Measuring Resilience of Healthcare Supply Chains: A Resilience Indicator Classification Proposal

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Abstract: The Healthcare Supply Chain (HSC) plays a vital role in ensuring efficient management of medical supplies and delivering timely, cost-effective healthcare services, ultimately impacting patient care and public health outcomes. Resilience in HSCs is critical, particularly to face socio-demographic shifts, disruptions, and operational failures. To monitor the resilience of HSCs, resilience indicators must be defined. This paper explores indicators used in literature to measure the resilience of supply chains to disruptions and assess which applies to the healthcare supply chain. A preliminary literature review identifies standard methodologies and indicators employed to measure resilience. The findings revealed a lack of healthcare-specific indicators, underscoring the need for further research in this area. The indicators were distinguished between static and dynamic resilience indicators. Additionally, the components of resilience indicators and phases of application were examined, shedding light on areas for improvement and future research directions. While significant progress has been made in understanding and measuring resilience, challenges remain, including real-time monitoring and computational complexity. Addressing these challenges will contribute to the development of effective strategies for enhancing supply chain resilience, particularly in healthcare.

Keywords: healthcare supply chain, HSC, resilience, indicator, performance measurement, KPI.

1. Introduction

The healthcare supply chain (HSC) is crucial for the efficient management of medical supplies, ensuring prompt and cost-effective healthcare services. HSCs are characterised by high levels of complexity caused by the movement of highly valuable goods, such as life-saving medical devices and drugs, and by the involvement of human lives. HSCs have distinctive social relevance as their reliability and stability directly impact public health. Additionally, current socio-demographic shifts, such as population ageing and growth, as well as disruptions and operational failures, have highlighted the importance of HSC resilience. Resilience is a property of complex socio-technical systems required for survival and acceptable performance under expected and unexpected conditions (Furstenau et al., 2022). It entails the capability of a supply chain to prepare, respond and recover from disruptions (Hohenstein et al., 2015). Indeed, supply chain managers need to be able to reorganise HSCs in the event of an unforeseen demand spike or shortage of supplies, as these events can have disastrous effects beyond poor economic metrics (Senna et al., 2023). Nowadays, supply chain managers are trying to find a way to eradicate the challenges associated with their supply chains. In this regard, effective performance indicators are in high demand to help organisations achieve this business goal (Ramezankhani et al., 2018). A performance indicator is a quantity that can be determined for a given business process, and it is used to measure, report and improve performance (Dumas et al., 2018). Performance indicators are organisation-dependent and should be derived from an organisation's objectives, strategy, mission and vision (Van Looy & Shafagatova, 2016). Performance indicators should be designed to have a reference value that should imply corresponding consequences depending on whether the actual measurement is below or above the desired value (Ojha et al., 2018). A resilient HSC, that succeeds at monitoring resilience performance, employs indicators to detect, prevent, and respond to disruptions and operational failures that might compromise their operations (Furstenau et al., 2022). Therefore, resilience indicators are applied to measure and monitor an organisation's ability to prepare for, respond to, and recover from an adverse event. Measuring resilience in supply chains is a problematic task because the interrelationships among supply chain resilience strategies are difficult to understand and manage (Kazemian et al., 2022). There is no single univocal and agreed definition of resilience for industrial and healthcare systems to transform the resilience concept into an operational tool for policy and management purposes (Xu et al., 2023). Even though measuring a supply chain's resilience is still debatable, the existing literature provides some indicators for addressing such an issue (Zahiri et al., 2017). This paper aims to analyse indicators used to measure resilience in industrial contexts, with a focus on those regarding HSC - which is at the forefront of responding to disruptive events and socio-demographic changes - and to propose a classification of these indicators inductively extracting classification dimensions from the analysed papers. The goal is to address a key concern raised by current supply chain researchers, who argue that it is crucial to consider quantitative factors when designing a resilient supply chain network (Kazemian et al., 2022). Indeed, the literature on measuring and analysing supply chain resilience is scarce (Chen et al., 2020). Thus, according to these considerations, the following research question was defined: *What are the key performance indicators* *for measuring resilience supply chains and which indicators apply to the HSC?* The remainder of the paper is structured as follows. Section 2 describes the methodology applied. Sections 3, 4 and 5 provide an analysis of the results The proposed resilience indicator classification is presented in Section 6. Discussion of possible future research directions is reported in Section 7. Finally, limitations and conclusions are addressed in the last section.

