most of them clinic KPI (Cavalcante et al., 2016) or more general and operational KPI (Habidin, 2015; Kanamori et al., 2016). However, this research detected that studies that aim to identify KPI measuring risks in Healthcare supply chains are lacking. To start filling this literature gap, this chapter brings a KPI mapping based on a literature survey, answering questions already raised in (VanVactor, 2011) such as “What metrics should be employed to evaluate success or failure in Healthcare logistics management? “

## 5.3. Chapter methodology

In this chapter was detected the need of another literature survey, in this sense, a systematic literature review was conducted using PRISMA as shown by Figure 32.

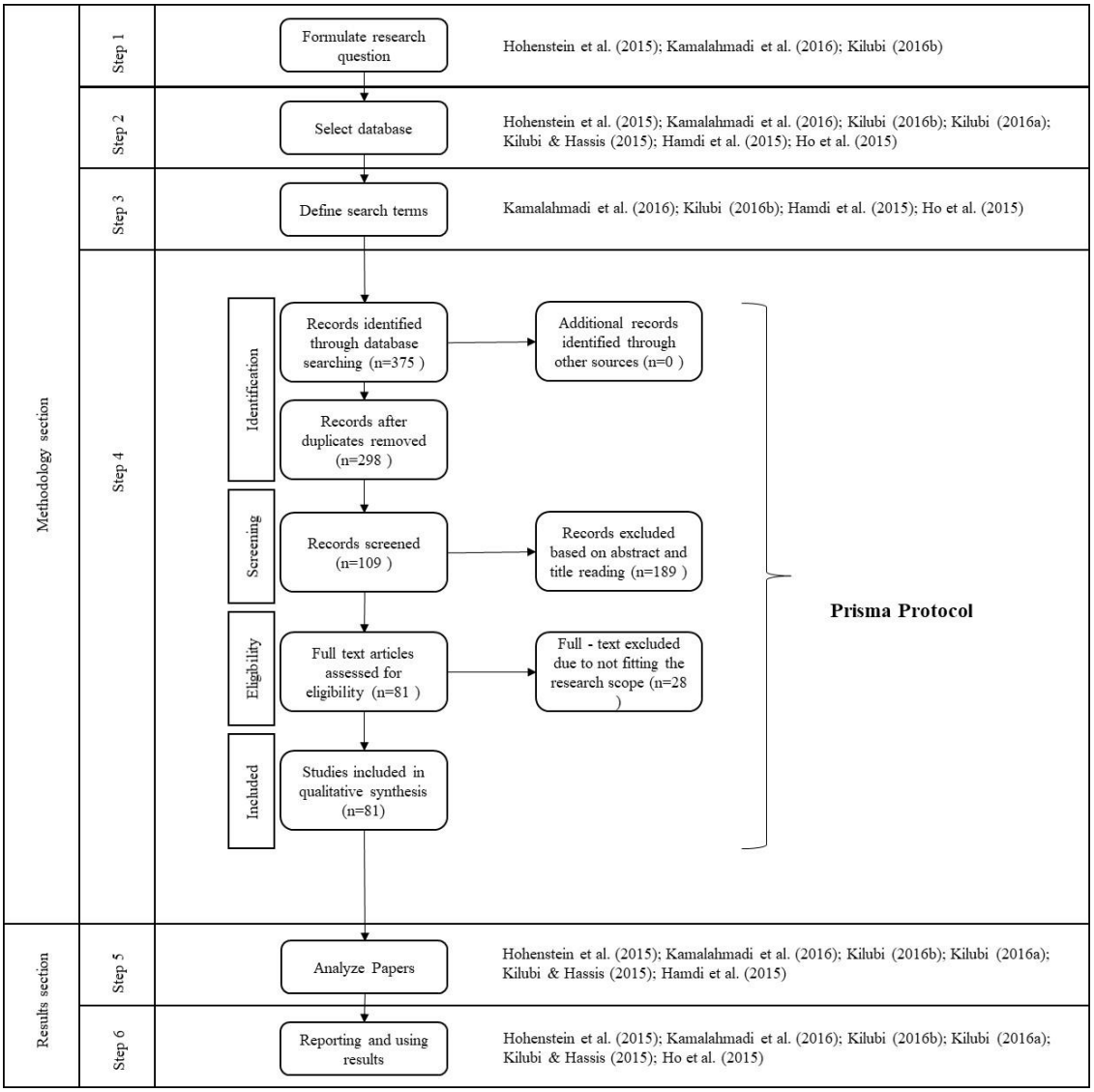



**Figure 32 -** Systematic literature review of KPI

## 5.4. Formulate research question

In the first step, is verified that the research scope is in adherence to the objectives and the study questions are precisely formulated to avoid ambiguity (Kilubi, 2016a).

RQ6 – Which metrics and indicators can be used to measure Healthcare Supply Chain Risks?

Because of the two research questions, the general objective of this paper is to identify HC SCRM/SCRes KPI providing metrics for academics and researchers to

develop new studies and support HC Chain improvement initiatives.

## 5.5. Select database

The database chosen for searching the research terms were Scopus and Web of Science. Scopus is the largest database of peer-reviewed literature and Web of Science can recover documents from 1945 to the present days. References (Kilubi and Haasis, 2015) and (Kamalahmadi and Parast, 2016) used ABS (associationofbusinessschools.org) ranking and limited their review to journals with 3 or 4 grade. Kilubi (Kilubi, 2016a) used peer-reviewed journals with a VHB ranking (vhb.online.org/startseite) of A+, A, B or C as selection criteria. In this paper these restrictions were not imposed to ensure that every relevant study were captured, which is consonant with the vision of (Ho et al., 2015).

## 5.6. Define search terms

The search strings were based in consolidated Supply Chain Risk Management and Supply Chain Resilience terminologies as shown in Table 24.

**Table 24 -** Search strings

| | ***Ocurrences*** | |
|---|---|---|
| ***Strings*** | **SCOPUS** | **Web of Science** |
| "SUPPLY CHAIN" AND "RISK" AND "INDICATOR" | 261 | 68 |
| "LEAN HEALTHCARE" AND "INDICATOR" | 5 | 1 |
| "SUPPLY CHAIN RISK MANAGEMENT" AND "INDICATOR" | 18 | 2 |
| "SUPPLY CHAIN RESILIENCE" AND "INDICATOR" | 13 | 4 |
| "SUPPLY CHAIN RISK MANAGEMENT" AND "HEALTHCARE" | 0 | 0 |
| "SUPPLY CHAIN RESILIENCE" AND "HEALTHCARE" | 1 | 1 |
| "HEALTHCARE" AND "LEAN INDICATOR" | 0 | 0 |
| "SUPPLY CHAIN RISK MANAGEMENT" AND "KPI" | 0 | 1 |
| ***Total*** | 298 | 77 |

**Source:** Authors

## 5.7. Select papers

The search took place in January 2019 and resulted in a total of 375 publications. Then, after duplicate removal there were 298 documents. An initial screening of publications that consisted in checking titles and abstracts was performed, aiming to

discard those that did not fit within the scope of this research, resulting in 109 articles ranging from the years 2002 to 2018. The last step was full-text reading which generated a final list with 81 papers that were analyzed to compose the KPI list. Steps 5 and 6 are shown in section

## 5.8. KPI mapping

The adopted performance measures in Healthcare organizations look to draw a picture of quality, equity, and efficiency of the medical care at different levels: caregiver, hospital, local health authority, region (Antonelli and Bruno, 2015). Additionally, health institutions have adopted methods of evaluating their services based on indicators (Silva et al., 2009).

Literature shows a good number of papers comprising clinic indicators including Cavalcante et al., 2016 and Minami et al., 2016. However, there are not many papers where Healthcare indicators are related to SCRM as a whole (Gu and Itoh, 2016; Zepeda, et al., 2016; Eiro and Torres-Junior, 2015).

In Healthcare organizations, high-risk exposure can lead to life losses, thus, it is essential to identify, assess and mitigate risks. Measuring Resilience is a questionable task, so there is still scope to identify and develop sustained metrics (Cardoso et al., 2015). Sometimes the indicators were identified without a direct citation in the paper. The papers often mentioned important factors to be measured leading to the decision of registering a correspondent KPI. Indicators that measure performance to assess quality of care are often chosen arbitrarily (Jones et al., 2014).

In this sense, a first list of KPIs was generated from the Systematic Literature Review. This initial list had 44 KPIs. The second phase consisted in analyzing the Supply Chain Operations Reference Model (SCOR 12.0) which is a reference model for Supply Chains. Thus, were selected 6 more KPIs generating a complete list of KPIs to be validated by HCSC professionals. The pre-test Consisted in 2 sub phases, i) 4 HC professionals analyzed the indicators text and suggested exclusion and inclusion of KPIs, ii) a sample of 20 HC professionals analyzed the KPI importance and made suggestions concerning text, inclusion and exclusion. Therefore, a final list of 66 KPI was generated to be statistically validated by HCSC professional, which was not in the scope of this thesis. Figure 33 shows the validation methodology.

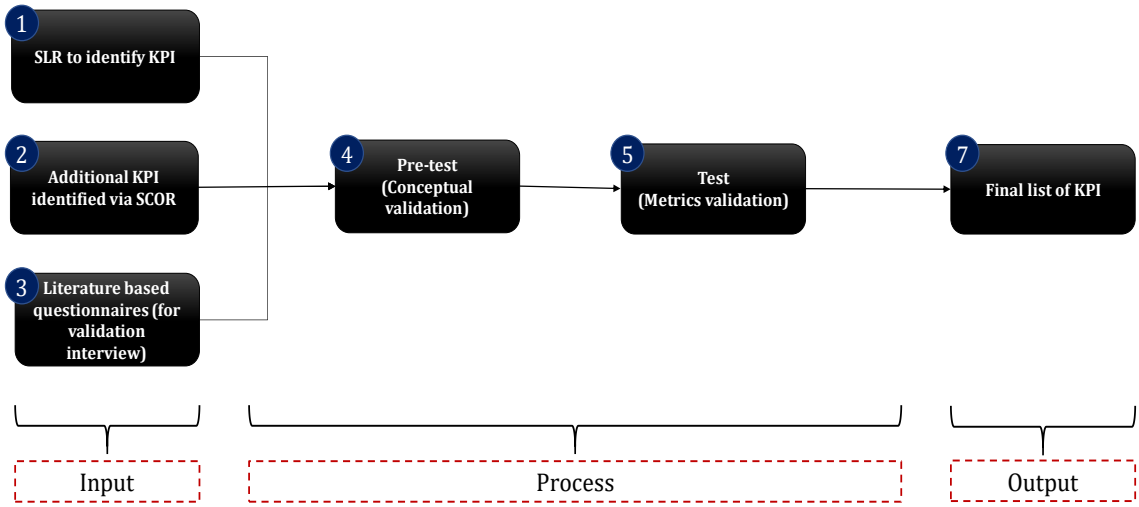



Figure 33 – KPI list validation methodology

Decision support systems in the form of dashboards, present crucial graphical information, to assist senior management to make the right decisions to achieve strategic goals within this complex environment. (Erdem et al., 2016). Information visualization can accelerate perception, provide insight and control of valuable data to gain a competitive advantage in making business decisions (Jasser et al., 2014). Table 25 and Table 26 show the final questionnaire to be distributed and quantitatively assessed.

**Table 25 -** Questionnaire I – General Questions

1) What is your age?
2) Gender: ( ) Male Female ( )
3) Are you employed? ( ) Yes ( ) No
4) Where do you work?
5) In which sector do you work? ( ) Public ( ) Private ( ) Both
6) What is your job description?
7) How much is your monthly family income? (including all family members)
( ) up to 500 USD ( ) 500 to 1000 USD ( ) 1,000 to 2,500 USD ( ) 2,500 to 5,000 USD ( ) More than 5,000 USD
8) Education:
( ) Elementary School ( ) High School ( ) College degree (Incomplete) ( )College degree (Complete)
( ) MBA (Incomplete) ( ) MBA complete ( )Master of Science (incomplete) ( ) Master of Science (Complete)
( ) PhD (incomplete) ( ) PhD (Complete)
9) In which Brazilian region do you live?
( )South ( )Southeast ( )Northeast ( )Center-West ( ) North

**Source**: Authors

The questionnaire made from Table 26 includes only one affirmative (The

following indicator is important). This affirmative should be evaluated in each KPI and the respondent must choose from a likert scale from 1 (Totally disagree) to 5 (Totally agree).

**Table 26 -** Questionnaire II) Final List of KPI

| Category | KPI | Reference |
|---|---|---|
| **Reliability** | Contract approval and issue time - personel | Rajesh (2016), Experts |
| | Contract approval and issue time - materials | Rajesh (2016), Experts |
| | Documentation accuracy | SCOR 12.0 |
| | Environmental impact | Francischini et al. 2014; Kolotzek et al. (2018) |
| | Forecast accuracy | Rajesh (2016) |
| | Order Fullfillment | SCOR 12.0 |
| | hospital/clinics cancellation rates | Briault 2013 |
| | Inventory accuracy rate | Rajesh (2016) |
| | Order compliance | Rajesh (2016) |
| | Quality: Complaints from employees | Gu and Itoh (2016), Reijula et al. (2014) |
| | Quality: complaints from patients | Experts |
| | Quality: Employees error rate | Li et al. (2015), Gu and Itoh (2016), Reijula et al. (2014) Rajesh (2016) |
| | Quality: Improvement initiatives and innovation | Minami et al. (2016), Gu and Itoh (2016), Habidin et al. (2015), Özkan and Onur (2014), McIntosh et al. (2014), Aoun and Hasnan (2013), Kekkonen et al. (2018), Mital et al. (2018) |
| | Quality: Patient satisfaction | Gu and Itoh (2016), Arnaboldi et al. (2015), Habidin et al. (2015), Kanamori et al. (2016), Speziale (2015), Eiro and Torres-Junior (2015), Kahraman, (2015), Chae et al. (2003), Reijula et al. (2014), Sedevich-Fons (2014), McIntosh et al. (2014), Aoun and Hasnan, (2013), Northcott and Harvey (2012), Robinson et al. (2012), Vidmar et al. (2012), Boulkedid et al. (2011) |
| **Responsiveness** | Average length of stay (Acute care) | Smith et al. (2014), Yan et al. (2014) |
| | Cycle time (Medical appointment average time) | Li et al. (2016), Reijula et al. (2014) |
| | Delivery Lead Time | Li et al. (2015), Li et al. (2016), Habidin et al. (2015), Kahraman (2015) |
| | Number of disruptions managed through flexibility | Rajesh (2016) |
| | Stock level | Francischini et al. 2014 |
| | Supply Availability | Mital et al. (2018) |
| **Agility** | Downside Supply Chain Adaptability | SCOR 12.0 |
| | On time delivery | Habidin et al. (2015) |
| | Put-away time ratio | SCOR |
| | Storage space utilization | Rajesh (2016) |
| | Upside Supply Chain Adaptability | SCOR 12.0 |
| | VaR (Value - at - Risk) | Heckmann et al. (2015), Li et al. (2016) |
| **Cost** | Amount of Debt | Francischini et al. 2014 |
| | Cancellation of purchasing/ procurement | Erdem et al. (2016) |
| | Costs of raw materials | Francischini et al. 2014 |
| | Credit Risk | Gu et al. (2017), He et al. (2016) |

| | | |
|---|---|---|
| | General costs | Li et al. (2015), VanVactor (2011), Khalili et al. (2016), Gu and Itoh (2016), Reijula et al. (2014), Sedevich-Fons (2014), Díaz et al. (2012) |
| | Human Resources Costs | Experts |
| | Inventory Costs | VanVactor (2011), Zepeda et al. (2016), Díaz et al. (2012) |
| | Maintenance repair costs per m² | SCOR 12.0 |
| | Mitigation costs | SCOR 12.0 |
| | Purchasing request (amounts and cost) - cost to source | Erdem et al. 2016) |
| | Transport costs | Li et al. (2015) |
| **Asset Management** | Equipment utilization | Gu and Itoh (2016) |
| | Financial Performance | Li et al. (2015), Li et al. (2016), Habidin et al. (2015), Kanamori et al. (2016), Speziale (2015), Eiro and Torres-Junior (2015), Kahraman (2015), Reijula et al. (2014), Sedevich-Fons (2014), McIntosh et al. (2014) |
| | Investments | Francischini et al. (2014) |
| | Maintenance efficiency | Shohet (2006) |
| | Revenues | Francischini et al. 2014 and SCOR 12.0 |
| **Hospital/Clinic Management** | Average experience in current department | (Gu and Itoh, 2016) |
| | Bed ocupancy | (Gu and Itoh, 2016) |
| | Continuous Education | Crema and Verbano (2015), Cavalcante et al. (2016), Minami et al. (2016), Efe and Efe (2016), Hammadi et al. (2015), Kahraman (2015) |
| | Dealer accessibility | Rajesh (2016) |
| | Frequency of night duty/shift | Gu and Itoh (2016) |
| | Inpatient Admission | Gu and Itoh (2016) |
| | Monthly number of inpatients | Gu and Itoh (2016) |
| | Monthly number of outpatients | Gu and Itoh (2016) |
| | New inpatients for day | Gu and Itoh (2016) |
| | Number of operations procedures | Gu and Itoh (2016) |
| | More visited diagnosis centers (visited by the patients) | Experts |
| | Number of outpatients per physician | Gu and Itoh (2016) |
| | Number of staff per bed | Gu and Itoh (2016) |
| | Outpatient waiting time | Gu and Itoh (2016), Gunal and Pidd (2011) |
| | Overbooking | Meekings and Briault (2013) |
| | Overtime | Gu and Itoh (2016) |
| | Paid leave | Gu and Itoh (2016) |
| | patient non-attendance | Meekings and Briault (2013) |
| | Patient no show rate | Experts |
| | Satisfaction of human resources | Francischini et al. 2014 |
| | Staff turnover | Gu and Itoh (2016), Hammadi et al. (2015) |
| | Unscheduled returns | Gu and Itoh, 2016 |
| | Wait time in ER/clinic | Gu and Itoh (2016), Reijula et al. (2014), Robinson et al. (2012), Díaz et al. (2012), Smith et al. (2014), Yan et al. (2014), Al-Katheeri et al. (2018), Meekings and Briault (2013) |
| | Working hours | Gu and Itoh (2016) |

Table 26 brings a first validated draft concerning SC risk/resilience KPI,

nevertheless, there is still much discussion to be done concerning this result. A relevant question would be, which of these KPIs are relevant to which company/tier? This question needs a robust quantitative study in order to be answered. The objective of this mapping is to find KPI relevant to HCSCRM, nevertheless, how far can one consider clinical KPI as strictly clinical and affirm they have no impact in SC whatsoever? This question must be addressed through many thorough case studies which will then be able to highlight details that a general review cannot. Some KPI even are written in a way that consists in a jargon of a specific sector, nonetheless, this study validated with experts and tried to minimize these problems writing a text that is as understandable as possible.

There are still many challenges remaining considering these KPIs implementation. HC organizations should analyze whether they have or not professionals trained to measure and compilate these indicators. Another important challenge is systems integration, where do the information will come from? HC organizations will have to hire more management-related professionals with solid data management formation and sensitize HC professionals of the KPIs importance (even if indirect) in saving patients' lives.

### 5.9. Qualitative interviews – KPI related analysis

PROF A affirms that the stock levels are analyzed in the light of their previously defined inventory policies and they use 3 or 4 different statistical methods to conduct the analysis (the methods were not detailed in the interview). A 24-month sample defines the product stock turnover, minimum and maximum quantities. The main objective is to never have supply disruptions which may result in loosing patient's lives.

PROF A.1 affirms that in the storerooms the inventory control is fairly good, the major risk is in keep tracking of nursing units' inventory. If the nursing needs a medicine with urgency, the storeroom often dispenses the medicine and do not keep track in any system to guarantee the quick dispensation. Nevertheless, it generates inventory accuracy issues if the stockman forgets to keep track later. Another important process is to map the homologated medicines and products in order to register the consumption and calculate minimum and maximum quantities.

The labeling process has the objective of providing traceability. The PrHN have one Warehouse in which the labeling process is already fully automated. This labeling

process is particularly important because it gives visibility of product information, for example when the product must be dispatched. They highlight the product receipt service level, dispensation time, stock turnover of storeroom and nursing units' stock, Cleaning and organization and OTIF. Supply assessment is responsible to define which is the optimum products mix for the hospital. The lack of an integrated system generates KPIs that are locally visualized via spreadsheets only. They have the knowledge that a high inventory level means a low level of working capital that could be invested in more beds or more hospitals. The pharmacists and nurses are consulted to validate the supply planning.

PROF B highlights Compliance as a very important KPI (He defines as the fulfillment of laws and conducts) to help mitigating supplier-related risks. In the PuHN there is no standard purchasing process, depending on the ability of the current manager. Usually as the manager leaves old practices such as political biases and corruption come back.

PROF E.1 highlights that their suppliers are constantly evaluated by the departments of quality and procurement. If they have to incorporate a new production line, they open a "Change Control" to assess whether or not the changes are being positive. This assessment has the objective helping to mitigate supply chain risks.

# 6. Risk Mitigation

## 6.1. Chapter abstract

The purpose of this chapter is to propose a framework for analyzing the relationships between the antecedent factors, mediators and consequences of healthcare supply chain resilience (HCSCRes), which can be applied for empirical studies in healthcare organizations. Based on the importance of identifying the determinants of HCSCRes, a qualitative and exploratory research was developed through an extensive review of the literature. The proposed framework of this research was developed to analyze healthcare organizations, including healthcare supply chain. In order to use the proposed framework in other industries (commerce, services), it will be necessary to make adaptations and adjustments on the observable variables and constructs. The paper has an important theoretical value in proposing scales for the HCSCRes factors and can be useful for future quantitative approach and surveys. Consequently, the researcher will be able to evaluate the scales of the factors and the intensity of the relations between observable variables in the formation of the constructs, as well as the intensity of influence among the constructs

**Keywords**: Supply Chain Resilience, Supply Chain Risk Management, Healthcare organizations

## 6.2. Chapter introduction

Profit – oriented organizations tend to increase operational efficiency, eliminating waste and mitigating risks to improve their position in market. Healthcare organizations find themselves in a tough spot, mostly because they must focus in cost reduction and increasing revenues to provide continuously improved healthcare services. Depending on the country, Healthcare organizations can either be public or private. Although public Healthcare organizations generally do not have to worry about bankruptcy, they still have the compromise to serve the taxpayer with the utmost service level. One way to succeed is to acquire the conscience that healthcare organizations are part of a complex supply chain, therefore, being susceptible to risks (Neiger et al., 2009). In this sense, healthcare

supply chain risk management (HCSCRM) is an important building block of Healthcare Supply Chain Resilience (HCSCRes), which contributes to Healthcare Supply Chain Performance (HCSCP). Increase of global scale catastrophes made researchers give increasingly more attention to SCRM (Coleman, 2006).

The first stage concerning Supply Chain Risk Management analysis is to visualize a Supply Chain as a set of cross – functional processes. Additionally, Risk analysis should considerate the whole Supply Chain to provide good results (Juttner et al., 2003; Juttner, 2005; Thun and Hoenig, 2011). Besides the usual supply chain risks (See for example petit et al., 2013) healthcare supply chains (HCSC) have additional risks such as long waiting times for a medical appointment, shortage of medical supplies and medicine, lack of beds, among others. Therefore, HCSC risks can often mean that patients with treatable diseases may perish due to a lack of operational efficiency.

To identify some relevant factors that make up HCSCRes, this paper aims to propose a framework to analyze the relationships between the antecedent factors, the mediators and the consequences of HCSCRes, which can be applied in empirical studies in the healthcare sector. Consequently, a literature review was carried out from the studies indexed in the Scopus® and ISI Web of Science databases, and other articles relevant to the development of the proposed framework.

## 6.3. Method

From the importance of identifying the determinants of SCRM, and the research objective of proposing an analysis framework (Rocco and Plakhotnik, 2009), a qualitative and exploratory research was developed (Duriau et al., 2007). The research was carried on through a literature review, based on Torraco (2005), which argue that a systematic review of the literature can be performed to identify relevant topics of a given area and to propose new analytical structures topic. It is worth noting that methodological rigor is fundamental in a literature review, especially with the detailed description of the data collection, in the justification for the standard of analytical categories, and in the quality criteria such as replicability, reliability and validity (Seuring and Gold, 2012). In this chapter the objective is to answer the following research question:

RQ7 – Which techniques can be used to mitigate SC Risks in Healthcare?