2. Methodology

The problem of quantitatively measuring supply chain resilience was addressed by performing a preliminary literature review to start investigating the topic and lay the groundwork for a more structured review. This type of review provides a preliminary assessment of the scope of available research literature and is able to inform policymakers as to whether a full systematic review is needed (Grant & Booth, 2009). This review does not aim to produce a critically appraised and synthesised result, but rather to provide an overview or map of the evidence (Munn et al., 2018). To this end, a three-step protocol was developed to identify a proper procedure for replicating literature reviews. A preliminary list of the keywords was identified and used to build a query: resilience AND (indicator* OR KPI) AND ("supply chain" OR supply-chain). Different terms are used by different authors to discuss performance measurement. We selected only the term indicator because it is the most used term in process-oriented literature and it is frequently used in relation to a key performance indicator (KPI), a KPI area, a performance indicator, or a process performance indicator (Van Looy & Shafagatova, 2016). We limited the research to the last ten years (2014 to 2024) to capture the evolution of resilience indicators in recent literature. We selected only scientific papers in the English language that were related to engineering and business, management, and accounting. The search was launched on the Scopus database and produced 73 papers. The researchers independently reviewed titles and abstracts of initially selected papers, selecting those that met the inclusion criteria. Disagreements over paper inclusion were resolved through discussion. After reviewing the titles and abstracts of selected papers, 48 papers were discarded because they did not align with the topics discussed in this paper. For instance, these papers only briefly mentioned indicators or resilience while the main topic was different (e.g., sustainability, digitalisation, technologies) or provided indicators not measuring resilience. Additionally, other studies measure resilience in terms of physical health rather than supply chain resilience and were consequently excluded. Finally, after reading each of the remaining papers, 7 papers were discarded as they did not introduce new indicators. From the remaining 18 papers, a backward snowballing process examining the references of selected studies was carried out, which resulted in a further 8 papers being added to the selection, for a total of 26 papers. With this process, papers proposing other resilience indicators not previously identified were added to the corpus. The resilience indicators discussed in each paper were inductively identified and extracted to understand which resilience indicators are most used and the characteristics, advantages, and disadvantages of each. Finally, a possible classification of resilience indicators was proposed.