In this sense, a content analysis technique was used to analyze the data, with a priori categories (Bardin, 2004), related to the antecedents' factors, the mediators and the consequences of HCSCRes, which determined the sub-categories of analysis:

a) Antecedents of HCSCRes: supply chain risk identification (RID); supply chain risk assessment (RAS); supply chain risk mitigation (RMI); supply chain integration (SCI).

b) Mediator of HCSCRes: Healthcare Supply Chain Risk Management (HCSCRM) and Healthcare Supply Chain 4.0 (HCSC40)

c) Consequences of HCSCRes: healthcare supply chain performance (SCP).

The literature review was based on the identification of relevant research works that were published between 2000 and 2018 in the Scopus® and ISI Web of Science databases. Scopus represents the largest database of articles and abstracts available on the scientific web while ISI Web of Science can recover papers from a greater year range. This study also used other sources of information for the construction of the theoretical reference, coming from other academic articles, which contributed significantly to the identification of HCSCRes-related factors. The first research string (STR1) was "supply chain risk management" (and variations of this string such as SCRM) in the period from 2000 to 2018, which returned 511 documents in Web of Science and 433 in scopus. Were only considered published papers, books, doctoral thesis and congress papers were not considered. After quality check and duplicates removal, there were a sample of 328 article, nevertheless, only 6 papers are studying healthcare or pharmaceutical organizations. In this sense, the search was broadened using the strings Healthcare AND Procurement, "Healthcare Supply Chain" AND Risk, "Healthcare Supply Chain" Healthcare AND Warehouse, which composed STR2. After applying the same procedure, The STR2 sample had a total of 97 papers.

After this search, there were still a significant body of knowledge which was not considered, therefore, the search looked for "Clinical Engineering" and High Reliability Organizations (STR3), which composed a total of 105 papers. Process automation is increasingly having a major role in all economy sectors, including healthcare. Business solutions such as IoT (Internet of Things) are starting to be applied to hospitals and clinics. In this sense, the conclusion is that "Industry 4.0" related concepts will play a

major role and will revolution the way Supply Chains are organized and will have a crucial contribution in SCRM. Therefore, the following search strings were added: ("Supply Chain 4.0”) AND ("Supply Chain Risk Management) (IoT OR "Internet of Things”) AND ("Supply Chain Risk Management") ("Supply Chain 4.0”) AND Healthcare, resulting in a sample of 26 papers. Figure 26 summarizes the complete literature review methodology.

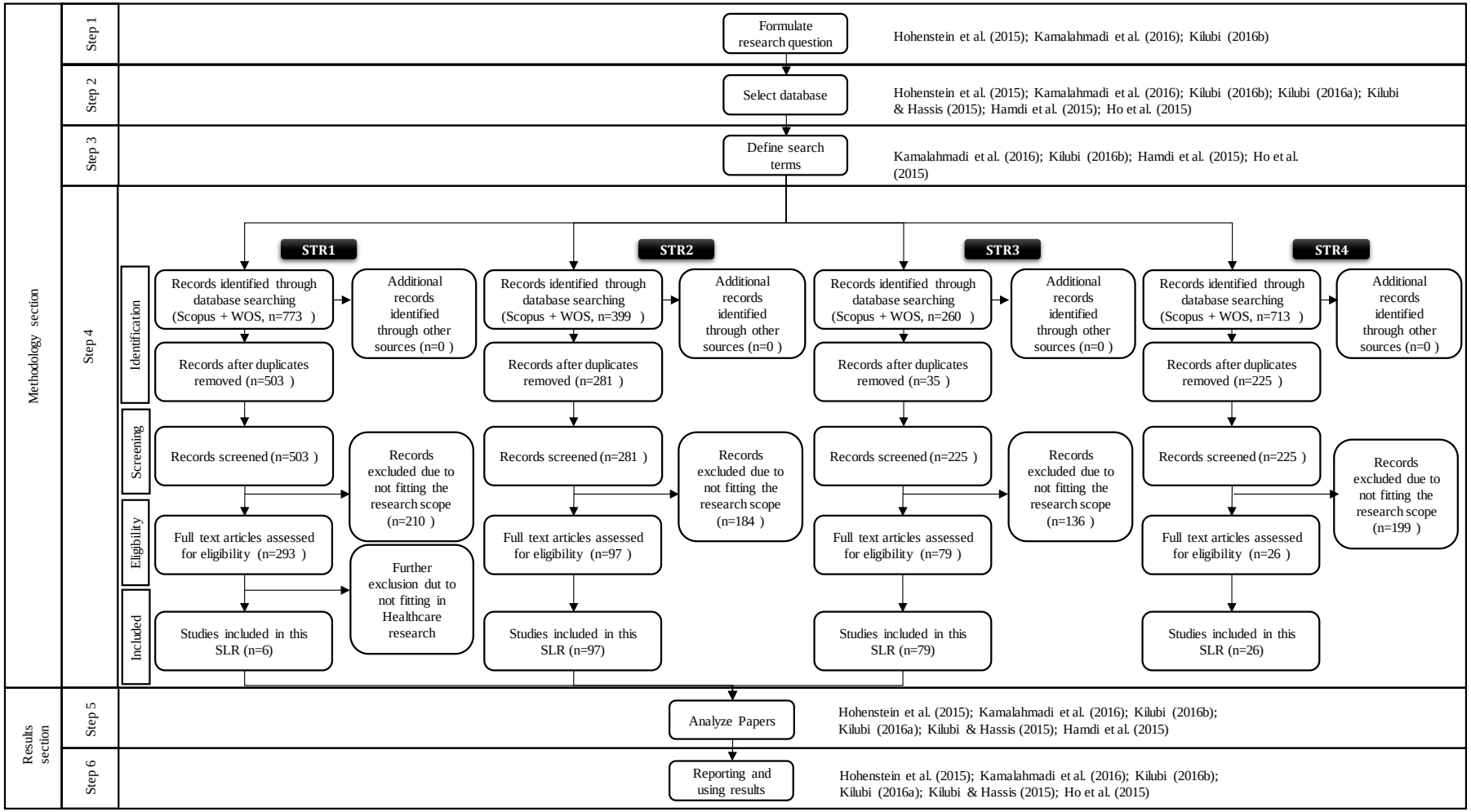



**Figure 34 -** Literature review workflow

## 6.4. Antecedents, Mediators and Consequences of Healthcare Supply Chain Resilience

The research strategy used the antecedent factors, mediators and consequences of HCSCRes to establish the observable and latent variables that compose a new HCSCRes analysis framework for healthcare organizations. The factors that precede HCSCRes are RID (Lu et al., 2017; Sinha et al., 2004; Zsidisin et al., 2004; Manuj and Mentzer, 2008; Chaudhuri et al., 2018), the RAS (Soni and Jain, 2011; Christopher and Peck, 2004; Ibey et al., 2015; Paté-Cornell and Cox, 2014), RMI (Juttner et al., 2003; Iakovou et al., 2007; Barroso et al., 2010; Sheffi and Rice, 2005; Chaudhuri et al., 2018; Norrman and Jansson, 2004; Chaudhuri et al., 2018), RIN (Ellinger, 2000; Thomé et al., 2012; Chaudhuri et al., 2018; Cagliano et al., 2016; Flynn et al., 2010; Chaudhuri et al., 2018; Tang, 2006; Barroso et al., 2010).

The HCSCRM actions are planned to optimize the risk management in a supply chain and increase the resilience, making the SC less prone to errors, disturbances and ripple effects. Considering HCSC, besides these benefits, can be added the possibility of saving lives. Although the main objective of HC organizations is saving lives, they still must be economically viable. Therefore, managing healthcare supply chain risks increases the supply chain resilience, which generate an improved healthcare supply chain performance. A healthcare chain must plan their resources deployment to sustain their services even during disruptions. Therefore, the notion of resilience was extended to medical SCs and it was defined as the capability of medical SC entities to work in a synchronized manner with an objective to provide uninterrupted medical services to patients in the event of a disruption. A robust and resilient SC or logistics network is the ultimate goal of SC risk management (Colicchia and Strozzi, 2012). In this sense, HCSCRes can generate internal factors (mediators of HCSCRes), which contribute to HCSCP. Lack or poor quality of data and lack of systems communication may be a cause of disruptions in a SC. In Healthcare organizations, imprecise data can result in wrong quantities of medicine and medical supplies, resulting in broken processes that impact in patient's treatment. In this sense, Internet of Things (IoT) devices can make a major difference, measuring and make the data available in real-time, providing more security and quality of data, accelerating processes that will result in better treatment. Ivanov et

al. (2018) highlight the importance of digitalization and industry 4.0 on the ripple effect in SCs. In general, humans perform bad in repetitive monotonous tasks and perform well in tasks that require cognitive abilities, thinking and solution design. In this sense, the automation of recurrent activities makes them less prone to errors, therefore contributing to HCSCP.

### 6.5. Antecedents of Healthcare Supply Chain Resilience

The factors related to Healthcare Supply Chain Risk Identification (RID), Healthcare Supply Chain Risk Assessment (RAS), Healthcare Supply Chain Risk Mitigation (RMI) and Healthcare Supply Chain Integration (SCI) are considered the antecedents of Healthcare Supply Chain Resilience.

The RID factor represents the supply chain risk identification, first, companies must know which risks are inherent to their business. An organization must periodically promote Risk identification practices to discover all the relevant risks (Kern et al., 2012; Fan and Stevenson, 2018). There is no risk mitigation methodology that works for all kinds of risks. An efficient risk mitigation strategy must be customized for the organization's needs; therefore, the risks must be well-known to trigger the risk assessment and risk mitigation (Kern et al., 2012; Fan and Stevenson, 2018). Lu et al. (2017) focus on supply chain security breaches and highlight security issues such as terrorist attacks, seizures of substandard foods and drug smuggling. Identification of risks and security breaches are features closely related. In such cases, prevention is the key (Hinrichs et al., 2013; Cochrane et al., 2017; Lu et al., 2017). Supply chain thinking includes promoting risk identification practices also for organizations that a company provide service (Lu et al., 2017), which includes risk register and documentation (Ibey et al., 2015) and holding all suppliers accountable for supply chain security (Lu et al., 2017). Organizations should work on detecting operations risks, e.g. internal or supplier monitoring, inspection and tracking (Sinha et al., 2004; Zsidisin et al., 2004; Manuj and Mentzer, 2008; Chaudhuri et al., 2018). Figure 3 represents the variables that constitute the Supply Chain Risk Identification factor.

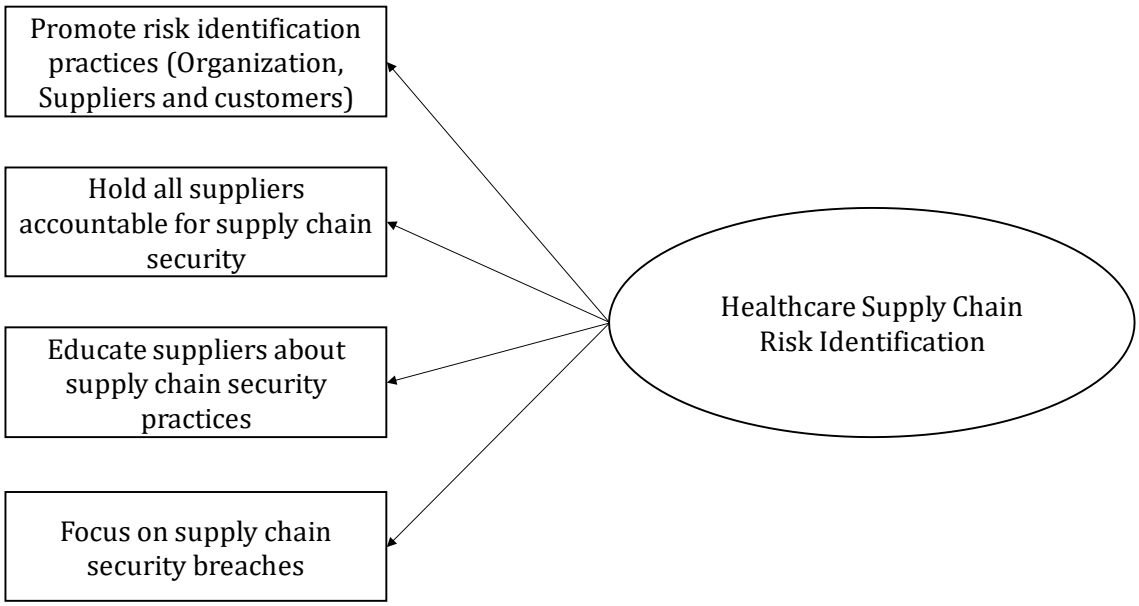



**Figure 35** – Healthcare Supply Chain Risk Identification factor

Once the Supply Chain risks are identified, they must be assessed (RAS). To prioritize and calculate the risk magnitude companies must have key process indicators (KPI) (Soni and Jain, 2011; Cruz et al., 2013; Nabelsi, 2011) providing SC-level visibility to the indicators (Soni and Jain, 2011; Christopher and Peck, 2004; Paté-Cornell and Cox, 2014). A good risk assessment demands maintaining a Supply Chain Risk Register, e.g. operational risks, technical risks, financial risks, legal risks, brand risk, environment risk, safety and health risk (SCOR - BP.150 Maintain Supply Chain Risk Register; Bektemur et al., 2018; Fukuda et al., 2008) and risk mapping that can either map supply-related risks (medicines and materials) as well as human-related risks like underperforming and absenteeism. After risk mapping, there should be a team designed to monitor the changes in probability or impact of risk events (SCOR - BP.173 Supply Chain Risk Monitoring; Ibey et al., 2015; Powell-Dunford et al., 2017). Following these steps, the SC can reach a clear understanding of where the greatest risks may exist in order to prioritize resources for risk mitigation and management (SCOR - BP.174 Supply Chain Risk Assessment; Ibey et al., 2015). Figure 36 represents the variables that constitute the Supply Chain Risk Assessment factor.

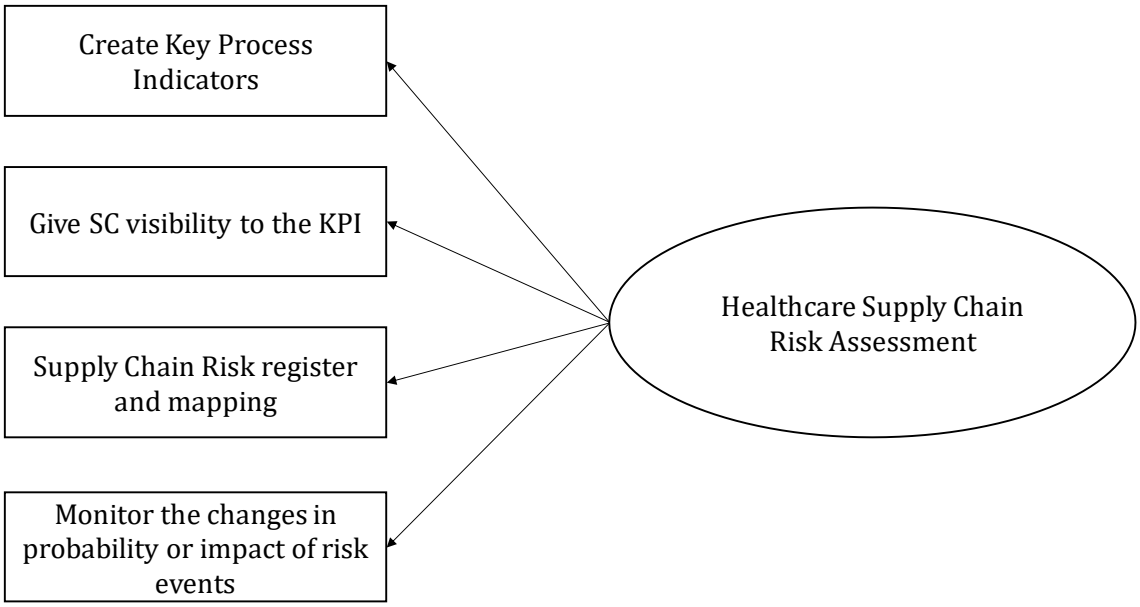



**Figure 36** - Healthcare Supply Chain Risk Assessment factor

Risk Mitigation (RMI) is a plan to reduce the probability of occurrence or minimize the impact of the risk (SCOR - BP.002 Risk Management Strategies). Risk mitigation strategies can be increased stockpile for buffer inventory (Juttner et al., 2003; Iakovou et al., 2007; Barroso et al., 2010; Hyman, 2008; Okoh and Haugen, 2015), multisourcing (Juttner et al., 2003; Iakovou et al., 2007; Barroso et al., 2010) and agility (Christopher and Peck, 2004). To quickly mitigate risks, organizations should designate a group of employees as first respondents in case of crisis like shortage of supplies and human resources (Lu et al., 2017; Okoh and Haugen, 2015). Effective communication across the supply chain is essential when a crisis hits (Lu et al., 2017), therefore, managers and employees should clearly communicate to avoid risks. In terms of preparedness it is crucial preventing operations risks, e.g., select a more reliable supplier, use clear safety procedures, preventive, maintenance and employees cross-training (Lu et al., 2017; Tomlin, 2006; Chaudhuri et al., 2018; Chaudhuri et al., 2018), responding to operations risks, e.g., backup suppliers, extra capacity and alternative transportation modes (Sheffi and Rice, 2005; Chaudhuri et al., 2018) and if prevention and response fails, recovering from operations risks is essential, e.g., task forces, contingency plans and clear responsibility (Norrman and Jansson, 2004; Chaudhuri et al., 2018). A SC should proactively develop a risk mitigation strategy (Lu et al., 2017), which is supported by the creation of a supply chain risk culture that extend beyond the boundaries of the

organization (Christopher and Peck, 2004; Barroso et al., 2010). Figure 37 represents the variables that constitute the Supply Chain Risk Mitigation factor.

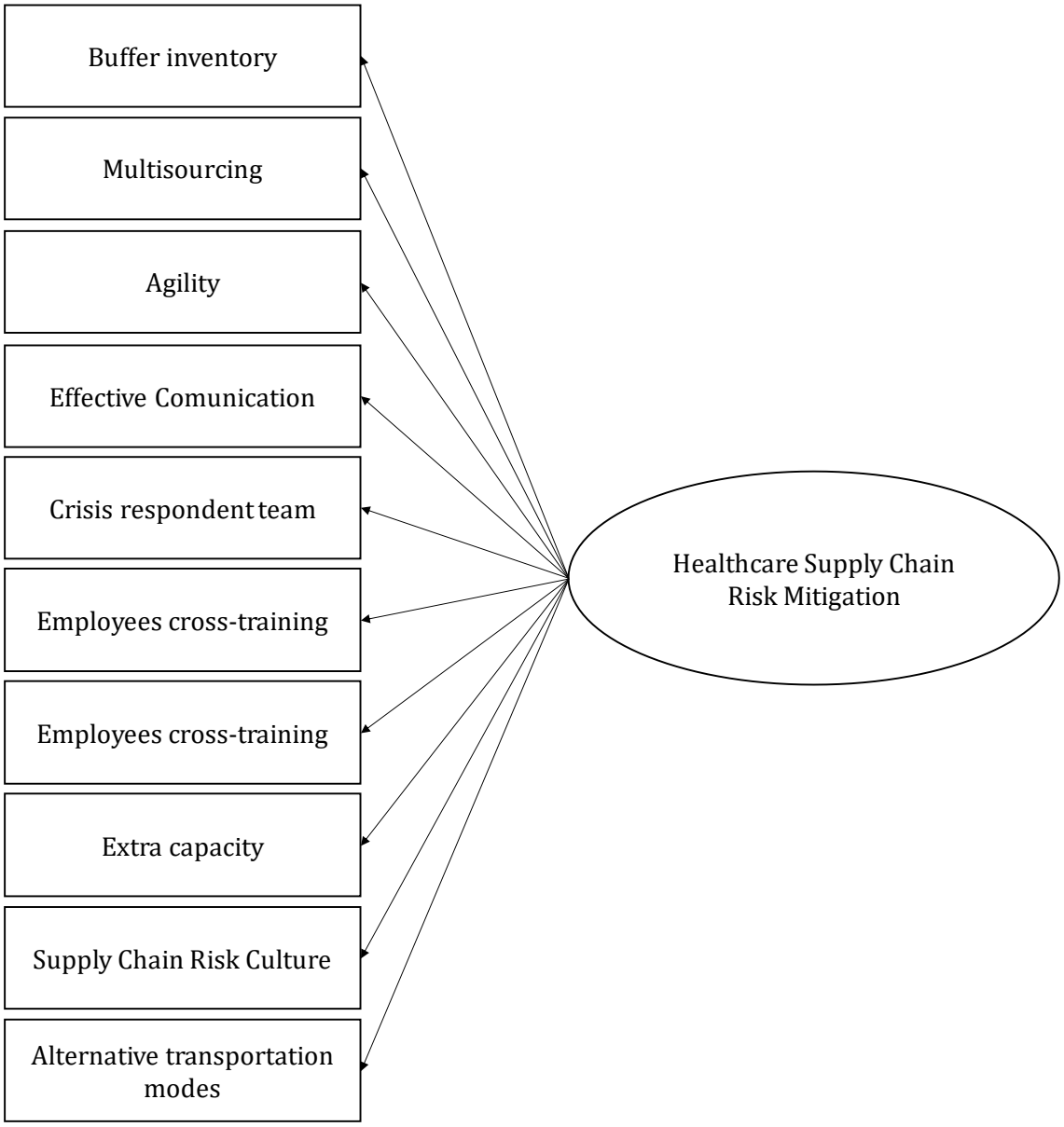



**Figure 37** – Healthcare Supply Chain Risk Mitigation

Supply Chain Integration have long been studied by scholars. Supply Chain Risk Management should be Collaborative in order to improve Supply Chain visibility and understanding (Friday et al., 2018; Juttner et al., 2003; Christopher and Peck, 2004; McCullough, 2014; Arquilla and Cram, 2005). Supply Risk Management should be Collaborative in order to improve Supply Chain visibility and understanding Friday et al. (2018); Juttner et al. (2003); Christopher and Peck (2004). Information Sharing (about

sales forecast, production plans, production progress and stock level) is the backbone of SCI. Information must be shared with purchasing department (Ellinger, 2000; Thomé et al., 2012; Chaudhuri et al., 2018; Chen et al. (2018; McCullough, 2014) with key suppliers (Cagliano et al., 2006; Flynn et al., 2010; Chaudhuri et al., 2018; Tang, 2006; Barroso et al., 2010; Chen et al., 2018; McCullough, 2014) and key customers (Flynn et al., 2010; Chaudhuri et al., 2018; Tang, 2006; Barroso et al., 2010; Muriana et al., 2017). As the chain become more integrated, companies should consider joint decision-making with purchasing department (about sales forecast, production plans and stock level) Thomé et al. (2012), Chaudhuri et al. (2018) McGowan (2012) Lin and Ho (2014), key suppliers, about product, process, quality improvement and cost control (Narasimhan and Das, 1999; Koufteros et al., 2005; Lin and Ho, 2014; Turhan and Vayvay, 2012) and key customers about product design/modifications, process design/modifications, quality improvement and cost control (Lengnick-Hall, 1996; Chaudhuri et al., 2018; Soni and Jain, 2011). There should be collaborative approaches with key customers and Key suppliers e.g. risk/revenue sharing, long-term agreements (Lambert et al., 1999; Chaudhuri et al., 2018; Iakovou et al., 2007; Soni and Jain, 2011; Ragatz et al., 2002, Dröge et al., 2004). Another essential feature is system coupling with key customers and key suppliers e.g. vendor managed inventory, just-in-time, Kanban, continuous replenishment (Frohlich and Westbrook, 2001; Chaudhuri et al., 2018; Cagliano et al., 2016; Vereecke and Muylle, 2006; Chaudhuri et al., 2018). Figure 38 represents the variables that constitute the Supply Chain Integration factor.

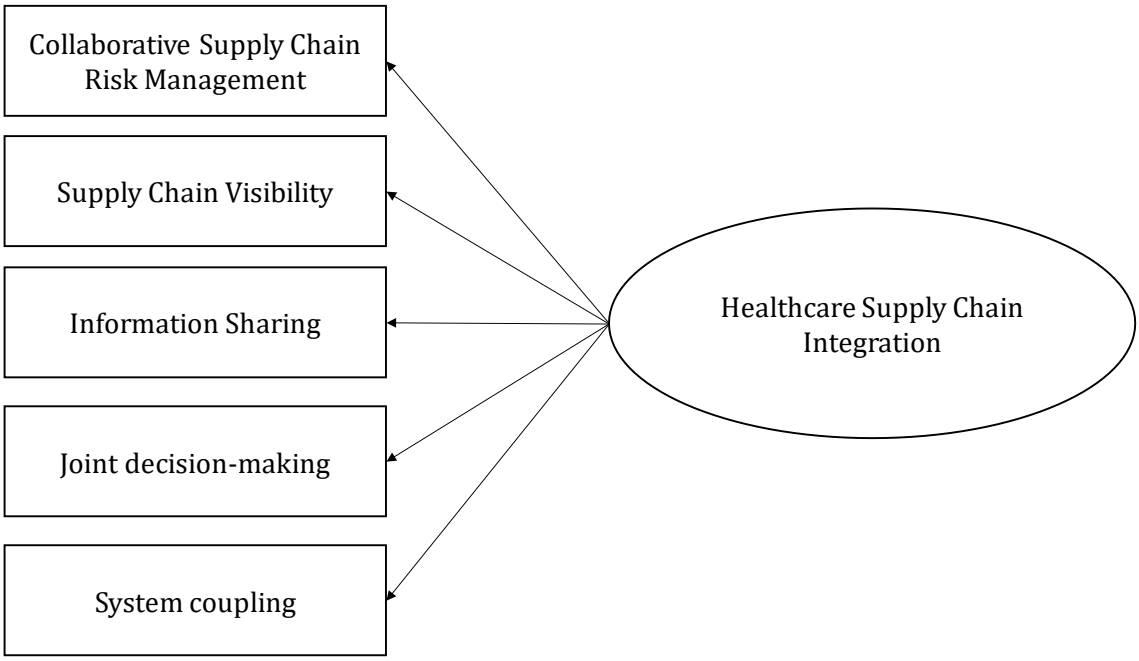



**Figure 38** - Healthcare Supply Chain Risk Integration

### 6.6. Mediators of Healthcare Supply Chain Resilience

Based on the literature, the factors that express HCSCRes process use mediators that refer to HCSCRM and HCSC40. To obtain RES, organizations should promote continuous education programs along the SC (Fukuda et al., 2008; David et al., 2008; Oumlil and Williams, 2011) forming a multi-skilled workforce (Ali et al., 2018). Cavalieri et al. (2017); Ali et al. (2018) highlight the importance of having strong collaboration mechanisms with government agencies. A resilient SC must develop good quality management systems (Ali et al., 2018; Wang et al., 2013; Sullivan et al., 2016; Griffith, 2015; Borelli et al., 2015). In Healthcare organizations, robust quality management systems often include accreditation or other quality certificates (Ali et al., 2018; Mobarek et al., 2006; Sullivan et al., 2016). Figure 39 represents the variables that constitute the Supply Chain Risk Identification factor.

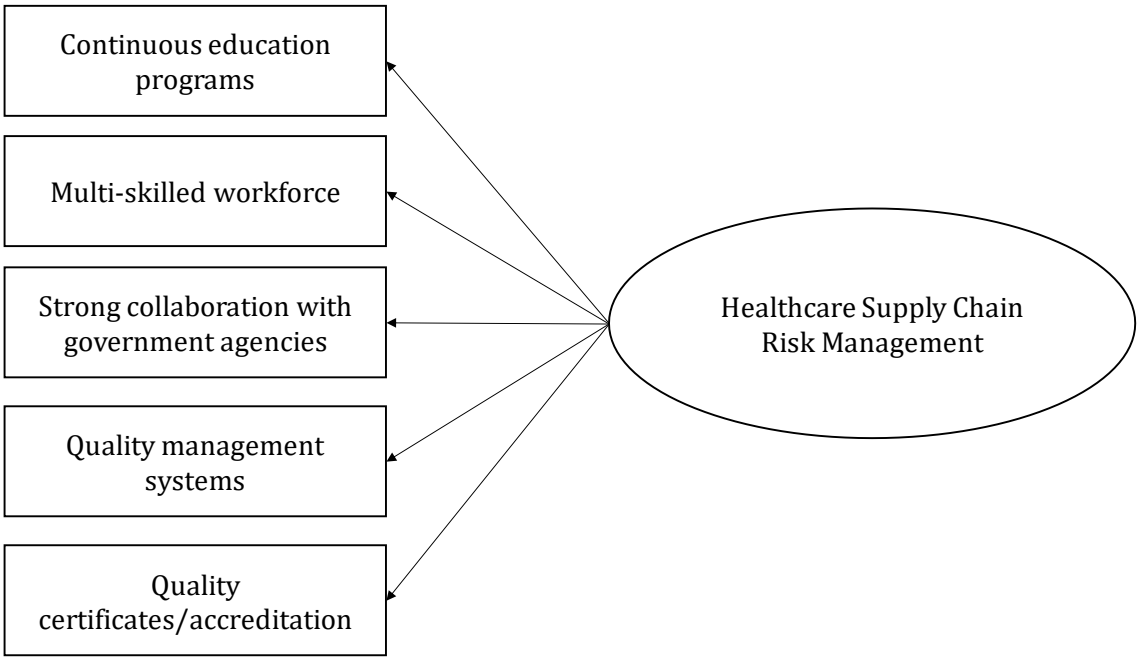



**Figure 39** - Healthcare Supply Chain Risk Management

Technology have always been a mean of process improvement. In this sense, the 4.0 revolution is contributing in terms of efficiency gain in a broad scope of industries and business. Therefore, technologies such as blockchain and Internet of Things IoT are also being applied to Healthcare SC. In general lines, blockchain is a digital ledger or distributed database that records transactions of value using a cryptographic hash function that is inherently resistant to modification (Mylrea et al., 2018). Network connected devices are used in industrial machines, household devices and Healthcare management systems in what has been called as the Internet of Things (Martínez-Caro et al., 2018). Industry 4.0 is based on intelligent devices deployment and full process automation (Kumari et al., 2018). Healthcare 4.0 can be considered an evolution of Healthcare 3.0 (hospital centric, where patients of had to do multiple hospital visits for their checkups) and includes advancements such fog and cloud computing for data storage and IoT for data collection (Kumari et al., 2018). IoT is increasingly becoming important for Healthcare organizations. IoT in Healthcare context is defined by Rodrigues et al. (2018) as Internet of Health Things (IoHT). Baker et al. (2017) affirm that Internet of Things Healthcare (presenting different nomenclature) can offer remote health monitoring and can generate benefits in different contexts, as for example, to monitor non-critical patients at home rather than in hospital, therefore, reducing the use of hospital resources. Joyia et al. (2017) present a literature review showing applications of IoT in Healthcare. The

authors define IoT applied to Healthcare as Internet of Medical Things (IoMT). The implementation of IoT has the potential to optimize processes (Roy et al., 2017; Griggs et al., 2018; Laplante et al., 2018; Javdani and Kashanian, 2018; Rodrigues et al., 2018; Baker et al., 2017; Park et al., 2017). As examples of processes, Griggs et al. (2018) created a communication system with a smart device that calls smart contracts and writes records of all events on the blockchain.

Laplante et al. (2018) described an approach to begin eliciting requirements for an IoT system to support ER activities. Due a better use of resources, patient data collection, among other features, IoT devices can help improving the quality of care (Martínez-Caro et al., 2018; Griggs et al., 2018; Javdani and Kashanian, 2018; Rodrigues et al., 2018; Joyia et al., 2017). HCSC Processes can have more compliance and security if they are supported by a blockchain (Mylrea and Gourisetti, 2018; Kumari et al., 2018; Griggs et al., 2018; Hiromoto et al., 2017) and IoT (Kouicem et al., 2018; Griggs et al., 2018; Hiromoto et al., 2017). Figure 40 represents the variables that constitute the Healthcare Supply Chain 4.0 factor.

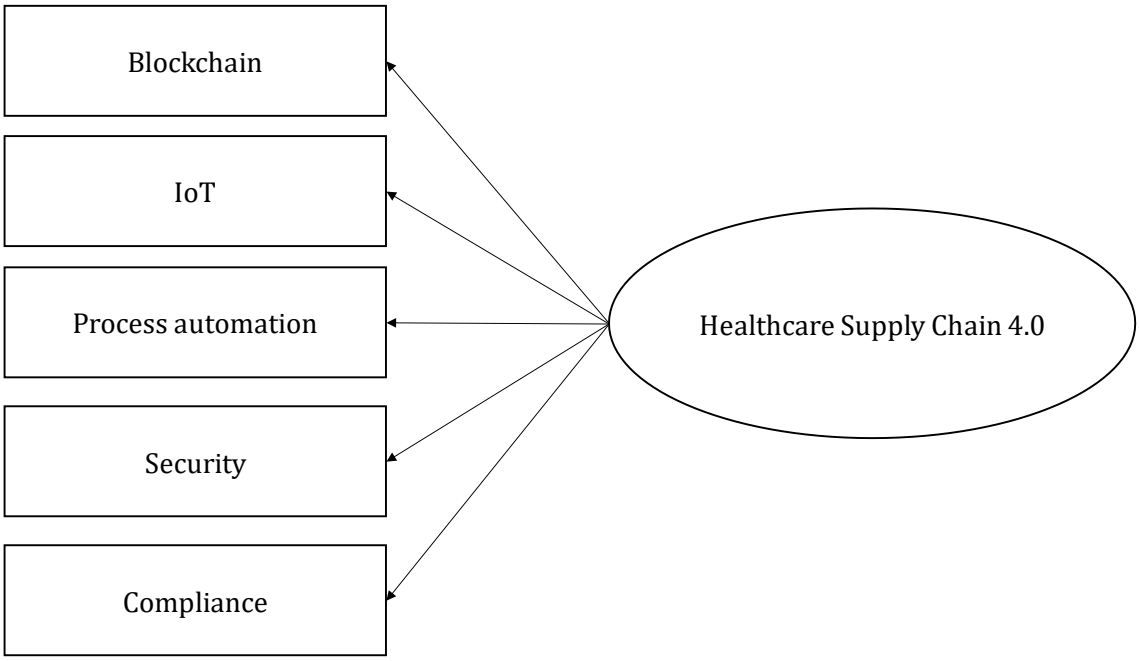



**Figure 40** - Healthcare Supply Chain 4.0

### 6.7. Consequences of Healthcare Supply Chain Resilience

Supply chain risk management should be considered a strategic activity because

of its impacts on operational, market and financial performances of a firm (Narasimhan and Talluri 2009). Supply Chain Performance if often measured by financial KPIs like EBTIDA. Nevertheless, HCSC Performance must profit (in order to survive) but its primarily objective is to save lives and provide good quality of care. In this sense, capable leadership is essential to obtain HCSC performance (Chiarini and Vagnoni, 2016). HCSC should pursue low levels of SC vulnerability, good levels of security, have low probability of cargo misuse and good capability of detecting defects in parts/products (Lu et al., 2017). The SC must develop practices that reduce theft/loss of products and the potential of drug smuggling (Lu et al., 2017). HCSC must develop a growingly patient satisfaction throughout the years (Hyman, 2008; Fukuda et al., 2008; Cochrane et al., 2017; Woodhouse et al., 2016; Van Spall et al., 2015). Figure 41 shows the variables of Healthcare Supply Chain Performance.

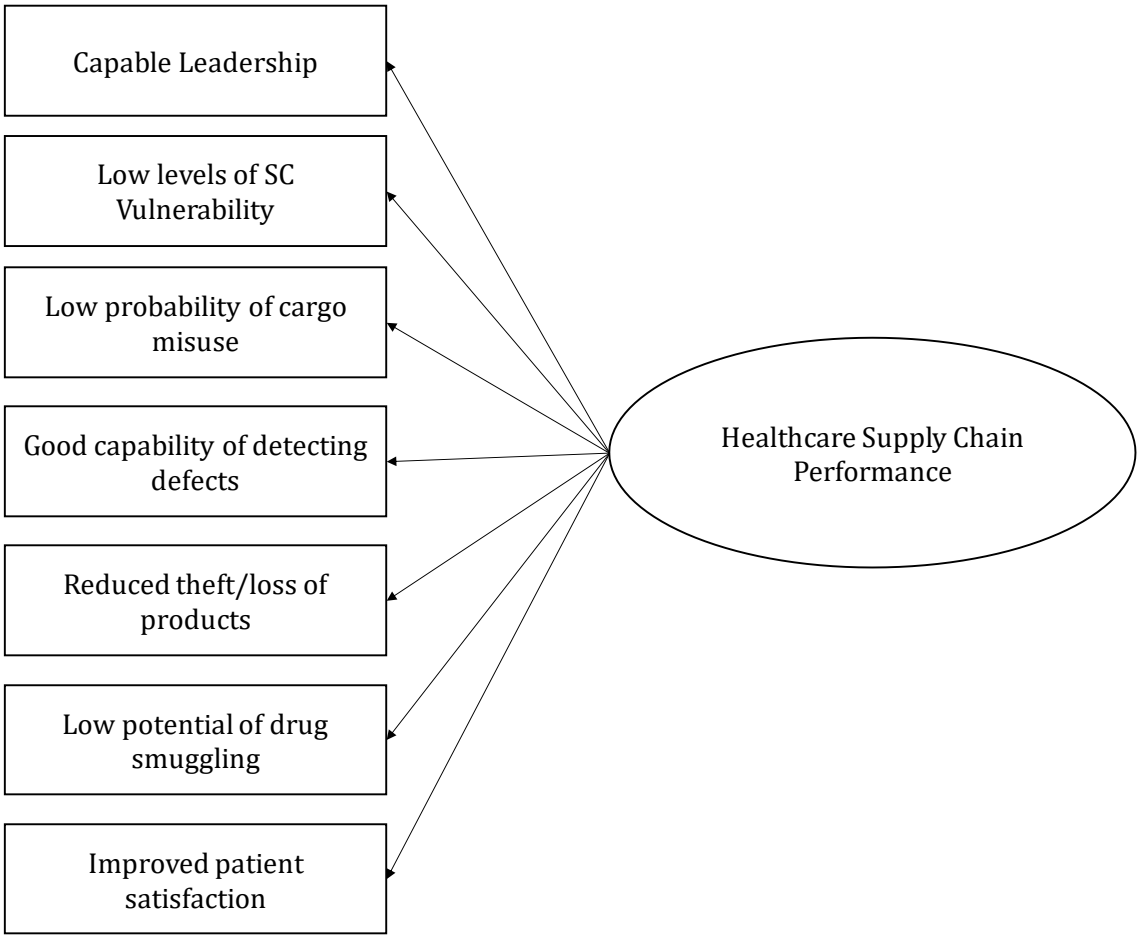



**Figure 41** - Healthcare Supply Chain Performance factor

### 6.8. Framework for Healthcare Supply Chain Management analysis

Based on the literature, the framework for the HCSCRM (Figure 42) analysis includes: antecedents of HCSCRM (RID, RAS, RMI and SCI); mediators of HCSCRM (HCSCRes and HCSC 4.0); and consequences of SCRM (HCSC Performance), which expresses the theoretical propositions of influence among the constructs.

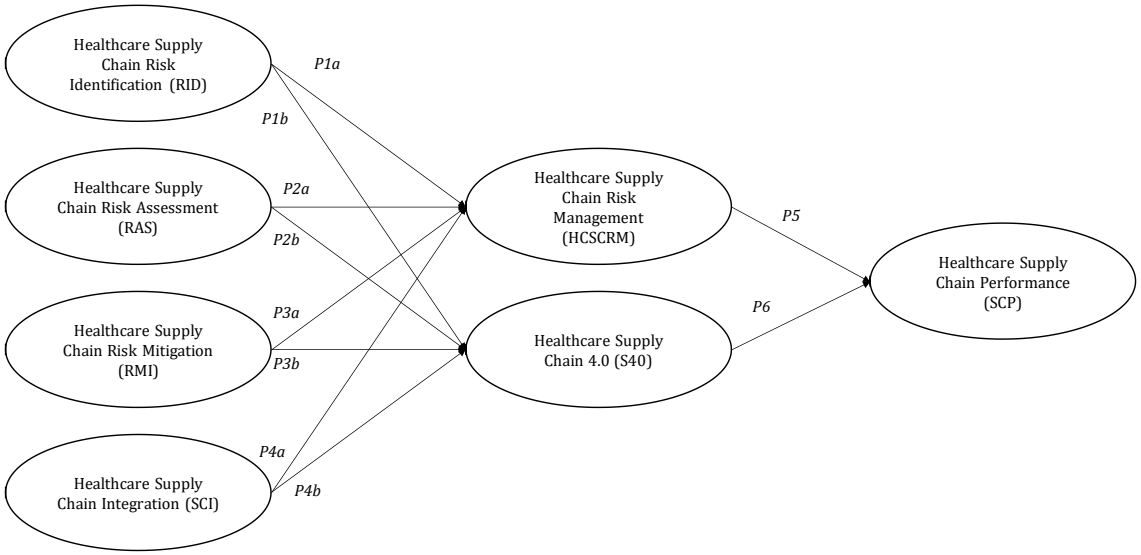



**Figure 42** - Framework for Healthcare Supply Chain Resilience analysis

### 6.9. P1 – Healthcare Supply Chain Risk Identification Drivers

Risk identification is the first step in the SCRM process, it involves the identification of risk types, factors or both (Ho et al., 2015) and is fundamental to obtain SCRM (Kwak et al. 2018). Risk identification involves a comprehensive and structured determination of potential SC risks associated with the given problem (Tummala and Schoenherr, 2011). To identify and classify risks according to their nature is an essential task before performing risk analysis and developing control strategies (Narasimhan and Talluri, 2009). Risks must be previously identified and mitigated before these issues worsen or potentially cause more harm (Vanvactor, 2016). The identification step must occur before the disruption happens, allowing managers to proactively avoid the impacts of the disruption (Craighead et al., 2007).

The initial stage of risk management is to identify risks that can influence supply chain operations directly or indirectly (Waters, 2011). Risk identification is the first step to deal with SC risks and will trigger all other risk management actions. HCSC have specific risks that have not yet been systematically mapped, therefore, RID applied to HCSC is crucial. Consequently, the first proposition suggests the existence of a positive relationship between RID and the mediators (RES and S40).

P1a. The RID positively influences RES

P1b. The RID positively influences S40

### 6.10. P2 – Healthcare Supply Chain Risk Assessment Drivers

Usually, most elements in risk assessment process are intangible, due to this subjectivity, evaluating multiple supply chain risks together becomes increasingly difficulty (Dong and Cooper, 2016). RAS is concerned with the determination of the likelihood of each risk factor Uncertainties can be assessed by objective information, and probability distributions for relevant SC risks or consequences can be derived (Tummala and Schoenherr, 2011). Most of researchers did not prioritize nor quantify the negative impact of neither risk types nor risk factors (Ho et al., 2015).

Risk Assessment is an essential phase to decide which risks to prioritize. It helps answering questions like: “Which are the most relevant risks concerning SC automation? Initial investment? Unqualified Workforce?”. Supply chain vulnerability identification and evaluation are extremely important to mitigate the supply chain risk (Liu et al., 2016).

Understanding supply chain vulnerability allows better decision-making process regarding risk exposure (Wagner and Bode, 2008). The understanding of correct Risk Assessment implies in understanding that overestimating information based on laboratory data can result in a misguided, misdiagnosis supply chain risks (Vanvactor, 2016). Risk assessment is the probability of an event occurring and the significance of the consequences (Ho et al., 2015). Blackhurst et al. (2008) affirm risk assessment must rely upon selection and definition of the categories to be weighted, compared and quantified.

The prioritization is a part of the Assessment and includes a prioritization process in which the risks with the greatest potential loss (or impact) and the greatest probability of occurring are handled first, and risks with a lower potential loss and lower probability of occurrence are handled in descending order (Ekwall et al., 2017).

Risk assessment is vital seen that organizations still have problems in forming a holistic view, and clear overestimations as well as underestimations concerning the risk impact of their processes (Vilko and Hallikas, 2012). Therefore, the second proposition suggests the existence of a positive relationship between RAS and the mediators.

P2a. The RAS positively influences RES

P2b. The RAS positively influences S40

### 6.11. P3 – Healthcare Supply Chain Risk Mitigation Drivers

The risk mitigation and contingency plans component involves the development of risk response action plans to contain and control the risks Tummala and Schoenherr (2011). Supply chain professionals must try to avoid a uniform response for every crisis (Vanvactor, 2016). Since it is not feasible and practical to develop mitigation and prevention strategies for every risk identified, risk-planning begins with the examination of the costs required to implement each preventive action to contain and manage the identified SC risks (Tummala and Schoenherr, 2011). Resilience is an outcome related to how people consider mitigating risks versus attempting to prevent them from ever occurring (Vanvactor, 2016).

Prior to risk mitigation, is essential that the risks are identified and properly assessed given that supply chain risk can be affected by multiple different sources and a firm’s supply chain risk mitigation strategy should be tailored to deal with the characteristics of risk contexts (Chang et al., 2015). Evaluating risk probability and severity is important for assessing appropriate supply chain risk mitigation strategy risk contexts can determine appropriate approaches for mitigation (Chang et al., 2015).

To manage the forms of risk that a SC is exposed to, companies are increasingly investing in risk management tools such as mitigation practices and contingency planning

(Ellis et al., 2011; Wiengarten et al., 2016). In this sense, the third proposition implies in a positive relation between RMI and the mediators.

P3a. The RMI positively influences HCSCRM

P3b. The RMI positively influences S40

### 6.12. P4 – Healthcare Supply Chain Integration Drivers

Supply Chain Integration includes processes that allow firms achieving efficiency through collaborative information exchange and coordination between internal activities and external partners (Ellinger et al., 2015). The limited information sharing, and collaboration limit the visibility of risks to some practitioners generating the need to provide a more holistic view by studying the processes involved as an integrated system (Vilko and Hallikas, 2012). Tang (2006) defines SCRM as the management of supply chain risks through coordination or collaboration among the supply chain partners to ensure profitability and continuity, nevertheless, the author understands that collaboration and coordination are premises for SCRM. Supply Chain Integration is being a response that companies are developing to manage an increased level of complexity (Wiengarten et al., 2016).

A lot has been discussed concerning risk identification, assessment and mitigation in SC-level. Nevertheless, if the SC is supposed to function as a one unique body there is unequivocal need of supply chain integration, given that the risks impact each tier in a very different way, making the risk prioritization and mitigation plans very different in each tier. Supply chain integration has been identified as a key practice to manage supply chains and achieve superior performance (Wiengarten et al., 2016). The tighter the Supply Chain integration, the better the performance (Kim, 2009; Wiengarten et al., 2016). The integration of internal and external processes with suppliers, customers, and functional areas generates competitive advantage (Ellinger et al., 2015). An important premise of SCI is that cross-functional and inter-organizational knowledge and information sharing improves performance (Ellinger et al., 2015). Prior to process automation, it is crucial that the processes are already clearly mapped, or the automation will accelerate low value-

added processes that could even be discontinued.

SCRM requires supply chain members to work to a single plan (Christopher and Lee 2004) Thus, SCRM is strongly supported by intra-firm and inter-firm processes to mitigate the effects of SC disruptions (Ellinger et al., 2015). In this sense, proposition 4 implies that there is a positive relationship between SCI and the mediators.

P4a. The SCI positively influences HCSCRM

P4b. The SCI positively influences S40

### 6.13. P5 – Healthcare Supply Chain Resilience Drivers

Literature provides many different definitions of Supply Chain Resilience, nevertheless, they converge in one concept: Resilience is the capability that a SC has of going through a disturbance and return to the former performance level or even a improved level (Carvalho et al, 2012). Supply chain risks often lead to supply chain disruptions. Developing resilience, through SCRM, is a way of protecting the SC or to help the SC to regain a performance level as quickly as possible (Blackhurst et al., 2018). Given the increase of global competition and Supply chains complexity, the likelihood of not achieving the desired supply chain (SC) performance increases, mainly due to the risk of SC failures (Tummala and Schoenherr, 2011). Given the level of connections that a SC has, it is very unlikely that a SC sustain competitivity with high performance if it lacks resilience. There are evidences attesting the dreadful effects of supply chain disruptions and ripple effects (Ivanov et al., 2018) on operational and financial performance with both immediate and long-term effects (Deane et al., 2009; Blackhurst et al., 2011).

Lack of supply chain risk management may result in economic and financial losses, reductions in product quality, delivery delays and loss of reputation in the eyes of customers and suppliers making risk management a core issue in planning and control of any organization (Hendricks and Singhal, 2003; Finch, 2004). Therefore, proposition 5 implies that there is a positive relationship between HCSCRM and SCP. SCRM effectively influences Supply Chain Performance (Wagner and Bode, 2008)

P5. The HCSCRM positively influences SCP

## 6.14. P6 – Healthcare Supply Chain 4.0

Disruptive innovations such as digitalization and Industry 4.0 influence the development of new paradigms, principles and models in supply chain management (SCM) (Ivanov et al., 2018). Since digital technology influences SCM, and SCM is influenced by disruption risks, it is logical to expect interrelations between digital technology and SC disruption risk management (Ivanov et al., 2018).