3. Supply chain resilience measurement method

Four methods are used in the literature to measure supply chain resilience: 1) case studies, 2) surveys, 3) modelling, and 4) simulation-based approaches (Ward & Hargaden, 2019). Case study methods are typically cross-sectional, and disruptions are categorised as a function of their likelihood of occurrence compared to the consequences of occurrence. An example is the development of a resilience framework that measures resilience as a function of a company's position and responsiveness. This resilience framework is unique to each company (Ward & Hargaden, 2019). The lack of longitudinal studies implies that it is not possible to fully understand how supply chain resilience evolves and how a supply chain's capacity for resilience might increase or decrease under adaptation pressures (Tukamuhabwa et al., 2015). Survey-based methods limit supply chain resilience understanding to what people in organisations are willing to share. This aspect is a limitation because they may have an imperfect understanding of their supply chains (Tukamuhabwa et al., 2015). Moreover, many indicators applied in the health sector are based on a quantitative evaluation by expert opinion. In this method, experts in the field are requested to evaluate specific resilience aspects like flexibility, visibility, and agility using a scale from 1 to 10. From these, a measure of overall resilience is derived. This approach leads to an inaccurate supply chain resilience assessment that is not based on the objective monitoring of specific relevant parameters. Mathematical modelling methods are appropriate for more tightly defined problems. The analysis of supply chain resilience literature shows that resilience indicators are usually bounded between [0, 1] and considered objective functions that must be maximised in addition to minimising supply chain cost as a primary objective (Hosseini et al., 2022). A key obstacle to using mathematical modelling methods for supply chain resilience evaluation surrounds data availability; in particular, it is often difficult to predict and quantify high-impact, low-probability events (Ward & Hargaden, 2019). Simulation models are utilised to put a system through stress tests to evaluate its performance under challenging conditions. A promising road is agent-based simulation since it allows the modelling of behaviour and preferences at an individual level (Piffari et al., 2022). Agents in this simulation can adapt and learn over time, enabling the representation of the dynamic characteristics of resilient supply chains. Managers can easily adopt the simulation-based approach to assess the resilience of their supply chain networks and their preparedness to face potential risks (Dixit et al., 2020). Despite these examples, the methodologies applied to measure resilience are still limited, and the research conducted so far has been largely qualitative rather than quantitative (Ward & Hargaden, 2019).

4. Supply chain and networks considered

Eighteen per cent of all collected indicators are specific to the HSC. Among these, pharmaceutical supply chains are most cited, as they are one of the most impacted by disruptions such as drug shortages, interruptions, and regulatory constraints (Ward & Hargaden, 2019). Then, reference is made to internal hospitals or hospitals' network performance (Cimellaro et al., 2010), medical devices, and medical equipment supply chains (Hasani, 2021). Additionally, generic HSCs are mentioned (Tippong et al., 2021). Other HSCs, such as transplants or blood, have received less attention also because such products are subject to very stringent and regulated management (Jalilvand et al., 2023). Concerning non-healthcare supply chains, those include the container logistics supply chain (Xu et al., 2023), intermodal freight transport (Chen & Miller-Hooks, 2012) and traffic network (Nogal et al., 2015).

According to the research objective, resilience indicators may pertain to a single node, multiple nodes, or the entire network. In a supply chain network, all entities, such as suppliers, manufacturers, distribution centres, retailers, and other involved organisations, are regarded as nodes, each playing a crucial role in the interconnected system. When the focus is on an individual actor operating within a supply chain, the proposed indicator assesses the resilience of that individual node. In further detail regarding the selected papers, the majority (65%) propose resilience indicators for assessing multiple nodes or the entire supply chain, 24% suggest indicators adaptable to multiple and single nodes, and finally, 12% of papers propose indicators for single-node resilience measurement. Generally, papers that propose a resilience indicator focused on a single node often address infrastructure disruptions, such as the impact of natural disasters like earthquakes (Cimellaro et al., 2010). From a practical perspective, it is more challenging to implement indicators that evaluate the resilience of an entire network due to the numerous interacting actors. The data to be collected would be scattered among different independent actors. Consequently, establishing a general KPI would necessitate collaboration and cooperation among various entities in the supply chain network. Although indicators focused on a single node are simpler to implement, they may not offer a comprehensive view of the entire supply chain system, potentially restricting the assessment of overall resilience. Indeed, in a supply chain, the performance of a single node is intricately linked to the operations of the upstream and downstream supply chains. Furthermore, the structure of a supply chain network significantly determines the degree of impact of the disruption. Indicators measuring the resilience of the entire supply chain network capture this (Dixit et al., 2020).

5. Supply chain resilience indicators

In this section, the supply chain resilience indicators found in the literature are discussed. In particular, the difference between static and dynamic indicators and the application phase (Section 5.1), the components of resilience indicators (Section 5.2) and specific indicators for the HSCs (Section 5.3) will be analysed.

5.1 Static and dynamic resilience indicators

Examining the specific resilience indicators proposed in the papers, it is possible to distinguish between *static* and *dynamic* indicators, as defined by Rose (2007). Static resilience indicators assess the ability of a system or organisation to withstand and recover from disturbances or shocks based on its inherent characteristics without considering real-time or ongoing changes. A static resilience indicator might involve resilience index values used to rank different supply chain networks under consideration from a resilience perspective or to maximise the resources available at a given time (Kazemian et al., 2022; Rose, 2007). Static resilience indicators provide a snapshot assessment of resilience potential but may not account for evolving conditions or dynamic responses to disruptions (Rose, 2007). The static resilience indicator can aid in pre-disruption network vulnerability assessment and making pre-disaster vulnerability-reduction investment decisions. For example, Ward and Hargaden (2019) propose the resilience gap computed as a function of the average vulnerability and capability scores. Where there are negative gaps, i.e., the vulnerability is more significant than its corresponding capability, targeted improvement can be implemented to address this gap. This aspect is helpful, considering that making supply chains resilient is a costly procedure. Dixit et al. (2020) compute resilience as a composite effect of density, centrality, connectivity, and network size. Managers can easily adopt these indicators to assess the resilience of their supply chain networks and their preparedness to face potential risks. Cimino et al. (2024) evaluated supply chain resilience as the percentage change in revenue in the presence of a disruption, compared to normal working conditions. Wang et al. (2024) propose to measure resilience as operations costs increase during the recovery time, simultaneously addressing uncertainty, decision-makers risk preferences, and resilience strategy.

Dynamic resilience indicators evaluate efforts of repair and reconstruction, which affect the time path of the organisation after a disruption. Dynamic resilience is thus more complex from an economic standpoint and more expensive to compute. In many cases, dynamic indicators require real-time or quasi-real-time monitoring. Indeed, they trace the trend of a performance indicator of interest over time following a disruption and during the recovery period (Caputo et al., 2023). Dynamic resilience indicators evaluate a system or organisation's adaptability and response capabilities over time, considering ongoing changes, interactions, and feedback loops. Dynamic resilience indicators focus on the system's ability to learn, adapt, and recover dynamically from disturbances. They often involve continuous monitoring, feedback mechanisms, and the ability to make real-time adjustments in response to changing conditions. Among dynamic indicators of resilience, one of the best-known and widely used approaches is the resilience triangle, first proposed by Bruneau et al. (2003), who measured the loss of performance of a system following a disruption (in that case, an earthquake), focusing on the area above a performance curve. The basic idea is that the greater the resilience of a system, the smaller the area of the resilience triangle. Indeed, a resilient supply chain is capable of minimising the immediate impact caused by disruption (reducing vertical depression following disruption) and the recovery time (shortening of the horizontal axis) (Ward &

Hargaden, 2019). Consequently, using the resilience triangle, resilience R is computed as:

$$R = \int_{t(0)}^{t(1)} [1 - P(t)]\, dt \quad (1)$$

where $P(t)$ is the normalised system performance at time t ($0\% \leq P(t) \leq 100\%$). Several other authors have extended this initial work to identify the relative area beneath the triangle as a quantitative resilience indicator. Starting from Bruneau's seismic resilience framework, Reed et al. (2009) introduced a straightforward methodology to quantify engineering resilience as the ratio of the area beneath the performance curve $P(t)$ and the time interval under consideration, enabling comparisons between various disruptions. Indeed, if recovery times vary among different systems, the indicators are unsuitable for comparing resilience. Then, Cimellaro et al. (2010) provided a resilience indicator as the area beneath the performance curve over a given period, defined as the control time. The control time for the decision analysis is usually based on the decision maker's interest in evaluating the effects of resilience strategies. Ouyang (2012) proposed resilience as the ratio of the area beneath the curve $P(t)$ and the area beneath the target performance curve, namely the performance curve if no disruption had occurred. Spiegler et al. (2012) considered that the performance may overshoot and/or undershoot before recovering, hence not assuming a triangular shape but an oscillatory behaviour. With this indicator, both positive and negative errors can be measured equally. Zobel (2014) measured resilience as the area beneath the performance curve $P(t)$, assuming that all systems will return to their original status before T*, selected by the decision maker to represent the maximum allowable time they would be willing to wait for recovery. Li et al. (2017) expressed resilience as the ratio of the integral of $P(t)$ within the maximum allowable recovery time T* to the integral of performance in the normal state. The maximum allowable recovery time T*, determined by users, is used as the time interval under consideration. If the system performance cannot return to baseline within the maximum allowable system recovery time, its resilience is considered low, and the area of the performance loss is large. The main criticalities of these indicators based on the resilience triangle include: 1) real-time monitoring of $P(t)$ to assess performance over time; 2) understanding when exactly the disruption has ended is crucial; the system may not always return to its initial performance level, sometimes it is lower, other times higher; 3) when a maximum recovery time is selected, it can be challenging to discern the criteria for its selection. These criticalities must depend on both the supply chain's characteristics and the disruption's characteristics. Another limitation of these indicators, as opposed to static indicators, is that most of them do not assess the system's resilience during the preparation phase. This phase occurs before a disruptive event takes place. A solution could be to try to combine the two types of indicators in order to obtain an overall one that allows the resilience of the supply chain to be assessed before, during, and after a disruptive event.

5.2 Resilience indicators' components

Another significant aspect of the classification of resilience indicators, as suggested in academic literature, involves examining their components. Components refer to the parameters that, when combined, make up a resilience indicator. Each component represents a specific aspect or characteristic that contributes to understanding how resilient a system is. 58% of supply chain resilience indicators are determined by observing a single variable over time. Examples include the dynamic indicators based on the resilience triangle described in Section 5.1. Such indicators monitor the development of a performance $P(t)$ over time. For example, $P(t)$ can be the operational capacity (Caputo et al., 2023), the normalised waiting time (Cimellaro et al., 2010), or the amount of product delivered and the average delivery distance (Li et al., 2017). Alternatively, composite indicators combine multiple parameters to derive resilience indicators. The advantage of these indicators is that they provide insight into which factors contribute to a resilient supply chain and which resilience strategies need to be implemented to reduce vulnerabilities. For instance, Dixit et al. (2020), based on the relationships between structural factors and supply chain resilience, proposed a resilience indicator determined by the density D of a network structure; the centrality CT of the network structure; the connectivity CV of a network; and the network size NS. The managers can then make informed decisions on how to increase resilience. For example, if the high density is identified as the major factor for reduced resilience, then the managers can increase the distance between the nodes. Xu et al. (2023) propose a two-dimensional resilience index composed of two parameters: affordability and recovery ability. Indeed, considering the impact of adverse events, the smaller the deviation level of the system, the stronger its recovery ability. At the same time, it is essential to consider the change in the system's internal states. The smaller the degree of change in the internal states under disruptions, the stronger the system's affordability. Furthermore, Zobel (2014) suggested a resilience indicator that distinguishes loss (immediate impact) and recovery time. This approach offers a more comprehensive understanding of resilient behaviour than solely assessing each system's overall resilience value. Kazemian et al. (2022) proposed the composite resilience index, computed based on eleven network factors: network complexity, source criticality, supplier complexity, density, node criticality, flow reliability, flow complexity, and network centralisation. This index will help decision-makers choose various risk mitigation strategies more effectively. Finally, the global supply chain resilience index is computed based on four key aspects: robustness, agility, leanness, and flexibility (Hasani, 2021). In conclusion, composite resilience indicators can influence decision-makers in prioritising which supply chain resilience strategies need to be developed (Hohenstein et al., 2015).