Industry 4.0, SC 4.0 are concepts that still require more formal definition and are becoming a Panacea. Although a Fully automated SC can generate efficiency and minimize several risks, it may as well generate others. For example, charging the devices (battery autonomy). Additionally, it requires a considerable amount of initial investment, high qualified workforce, among other features.

As a clear example of 4.0 technology applied to HCSC, Tseng et al. (2018) suggest a blockchain as the base of the data flow of drugs to create transparent drug transaction data and improve the SC performance. Software, hardware and Radio Frequency Identification (RFID) technology improve the track and trace of drugs in the supply chain and are considered relatively mature and easy to adopt (Mackey, 2017)

Blockchain technology could create an encrypted, distributed, and immutable data ledger with possibility of being applied in the healthcare sector, including sharing of information with stakeholders while ensuring data integrity and protecting patient privacy (Tseng et al., 2013). Literature still lacks studies concerning more 4.0 technologies applied in HCSC although there is some evidence. In this sense, Proposition 6 suggests a positive relationship between HCSC40 and SCP.

P6. The S40 positively influences SCP

## 6.15. Qualitative interviews

This chapter built a framework that leads to HCSCRes and Leads to HCSC Performance. PROF A highlights the importance of a critical item list. In the PrHN the items with coverage equal or smaller than 7 days are flagged as critical. The team keeps

a continuous work of homologating products even if they are not in stock to build a substitute catalogue. This work is sustained by the competence of pharmacists and nurses which attest the quality. Nevertheless, the ideal would be that such standardization to be done in a network level, nowadays, it is still done locally.

The network already has a medicine unitarization machine, which can serve at about 80% of hospitals demands. The machine can automatically cut and pack pills. In terms of automation, they have KPIs automated via MS Power BI, which allows information to flow faster along the supply chain. In terms of sustainable risks mitigation, the PrHN has 100% of its hospitals in compliance with the law. The manager highlights the importance of having one employee to personally inspect the waste disposal. If the third party contracted to dispose the waste does not comply with the law the hospital network is still legally accused. The cardboard boxes (containing mainly food) is alto a sustainability problem in healthcare units. The manager highlights that all the cardboard boxes stay in the warehouse and in the nutrition department the food supplies are disposed as if they were in a supermarket.

PROF B shows the PuHN side and the management differences, in the public sector procurement has severe regulation. The manager affirms that an essential risk mitigation strategy to comprise with the law is to map and standardize the demand flows and establishing an annual procurement calendar organizing all demands. If the public managers strictly comply with the law, the private suppliers also start to have fairer prices and create a trend of reducing costs in this chain. Respecting the combined payment dates with suppliers is also crucial, consecutive delays in payment generate mistrust by the suppliers and prices raise. The CE department plays a major role in costs mitigation, avoiding hospitals insolvency, the manager describes an example where a contract of about 150,000 BRL were cut to 50,000 BRL due to a detailed CE study about the lung ventilators maintenance contracts. The CE department can also precisely tell when a new equipment must be bought. Nevertheless, if a partnership culture with the suppliers could be created, the SC would be much more benefited.

PROF B.1 affirm that the network should always incorporate new technologies, nevertheless, it should follow some logical steps: i) Professional training before using the new equipment, ii) Test phase, to evaluate performance, quality and the benefits, iii) approving or not the equipment, based on the test phase and benefits evaluation.

PROF F.1 shows the vision of an OEM and highlights the importance of constantly monitor possible changes in product forecast. In this case a long-term solid relation with the suppliers is essential to obtain flexibility. Such relation must be tailored with more the one supplier to mitigate supply risks. This integration and relationship must be supported by integrated systems which facilitate the demand understanding and lead times, avoiding excessive stock, delays and guarantees that the right quantities of the right products are bought.

PROF H.1 also highlights the crucial importance of Supplier-buyer integration to avoid supply problems. When a "win-win" relationship is developed, the negotiation is easier and avoid SC disruptions.

## 6.16. Discussion

Companies must reinvent themselves, traditional retailers are investing heavily in technology and broadening their scope offering technological solutions. To obtain maximum profit from a process automation, it is imperative that the process passes through an optimization process (or be discontinued if the diagnosis shows it does not add value). If the machine or the process are defective, IoT devices may not function or provide low-quality imprecise data, in this sense, it is reasonable to combine automation with traditional process improvement methodologies such as Lean/Six-Sigma and Business Process Management. Concerning healthcare organizations, there are some extra difficulties. For example, healthcare professionals do not have training in management or risk mitigation techniques, moreover, concepts like Lean, Six-Sigma, Business Process Management and efficiency are often seen as precariousness of work and associated with job losses, which characterizes a cultural barrier not easy to transpose. Companies should not only develop isolated risk management initiatives and suppose that the SC is profiting from them. There should be a robust SC-level risk mitigation culture which permeates the entire chain, developing strategic partnerships with vendors searching where are the opportunities of cutting costs. Concerning process automation and IoT devices installation, The OEM must analyze whether is better to buy new machinery or adapt the existing ones to the IoT devices.

In the next 10 years, businesses will have to reinvent themselves, reaching new quality

levels, while reducing costs to provide healthcare to an increasingly elderly population, providing mass healthcare. Human resources will have to adapt to these changes and training programs will have to update its syllabus to include at least the basics of how to deal with such technologies. Supply Chain Integration will increasingly become a mandatory feature. If an OEM is fully automated but the systems do not couple with the wholesaler or the retailer, the benefits of such automation will be reduced or in last analysis will not even be noted. To fully reach SCRM is essential at one hand to identify, assess and mitigate risks and in the other hand to increase Supply Chain Resilience.
Industry 4.0 is still a new concept that need further definition. The lack of papers applying 4.0 techniques to healthcare organization makes it difficult to measure the benefits (or hazards), therefore it needs empirical validation. Concerning HCSC automation, is it always viable? Which processes can be automated, and which ones should remain strictly made by humans? What is the human factor role in a Hospital 4.0? These questions still require validation.

There is also possibility of medical impacts on patients, therefore, should exist a multidisciplinary team including engineers and doctors to measure the impacts for the treatment that the patient must deal with a machine.

Which risks a fully automated SC could mitigate and which risks may be generated it is still unclear. Many papers converge to a framework that include Identification, Assessment e Mitigation as a way of building SCRM, nevertheless, what is the importance of each phase and the importance of the variables that build the constructs?

Papers usually do not formally highlight integration in the Identification, Assessment e Mitigation framework, nevertheless, integration is essential to mitigate, for example, the bullwhip effect.

Literature still does not discuss enough whether a risk mitigation strategy can become a risk itself. For example, the safety stock. It can prevent rupture and delivery fails, nevertheless, literature lacks to mention the risks of maintaining too much safety stock.

Studies in SCRM are increasing in both quantity and quality, nevertheless, there are still not many case-studies about risk culture implementation in SC-level. Moreover, risk management approaches are either too general or require pieces of information not

regularly recorded by organizations. (Cagliano et al., 2012)

## 6.17. Conclusions, contributions, limitations and future research

This chapter had the objective of conducting a literature review, which revealed the factors that influence HCSCRes considering the antecedents, mediators and consequences of HCSCRes. The main theoretical contribution of this paper includes the framework presented in Figure 10 for further empirical validation. As a secondary contribution, the framework generates a discussion considering the healthcare chain and its relationship with new concepts such as the Industry 4.0. Although the framework is motivated by a Healthcare Supply Chain Analysis, it is generic enough to be adapted to other segments. As a research limitation, the results obtained are product of the method of choice, which include database selection and the stipulated period. As the research shows, Identify, Assess and mitigate risks seems to be a well consolidated pathway to Manage Supply chain risks, generating supply chain resilience and obtaining supply chain performance. The research results allowed the formulation of new research questions (NRQ):

NRQ1 – What are the statistical correlation between the constructs?

NRQ2 – Which variables are more important to obtain HCSCRes?

However, this framework is a starting point which can be an important tool to help researchers formulate mathematical model as well as empirical validation.

# 7. General Discussion, Conclusion and Further Research

The general objective of this thesis was to construct a conceptual framework that address resilience to the Healthcare Supply Chain through Supply Chain Risk Management. The general objective was divided into: i) Present a formal definition of Healthcare Supply Chain Risk Management, ii) Propose a framework that is generic enough to apply SCRM to Healthcare Supply Chains, iii) Identify Healthcare Supply Chain Risks and validate via interviews. with Healthcare Supply Chain professionals, iv) Identify KPIs present in the literature and mentioned by the interviewed professionals, v) Propose a framework to generate resilience in Healthcare Supply Chains and analyze the strategies used by the interviewed professionals. In this sense are addressed the following research questions:

RQ1 – Which techniques have been employed by authors in the literature to perform SCRM?

RQ2 – Which market segments are being approached by authors in the SCRM literature?

RQ3 – What are the research gaps/unexplored opportunities respective to applying SCRM in Healthcare organizations?

RQ4 – Which is the definition of Healthcare Supply Chain Risk Management?

RQ5 – What are the more relevant Risks to the Healthcare Supply Chains?

RQ6 – Which metrics and indicators can be used to measure Healthcare Supply Chain Risks?

RQ7 – Which techniques can be used to mitigate SC Risks in Healthcare?

RQ1, RQ2 and RQ3 were answered by chapter 3 and the bibliometric analysis. The most popular techniques to approach SCRM included Mathematical Programming, Simulations and Structural Equation Modeling. The papers mainly concentrate in the automotive segment, food industry and agriculture. There were not found any studies that systematically mapped a HCSC, so, were created a category that included Pharmaceutical and Healthcare segments and were not located any studies about distributors or OEM's suppliers. In this sense there is a gap of studies in this area, which creates opportunities of exploring this supply chain. The RQ4 was addressed by chapter 4 via an extensive

literature review, generating the definition: Healthcare Supply Chain Risk Management is *the Process of identify, Assess, Mitigate and Monitor Supply Chain Risks Aiming to provide the best quality of care through SC processes integration, with sustainable profit avoiding supply shortage, Valuing HC and Clinical Engineering professionals, having in consideration that local actions may generate hazards to all HCSC generating SCREs and HRHCN.* Chapter 4 also addressed RQ5 by creating table 9, which summarizes the risks found in the literature and table 22 shows which risks are validated by which HCSC professional. The RQ6 is addressed by chapter 6 which systematically mapped KPI, validated and validated the list with HC experts. The answer to RQ7 was given by chapter 7, in which a complete framework was constructed based in prepositions found in the literature. Specific mitigation strategies were identified via qualitative interviews with HCSC professionals. First, this thesis can serve as a guide to address SCRM and SCRes in all HCSC as it provides a list of risks, techniques, measuring KPIs and mitigation strategies that can serve as an initial benchmarking to risk initiatives in a Supply Chain – level. An extensive systematic literature review was conducted and there were not found any similar study (That built a framework to address HC SCRM and approached it with solid literature basis and HC professional's validation), in this sense it can be considered relevant. This thesis generated as results: i) A SLR methodology based on a known protocol and well-cited review papers, ii) a bibliometric analysis conducted using the package Bibliometrix (present in R software) and also an artisanal approach that included a classification of each paper, iii) the bibliometric analysis revealed which papers are the most cited, the most relevant authors and other important statistics that help to set a panorama of this subject, iv) The framework proposed was run, including, risk identification, where the risks were mapped and validated by HCSC professional and a formal definition of HC SCRM was proposed, v) The risk assessment topic was assessed via KPI mapping supported by HCSC professionals, vi) A complete SCRM framework was addressed via SLR and a questionnaire was prepared for further application and robust statistical analysis.

As further studies opportunities, the application of the questionnaire prepared to confirm or to reject the hypothesis raised in chapter 7, as well as a broader KPI list validation (present in chapter 6). The KPI list in a larger sample to statistically affirm which KPI are more relevant to each HCSC organization. The next step would be to test in a specific

case study and see whether is possible to automate the whole framework.

## References

ABDULSALAM, Y.; GOPALAKRISHNAN, M.; MALTZ, A.; SCHNELLER, E. Health Care Matters: Rs in and of the Health Sector. **Journal of Business Logistics**, v.36, n.4, p. 335–339, 2015.

ABOLGHASEMI, M.; KHODAKARAMI, V.; TEHRANIFARD, H. A new approach for supply chain risk management: Mapping SCOR into Bayesian network. **Journal of Industrial Engineering and Management**, v.8, n.1, p. 280–302, 2015.

ABOUMATAR, H.J.; WEAVER, S.J.; REES, D.; ROSEN, M.A.; SAWYER, M.D.; PRONOVOST, B. J. Towards high-reliability organising in healthcare: A strategy for building organisational capacity. **BMJ Quality and Safety**, v.26, n.8, p. 663–670, 2017. doi:10.1136/bmjqs-2016-006240.

ABUKHOUSA, E.; AL-JAROODI, J.; LAZAROVA-MOLNAR, S; MOHAMED, N. Simulation and modeling efforts to support decision making in healthcare supply chain management. **The Scientific World Journal**, v. 2014, article ID 354246, 2014. http://dx.doi.org/ 10.1155/2014/354246.

AFSHAN, N.; SINDHUJA J. Supply chain integration in healthcare industry in India: challenges and opportunities. **Global Business Advancement**, v. 8, n. 4, 2015. https://doi.org/10.1504/JGBA.2015.074029.

AGUILAR-ESCOBAR, V. G.; GARRIDO-VEGA, P. Gestión Lean en logística de hospitales: estudio de un caso. **Revista de Calidad Asistencial,** v. 28, n.1, p. 42-49, 2013.

ALI, Imran; NAGALINGAM, Sev; GURD, Bruce. A resilience model for cold chain logistics of perishable products. **The International Journal of Logistics Management**, v. 29, n.3, p. 922-941, 2018. https://doi.org/10.1108/ IJLM-06-2017-0147.

AL-KATHEERI, H.; EL-JARDAL, F.; ATAYA, N.; ABDULLA SALEM, N.; ABBAS, BADR; JAMAL, D. Contractual health services performance agreements for responsive health systems: from conception to implementation in the case of Qatar. **International Journal for Quality in Health Care**, 2018, v.30, n.3, p. 219–226. doi: 10.1093/intqhc/mzy006.

AL OWAD, A.; KARIM, M. A.; LIN, M. Integrated Lean Six Sigma Approach for Patient Flow Improvement in Hospital Emergency Department. **Advanced Materials Reserarch**, v. 834-836, n. 19, p. 1893-1902, 2013.

ANCARANI, A.; DI MAURO, C. The human side of supply chains: a behavioural perspective of supply chain risk management. In: EVANGELISTA, P.; MCKINNON,

A.; SWEENEY, E.; ESPOSITO, E. **Supply Chain Innovation for Competing in Highly Dynamic Markets: Challenges and Solutions**. ICI Global, Hershey (USA). 2011.

ANCARANI, Alessandro; DI MAURO, Carmela; GITTO, Simone; MANCUSO, Paolo; AYACH, Ali.Technology acquisition and efficiency in Dubai hospitals. **Technological Forecasting & Social Change**, v. 113, p. 475–485, 2016. https://doi.org/10.1016/j.techfore.2016.07.010.

ANTONELLI, D.; BRUNO, G. Application of Process Mining and Semantic Structuring Towards a Lean Healthcare Network. **Advances in Information and Communication Technology**, v. 463, p. 497-508, 2015.

AOUN, M.; HASNAN, N. Lean production and TQM: Complementary or Contradictory Driving Forces of Innovation Performance?. **International Journal of Innovation Science**, v.5, n. 4, p. 237–252, 2013. doi: 10.1260/1757-2223.5.4.237.

APICS. **SCOR 12.0** Supply Chain Operations Reference Model. Chicago, 2017.

ARIA, M.; CUCCURULLO, C. Bibliometrix: An R-tool for comprehensive science mapping analysis. **Journal of Informetrics**, v.11, n.4, p. 959–975, 2017.

ARNABOLDI, M.; LAPSLEY, I.; STECCOLINI, I. Performance Management in the Public Sector: The Ultimate Challenge. **International Journal of Public Sector Management**, v. 31, n. 1, p. 1-22, 2015.

ARSHOFF, Larry; HENSHALL, Chris; JUZWISHIN, Don; RACETTE, Ray. Procurement change in Canada: An opportunity for improving system performance. **Healthcare Management Forum**, v. 25, n. 2, p.66-69, 2012. DOI: 10.1016/j.hcmf.2012.03.002.

ARVAN, Meysam; TAVAKKOLI-MOGHADDAMA, Reza; ABDOLLAHI, Mohammad. Designing a bi-objective, multi-product supply chain network for blood supply. **Uncertain Supply Chain Management**, v. 3 , n. 2015, p. 57–68. DOI: 10.5267/j.uscm.2014.8.004.

ASKFORS, Ylva; FORNSTEDT, Helena. The clash of managerial and professional logics in public procurement: Implications for innovation in the health-care sector. **Scandinavian Journal of Management**, v. 34, n. 1, p. 78–90, 2018.

AYUSO, S.; ROCA, M.; COLOMÉ, R. The role of collaboration in supply chain resilience. **Supply Chain Management: An International Journal**, v. 14, n. 2, p. 75–86, 2009.

AWOFISAYO, Sunday Olajide; JIMMY, Uwah Aniefiok; EYEN, Nse Okon. Procurement of prescription only medicine (pom); sources, pattern and appropriateness. **Journal of Applied Pharmaceutical Science**, v.1, n. 7, p. 46-49, 2011.

AZADEH, A.; HAGHIGHI, S.M.; GAEINI, Z.; SHABANPOUR, N. Optimization of

healthcare supply chain in context of macro ergonomics factors by a unique mathematical programming approach. **Appl Ergon, v.** 55, p. 46–55, 2016.

AZEVEDO, S. G.; CARVALHO, H.; CRUZ - MACHADO, V.; GRILO, F. The influence of agile and resilient practices on supply chain performance: an innovative conceptual model proposal. In: BLECKER, T.; KERSTEN, W.; LUTHJE, C. **Innovative Process Optimization Methods in Logistics: Emerging Trends, Concepts and Technologies**. Erich Schmidt Verlag GmbH and Co. KG, Hamburg, Germany, 2010.

BAHENSKY, J. A.; ROE, J.; BOLTON, R. Lean sigma-will it work for healthcare? **Journal of healthcare information management: JHIM**, v. 19, n. 1, p. 39-44, 2005.

BAKER, P. An exploratory framework of the role of inventory and warehousing in international supply chains. **The International Journal of Logistics Management**, v. 18, n. 1, p. 64-80, 2007.

BAKER, S. B.; XIANG, W.; ATKINSON, I. Internet of Things for Smart Healthcare: Technologies, Challenges, and Opportunities. **IEEE Access**, v. 5, p. 26521-26544. DOI: 10.1109/ACCESS.2017.2775180.

BALCÁZAR-CAMACHO, Delio Alexander; LÓPEZ-BELLO, Cesar Amílcar; ADARME-JAIMES, Wilson. Strategic guidelines for supply chain coordination in healthcare and a mathematical model as a proposed mechanism for the measurement of coordination effects. **DYNA**, v. 83, n.197, p. 203-211, 2016. http://dx.doi.org/10.15446/dyna.v83n197.55596.

BANDALY, D.; SHANKER, L.; KAHYAOGLU, Y.; SATIR, A. Supply chain risk management – II: A review of operational, financial and integrated approaches. **Risk Management**, v. 15, n. 1, p. 1–31, 2013.

BARACH, P.; KLEINMAN, L. C. Measuring and improving comprehensive pediatric cardiac care: Learning from continuous quality improvement methods and tools. **Progress in Pediatric Cardiology**, v. 48, p. 82-92, 2018.

BARDIN, L. **Análise de conteúdo**. 3 ed. Lisboa: Edições 70. 2004.

BARROSO, A. P.; MACHADO, V. H.; MACHADO, V. C. The Resilience Paradigm in the Supply Chain Management: A Case Study In: IEEE International Conference on Industrial Engineering and Engineering Management, 2010, Macao **Anais eletrônicos**…Acesso em: 13 de ago. 2018.

BEKTEMUR, Guven; MUZOGLU, Nedim; MEHMET, Ali Arici; KARAASLAN, Melike Kaya. Cost analysis of medical device spare parts Pakistan. **Journal of Medical Sciences**, v. 34, n.2, p. 472-477. doi: 10.12669/pjms.342.14245.

BENDAVID, Y; BOECK, H.; PHILIPPE, R. Redesigning the replenishment process of medical supplies in hospitals with RFID. **Bus Process Manag J**, v.16, n. 6, p. 991–1013, 2010. https://doi.org/10.1108/14637151011093035.

BENDUL, J. C.; SKORNA, A. C. H. Exploring impact factors of shippers' risk prevention activities: A European survey in transportation. **Transportation Research Part E: Logistics and Transportation Review**, v. 90, p. 206–223, 2016.

BENTLEY, T.G.; EFFROS R.M.; PALAR, K.; KEELER, E.B. Waste in the US health care system: a conceptual framework. **The Milbank Quarterly**, v. 86, n. 4, p. 629–659, 2008.

BERTHOD, Olivier; GROTHE-HAMMER, Michael; MÜLLER-SEITZ, Gordon; RAAB, Jörg; SYDOW, Jörg. From High-Reliability Organizations to High- Reliability Networks: The Dynamics of Network Governance in the Face of Emergency. **Journal of Public Administration Research and Theory**, v. 27, n.2, p. 352-371, 2016. https://doi.org/10.1093/jopart/muw050.

BEVILACQUA, Maurizio; MAZZUTO, Giovanni; PACIAROTTI, Claudia. A combined IDEF0 and FMEA approach to healthcare management reengineering. **Int. J. Procurement Management**, v. 8, n. 1/2, 2015.

BHAMRA, R.; DANI, S.; BURNARD, K. Resilience: The concept, a literature review and future directions. **International Journal of Production Research**, v. 49, n .18, p. 5375–5393, 2011.

BHAKOO, Vikram; CHOI, Thomas. The iron cage exposed: Institutional pressures and heterogeneity across the healthcare supply chain. **Journal of Operations Management**, v. 31, p. 432–449, 2013.

BHAT, S.; GIJO, E. V.; JNANESH, N. A., Application of Lean Six Sigma methodology in the registration process of a hospital. **International Journal of Productivity and Performance Management**, v. 63, n. 5, p. 613-643, 2014.

BLACKHURST, Jennifer V; SCHEIBE, Kevin P.; JOHNSON, Danny J. Supplier risk assessment and monitoring for the automotive industry. **International Journal of Physical Distribution & Logistics Management**, v. 38, n. 2, p. 143 – 165, 2008.

BLACKHURST, J.; DUNN, K.S.; CRAIGHEAD, C.W. An empirically derived framework of global supply resiliency. **J. Bus. Logist**, v. 32, n. 4, p. 374–391, 2011.

BLACKHURST, Jennifer; RUNGTUSANATHAMB, M. Johnny; SCHEIBEC, Kevin; AMBULKARD, Saurabh. Supply chain vulnerability assessment: A network based visualization and clustering analysis approach. **Journal of Purchasing and Supply Management**, v. 24, n.1, p. 21–30, 2018. https://doi.org/10.1016/j.pursup.2017.10.004.

BONILLA, C.; PAWLICKI, T.; PERRY, L.; WESSELINK, B. Radiation oncology: Lean Six Sigma project selection based on patient and staff input into a modified quality function deployment. **International Journal of Six Sigma and Competitive Advantage**, v. 4, n. 3, p. 196-208, 2008.

BORELLI, G.; ORRÙ, P.F.; ZEDDA, F. Performance analysis of a healthcare supply chain for RFID-enabled process reengineering. **International Journal of Procurement Management**, v. 8, n. 1/2, p. 169-181, 2015.

https://doi.org/10.1504/IJPM.2015.066293.

BOWERSOX, D. J.; STANK, T. P.; DAUGHERTY, P. Lean Launch: Managing Product Introduction Risk Through Response Based Logistics. **Journal of Product Innovation Management**, v. 16, n. 6, p. 557–568, 1999.

BOYLE, F.; SHERMAN, D. Scopus: The product and its development. **The Serials Librarian**, v. 49, n. 3, p. 147-153, 2006.

BREEN, Liz; CRAWFORD, Helen. Improving the pharmaceutical supply chain: Assessing the reality of equality through ecommerce application in hospital pharmacy. **International Journal of Quality & Reliability Management**, v. 22, n. 6, p.572-590, 2005. https://doi.org/10.1108/02656710510604890.

BRASIL, IBGE. **Produto Interno Bruto**, disponível em: https://seriesestatisticas.ibge.gov.br. Acesso em: 13 de ago. 2018.