5.3 Healthcare resilience indicators

While supply chain resilience indicators are commonly studied in industrial contexts, the healthcare sector is relatively new to this research area. Current resilience indicators for the HSC lack variables that can monitor critical aspects of healthcare, including health status, patient volume, and mortality rates. Resilience indicators should reveal population health and the quality of healthcare network performance. They should also serve as a benchmark for resilience across different emergency response strategies, providing information for decision-makers to enhance emergency medical responses (Tippong et al., 2021). Only a small fraction of the selected articles incorporates specific indicators tailored to the healthcare system, highlighting the scarcity of such focused research. For example, Tippong et al. (2021) classified HSC resilience indicators in various dimensions, including time-based indicators such as patients' waiting time, door-to-doctor time, and length of stay. In particular, it is relevant to consider whether and how they vary during a disruption compared to ordinary situations. Other dimensions of classification proposed by Tippong et al. (2021) are based on the number of patients; costs and utilisation rate. Another paper considering healthcare-specific resilience indicators includes hospital functionality, representing the quality of services it provides. Functionality is defined as a normalised waiting time and a distinction between the waiting time before and after the critical condition is made (Cimellaro et al., 2010). Neglecting indicators related to health status, patient volume, and service quality in HSC resilience poses a significant challenge. Indeed, performance in the health sector goes beyond mere economic considerations, and the social impacts it has on the population must be considered, such as saving lives, improving patient care, and optimising service levels and treatment quality.

6. Resilience indicator classification

Based on the literature findings, we developed a classification proposal for resilience indicators (Figure 1). The first classification dimension is based on measuring and collecting resilience indicators, which can be done through case studies, interviews, mathematical modelling, or simulation, as emerged from the literature. The second classification dimension concerns the context, distinguishing between generic supply chains and specific ones (e.g., healthcare), as well as the level of detail, which can focus on a single node or the interaction between several nodes. The third classification dimension is based on the behaviour of the resilience indicators, whether static or dynamic, as discussed in Section 5.1. Indicators are also classified concerning the application phase, whether before an interruption to measure the state of preparedness for a possible adverse event or after an interruption to measure the supply chain's ability to respond and recover. While dynamic indicators primarily focus on measuring post-interruption resilience, static indicators concentrate on measuring pre-interruption resilience; however, exceptions exist. The final dimension of classification concerns the components of the indicators, specifically differentiating between indicators that measure a single variable and those composed of an aggregation of variables, as detailed in section 5.2. This classification is helpful as it offers a common framework to organise and categorise indicators, making research standardisation and result comparison between studies easier. It can also provide a common basis for exploring new indicators, complementing those currently described in the literature. Moreover, this classification can be used to create practical tools and methods for gathering, analysing, and interpreting indicators, enhancing the practical application of research in real-world scenarios.

7. Discussion and future research direction

The literature has discussed resilience indicators for almost 20 years (Chen et al., 2020). However, their practical implementation is often limited due to the requirement for real-time performance monitoring systems that many companies lack. Additionally, the computation methods are not immediate and intuitive, which can hinder their adoption, especially for dynamic indicators. Even in its simplest form, applying this general concept to the various specific physical and organisational systems that disruptions can impact presents significant conceptual and measurement challenges (Bruneau et al., 2003). Beyond the real-time monitoring and computational complexity, an additional limitation is the need to estimate a disruptive event's maximum impact and duration, which is used within some indicators. For example, some proposed indicators require organisations to estimate the maximum potential disruption (Rose, 2007), the post-disruption demand that can be met (Chen & Miller-Hooks, 2012), and the duration of the disruption (Nogal et al., 2015; Ojha et al., 2018). These values are not easy to estimate because they depend on the characteristics of the supply chain under consideration, for instance, the level of preparedness against adverse events, and the characteristics of the disruption, such as the event's severity. Indicators based on expert opinion offer a solution to the issue of computational complexity. Through questionnaires, experts evaluate the organisation's flexibility, agility, and visibility (Hasani, 2021). However, there is still a lack of quantitative values that can evaluate the resilience of the supply chain. At the same time, most of the resilience measurement results obtained in these studies are based on non-objective resilience composition, which cannot be combined with actual production. Therefore, it is necessary to develop an indicator which is based on actual operations and can describe the indicators of supply chain resilience by intuitive and quantitative results (Chen et al., 2020). Future research should focus on evaluating the applicability of these indicators to real cases by trying to simplify their computation and interpretation for companies.