CAGLIANO, Anna Corinna; GRIMALDI, Sabrina; RAFELE, Carlo. Paving the Way for Warehouse Centralization in Healthcare: A Preliminary Assessment Approach. **American Journal of Applied Sciences**, v.13, n.5, p. 490-500, 2016.

CALIL, S.J.; RAMÍREZ, E.F.F. Engenharia clinica: Parte I - Origens (1942-1996). **Semina: Ci. Exatas/ Tecnol**. Londrina, v. 21, n. 4, p. 27-33, 2000.

CALLEA, Giuditta; ARMENI, Patrizio; MARSILIO, Marta; JOMMI, Claudio; TARRICONE, Rosanna. The impact of HTA and procurement practices on the selection and prices of medical devices. **Social Science & Medicine,** v**.** 174, p. 89-95, 2017.

CAMPLING, Natasha C.; PITTS, David G.; KNIGHT, Paul V.; ASPINALL, Richard. A qualitative analysis of the effectiveness of telehealthcare devices (ii) barriers to uptake of telehealthcare devices. **Health Services Research**, v. 17, n.1, p.1-9, 2017.

CAI, J.; LIU, X.; XIAO, Z.; LIU, J. Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment. **Decision Support Systems**, v. 46, n. 2, p. 512-521, 2009.

CANTOR, E. D.; BLACKHURST, J.; PAN, M.; CRUM, M. Examining the role of stakeholder pressure and knowledge management on supply chain risk and demand responsiveness. **International Journal of Logistics Management**, v. 25, n. 1, p. 202–223, 2014.

CARBONEAU, C.; BENGE, E.; JACO, M. T.; ROBINSON, M. A. Lean Six Sigma team increases hand hygiene compliance and reduces hospital-acquired MRSA infections by 51%. **Journal for healthcare quality**, v. 32, n. 4, p. 61-70, 2010.

CARDOSO, S. R.; BARBOSA-PÓVOA N, Ana Paula; RELVAS, Susana; NOVAIS, Augusto Q. Resilience metrics in the assessment of complex supply chains performance operating under demand uncertainty. **Omega**, v. 56, p. 53–73, 2015. doi: 10.1016/j.omega.2015.03.008.

CARNEIRO, M. C.; RIBAS, G. P.; HAMACHER, S. Risk management in the oil supply chain: A CVaR approach. **Industrial and Engineering Chemistry Research**, v. 49, n. 7, p. 3286-3294, 2010.

CARPENTER, S.; WALKER, B.; ANDERIES, J. M.; ABEL, N. From metaphor to measurement: resilience of what to what? **Ecosystems**, v. 4, n. 8, p. 765–781, 2001.

CARVALHO, H.; CRUZ MACHADO, V. Designing principles to create resilient supply chains. In: Proceedings of the 2007 industrial engineering research conference, 2007, Nashville. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

CARVALHO, H.; CRUZ-MACHADO, V.; TAVARES, J. G. A mapping framework for assessing Supply Chain resilience. **International Journal of Logistics Systems and Management**, v. 12, n. 3, p. 354-373, 2012.

CAVALCANTE, P. S.; ROSSANEIS, M. A.; HADDAD, M. C. L.; GABRIEL, C. S. Indicadores de qualidade utilizados no gerenciamento da assistência de enfermagem hospitalar. **Revista Enfermagem UERJ**, v. 23, n. 6, p. 787-793, 2015.

CAVALCANTE, Paloma de Souza; ROSSANEIS, Mariana Angela; HADDAD, Maria do Carmo Lourenço; GABRIEL, Carmen Silvia. Healthcare quality indicators used in hospital nursing care management. **Revista Enfermagem UERJ**, v. 23, n.6, p. 787-793, 2016.

CHADEGANI, A.; SALEHI, H.; YUNUS, M. M.; FARHADI, H.; FOOLADI, M.; FARHADI, M.; ALE EBRAHIM, N. A comparison between two main academic literature collections: Web of science and scopus databases. **Asian Social Science**, v. 9, n. 5, p. 18-26, 2013.

CHAE, Young M.; KIM, Hye S.; TARK, Kwan C.; PARK, Hyun J.; SEUNG, H. Ho. Analysis of healthcare quality indicator using data mining and decision support system. **Expert Systems with Applications**, v.24, n.2, p. 167–172, 2003. https://doi.org/10.1016/S0957-4174(02)00139-2.

CHAKRABORTY, S.; BHATTACHARYA, S.; DOBRZYKOWSKI, D. D. Impact of Supply Chain Collaboration on Value Co-creation and Firm Performance: A Healthcare Service Sector Perspective. **Procedia Economics and Finance,** v. 11, p. 676-694, 2014.

CHANDRA, C.; KACHHAL, S. Managing Health Care Supply Chain: Trends, Issues, and Solutions from a Logistics Perspective. In: Proceedings of the Sixteenth Annual Society of Health Systems Management Engineering Forum, 2004, Orlando. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

CHANG, W.; ELLINGER, A.E.; BLACKHURST, J. A contextual approach to supply chain risk mitigation. **International Journal of Logistics Management,** v.26, n.3, p. 642-656, 2015.

CHAUDHURI, Atanu; BOER, Harry; TARAN,Yariv. Supply chain integration, risk management and manufacturing flexibility. **International Journal of Operations & Production Management**, v. 38, n. 3, p. 690-712, 2018.

https://doi.org/10.1108/IJOPM-08-2015-0508.

CHATTERJEE, K.; KAR, S. Multi-criteria analysis of supply chain risk management using interval valued fuzzy TOPSIS. **Opsearch**, v. 53, n. 3, p. 474–499, 2016.

CHEN, X.; JING, P.; XI, Z. General Framework for Evaluation Supply Chain Resilience. In: ASME. International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Volume 2A: 42nd Design Automation Conference, 2016, Charlotte, **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

CHENG, S.; BAMFORD, D.; PAPALEXI, M.; DEHE, B. Improving access to health services – challenges in Lean application. **International Journal of Public Sector Management**, v. 28, n. 2, p. 121-135, 2015.

CHIARINI, Andrea; VAGNONI, Emidia. Environmental sustainability in European public healthcare: Could it just be a matter of leadership?. **Leadership in Health Services**, v. 29, n. 1, p.2-8, 2016. doi: 10.1108/LHS-10-2015-0035.

CHIARINI, Andrea; OPOKU, Alex; VAGNONI, Emidia. Public healthcare practices and criteria for a sustainable procurement: A comparative study between UK and Italy. **Journal of Cleaner Production**, v. 162, p. 391-399, 2017.

CHO, C. C.; CHIU, A.; HUANG, S.Y.; LIU, S.Z. Cost drivers for managing dialysis facilities in a large chain in Taiwan. **Management Decision**, 2018. https://doi.org/10.1108/MD-06-2017-0550.

CHONG, Alain Yee-Loong; LIU, Martin; LUO, Jun; KENG-BOON, Ooi. Predicting RFID adoption in healthcare supply chain from the perspectives of users. **Int. J. Production Economics,** v. 159, p. 66–75, 2015. https://doi.org/10.1016/j.ijpe.2014.09.034.

CHOWDHURY, M. M. H.; QUADDUS, M. Supply chain readiness , response and recovery for resilience Introduction. **Supply Chain Management: An International Journal**, v. 21, n. 6, p. 1–46, 2016.

CHRISTOPHER, M.; PECK, H. Building the resilient supply chain. **International Journal of Logistic Management**, v. 15, n. 2, p. 1–13, 2004.

CHRISTOPHER, Martin; LEE, Hau. Mitigating supply chain risk through improved confidence. **International Journal of Physical Distribution & Logistics Management**, v. 34, n. 5, p. 388 – 396, 2004.

COCHRANE, Bonnie S.; HAGINS JR, Mitch; PICCIANO, Gino; KING, John A.; MARSHALL, David A.; NELSON, Brian; DEAO, Craig. High reliability in healthcare: creating the culture and mindset for patient safety. **Healthcare Management Forum,** v.30, n.2, p. 61-68, 2017. https://doi.org/10.1177/0840470416689314.

COELHO, L. C.; FOLLMAN, N.; TABOADA, M. C. R. O impacto do compartilhamento de informações na redução do efeito chicote na cadeia de

abastecimento. **Revista Gestão & Produção**, v. 16, n. 4, p. 571-583, 2009.

COLEMAN, L. Frequency of Man-Made Disasters in the 20 th Century. **Journal of Contingencies and Crisis Management**, v. 14, n. 1, p. 3-11, 2006.

COLICCHIA, C.; DALLARI, F.; MELACINI, M. A simulation-based framework to evaluate strategies for managing global inbound supply risk. **International Journal of Logistics Research and Applications**, v. 14, n. 6, p. 371–384, 2011.

COLICCHIA, Claudia; STROZZI, Fernanda. Supply chain risk management: a new methodology for a systematic literature review. **Supply Chain Management: An International Journal**, v. 17, n 4, p. 403 – 418, 2012.

COOPER, M. C.; ELLRAM, L. M.; GARDNER, J. T.; HANKS, A. M. Meshing multiple alliances. **Journal of Business Logistics**, v. 18, n. 1, p. 67-89, 1997.

COPES, H.; CARDWELL, S.; SLOAN, J. J. h-Index and m-Quotient Benchmarks of Scholarly Impact in Criminology and Criminal Justice: A Preliminary Note. **Journal of Criminal Justice Education**, v. 23, n. 4, p. 441-461, 2012.

COSTA, L. B. M.; GODINHO FILHO, M. Lean healthcare: review, classification and analysis of literature. **Production Planning & Control**, v. 7287, p. 1–14, 2016.

COSTA, L. B. M.; FILHO, M. G.; RENTES, A. F.; BERTANI, T. M.; MARDEGAN, R. Lean healthcare in developing countries: evidence from Brazilian hospitals. **International Journal of Health Planning and Management**, v. 32, p. E99–E120, 2017.

CRAIGHEAD, C.; BLACKHURST, J.; RUNGTSUNATHAM, M.J.; HANDFIELD, R. The severity of supply chain disruptions: design characteristics and mitigation capabilities. **Decision Sciences**, v. 38, n. 1, p. 131-156, 2007.

CREMA, M.; VERBANO, C. How to combine lean and safety management in health care processes: A case from Spain. **Safety Science**, v. 79, p. 63-71, 2015.

CREMA, M.; VERBANO, C. Identification and development of Lean and Safety projects. **Safety Science**, v. 89, p. 319-337, 2016.

CROXTON, K.; DASTUGUE, S.; LAMBERT, D.; ROGERS, D. The Supply Chain Management Processes. **The International Journal of Logistics Management**, v. 12, n. 2, p. 13-16, 2001.

CRUZ, Antonio Miguel; GUARÍN, Mayra R. Determinants in the number of staff in hospitals' maintenance departments: a multivariate regression analysis approach. **Journal of Medical Engineering & Technology**, v. 41, n. 2, p. 151-164, 2017. DOI: 10.1080/03091902.2016.1243168.

CRUZ, Antonio Miguel; RINCON, Adriana Maria Rios; HAUGAN, Gregory L. Measuring the Performance of Maintenance Service Outsourcing. **Biomedical Instrumentation and Technology**, v.47, n.6, p. 524-535, 2013.

CURATOLO, N. A.; LAMOURI, S. A.; HUET, J. C. B.; RIEUTORD, A. C. A critical analysis of Lean approach structuring in hospitals. **Business Process Management Journal**. v. 20, n. 3, p.433-454, 2014.

D'ANDREAMATTEO, A.; IANNI, L.; LEGA, F.; SARGIACOMO, M. Lean in Healthcare: a comprehensive review. **Health Policy**, v. 119, n. 9, p. 1197-1209, 2015.

DAVENPORT, Paul B.; CARTER, Kimberly F; ECHTERNACH, Jeffrey M.; TUCK, Christopher R. Integrating High-Reliability Principles to Transform Access and Throughput by Creating a Centralized Operations Center. **The Journal of Nursing Administration**, v. 48, n. 2, p 93-99, 2018.

DAVID, Yadin; JARAMILLO, Fred; STIEFEL, Robert H. Educational Challenges in Clinical Engineering Profession: A Survey. **Journal of Clinical Engineering,** v.33, n.3, p. 154-158, 2008.

DEANE, J.; CRAIGHEAD, C.; RAGSDALE, C. Mitigating environmental and density risk in global sourcing. **Int. J. Phys. Distrib. Logist. Manag**, v. 39, n. 10, p. 861–883, 2009.

DEL SOLAR, João; SOARES, Fabiano Araujo; MENDES, Cristiano Jacques Miosso Rodrigues. Brazilian clinical engineering regulations: health equipment management and conditions for professional exercise. **Research on Biomedical Engineering**, v.33, n.4, p. 301-312, 2017. http://dx.doi.org/10.1590/2446-4740.01517.

DE MEYER, N.; SNOECK, M.; CATTRYSSE, D.; VAN ORSHOVEN J. A reference data model to support biomass supply chain modelling and optimization. **Environmental Modelling & Software,** v. 83, p. 1-11, 2016.

DIAS A. C.; REIS, A. C.; OLIVEIRA, R. P.; MARUYAMA, U.G.R.; MARTINEZ, P. Lean manufacturing in healthcare: a systematic review of literature. **Revista Produção e Desenvolvimento**, v. 4, n. 2, p.111-122, 2018.

DÍAZ, Angel; PONS, Juan; SOLÍS, Luis. Improving healthcare services: lean lessons from Aravind. **Int. J. Business Excellence**, v. 5, n. 4, 2012.

DHILLON, B.S. Medical Device Reliability and Associated Areas. 1st Edn., CRC Press, ISBN-10: 1420042238, 264p., 2000.

DOLATABADI, A. H. K.; NAJAFI, E.; TAGHAVIFARD, M. T. A confident supply chain network model using credibility measure under uncertainty condition. **Journal of Intelligent and Fuzzy Systems**, v. 28, n. 5, p. 2127–2140, 2015.

DONG, Qingxing; COOPER, Orrin. An orders-of-magnitude AHP supply chain risk assessment framework. **Int. J. Production Economics,** v.182, p. 144–156, 2016.

DRÖGE, C.; JAYARAM, J.; VICKERY, S.K. The effects of internal versus external integration practices on time-based performance and overall firm performance. **Journal of Operations Management**, v. 22, n. 6, p. 557-573, 2004.

DUNDAS, N.; ZIADIE, M.S.; REVELL, P.; BROCK, E.; MITUI, M.; ROGERS, B. A. Lean Laboratory. **The Journal of Molecular Diagnostics**, v. 13, p. 175–179, 2011.

DURACH, C. F.; WIELAND, A.; MACHUCA, J. A. D. Antecedents and Dimensions of Supply Chain Robustness : A Systematic Literature Review. **International Journal of Physical Distribution & Logistics Management**, v. 45, n. 1, p. 118–137, 2015.

DURIAU, V.J.; REGER, R.K.; PFARRER, M.D. A content analysis of the content analysis lit- erature in organization studies research themes, data sources, andmethodological re-finements. **Organ. Res. Methods**, v. 10, p. 5-34, 2007.

EFE, Burak; EFE, Ömer Faruk. An Application of Value Analysis for Lean Healthcare Management in an Emergency Department. **International Journal of Computational Intelligence Systems**, v. 9, n. 4, p. 689-697. DOI: 10.1080/18756891.2016.1204117.

EGGHE, L. Theory and practise of the g-index. **Scientometrics**, v. 69, n. 1, p. 131–152, 2006.

EKWALL, Daniel; LANTZ, Björn. Supply Chain Risk Analysis and Assessment: Cargo Theft. **Transportation Journal**, v. 55, n. 4, p. 400-419, 2017.

EIRO, N. Y.; TORRES JUNIOR, A. S. Comparative study: TQ and Lean Production ownership models in health services. **Revista Latino-Americana de Enfermagem**, v. 23, n. 5, p. 846-854, 2015.

ELANGOVAN, D.; SUNDARARAJ, G.; DEVADASAN, S.R.; KARUPPUSWAMY, P. Analysis of time delays for loss reduction in an automobile components manufacturing organisation using a proactive supply chain risk management model. **International Journal of Services, Economics and Management**, v. 2, n. 3/4, p. 385, 2010.

ELLINGER, Alexander E.; CHEN, Haozhe; TIAN, Yu; ARMSTRONG, Craig. Learning orientation, integration, and supply chain risk management in Chinese manufacturing firms. **International Journal of Logistics Research and Applications**, v.18, n.5, 2015. DOI: 10.1080/13675567.2015.1005008.

ELLINGER, A.E. Improving marketing/logistics cross-functional collaborations in the supply chain. **Industrial Marketing Management**, v. 29, n. 1, p. 85-96, 2000.

ELLIS, S.C.; SHOCKLEY, J.; HENRY, R.M. Making sense of supply disruption risk research: A conceptual framework grounded in enactment theory. **J. Supply Chain Manag**, v. 47, n. 2, 65–96, 2011.

ERDEM, Sabri; KIZILELMA, Turan Tolgay; VURAL, Ceren Altuntaş. Supporting Healthcare Executive Managers' Decisions Through Dashboards. **Journal of Information & Knowledge Management**, v. 15, n. 1, 2016. https://doi.org/10.1142/S0219649216500052.

ESSA, Youssef M.; ATTIYA, Gamal; El-Sayed, Ayman; EL-MAHALAWY, Ahmed. Data processing platforms for electronic health records. **Health and Technology,** v.8, p. 271–280, 2018.

FAHIMNIA, B.; TANG, C. S.; DAVARZANIC, H.; SARKISD, J. Quantitative Models for Managing Supply Chain Risks: A Review. **European Journal of Operational Research,** v. 247, n. 1, p. 1–15, 2015.

FAN, H.*;* LI, G.; SUN, H.; CHENG, T.C.E. An information processing perspective on supply chain risk management: Antecedents, mechanism, and consequences. **International Journal of Production Economics**, v. 185, p. 63–75, 2017.

FAN, Yiyi; STEVENSON, Mark. A review of supply chain risk management: definition, theory, and research agenda. **International Journal of Physical Distribution & Logistics Management**, v.48, n. 3, 2018. https:// doi.org/10.1108/IJPDLM-01-2017-0043.

FAN, W.; GU, J.; TANG, H.; GAO, X. Risk Management in End-to-End Global Supply Chain. In: 11th International Conference of Chinese Transportation Professionals (ICCTP), 2011, Nanjing. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

FANG, D.; WENG, W. KPI evaluation system of location decision for plant relocation from the view of the entire supply chain optimization. In: Proceedings of the IEEE International Conference on Automation and Logistics (ICAL 2010), 2010, Macau, Hong Kong. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

FARLEY, Jessica; M.; SURAWEERA, Inoka; PERERA, W. L. S. P.; HESS, Jeremy; EBI, Kristie L. Evaluation of flood preparedness in government healthcare facilities in Eastern Province, Sri Lanka. **Global Health Action**, v. 10, n. 1, 2017. DOI: 10.1080/16549716.2017.1331539.

FIKSEL, J. Sustainability and Resilience: Toward a Systems Approach. **Sustainability: Science, Practice, & Policy**, v. 2, n. 2, p. 1-8, 2006.

FINCH, P. Supply chain risk management. **Supply Chain Management**, v. 9, n. 2, p.183–196, 2004.

FLYNN, B.B.; HUO, B.; ZHAO, X. The impact of supply chain integration on performance: a contingency and configuration approach. **Journal of Operations Management**, v. 28 n. 1, p. 58-71, 2010.

FRANCESCHINI, Fiorenzo; GALETTO, Maurizio; TURINA, Elisa. Impact of performance indicators on organisations: a proposal for an evaluation model. **Production Planning & Control**, v. 25, n. 9, p. 783-799, 2014. DOI: 10.1080/09537287.2012.756128.

FREISE, M.; SEURING, S. Social and environmental risk management in supply chains: a survey in the clothing industry. **Logistics Research**, v.8, n. 1, p. 1-12, 2015.

FRIDAY, Derek; RYAN, Suzanne; SRIDHARAN, Ramaswami; COLLINS, David. Collaborative risk management: a systematic literature review. **International Journal of Physical Distribution & Logistics Management**, v.48, n.3, 2018. https://doi.org/10.1108/IJPDLM-01-2017-0035.

FUKUDA, Haruhisa; IMANAKA, Yuichi; HIROSE, Masahiro; HAYASHIDA, Kenshi. Economic evaluations of maintaining patient safety systems in teaching hospitals. **Health Policy**, v. 88, n.2-3, p. 381-391, 2008.

FROHLICH, M.T.; WESTBROOK, R. Arcs of integration: An international study of supply chain strategies. **J. Oper. Manag**, v. 19, n. 2, 185–200, 2001.

GELDERMAN, Cees J.; SEMEIJN, Janjaap; VLUGGEN, Rob. Development of sustainability in public sector procurement. **Public Money & Management**, v. 3, n. 6, p. 435-442, 2017. DOI: 10.1080/09540962.2017.1344027.

GHANNOUCHI, Sonia Ayachi; MABROUK, Karim; GHANNOUCHI, Slah. Proposal of data warehouse in the context of healthcare process reengineering. **Business Process Management Journal**, v.16, n.4, p. 688-712, 2010.

GIUNIPERO, L.; ELTANTAWY, C.; ALY, R. Securing the upstream supply chain: a risk management approach. **International Journal of Physical Distribution & Logistics Management**, v. 34, n. 9, p. 698-713, 2004.

GLÄNZEL W.; SCHUBERT A. Analysing Scientific Networks Through Co-Authorship. In: MOED H. F.; GLÄNZEL W.; SCHMOCH U. **Handbook of Quantitative Science and Technology Research**. Springer, Dordrecht, 2004.

GOLDRATT, E. M. **What Is This Thing Called the Theory of Constraints and How Should It Be Implemented?** North River Press, Croton-on-Hudson, NY.Goldsmith, 1990.

GÖLGECI, I.; PONOMAROV, S. Y. Does firm innovativeness enable effective responses to supply chain disruptions? An empirical study. **Supply Chain Management**, v. 18, n. 6, p. 604–617, 2013.

GÖLGECI, I.; PONOMAROV, S. Y. How does firm innovativeness enable supply chain resilience? The moderating role of supply uncertainty and interdependence. **Technology Analysis & Strategic Management**, v. 27, n. 3, p. 267–282, 2015.

GOMES, A.; SENNA, P.; MONTEIRO, A.; PINHA, D. Study on techniques and tools used in lean healthcare implementation: a literature review. **Brazilian Journal of Operations & Production Management**, v. 13, n. 4, p.406-420, 2016.

GRÖTSCH, V. M.; BLOME, C.; SCHLEPER, M. C. Antecedents of proactive supply chain risk management – a contingency theory perspective. **International Journal of Production Research**, v. 51, n. 10, p. 2842–2867, 2013.

GROVE, A. L.; MEREDITH, J. O.; MACINTYRE, M.; ANGELIS, J.; NEAILEY, K. UK health visiting: challenges faced during lean implementation. **Leadership in Health**

**Services**, v. 23, n. 3, p. 204 – 218, 2010.

GRIFFITH, John R. Understanding High-Reliability Organizations: Are Baldrige Recipients Models?. **Journal of Healthcare Management,** v.60, n.1, p. 44-61, 2015.

GRIGGS, Kristen N.; OSSIPOVA, Olya; ·KOHLIOS, Christopher; · BACCARINI, Alessandro N; HOWSON,· Emily A.; HAYAJNEH, Thaier. Healthcare Blockchain System Using Smart Contracts for Secure Automated Remote Patient Monitoring. **J Med Syst**, v.42, n.7, p. 1-7, 2018. doi: 10.1007/s10916-018-0982-x.

GRUDINSCHI, Daniela; SINTONEN, Sanna; HALLIKAS, Jukka. Relationship risk perception and determinants of the collaboration fluency of buyer–supplier relationships in public service procurement. **Journal of Purchasing & Supply Management,** v. 20, n.2, 82–91, 2014. https://doi.org/10.1016/j.pursup.2014.03.004.

GU, Xiuzhu; ITOH, Kenji. Performance indicators: healthcare professionals' views. **International Journal of Health Care Quality Assurance**, v. 29, n. 7, p. 801 – 815, 2016. http://dx.doi.org/10.1108/IJHCQA-12-2015-0142.

GUIMARÃES, C. M.; J. C. CARVALHO. Lean Healthcare across Cultures: State-of-the-Art. **American International Journal of Contemporary Research**, v. 2, n. 6, p. 187–206, 2012.

GÜNAL, M.M.; PIDD, M. DGHPSIM: Generic simulation of hospital performance. **ACM Trans Model. Comput. Simulat**, v. 21, n.4, 2011. doi:10.1145/2000494.2000496.

GUNDERSON, L. H. Ecological resilience in theory and application. **Annual review of ecology and systematics**, v. 31, p. 425-439, 2000.

GUPTA, S.; KAPIL, S.; SHARMA, M. Improvement of laboratory turnaround time using lean methodology. **International Journal of Health Care Quality Assurance**, v. 31, n. 4, p.295-308, 2018.

GUVEN - USLU, P.; CHAN, H. K.; IJAZ, S.; BAK, O.; WHITLOW, B.; KUMAR, V. In-depth study of 'decoupling point' as a reference model: an application for health service supply chain. **Production Planning & Control: The Management of Operations**, v. 25, n. 13-14, p. 1107-1117, 2014.

GUY, Bonnie; Williams, David R.; Aldridge, Alicia; Roggenkamp, Susan. Approaches to Organizing Public Relations Functions in Healthcare. **Health Marketing Quarterly**, v. 24, n. 3-4, p. 1-18, 2007. doi: 10.1080/07359680802118969.

HABIDIN, N. F.; KHAIDIR, N. A.; SHAZALI, N. A.; ALI, N.; JAMALUDIN, N. H. The development of process innovation and organizational performance in Malaysian healthcare industry. **International Journal of Business Innovation and Research,** v. 9, n. 2, p. 148-162, 2015.

HABIDIN, N.F.; SHAZALI, N.A.; SALLEH, M.I.; ZAINOL, Z.; HUDIN, N.S.; MUSTAFF, W.S.W. A review of supply chain innovation and healthcare performance

in healthcare industry. **Int J Pharm Sci Rev Res, v.** 35, n. 1, p. 195–200, 2015.

HABLI, Ibrahim; WHITE, Sean; SUJAN, Mark; HARRISON, Stuart; UGARTE, Marta. What is the safety case for health IT? A study of assurance practices in England. **Safety Science**, v.110, p. 324–335, 2018.

HAIMES, Y. Y. On the definition of vulnerabilities in measuring risks to infrastructures. **Risk Analysis**, v.26, n. 2, p. 293-296, 2006.

HALL, N. The rise of inventory management in operating theatre departments. **Journal of Perioperative Practice**, v.26, n.10, p. 221-224, 2016.

HALLIKAS, J.; VIROLAINEN, V. M.; TUOMINEN, M. Risk analysis and assessment in network environments: A dyadic case study. **International Journal of Production Economics**, v. 78, n. 1, p. 45–55, 2002.

HALLIKAS, J.; KARVONEN, I.; PULKKINEN, U.; VIROLAINEN, V-M.; TUOMINEN, M. Risk management processes in supplier networks, **International Journal of Production Economics**, v. 90, n. 1, p. 47–58, 2004.

HAMDI, F.; GHORBEL, A.; MASMOUDI, F.; DUPONT, L. Optimization of a supply portfolio in the context of supply chain risk management: literature review. **Journal of Intelligent Manufacturing**, v. 29, n. 4, p. 763-788, 2015.

HAMEL, G.; VÄLIKANGAS, L. The Quest for Resilience. **Harvard Business Review**, v. 81, n. 9, p. 1-21, 2003.

HARRIS, Daniel R.; HENDERSON, Darren W.; KAVULURU, Ramakanth; STROMBERG, Arnold J.; JOHNSON, Todd R. Using Common Table Expressions to Build a Scalable Boolean Query Generator for Clinical Data Warehouses IEEE. **Journal of Biomedical and Health Informatics.** v.18, n.5, p. 1607-1613, 2014.

HE, Zeshui Xu; GU, Jing. An approach to group decision making with hesitant information and its application in credit risk evaluation of enterprises. **Applied Soft Computing**, v. 43, p. 159–169, 2016.

HECKMANN, I.; COMES, T.; NICKEL, S. A critical review on supply chain risk – Definition, measure and modeling. **Omega**, v. 52, p. 119-132, 2015.

HELO, Javad Rouzafzoon Petri. Developing service supply chains by using agent based simulation. **Industrial Management & Data Systems**, v. 116, n. 2, p. 255-270, 2016.

FANG, D.; WENG, W. KPI evaluation system of location decision for plant relocation from the view of the entire supply chain optimization. In: Proceedings of the IEEE International Conference on Automation and Logistics (ICAL 2010), 2010, Macau, Hong Kong. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

HENDRICKS, K.B.; SINGHAL, V. R. The Effect of Supply Chain Glitches on Shareholder Wealth. **Journal of Operations Management**, v.21, n. 5, p. 501–522, 2003.

HIRSCH, J. E. An index to quantify an individual's scientific research output. **Proceedings of the national academy of sciences of the united states of America**, v. 102, n. 46, pp. 16569-16572, 2005.

HIROMOTO, Robert E.; HANEY, Michael; VAKANSKI, Aleksandar. A Secure Architecture for IoT with Supply Chain Risk Management. In: Proceedings of the IEEE International Conference on Intelligent Data Acquisition and Advanced Computing Systems: Technology and Applications (IDAACS), 2017.
**DOI:** 10.1109/IDAACS.2017.8095118. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

HO, W.; ZHENG, T.; YILDIZ, H.; TALLURI, S. Supply chain risk management: a literature review. **International Journal of Production Research**, v. 53, n. 16, p. 5031–5069, 2015.

HOHENSTEIN, N. O.; FEISEL, E.; HARTMANN, E.; GIUNIPERO, L. Research on the phenomenon of supply chain resilience A systematic review and paths for further investigation. **International Journal of Physical Distribution & Logistics Management**, v. 45, n. 1/2, p. 90–117, 2015.

HOLDEN, R. J. Lean thinking in emergency departments: a critical review. **Annals of Emergency Medicine**, v. 57, n. 3, p. 265–278, 2011.

HOLLING, C. S. Resilience and Ecological Systems. **Annual Review of Ecological and Systematics**, v. 4, p. 1-23, 1973.

HONG, P.; MARVEL, J. H.; MODI, S. A survey of business network integration: Implications for quality and productivity performance. **International Journal of Productivity and Quality Management**, v. 15, n. 2, p. 131–152, 2015.

HØYLAND, Sindre Aske; SKOTNES, Ruth Østgaard; HOLTE, Kari Anne. An empirical exploration of the presence of HRO safety principles across the health care sector and construction industry in Norway. **Safety Science**, v.107, p. 161–172, 2018.

HYMAN, William A. High reliability clinical engineering organizations. **Journal of Clinical Engineering**, v. 33, n.3, p. 143-150, 2008.

IAKOVOU, E.; VLACHOS, D.; XANTHOPOULOS, A. An analytical methodological framework for the optimal design of resilient supply chains. **International Journal of Logistics Economics and globalization**, v. 1, n. 1, p. 1-20, 2007.

IBGE, **Rendimento domiciliar per capita em 2017**, Disponível em: https://agenciadenoticias.ibge.gov.br/agencia-noticias/2013-agencia-de-noticias/releases/20154-ibge-divulga-o-rendimento-domiciliar-per-capita-2017.html. Acesso em: 13 de ago. 2018.

IANNONE, Raffaele; LAMBIASE, Alfredo; MIRANDA, Salvatore; RIEMMA, Stefano; SARNO, Debora. Pulling drugs along the supply chain: Centralization of hospitals' inventory. **International Journal of Engineering Business Management,** v.6, n.1, p. 1-11, 2014.

IBEY, Andrew A. M.; KING, Doug; HSIEH, Tony; HUTNAN, Tim; DIXON, John; SOET, Richard. Implementing a computerized maintenance management system for a consolidated program. **Journal of Clinical Engineering,** v.40, n.4, p. 202-209, 2015.

IVANOV, D.; DOLGUI, A.; SOKOLOV, B. Applicability of optimal control theory to adaptive supply chain planning and scheduling. **Annual Reviews in Control**, v. 36, n. 1, p. 73–84, 2012.

JANNOT, Anne-Sophie; ZAPLETAL, Eric; AVILLACH, Paul; Mamzer, Marie-France; BURGUNA, Anita; DEGOULET, Patrice. The Georges Pompidou University Hospital Clinical Data Warehouse: A 8-years follow-up experience. **International Journal of Medical Informatics**, v.102, p. 21–28, 2017.

JASSER, Al-Kassab Z; OUERTANI, M; SCHIUMA, G; NEELY, A. Information visualization to support management decisions. **International Journal of Information Technology & Deci- sion Making**, v. 13, n. 2, p. 407–428, 2014.

JAVDANI, Hamideh; KASHANIAN, Hooman. Internet of things in medical applications with a service-oriented and security approach: a survey. **Health Technol**., v. 8, p. 39–50, 2018. DOI 10.1007/s12553-017-0180-8.

JENKINS, Trevor. Direct procurement of wound management products. **British Journal of Community Nursing**, v.19, n.3, p. S21-S27, 2014.

JIANLIN, Y., 2010. The Risk Management of Supply Chain. In: Proceedings of the International Conference on Management and Service Science (MASS), 2010, Wuhan. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

JOYIA, Gulraiz J; LIAQAT, R. M.; FAROOQ, Aftab; REHMAN, Saad. Internet of medical things (IOMT): Applications, benefits and future challenges in healthcare domain. **Journal of Communications**, v. 12, n. 4, 2017.

JUTTNER, U. Supply chain risk management: Understanding the business requirements from a practitioner perspective. **The International Journal of Logistics Management**, v. 16, n. 1, p. 120-141, 2005.

JUTTNER, U.; PECK, H.; CHRISTOPHER, M. Supply chain risk management: outlining an agenda for future research. **International Journal of Logistics: Research & Applications,** v. 6, n. 4, p. 197-210, 2003.

KAHRAMAN, Unal A. Analysis of interactions between performance indicators with fuzzy decision making approach in healthcare management. **Journal of Intelligent Manufacturing,** v.0, p. 1-16. DOI: 10.1007/s10845-015-1147-0.

KAMALAHMADI, M.; PARAST, M. M. A review of the literature on the principles of enterprise and supply chain resilience: Major findings and directions for future research. **International Journal of Production Economics**, v. 171, p. 116–133, 2016.

KANAMORI, S.; CASTRO, M. C.; SOW, S.; MATSUNO, R.; CISSOKHO, A.; JIMBA, M. Impact of the Japanese 5S management method on patients and caretakers

satisfaction: a quasi-experimental study in Senegal. **Global Health Action**, v. 1, n. 6, p. 1-14, 2015.

KANAMORI, Shogo; CASTRO, Marcia C.; SOW, Seydou; MATSUNO, Rui; CISSOKHO, Alioune; JIMBA, Masamine. Impact of the Japanese 5S management method on patients' and caretakers' satisfaction : a quasi-experimental study in Senegal. **Global Health Action**, v.1, n.6, p. 1-14, 2016.

KANNENGIESSER, U.; NEUBAUER, M.; HEININGER, R. Integrating business processes and manufacturing operations based on S-BPM and B2MML. In: Proceedings of the 8th International Conference on Subject-oriented Business Process Management, S-BPM ONE 2016, 2010, New York. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

KAUPPI, K.; LONGONI, A.; CANIATO, F.; KUULA, M. Managing country disruption risks and improving operational performance: risk management along integrated supply chains. **International Journal of Production Economics**, v. 182, p. 484–495, 2016.

KASTANIOTI, Catherine; KONTODIMOPOULOSA, Nick; STASINOPOULOSA, Dionysis; KAPETANEASA, Nikolaos; POLYZOS, Nikolaos. Public procurement of health technologies in Greece in an era of economic crisis. **Health Policy**, v. 109, n.1, p. 7– 13, 2013.

KATSALIAKI, Korina; MUSTAFEE, Navonil. Improving decision making in healthcare services through the use of existing simulation modelling tools and new technologies. **Transforming Government: People, Process and Policy**, v. 4, n. 2, p. 158 – 171, 2010.

KEAY, S.; MCCARTHY, J. P.; CAREY-SMITH, B. E. Medical equipment libraries: implementation, experience and user satisfaction. **Journal of Medical Engineering & Technology**, v. 39, n. 6, p. 354-362, 2015. DOI: 10.3109/03091902.2015.1059507.

KERAMYDAS, C.; TSIOLIAS, D.; VLACHOS, D.; IAKOVOU, E. A simulation methodology for evaluating emergency sourcing strategies of a discrete part manufacturer. **International Journal of Data Analysis Techniques and Strategies**, v. 7, n. 2, p. 141–155, 2015.

KEKKONEN, Päivi; POHJOSENPERÄ, Timo; KANTOLA, Hannele; VÄYRYNEN, Seppo. Rational and participative task allocation between the nursing staff and the logistics support service provider in healthcare. **Human Factors and Ergonomics In Manufacturing**, v.28, n.3, p. 117-129, 2018.

KERN, D.; MOSER, R.; HARTMANN, E.; MODER, M. Supply chain risk management model development and empirical analysis**. International Journal of Physical Distribution & Logistics Management**, v. 42, n. 1, p. 60-82, 2012.

KESSLER, M. M. Bibliographic coupling between scientific papers. **American Documentation**, v. 14, n. 1, p.10-25, 1963.

KHALILI, Jolai and Torabi, 2016 Seyed Mohammad Khalili, Fariborz Jolai & Seyed Ali Torabi (2016): Integrated production–distribution planning in two-echelon systems: a resilience view. **International Journal of Production Research**, v.55, n.4, 2016. DOI: 10.1080/00207543.2016.1213446.

KHALILI, S. M.; JOLAI, F.; TORABI, S. A. Integrated production–distribution planning in two-echelon systems: a resilience view. **International Journal of Production Research**, v. 55, n. 4, p. 1040-1064, 2017.

KHAN, O.; BURNES, B. Risk and Supply Chain Management: Creating a Research Agenda. **International Journal of Logistics Management**, v. 18, n. 2, p. 197–216, 2007.

KHANGURA, Sara; POLISENA, Julie; CLIFFORD, Tammy J.; FARRAH, Kelly; KAMEL, Chris. Rapid review: An emerging approach to evidence synthesis in health technology assessment. **International Journal of Technology Assessment in Health Care**, v. 30, n. 1, p. 20–27, 2014.

KILUBI, I.; HAASIS, H. D. Supply chain risk management enablers-A framework development through systematic review of the literature from 2000 to 2015. **International Journal of Business Science and Applied Management**, v. 10, n. 1, p. 35-54, 2015.

KILUBI, I. Investigating current paradigms in supply chain risk management – a bibliometric study. **Business Process Management Journal**, v. 22, n. 4, p. 662–692, 2016a.

KILUBI, I. The strategies of supply chain risk management – a synthesis and classification. **International Journal of Logistics Research and Applications**, v. 19, n. 6, p. 604–629, 2016b.

KIM, S. W. An Investigation on the Direct and Indirect Effect of Supply Chain Integration on Firm Performance. **International Journal of Production Economics**, v.119, n. 2, p. 328–346, 2009.

KNIGHT, Amy K; BLESSNER, Paul; Bill A. Olson; TIMOTHY D. Blackburn. Strategic sourcing and corporate social responsibility: Aligning a healthcare organization's strategic objectives. **Journal of Purchasing & Supply Management**, v. 23, p. 94–104, 2017.

KNOWLES, S.; BARNES, I. Lean laboratories: laboratory medicine needs to learn from other industries how to deliver more for less. **Journal of Clinical Pathology**, v. 66, n. 8, p. 635–637, 2013.

KOKILAM, Monica Balakrishnan; JOSHI, Harish G.; KAMATH, Veena Ganesh. Strengthening the Pharmaceutical Supply Chain Management with Information Communication Technology Intervention. **Journal of Health Management,** v. 18, n. 2, p. 274–289. https://doi.org/10.1177/0972063416637719.

KOLOTZEK, C.; HELBIG, C.; THORENZ, A.; RELLER, A.; TUMA, A. A company

oriented model for the assessment of raw material supply risks: environmental impact and social implications. **J. Clean. Prod,** v**.** 176, p. 566–580, 2018.

KOUFTEROS, X.; BABBAR, S.; KAIGHOBADI, M. A paradigm for examining second-order factor models employing structural equation modeling. **International Journal Production Economics**, v.120, p.633-652, 2009.

KOUICEM, Djamel Eddine; BOUABDALLAH, Abdelmadjid; LAKHLEF, Hicham. Internet of things security: A top-down survey. **Computer Networks**, v. 141, p. 199–221, 2018. https://doi.org/10.1016/j.comnet.2018.03.012.

KOUVELIS, P.; DONG, L.; BOYABATLI, O.; LI, R. **Handbook of Integrated Risk Management in Global Supply Chains**, John Wiley & Sons, Hoboken, NJ, 2011.

KUMAR, S.; HARRISON, G. Expect the Unexpected : Supply Chain Disruption and Opportunity for US Companies — A Business Case. **Transportation Journal**, v. 51, n. 1, p. 118–136, 2012.

KUMAR, Arun; OZDAMAR, Linet; PENG NG, Chai. Procurement performance measurement system in the health care industry. **International Journal of Health Care Quality Assurance**, v. 18, n. 2, p.152-166, 2005. https://doi.org/10.1108/09526860510588179.

KUMAR, Sameer; SWANSON, Eric; TRAN, Thuy. RFID in the healthcare supply chain: Usage and application. **International Journal of Health Care Quality Assurance,** v.22, n.1, p. 67-81, 2009.

KUMAR, S.; KUMAR, S.; KRETSCHMER, H. Collaboration in Research Productivity in Oil Seed Research Institutes of India. In: Proceedings of international Conference on Webometrics, Informetrics and Scientometrics, Berlim, 2008. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

KRAMER, D. B.; Xu, S.; KESSELHEIM, A. S. How does medical device regulation perform in the United States and the European union? A systematic review. **PLoS Medicine**, v. 9, n.7, 2012. https://doi.org/10.1371/journal.pmed.1001276.

KRITCHANCHAI, Duangpun; MEESAMUT, Watcharaphong. Developing Inventory Management in Hospital. **Int. J Sup. Chain. Mgt,** v.4, n.2, p. 11-19, 2015.

KUMARI, Aparna; TANWAR, Sudeep; TYAGI, Sudhanshu; KUMAR, Neeraj. Fog computing for Healthcare 4.0 environment: Opportunities and challenges. **Computers and Electrical Engineering**, v.72, p.1–13, 2018.

KWAK, Dong-Wook; RODRIGUES, Vasco Sanchez; MASON, Robert; PETTIT, Stephen; BERESFORD, Anthony. Risk interaction identification in international supply chain logistics: Developing a holistic model. **International Journal of Operations & Production Management**, v. 38, n. 2, p.372-389, 2018. https://doi.org/10.1108/IJOPM-03-2016-0121.

LAMBERT, D. M.; COOPER, M. C. Issues in Supply Chain Management. **Industrial**

**Marketing Management**, v. 83, n. 1, p. 65–83, 2000.

LAMBERT, D. M.; POHLEN, T. L. Supply chain metrics. **The International Journal of Logistics Management**, v. 12, n. 1, p. 1-19, 2001.

LAMBERT, D. M.; GARCIA - DASTUGUE, S. J.; CROXTON, K. L. An evaluation of process- oriented supply chain management frameworks. **Journal of Business Logistics**, v. 26, n. 1, p. 25–51, 2005.

LANDRY, S.; BEAULIEU, M. Handbook of Healthcare Operations Management. Chapter 18 The Challenges of Hospital Supply Chain Management, from Central Stores to Nursing Units In: DENTON, B. T. **Handbook of Healthcare Operations Management**. New York: International Series in Operations Research & Management Science, 2007.

LAPLANTE, Nancy L.; LAPLANTE, Phillip A.; VOAS, Jeffrey M. Stakeholder Identification and Use Case Representation for Internet of Things Applications in Healthcare. **IEEE Systems Journal,** v.12, n.2, p. 1589-1597, 2018.

LAVASTRE, O.; GUNASEKARAN, A.; SPALANZAN, A. Supply chain risk management in French companies. **Decision Support Systems**, v. 52, n. 4, p. 828-838, 2012.

LEHOUX, N.; LEBEL, L.; ELLEUCH, M. Benefits of inter-firm relationships: application to the case of a five sawmills and one paper mill supply chain. **Information Systems And Operational Research**, v. 54, n. 3, p. 192-209, 2016.

LEIRAS, A.; BRITO JR, I. PERES, E. Q.; BERTAZZO, T. R.; YOSHIZAKI, H. T. Y. Literature review of humanitarian logistics research: trends and challenges. **Journal of Humanitarian Logistics and Supply Chain Management**, v. 4, n. 1, p. 95-130, 2014.

LENGNICK-HALL, C.A. Customer contributions to quality: a different view of the customer-oriented firm. **Academy of Management Review**, v. 21, n. 3, p.791-824, 1996.

LEVARY, R. R. Ranking foreign suppliers based on supply risk. **Supply Chain Management: An International Journal**, v. 12, n. 6, p. 392-394, 2007.

LI, L. X. B.; LEONG, W. C.; KEONG, G. The impact of strategic operations management decisions on community hospital performance. **Journal of Operations Management**, v. 20, p. 389–408, 2002.

LI, G.; LIN, Y.; WANG, S.; YAN, H. Enhancing agility by timely sharing of supply information. **Supply Chain Management: An International Journal**, v. 11, n. 5, p. 425-435, 2006.

LI, X.; DEKKER, R.; HEIJI, C.; HEKIMOĞLU, M. Assessing End-Of-Supply Risk of Spare Parts Using the Proportional Hazard Model. **Decision Sciences,** v. 47, n. 2, p. 373-394, 2016.

LI, Z. P.; LIM, L. H.; CHEN, X. S.; TAN, C. S. Supplier selection decision-making in supply chain risk scenario using agent based simulation. In: IEEE International Conference on Industrial Engineering and Engineering Management (IEEM 2015), Singapore, 2015. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

LIU, Jiaguo; LIU, Fan; ZHOU Huan; KONG, Yudan. An Integrated Method of Supply Chains Vulnerability Assessment. **Scientific Programming**, v. 2016, Article ID 2819238, 10 pages, 2016. https://doi.org/10.1155/2016/2819238.

LINGG, Myriam; WYSS, Kaspar; DURÁN-ARENAS, Luis. Effects of procurement practices on quality of medical device or service received: A qualitative study comparing countries. **BMC Health Services Research**, v. 16, n. 362, 2016. DOI 10.1186/s12913-016-1610-4.

LONSDALE, C. Effectively managing vertical supply relationships: a risk management model for outsourcing. **Supply Chain Management: An International Journal**, v. 4, n. 4, p. 176–183, 1999.

LU, Guanyi; KOUFTEROS, Xenophon; LUCIANETTI, Lorenzo. Supply Chain Security: A Classification of Practices and an Empirical Study of Differential Effects and Complementarity. **IEEE Transactions on Engineering Management,** v.64, n.2 p.234-248, 2017.

MACKEY, T.K.; NAYYAR, G. A review of existing and emerging digital technologies to combat the global trade in fake medicines. **Expert Opin. Drug Saf.**, v. 16, p. 587–602, 2017.

MAHFOUD, A; EL BARKANY, A; EL BIYAALI, A. Preventive Maintenance Optimization in Healthcare Domain: Status of Research and Perspective. **Journal of Quality and Reliability Engineering**, v. 2016, Article ID 5314312, 2016. https://doi.org/10.1155/2016/5314312.

MANDAL, S. Supply chain resilience: a state-of-the-art review and research directions. **International Journal of Disaster Resilience in the Built Environment**, v. 5, n. 4, p. 427-453, 2014.

MANDAL, S. The influence of organizational culture on healthcare supply chain resilience: moderating role of technology orientation. **Journal of Business & Industrial Marketing**, v. 32, n. 8, p.1021-1037, 2017.

MANDAL, S.; JHA, R. R. Exploring the importance of collaborative assets to hospital-supplier integration in healthcare supply chains. **International Journal of Production Research**, v. 56, n. 7, p. 2666-2683, 2017.

MANUJ, Ila; MENTZER, John T. Global supply chain risk management strategies. **International Journal of Physical Distribution & Logistics Management**, v. 38, n. 3, p.192-223, 2008. https://doi.org/10.1108/09600030810866986.

MARTÍNEZ-CARO, Eva; CEGARRA-NAVARRO, Juan Gabriel; GARCÍA-PÉREZ, Alexeis; FAIT, Monica. Healthcare service evolution towards the Internet of Things: An

end-user perspective. **Technological Forecasting & Social Change**, v.136, p. 268–276, 2018. https://doi.org/10.1016/j.techfore.2018.03.025.

MARTINEZ-CÓRCOLES, Mario. High reliability leadership: A conceptual framework. **Journal of Contingencies and Crisis Management,** v. 26, n.2, p. 237-246, 2018.

MEEKINGS, Alan; BRIAULT, Steve. The "control tower" approach to optimising complex service delivery performance. **Measuring Business Excellence**, v. 17, n. 3, p. 15 – 27, 2013.

MEEHAN, Joanne; MENZIES, Laura; MICHAELIDES, Roula. The long shadow of public policy; Barriers to a value-based approach in healthcare procurement. **Journal of Purchasing and Supply Management, v.** 23, p. 229–241, 2017.

MCCLEAN, S.; GARG, L.; MEENAN, B. ET AL. Using Markov Models to Find Interesting Patient Pathways. In: Proceedings of the Twentieth IEEE International Symposium on Computer-Based Medical Systems, IEEE Computer Society, Maribor, 2007. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

MCCULLOUGH, Charles E. An experiment in collaboration - Sharing clinical engineering computerized maintenance management data with food and drug administration's MedSun project. **Journal of Clinical Engineering,** v.39, n.1, p. 33-36, 2014.

MCGOWAN, R. Establishing and Sustaining Collaboration Between Information Technology and Clinical Engineering Staff. **Journal of Clinical Engineering,** v.37, n.1 p.22-23, 2012.

MCINTOSH, Sheppy; COHEN, Ivan. Illusion or delusion – Lean management in the health sector. **International Journal of Health Care Quality Assurance**, v. 27, n. 6, p. 482 – 492, 2014. http://dx.doi.org/10.1108/IJHCQA-03-2013-0028.

MCKONE-SWEET, K.E.; HAMILTON, P.; WILLIS, S.B.The ailing healthcare supply chain: a prescription for change. **J. Supply Chain Manag.,** v**.** 41, p. 4–17, 2005. http://dx.doi.org/10. 1111/j.1745-493X.2005.tb00180.x.

MICHELI, G. J. L.; CAGNO, E.; ZORZINI, M. Supply risk management vs supplier selection to manage the supply risk in the EPC supply chain. **Management Research News**, v. 31, n. 11, p. 846-866, 2008.

MILCH, Vibeke Milch;· LAUMANN, Karin. Sustaining safety across organizational boundaries: a qualitative study exploring how interorganizational complexity is managed on a petroleum producing installation. **Cognition, Technology & Work,** v.20, n.2, p.179–204., 2018.

MILOSEVIC, Ivana; BASS, A. Erin; COMBS, Gwendolyn M. The Paradox of Knowledge Creation in a High-Reliability Organization: A Case Study. **Journal of Management,** v. 44, n. 3, p. 1174 –1201, 2018. DOI: 10.1177/0149206315599215.

MINAMI, Christina A. et al., Process improvement in surgery. **Current Problems in Surgery**, v.53, n.2 p.62-96, 2006.

MISHRA, Jyoti L.; HOPKINSON, Peter G.; TIDRIDGE, Gin. Value creation from circular economy-led closed loop supply chains: a case study of fast-moving consumer goods. **Production Planning & Control**, v. 29, n. 6, p. 509-521, 2018. DOI: 10.1080/09537287.2018.1449245.

MITAL Monika; GIUDICE, Manlio Del; PAPA, Armando. Comparing supply chain risks for multiple product categories with cognitive mapping and Analytic Hierarchy Process. **Technological Forecasting & Social Change**, v.131, p. 159–170, 2018.

MOHAPATRA, P.; NANDA, S.; ADHIKARI, T. Resilience measurement of a global supply chain network. In: 2015 IEEE 9th International Conference on Intelligent Systems and Control (ISCO), Coimbatore, 2015. **Anais eletrônicos**… Acesso em: 13 de ago. 2018.

MOBAREK, Iyad; TARAWNEH, Waleed Al; LANGEVIN, Francois; IBBINI, Mohammad. Fully Automated Clinical Engineering Technical Management System. **Journal of clinical engineering,** v.31, n.1, p.46-60, 2006.

MOHER, D.; LIBERATI, A.; TETZLAFF, J.; ALTMAN, D. G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. **PLoS Medicine**, v. 6, n. 7, p. 1-9, 2009.

MONROE - WISE, A.; REISNER, E.; SHERR, K.; OJAKAA, D.; MBAU, L.; KISIA, P.; MUHULA, S.; FARQUHAR, C. Using lean manufacturing principles to evaluate wait times for HIV-positive patients in an urban clinic in Kenya. **International Journal of STD and AIDS**, v. 28, n. 14, p. 1410-1418, 2017.

MOSTAFAEIPOUR, A.; QOLIPOUR, M.; ESLAMI, H. Implementing fuzzy rank function model for a new supply chain risk management. **The Journal of Supercomputing**, v. 73, n. 8, p. 3586–3602, 2017.

MUHS, K. S.; KARWOWSKI, W.; KERN, D. International Journal of Industrial Ergonomics Temporal variability in human performance: A systematic literature review. **International Journal of Industrial Ergonomics**, v. 64, n. 8, p. 31–50, 2018.

MUDYARABIKWA, O.; REGMI, K. Public-private partnerships and efficiency in public procurement of primary healthcare infrastructure: a qualitative research in the NHS UK. **Journal of Public Health**, v.24, n.2, p. 91–100, 2016.

MUDYARABIKWA, Oliver; TOBI, Patrick; REGMI, Krishna. Public-private partnerships to improve primary healthcare surgeries: Clarifying assumptions about the role of private provider activities. **Primary Health Care Research and Development**, v.18, p. 366–375, 2017. doi:10.1017/S1463423617000147.

MURIANA, Cinzia; VIZZINI, Giovan Battista; PIAZZA, Tommaso; GILIA, Giulio; MISTRETTA, Vincenzo. Effectiveness of an electronic health record-data warehouse

system implementation: return on investment analysis. **International Journal of Medical Engineering and Informatics**, v. 9, n. 4, 2017.

MUSTAFFA, Noorfa Haszlinna; POTTER, Andrew. Healthcare supply chain management in Malaysia: A case study. **Supply Chain Management: An International Journal,** v. 14, n.3, p. 234–243, 2009. DOI 10.1108/13598540910954575.

MYLREA, Michael; GOURISETTI, Sri Nikhil Gupta. Blockchain for Supply Chain Cybersecurity , Optimization and Compliance. 2018 Resilience Week (RWS). **Anais eletrônicos**… Acesso em: 13 de ago. 2018. DOI: 10.1109/RWEEK.2018.8473517.

NATARAJARATHINAM, M.; CAPAR, I.; NARAYANAN, A. Managing supply chains in times of crisis: a review of literature and insights. **International Journal of Physical Distribution and Logistics Management**, v. 39, n. 7, p. 535-573, 2009.

NABELSI, Véronique. Performance measurement in the healthcare supply chain. **International Journal of Services, Economics and Management,** v.3, n.2, p. 137-156, 2011.

NARASIMHAN, R.; DAS, A. An empirical investigation of the contribution of strategic sourcing to manufacturing flexibilities and performance. **Decision Sciences**, v.30, n.3, p.683–718, 1999.

NARASIMHAN, Ram; TALLURI, Srinivas. Perspectives on risk management in supply chains. **Journal of Operations Management**, v. 27, p. 114–118, 2009.

NEIGER, D.; ROTARU, K.; CHURILOV, L. Supply chain risk identification with value-focused process engineering. **Journal of Operations Management**, v. 27, n. 2, p. 154-168, 2009.

NIEMSAKUL, J.; ISLAM, S. M. N.; SINGKARIN, D.; SOMBOONWIWAT, T. Cost-benefit sharing in healthcare supply chain collaboration. **International Journal of Logistics Systems and Management**, v. 30, n. 3, p. 406-420, 2018.

NOLLET, Jean; BEAULIEU, Martin The development of group purchasing: An empirical study in the healthcare sector. **Journal of Purchasing and Supply Management**, v.9, n.1, p.3-10, 2003.

NORRMAN, A.; JANSSON, U. Ericsson´s proactive supply chain risk management approach after a serious sub-supplier accident. **International Journal of Physical Distribution & Logistics Management**, v. 34, n. 5, p. 434–456, 2004.

NORTHCOTT, Herbert C.; HARVEY, Michael D. Public perceptions of key performance indicators of healthcare in Alberta, Canada. **International Journal for Quality in Health Care,** v.24, n.3, p. 214-223, 2012.

OKOH, Peter; HAUGEN, Stein. Improving the robustness and resilience properties of maintenance. **Process Safety and Environmental Protection**, v. 9 4, n.C, p. 212–226, 2015.

OJHA, D.; GOKHALE, R. A. Logistical business continuity planning-scale development and validation. **The International Journal of Logistics Management**, v. 20, n. 3, p. 342–359, 2009.

OLIVEIRA, U. R.; MARINS, F. A. S.; ROCHA, H. M.; SALOMON, V. A. P. The ISO 31000 standard in supply chain risk management. **Journal of Cleaner Production**, v. 151, n.10, p. 616–633, 2017.

OLSON, D. L.; WU, D. A review of enterprise risk management in supply chain. **Kybernetes**, v. 39, n. 5, p. 694–706, 2010.

OUMLIL, A.B; WILLIAMS, A.J. Strategic alliances and organisational buying: an empirical study of the healthcare industry. **International Journal of Procurement Management,** v. 4, n. 6, 2011.

ÖZKAN, Yildiz; ONUR, Demirors. Healthcare quality indicators – a systematic review. **International Journal of Health Care Quality Assurance**, v. 27, n. 3, p. 209 – 222, 2014.

PATÉ-CORNELL, Elisabeth; COX JR , Louis Anthony. Improving risk management: From lame excuses to principled practice. **Risk Analysis**, v. 34, n. 7, 2014 p. 493-511, 2014.

PAWLICKI, T.; MUNDT, A. J. Quality in radiation oncology. **The International Journal of Medical Physics research and practice**, v. 34, n. 5, p.1529–1534, 2007.

PETIT, T. J.; CROXTON, K. L.; FIKSEL, J. Ensuring Supply Chain Resilience: Development and Implementation of an Assessment Tool. **Journal of Business Logistics**, v. 34, n. 1, p. 46–76, 2013.

PICCININI, Paolo; GAMBERINI, Rita; PRATI, Andrea; RIMINI, Bianca; CUCCHIARA, Rita. An automated picking workstation for healthcare applications **Computers & Industrial Engineering**, v.64, n.2, p. 653–668, 2013.

PLANOS DE SAÚDE TODOS AQUI, **Comparativo de planos de saúde**, 2018. Disponível em: https://www.planosdesaudetodosaqui.com.br/. Acesso em: 24 de maio 2019.

PONOMAROV, S. Y.; HOLCOMB, M. C. Understanding the concept of supply chain resilience. **The International Journal of Logistics Management**, v. 20, n. 1, p.124-143, 2009.

PORTAL G1 – **Patients in Campinas/SP wait an average of 1 year for medical appointments**, 2018. Disponível em: https://g1.globo.com/sp/campinas-regiao/noticia/pacientes-esperam-em-media-um-ano-por-consulta-de-especialidades-mais-procuradas-em-campinas.ghtml. Acesso em: 24 de maio 2019.

PORTAL G1argues that D'Or network is overcharging the procedures, therefore, they could not reach an agreement (Portal G1) Acesso em: 27 de abr. 2019.

POURNADER, M.; ROTARU, K.; KACH, P.A.; HAJIAGHA, H.R.S. An analytical model for system-wide and tier - specific assessment of resilience to supply chain risks, **Supply Chain Management: An International Journal**, v. 21, n. 5, p. 589-609, 2016.

POWELL-DUNFORD, Nicole; MCPHERSON, Mark K.; PINA, Joseph S.; GAYDOS, Steven J. Transferring Aviation Practices into Clinical Medicine for the Promotion of High Reliability. **Aerospace Medicine and Human Performance**, v.88, n.5, p. 487-491, 2017.

PRADA, Gabriela . Value-based procurement: Canada's healthcare imperative. **Healthcare Management Forum**, v.29, n.4, p. 162-164, 2016.

PUJAWAN, I. N.; GERALDIN, L. H. House of risk: a model for proactive supply chain risk management. **Business Process Management Journal**, v. 15, n. 6, p. 953-967, 2009.

PUTTERGILL, B.; KRUGER, D.; BRAND, M.; VELLER, M. G. Suture material use and procurement: An audit of a public hospital surgical system in Gauteng, South Africa. **South African Journal of Surgery**, v.56, n.2, p. 45-49, 2018.

RAGATZ, G.L., HANDFIELD, R.B., PETERSEN, K.J. Benefits associated with supplier integration into new product development under conditions of technology uncertainty. **J. Bus. Res**, v. 55, n. 5, p. 389–400, 2002.

RAHIMNIA, F.; MOGHADASIAN, M. Supply chain leagility in professional services: how to apply decoupling point concept in healthcare delivery system. **Supply Chain Management: An International Journal**, v. 15, n. 1, p. 80–91, 2010.

RAHMAN, S. The theory of constraints' thinking process approach to developing strategies in supply chains. **International Journal of Physical Distribution & Logistics Management**, v. 32, n. 10, p. 809 – 828, 2002.

RAJAN, A.; SULLIVAN, R.; BAKKER, S.; VAN HARTEN, W. H. Critical appraisal of translational research models for suitability in performance assessment of cancer centers. **Oncologist**, v. 17, n. 12, p. e48–e57, 2012.

RAJESH, Rajagopal. Forecasting supply chain resilience performance using grey prediction. **Electronic Commerce Research and Applications**, v. 20, p. 42–58, 2016. DOI: 10.1016/j.elerap.2016.09.006.

RAJESH, R. Technological capabilities and supply chain resilience of firms: A relational analysis using Total Interpretive Structural Modeling (TISM). **Technological Forecasting and Social Change**, v. 118, p. 161-169, 2017.

RAKOVSKA, M. A.; STRATIEVA, S. V. A taxonomy of healthcare supply chain management practices. **Supply Chain Forum: An International Journal**, v. 19, n. 1, p. 4-24, 2018.

RAMANUJAM, R.; GOODMAN, P.S. Latent errors and adverse organizational consequences: a conceptualization. **J. Organ. Behav**, v.24, n. 7, p. 815–836, 2003. doi.org/ 10.1002/job.218.

REIJULA, Jori; NEVALA, Nina; LAHTINEN, Marjaana; RUOHOMÄKI, Virpi; REIJULA, Kari. Lean design improves both health-care facilities and processes: a literature review. **Intelligent Buildings International**, v.6, n.3, p. 170-185, 2014. DOI: 10.1080/17508975.2014.901904.

RICE, J. B.; CANIATO, F., Building a secure and resilient supply network Supply Chain. **Management Review**, v.7, n. 5, p. 22-30, 2003.

RILEY, J. M.; KLEIN, R.; MILLER, J.; SRIDHARAN, V. How internal integration, information sharing, and training affect supply chain risk management capabilities. **International Journal of Physical Distribution & Logistics Management**, v. 46, n. 10, p. 35–43, 2016.

ROBERTS, K. H. Some characteristics of one type of high-reliability organization. Organization Science, v. 1, p. 160-176, 1990.

ROBINSON, S.; RADNOR, Z. J.; BURGESS, N.; WORTHINGTON, C. SimLean: Utilising simulation in the implementation of lean in healthcare. **European Journal of Operational Research**, v. 219, n. 1, p. 188-197, 2012.

ROCCO, T.S.; PLAKHOTNIK, M.S. Literature reviews, conceptual frameworks, and theoretical frameworks: terms, functions, and distinctions. **Human Resource Development Review**, v. 8, n. 1, p. 120-130, 2009.

RODRIGUES, J. P.; REZENDE SEGUNDO, Dante Borges de; JUNQUEIRA, Heres Arantes, SABINO, Murilo Henrique; PRINCE, Rafael Maciel; AL-MUHTADI, Jalal; ALBUQUERQUE, Victor Hugo C. de. Enabling Technologies for the Internet of Health Things. **IEEE Access**, v.6, p. 13129-13141, 2018.

ROTTER, T.; PLISHKA, C. T.; ADEGBOYEGA, L.; FIANDER, M.; HARRISON, E. L.; FLYNN, R.; CHAN, J. G.; KINSMAN, L. Lean Management in Health Care: Effects on Patient Outcomes, Professional Practice, and Healthcare Systems. **Cochrane Database of Systematic Reviews**, n. 11, p. 1-13, 2017.

ROY, P. C.; ABIDI, S. R.; ABIDI, S. S. R. Possibilistic activity recognition with uncertain observations to support medication adherence in an assisted ambient living setting. **Knowl.-Based Syst**., v. 133, p. 156–173, 2017. https://doi.org/10.1016/j.knosys.2017.07.008.

SAEN, F. R.; FISHER, R.; MAHDILOO, M. Sustainable supply chain modeling and optimization. **Transportation Research Part D: Transport and Environment**, v. 48, p. 409-410, 2016.

SCHMITT, A. J.; SINGH, M. A quantitative analysis of disruption risk in a multi-echelon supply chain. **International Journal of Production Economics**, v. 139, n. 1, p. 22-32, 2012.

SEDEVICH-FONS , Leonardo. Financial indicators in healthcare quality management systems. **The TQM Journal**, v. 26, n. 4, p. 312 – 328, 2014. DOI: http://dx.doi.org/10.1108/TQM-01-2014-0009.

SEURING, S.; GOLD, S. Conducting content-analysis based literature reviews in supply chain management. **Supply Chain Management: An International Journal**, v. 17, n. 5, p. 544-555, 2012.

SHASHANK, R.; GOLDSBY, T. I believe, therefore I care. **The International Journal of Logistics Management**, v. 20, n. 1, p. 14–15, 2009.

SHOHET, Igal M. Key Performance Indicators for Strategic Healthcare Facilities Maintenance. **Journal of Construction Engineering and Management,** v.132, n.4, p. 345-352, 2006.

SHUAI, Y.; WANG, X.; ZHAO, L. Research on measuring method of supply chain resilience based on biological cell elasticity theory. In: 2011 IEEE International Conference on Industrial Engineering and Engineering Management, Singapore, 2011. **Anais eletrônicos**…Acesso em: 13 de ago. 2018.

SIB/ANS/MS – IBGE/DataSus, **Sistema de informações de beneficiários de planos privados de saúde, por cobertura assistencial**. Disponível em: http://www.ans.gov.br/index.php/aans/quem-somos/227-dados-gerais. Acesso em: 13 de ago. 2018.

SILVA, C. S.; GABRIEL, C. S.; BERNARDES, A.; ÉVORA, Y. D. M. Opinião do enfermeiro sobre indicadores que avaliam a qualidade na assistência de enfermagem. **Revista Gaúcha de Enfermagem**, v.30, n.2, p. 263-271, 2009.

SINHA, P. R.; WHITMAN, L. E.; MALZAHN, D. Methodology to mitigate supplier risk in an aerospace supply chain. **Supply Chain Management: An International Journal**, v. 9, n. 2, p. 154-68, 2004.

SMALL, H. Co-citations in the scientific literature : a new measure of the relationship beetween two documents. **Journal of the American Society for Information Science**, v. 24, n. 4, p. 265-269, 1973.

SMITH, Christopher; CHRISTIANSEN, Tanya; DICK, Don; HOWDEN, Jane Squire; WASYLAK, Tracy; WERLE, Jason. Performance management tools motivate change at the frontlines . **Healthcare Management Forum**, v.27, n.1, p. 15-19, 2014.

SMITH, R. The world's biggest economies in 2018. In: **World Economic Forum**, 2018, Disponível em: https://www.weforum.org/agenda/2018/04/the-worlds-biggest-economies-in-2018/. Acesso em: 13 de ago. 2018.

SODHI, M. S.; SON, B-G.; TANG, C. S. Researchers' perspectives on supply chain risk management. **Production and Operations Management**, v. 21, n. 1, p. 1-13, 2012.

SONG, C.; ZHUANG, J. Modeling a Government-Manufacturer-Farmer game for food supply chain risk management. **Food Control,** v. 78, p. 443–455, 2017.

SONI, U.; JAIN, V. Minimizing the vulnerabilities of supply chain: A new framework for enhancing the resilience. In: Industrial Engineering and Engineering Management (IEEM), 2011 IEEE International Conference, Singapura, 2011. **Anais eletrônicos**... Acesso em: 13 de ago. 2018.

SORENSEN, L. B. How risk and uncertainty is used in supply chain management: a literature study. **International Journal of Integrated Supply Management**, v. 1, n. 4, p. 387–409, 2005.

SPEZIALE, Giuseppe. Strategic management of a healthcare organization: Engagement, behavioural indicators, and clinical performance. **European Heart Journal**, v.17, p. A3-A7, 2015.

SPISAK, Cary; MORGAN, Lindsay; EICHLER, Rena; ROSEN, James; SERUMAGA, Brian; WANG, Angela. Results-Based Financing in Mozambiques Central Medical Store: A Review After 1 Year. **Global Health: Science and Practice**, v.4, n.1, p. 165-177, 2016.

SREEDEVI, R.; SARANGA, H. Uncertainty and supply chain risk: The moderating role of supply chain flexibility in risk mitigation. **International Journal of Production Economics**, v. 193, p. 332-342, 2017.

SUDHIER, P. K. G. Lotka's Law and patterns of author productivity in the Area of physical Review. **Journal of Library & Information Technology**, v. 33, n. 6, p. 457-464, 2013.

SULLIVAN, Jennifer L.; RIVARD, Peter E.; SHIN, Marlena H.; ROSEN, Amy K. Applying the high reliability health care maturity model to assess hospital performance: A VA case study. **Joint Commission Journal on Quality and Patient Safety**, v.42, n. 9, p. 389-399, 2016.

SVENSSON, G. Sub-contractor and customer sourcing and the occurrence of disturbances in firms' inbound and outbound logistics flows. **Supply Chain Management: An International Journal**, v. 8, n. 1, p. 41-56, 2003.

SYAHRIR, I.; SUPARNO, B.; VANANY, I. Healthcare and disaster supply chain: literature review and future research. **Procedia Manufacturing**, v. 4, p. 2-9, 2015.

TANG, C. S. Perspectives in supply chain risk management. **International Journal of Production Economics,** v. 103, n. 2, p. 451–488, 2006.

TANG, O.; MUSA, N. Identifying risk issues and research advancements in supply chain risk management. **International Journal of Production Economics**, v. 133, p. 25–34, 2011.

TAYLOR, P.; DANI, S.; DEEP, A. International Journal of Logistics Research and Applications : A Leading Journal of Supply Chain Management Fragile food supply chains: reacting to risks. **International Journal of Logistics: Research and Applications**, v. 5567, p. 37–41, 2010.

THUN, J. H.; HOENIG, D. An Empirical Analysis of Supply Chain Risk Management in the German Automotive Industry. **International Journal of Production Economics**, v. 131, n. 1, p. 242-249, 2011.

THUN, J-H.; DRÜKE, M.; HOENIG, D. Managing uncertainty – an empirical analysis of supply chain risk management in small and medium-sized enterprises. **International Journal of Production Research**, v. 49, n. 18, p. 5511–5525, 2011.

TIPMONTIAN, J.; SURYAPRAKASA, R. K.; RAJMOHAN, M. Selection of Handling of Route in Postharvest Supply Chain using Fuzzy Delphi Method and Dynamic Programming. **Journal of Applied Sciences Research**, v. 8, n. 8, p. 4207–4214, 2012.

THOMÉ, A.M.T.; SCAVARDA, L.F.; FERNANDEZ, N.S.; SCAVARDA, A.J. Sales and operations planning and the firm performance. **International Journal of Productivity and Performance Management**, n. 61, n.4, p.359-381, 2012.

TOMLIN, B. On the Value of Mitigation and Contingency Strategies for Managing Supply Chain Disruption Risks. **Management Science, v.** 52, p. 639–657, 2006.

TORABI, S. A.; BAGHERSAD, M.; MANSOURI, S. A. Resilient supplier selection and order allocation under operational and disruption risks. **Transportation Research Part E: Logistics and Transportation Review**, v. 79, p. 22-48, 2015.

TORRACO, R. J. Writing integrative literature reviews: Guidelines and examples. **Human Resource development Review**, v.4 n.3 p.356-367, 2005. https://doi.org/10.1177/1534484305278283.

TSENG, M.L.; CHIU, A.S.F.; TAN, R.R.; MANALANG, A.B. Sustainable consumption and production for Asia: sustainability through green design and practice. **J. Clean. Prod,** v. 40, p. 1–5, 2013. https://doi.org/10.1016/j.jclepro.2012.07.015.

TUMMALA, R.; SCHOENHERR, T. Assessing and Managing Risks Using the Supply Chain Risk Management Process (SCRMP). **Supply Chain Management**, v. 16, p. 474–483, 2011.

TURHAN, S.N.; VAYVAY, O. Vendor managed inventory via SOA in healthcare supply chain management. **Int. J. Business Information Systems**, v. 9, n. 4, 2012.

TUKAMUHABWA, B. R.; STEVENSON, M.; BUSBY, J.; ZORZINI, M. Supply chain resilience: definition, review and theoretical foundations for further study. **International Journal of Production Research**, v. 53, n. 18, p. 5592–523, 2015.

VAN DEMARK, R. E.; SMITH, V. J. S.; FIEGEN, A. Lean and Green Hand Surgery. **Journal of Hand Surgery**, v.43, n. 2, p. 179-181, 2018.

VAN DER PUTTEN, Wilhelm, J.. Much Ado About Nothing': on the distinction between medical physics and clinical engineering. **Int. J. Healthcare Technology and Management**, n. 11, n. 6, 2010. DOI: 10.1504/IJHTM.2010.036924.

VAN SPALL, Harriette; KASSAM; Alisha; TOLLEFSON, Travis T. Near-misses are an opportunity to improve patient safety: Adapting strategies of high reliability organizations to healthcare. **Current Opinion in Otolaryngology and Head and Neck Surgery**, v.23, n.4, p. 292-296, 2015.

VANVACTOR, J. D. Cognizant healthcare logistics management: ensuring resilience during crisis. **International Journal of Disaster Resilience in the Built Environment**, v. 2, n. 3, p. 245-255, 2011.

VANVACTOR, Jerry D. Healthcare logistics in disaster planning and emergency management: A perspective. **Journal of Business Continuity & Emergency Planning,** v.10, n. 2, p. 157-176, 2016.

VARGAS, J.; GONZALEZ, D. Model to assess supply chain resilience International **Journal of Safety and Security Engineering**, v. 6, n. 2, p. 282–292, 2016.

VATOVEC, C.; SENIER, L.; BELL, M. An ecological perspective on medical care: environmental, occupational, and public health impacts of medical supply and pharmaceutical chains. **EcoHealth**, v.10, n.3, p. 257–267. 2013.

VEGTING, I. L.; VAN BENEDEN, M.; KRAMER, M. H.; THIJS, A.; KOSTENSE, P. J.; NANAYAKKARA, P. W. How to Save Costs by Reducing Unnecessary Testing: Lean Thinking in Clinical Practice. **European Journal of Internal Medicine**, v. 23, n. 1, p. 70–75, 2012.

VENKATESWARAN, Sanjith; NAHMENS, Isabelina; IKUMA, Laura. Improving healthcare warehouse operations through 5S. **IIE Transactions on Healthcare Systems Engineering**, v.3, n.4, p. 240-253, 2013.

VERBEEK, A.; DEBACKERE, K.; LUWEL, M.; ZIMMERMANN, E. Measuring progress and evolution in science and technology-I: the multiple uses of bibliometric indicators. **International Journal of Management Reviews**, v. 4, n. 2, p. 179-211, 2002.

VEREECKE, A.; MUYLLE, S. Performance improvement through supply chain collaboration in Europe. **Int. J. Oper. Prod. Manag**, v. 26, n.11, p. 1176–1198, 2006.

VIANI, Costanza; VACCARIB, Mentore; TUDOR, Terry. Recovering value from used medical instruments: A case study of laryngoscopes in England and Italy. **Resources, Conservation and Recycling**, v.111, p. 1–9, 2016.

VIEIRA, E. S.; GOMES, J. A. N. F. A comparison of Scopus and Web of Science for a typical university. **Scientometrics**, v. 81, n. 2, p. 587-600, 2009.

VIDMAR, Gaj; BLAGUS, Rok; LUBOŠ, S; STEHLÍK, Milan. Business indicators of healthcare quality outlier detection in small samples. **Applied Stochastic Models in Business and Industry**, v.28, p. 282-295, 2012.

VON BROCKE, J.; SCHMIEDEL, T.; RECKER, J.; TRKMAN, P.; MERTENS, W.; VIAENE, S. Ten Principles of Good Business Process Management. **Business Process**

**Management Journal**, v. 20, n. 4, p. 530-548, 2014.

VILKO, Jyri P.P.; HALLIKAS, Jukka M. Production Economics Risk assessment in multimodal supply chains. **Int. J. Production Economics**, v.140, n. 2, p. 586-595, 2012.

WAGNER, S.M.; BODE, C. An empirical examination of supply chain performance along several dimensions of risk. **J Bus Logistics**, v. 29, n.1, p. 307–325, 2008.

WALKER, Amy. HTM Professionals And Electronic Health Records. **Biomedical Instrumentation Technology**, v.46, n. 2, p. 112-5, 2012. doi: 10.2345/0899-8205-46.2.112.

WANG, Binseng; TORGEIR, Rui; KOSLOSKY, Jared; FEDELE, Jim; SALIL, Balar; HERTZLER, Lawrence W.; POPLIN, Brian . Evidence-Based Maintenance: Part IV—Comparison of Scheduled Inspection Procedures. **Journal of Clinical Engineering**, v.38, n. 3, p 108–116, 2013. doi: 10.1097/JCE.0b013e31829a2a45.

WANG, M.; JIE, F.; ABARESHI, A. Evaluating logistics capability for mitigation of supply chain uncertainty and risk in the Australian courier firms. **Asia Pacific Journal of Marketing and Logistics**, v. 27, n. 3, p. 486–498, 2014.

WATERS, D. **Supply Chain Risk Management**, Vulnerability and Resilience in Logistics. Replica Press Pvt. Ltd., New Delhi, India, 2011.

WEICK, K. E.; SUTCLIFFE, K. M.; OBSTFELD, D. Organizing for high reliability: processes of collective mindfulness. in SUTTON, R. S.; STAW, B. M. **Research in Organizational Behavior**, Jai Press, Stanford, 1999.

WIELAND, A.; WALLENBURG, C. M. Dealing with supply chain risks. **International Journal of Physical Distribution & Logistics Management**, v. 42, n. 10, p. 887–905, 2012.

WIENGARTEN, F.; HUMPHREYS, P.; GIMENEZ, C.; MCIVOR, R. Risk, risk management practices, and the success of supply chain integration. **International Journal of Production Economics**. v. 171, p. 361–370, 2016.

WILKINSON, Grahame; DRUMMOND, Michael. Impact of reimbursement policies on the adoption of medical devices in an outpatient setting. **Health Policy and Technology,** v. 3, p. 281–286, 2014.

WOODHOUSE, Kristina Dema; VOLZ, Edna; MAITY, Amit; GABRIEL, Peter E.; SOLBERG, Timothy D.; BERGENDAHL Howard W.; HAHN, Stephen M. Journey Toward High Reliability: A Comprehensive Safety Program to Improve Quality of Care and Safety Culture in a Large. **Multisite Radiation Oncology Department**, v.12, n.5, p. e603-e612, 2016.

WU, D. D.; OLSON, D. L. Enterprise Risk Management: A DEA VaR Approach in Vendor Selection. **International Journal of Production Research**, v. 48, n. 16, p. 4919–4932, 2010.

YAN, Y.H.; CHEN, Y.; KUNG, C.M.; PENG, L.J. et al. Continuous Quality Improvement of Nursing Care: Case Study of a Clinical Pathway Revision for Cardiac Catheterization. **Journal of Nursing Research**, v.19, n.3, p. 181-189, 2014.

YU, T.; DEMIRLI, K.; BHUIYAN, N. A general framework for lean transformation of hospitals". In Industrial Engineering and Operations Management (IEOM), Dubai, 2015. **Anais eletrônicos**… Acesso em 13 de ago. 2018.

ZACHARY, W.; JASON, E. L.; STEPHEN, A. L. Supply chain security: an overview and research agenda. **The International Journal of Logistics Management**, v. 19, n. 2, p. 254-281, 2008.

ZENG, B.; YEN, B. P-C. Rethinking the Role of Partnerships in Global Supply Chains: A Risk-Based Perspective. **International Journal of Production Economics**, v. 185, p. 52–62, 2017.

ZEPEDA, E. D.; NYAGA, G. N.; YOUNG, G. J. Supply chain risk management and hospital inventory: Effects of system affiliation. **Journal of Operations Management**. v. 44, p. 30-47, 2016.

ZSIDISIN, G.; PANELLI, A.; UPTON, R. Purchasing organization involvement in risk assessments, contingency plans, and risk management: an exploratory study. **Supply Chain Management: An International Journal**, v. 5, n. 4, p. 187–198, 2000.

ZSIDISIN, G.A.; ELLRAM, L.M.; CARTER, J.R.; CAVINATO, X. An analysis of supply risk assessment techniques. **Int J Phys Distrib Logist Mngt**, v. 34, n.5, p. 397–413, 2004.

# Appendices

## Interview Protocol

| *Interview Questions* | *Português* | *Authors* |
|---|---|---|
| **General background** | **Contexto Geral** | |
| **Overview of purpose of study** | Propósito geral do estudo - Explicado no e-mail | **Gaudenzi et al. (2017)** |
| **Confidentiality assurance permission to audiotape** | Certificação de confidencialidade e permissão para gravar | **Gaudenzi et al. (2017)** |
| **Background on organization, position, job title and responsibilities.** | Diga por favor Background da organização, sua posição, título, responsabilidades | **Fan and Stevenson (2018)** |
| **What is your understanding of buyer-supplier relationships, SCR and risk identification in particular?** | Qual o seu entendimento da relação comprador-fornecedor, Riscos em Cadeias de Suprimentos e identificação de riscos em geral? | **Fan and Stevenson (2018)** |
| **Supply chain risks and risk identification strategies** | **Riscos em SC e estratégias de identificação de riscos** | |
| **Which of the following SCRs are most relevant to your company?** | Quais dos seguintes riscos de SC são mais relevantes para sua organização? | **Fan and Stevenson (2018)** |
| **Inability to meet quality requirements;** | Incapacidade de atender requisitos de qualidade | **Fan and Stevenson (2018)** |
| **Inability to adapt to required product design or technological changes;** | Incapacidade de adaptar os produtos requeridos a mudanças tecnológicas e de design | **Fan and Stevenson (2018)** |
| **Failures to make delivery requirements;** | Falha ao cumprir requisitos de entrega | **Fan and Stevenson (2018)** |
| **Cannot provide competitive pricing (including sudden hike in costs);** | Incapacidade de fornecer preços competitivos | **Fan and Stevenson (2018)** |
| **Supplier opportunism (including intellectual property risk);** | Oportunismo do fornecedor (incluindo riscos de propriedade intelectual) | **Fan and Stevenson (2018)** |
| **Contractual agreements;** | Acordos contratuais | **Fan and Stevenson (2018)** |
| **Single source of supply;** | Único fornecedor | **Fan and Stevenson (2018)** |
| **Selection of wrong partner;** | Seleção errada de parceiros | **Fan and Stevenson (2018)** |
| **Financial instability, including bankruptcy;** | Instabilidade financeira, incluindo falência | **Fan and Stevenson (2018)** |
| **Lack of supplier involvement;** | Falta de envolvimento do fornecedor | **Fan and Stevenson (2018)** |
| **Sustainability related problems.** | Problemas relacionados à sustentabilidade | **Fan and Stevenson (2018)** |
| **Are there any other SCRs (not listed) that are relevant to your company?** | Existem outras questões relacionas a risco de SC que são relevantes para sua organização | **Fan and Stevenson (2018)** |
| **What strategies has your company used to identify risks, and how effective have these been?** | Que estratégias sua organização usa para identificar riscos e como essas práticas têm acontecido efetivamente | **Fan and Stevenson (2018)** |
| **Types of BSR, SCR and risk identification** | **Tipos de SCR e identificação de riscos** | |
| **What are the different types (characteristics) of working relationships with your suppliers? How critical is a supplier in each type to your overall business?** | Quais são os diferentes tipos (características) das relações de trabalho com seus fornecedores? Quão crítico é o fornecedor para o seu negócio em geral? | **Fan and Stevenson (2018)** |
| **How do the types of relationships you have with suppliers affect the SCR?** | Como os tipos de relacionamentos que vocês têm com os fornecedores afetam os riscos em SC? | **Fan and Stevenson (2018)** |

| | | |
|---|---|---|
| **How has working with your suppliers (with examples from different types of relationships) influenced risk identification?** | Como trabalhar com seus fornecedores influenciou na identificação de riscos? | **Fan and Stevenson (2018)** |
| **How would you evaluate your working relationships with your suppliers regarding SCRs and SCRM?** | Como você avalia suas relações de trabalho com os fornecedores com relação a Riscos em SC e SCRM? | **Fan and Stevenson (2018)** |
| **Final comments** | **Comentários finais** | |
| **Are there any further comments that you think are relevant to this research that either affect the company now or may do in the future?** | Existe mais algum comentário que você ache elevante para esta pesquisa que possa afetar sua organização agora ou no futuro? | **Fan and Stevenson (2018)** |

# Questionnaire ready to be distributed

| *Observable Variables* | *Reference* |
|---|---|
| **SC Risk identification** | |
| **IDEN1)** Acredito ser importante para uma organização promover práticas de identificação de riscos de maneira periódica | Author |
| **IDEN2)** Acho importante informar e qualificar os fornecedores sobre práticas de segurança na cadeia de suprimentos | Lu et al. (2017) |
| **IDEN3)** Considero fundamental promover práticas de identificação de risco para organizações que nós prestamos serviço | Lu et al. (2017) |
| **IDEN4)** No que diz respeito à segurança em cadeias de suprimentos, a estratégia deve ser focada em prevenção. As organizações da cadeia deveriam identificar os principais problemas de segurança. | Lu et al. (2017) |
| **IDEN5)** Considero importante envolver todos os fornecedores, para que estes se responsabilizem pela segurança da cadeia de suprimentos. | Lu et al. (2017) |
| **IDEN6)** Acredito que devamos trabalhar sempre procurando detectar riscos operacionais (Aplicando monitoramento interno e dos fornecedores, inspeção e rastreamento) | Sinha et al. (2004), Zsidisin et al. (2004) Manuj and Mentzer (2008) Chaudhuri et al. (2018) |
| **Promote SC Risk Assessment** | |
| **ASSE1)** Acredito que as organizações da cadeia devem ter indicadores chave de processos. | Author |
| **ASSE2)** Acredito que as organizações da cadeia devem promover a visibilidade de nossos indicadores - chave de processos. | Soni and Jain (2011); Christopher and Peck (2004) |
| **ASSE3)** Uma boa prática de avaliação consiste em saber o que fazer quando são encontradas falhas de segurança ou crises em uma cadeia de suprimentos. | Lu et al. (2017) |
| **ASSE4) Considero** uma boa prática mapear riscos relacionados a suprimentos (materiais de almoxarifado e medicamentos) | Author |
| **ASSE5) Considero** essencial mapear riscos relacionados a recursos humanos (absenteísmo, baixo - desempenho, entre outros.) | Author |
| **ASSE6)** Considero essencial manter um registro de riscos que afetem à cadeia de suprimentos (riscos operacionais, riscos técnicos, riscos financeiros, riscos legais, riscos de marca, riscos ambientais, riscos relacionados à saúde e segurança, etc.) | SCOR - BP.150 Maintain Supply Chain Risk Register |
| **ASSE7)** A organização onde trabalho tem estabelecido um processo formal de monitoramento contínuo de mudanças na probabilidade ou impacto de eventos de risco | SCOR - BP.173 Supply Chain Risk Monitoring |
| **ASSE8)** A organização onde trabalho possuí um claro entendimento de onde os maiores riscos estão localizados de forma a priorizar os recursos de mitigação e gerenciamento de riscos. | SCOR - BP.174 Supply Chain Risk Assessment |
| **Promote SC Risk Mitigation** | |
| **MITI1)** Sempre que possível, a organização deveria manter uma quantidade de produtos maior que a necessária para utilizar como estoque-pulmão. | Juttner et al. (2003); Iakovou et al. (2007); Barroso et al. (2010) |

| | |
|---|---|
| **MITI2)** Considero que uma estratégia de múltiplos fornecedores deve ser utilizada como forma de obter flexibilidade. | Juttner et al. (2003); Iakovou et al. (2007); Barroso et al. (2010) |
| **MITI3)** Acredito que se os fornecedores pudessem ser mais ágeis, seria mais fácil responder rapidamente a mudanças imprevisíveis na demanda e quantidade de suprimentos necessários. | Christopher and Peck (2004) |
| **MITI4)** Considero que organizações deveriam designar um grupo de colaboradores treinados para responder de forma imediata em caso de crise ou emergência (falta de suprimentos, recursos humanos, etc.). | Lu et al. (2017) |
| **MITI5)** Considero que quando uma crise acontecer deve haver comunicação efetiva ao longo da cadeia de suprimentos. | Lu et al. (2017) |
| **MITI6)** Acredito que os colaboradores deveriam receber treinamento cruzado como um mecanismo de lidar com rupturas na cadeia de suprimentos. | Lu et al. (2017) |
| **MITI7)** Considero importante prevenir riscos em operações (por exemplo, selecionar um fornecedor mais confiável, usar procedimentos claros de segurança, manutenção preventiva, etc.) | Tomlin (2006) Chaudhuri et al. (2018) Chaudhuri et al. (2018) |
| **MITI8)** Acredito ser relevante responder a riscos operacionais (por exemplo, fornecedores reserva, capacidade extra, modais alternativos de transporte, etc.) | Sheffi and Rice (2005) Chaudhuri et al. (2018) |
| **MITI9)** Acredito que a recuperação de riscos operacionais que se materializam é essencial (por exemplo, forças-tarefas, planos de contingência, responsabilidades claramente atribuídas). | Norrman and Jansson (2004) Chaudhuri et al. (2018) |
| **MITI10)** Acredito ser importante criar uma cultura de mitigação de riscos na cadeia de suprimentos que se estenda além das fronteiras organizacionais | Christopher and Peck (2004); Barroso et al. (2010) |
| **MITI11)** Na organização em que trabalho a estratégia de gestão de risco da cadeia de suprimentos pode ser classificada como proativa | Lu et al. (2017) |
| **MITI12)** Mitigação de riscos é um plano para reduzir a probabilidade de ocorrência ou minimizar o impacto do risco. | SCOR - BP.002 Risk Management Strategies |
| **Supply Chain Integration** | |
| **INTE1)** Considero uma boa prática compartilhar informações com o departamento de compras (por exemplo, previsão de demanda, planos de produção, progresso da produção e níveis de estoque). | Ellinger (2000), Thomé et al. (2012), Chaudhuri et al. (2018) |
| **INTE2)** Considero uma boa prática tomar decisões em conjunto com o departamento de compras uma boa prática por exemplo, previsão de demanda, planos de produção, progresso da produção e níveis de estoque). | Thomé et al. (2012), Chaudhuri et al. (2018) |
| **INTE3)** Acredito que deveria haver compartilhamento de informações com fornecedores - chave (por exemplo sobre previsão de vendas, planos de produção, rastreamento de pedidos, status da entrega e níveis de estoque). | Cagliano et al. (2006), Flynn et al. (2010), Chaudhuri et al. (2018); Tang (2006); Barroso et al. (2010); Barroso et al. (2010) |
| **INTE4)** Acredito que organizações deveriam desenvolver abordagens colaborativas com fornecedores - chave (por exemplo, desenvolvimento de fornecedores, compartilhamento de risco/receita, acordos de longo prazo e etc.). | Ragatz et al., Spekman, Lambert et al. (1999), Dröge et al. (2004), Chaudhuri et al. (2018); Soni and Jain (2011) |
| **INTE5)** Acredito que deveria haver decisões em conjunto com fornecedores - chave (por exemplo, sobre produtos, processos, melhoria da qualidade, controle de custos etc.). | Narasimhan and Das (1999), Koufteros et al (2005) |
| **INTE6)** Considero essencial que os sistemas de informação sejam integrados com fornecedores - chave (por exemplo, estoque controlado por fornecedores - VMI, Just-in-Time, Kanban, reabastecimento contínuo). | Frohlich and Westbrook (2001), Cagliano et al (2006), Vereecke and Muylle (2006) Chaudhuri et al. (2018) |
| **INTE7)** Considero relevante compartilhar informação com clientes - chave (por exemplo sobre previsão de vendas, planos de produção, rastreamento de pedidos, status da entrega e níveis de estoque). | Zhao et al. (2008), Flynn et al. (2010) Chaudhuri et al. (2018); Tang (2006); Barroso et al. (2010); Barroso et al. (2010) |
| **INTE8)** Deveriam existir abordagens colaborativas com clientes - chave (por exemplo, compartilhamento de risco/receita, acordos de longo prazo e etc.). | Lambert et al. (1999) Chaudhuri et al. (2018); Iakovou et al. (2007); Soni and Jain (2011) |

| | |
|---|---|
| **INTE9)** Considero essencial que os sistemas de informação sejam integrados com clientes - chave (por exemplo, estoque controlado por fornecedores - VMI, Just-in-Time, Kanban, reabastecimento contínuo). | Frohlich and Westbrook (2001) Chaudhuri et al. (2018) |
| **INTE10)** Acredito que deveria haver decisões em conjunto com clientes - chave (por exemplo,sobre design ou modificação de produtos, desenho ou melhoria de processos, melhoria da qualidade, controle de custos e etc.). | Lengnick-Hall (1996) Chaudhuri et al. (2018); Soni and Jain (2011) |
| **INTE11)** Acredito que o gerenciamento de risco deveria ser colaborativo, de forma a melhorar o entendimento e visbilidade da cadeia de suprimentos. | Friday et al. (2018); Juttner et al. (2003);Christopher and Peck (2004) |
| **SCRM** | |
| **SCRM1)** Acredito que a organização onde trabalho deveria possuir acreditação ou outros certificados de qualidade. | Ali et al. (2018) |
| **SCRM2)** Considero que a organização onde trabalho deveria ter trabalhadores com múltiplas habilidades | Ali et al. (2018) |
| **SCRM3)** Acredito que a organização em que trabalho deveria ter um sistema de gerenciamento da qualidade. | Ali et al. (2018) |
| **SCRM4)** Acredito ser essencial que a organização possua um forte mecanismo de colaboração com agências governamentais. | Ali et al. (2018) |
| **SCRM5)** Acredito que uma organização resiliente deva possuir programas de educação continuada. | Author |
| **HC SC 4.0** | |
| **SC401) Acredito** que os processos da nossa cadeia de suprimentos teriam maior compliance e segurança se fossem suportados por blockchain | Mylrea and Gourisetti (2018); Kumari et al. (2018); Griggs et al. (2018); Hiromoto et al. (2017) |
| **SC402)** Acredito que a implementação de dispositivos de IoT (Internet das Coisas) otimizaria nossos processos. | Roy et al. (2017); Griggs et al. (2018); Laplante et al. (2018); Javdani and Kashanian (2018); Rodrigues et al. (2018); Baker et al. (2017); Park et al. (2017) |
| **SC403)** Acredito que nossa cadeia de suprimentos seria mais eficiente se tivesse apoio de IoT e Blockchain | Roy et al. (2017) |
| **SC404)** Acredito que a implementação de dispositivos IoT possa ajudar na melhoria dos cuidados ao paciente. | Martínez-Caro et al. (2018); Griggs et al. (2018); Javdani and Kashanian (2018); RODRIGUES et al. (2018); Joyia et al. (2017) |
| **SC405)** Acredito que minha organização se beneficiaria de uma base de dados bem estruturada (contendo informações sobre pacientes, fornecedores, clientes ou pacientes) | Guha and Kumar (2018) |
| **SC406)** Acredito que IoT tornaria nossa cadeia de suprimentos mais segura | Kouicem et al. (2018); Griggs et al. (2018); Hiromoto et al. (2017) |
| **HC SC Performance** | |
| **HSCP1)** Nossa organização tem tido uma melhor satisfação dos pacientes nos últimos 3 anos. | Ali et al. (2018) |
| **HSCP2)** Acredito que nossa organização esteja vivenciando uma redução dos roubos. | Lu et al. (2017) |
| **HSCP3)** A organização em que trabalho melhorou a capacidade de detectar peças ou produtos falsificados. | Lu et al. (2017) |
| **HSCP4)** Acredito que a probabilidade da nossa cadeia de suprimentos seja comprometida (por exemplo, rupturas, desastres, ou eventos que interrompam as ações) seja pequena. | Lu et al. (2017) |
| **HSCP5)** Acredito que a nossa probabilidade de uso indevido da carga seja pequena. | Lu et al. (2017) |
| **HSCP6)** Acredito que temos baixos níveis de vulnerabilidade na cadeia de suprimentos. | Lu et al. (2017) |
| **HSCP7)** Acredito que nossa cadeia de suprimentos tenha baixos níveis de segurança. | Lu et al. (2017) |
| **HSCP8)** Acredito que obtivemos uma redução/menor potencial de tráfico de drogas. | Lu et al. (2017) |