The healthcare sector has the objective of preserving or restoring patients' health, but the scarcity of indicators that take these aspects into account does not allow a thorough monitoring of the system's resilience. The global healthcare sector faces major obstacles from legislative and regulatory barriers, as well as globalisation and high cost (Dixit et al., 2019). The implementation of HSC management is also more complex as healthcare organisations and hospitals have to perform highly precise tasks (Mustaffa & Potter, 2009). These factors may have determined a gap with respect to other sectors. In addition, healthcare-specific indicators to monitor the system's resilience, especially from the population health perspective are difficult to measure objectively. Moreover, the economic efficiency of the healthcare system has been a significant focus for

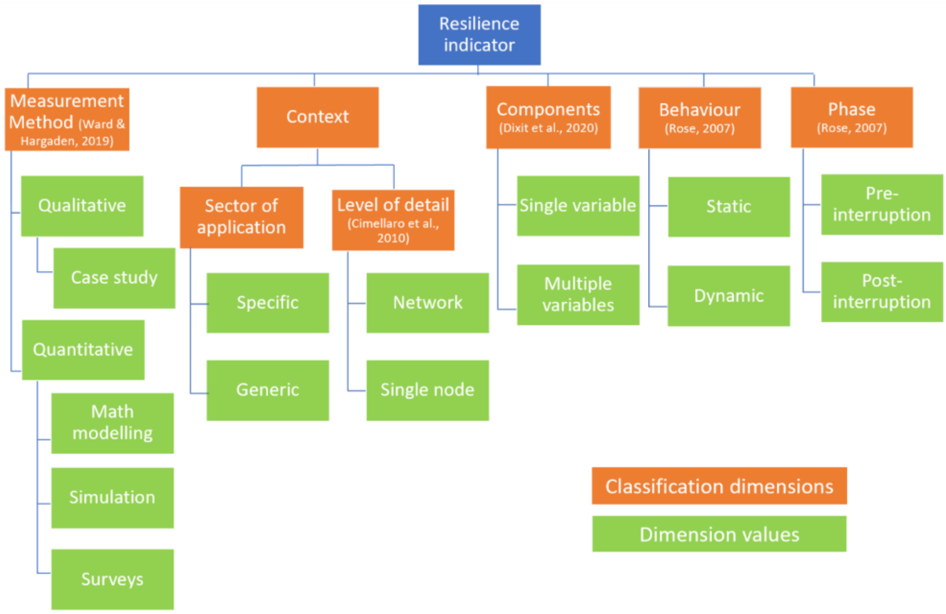

Figure 1: Resilience indicators classification.

health policymakers and economic analysts in recent years. Emphasis on efficiency can potentially hinder their resilience in several ways. Strategic investments in crisis preparation, such as enhancing infrastructure and information systems or formulating contingency plans, are crucial for fostering resilience. However, these investments may be considered unnecessary or too expensive when focusing solely on efficiency. Therefore, future research should investigate the long-term trade-off between efficiency and resilience and explore strategies to balance both goals. Proposing indicators that integrate these two aspects and consider the trade-off. Which is still quite limited in the state of the art.

8. Conclusion

We proposed a preliminary literature review and a classification of indicators used to measure the resilience of healthcare and non-healthcare supply chains. This analysis showed that indicators can be distinguished into static and dynamic. Some indicators are used to measure resilience before an interruption, and others are used after an interruption has already occurred. Furthermore, some indicators are composite and consist of the aggregation of several single parameters, allowing areas for improvement to be identified. Finally, HSCs remain under-researched, yet disruptions in HSCs can be catastrophic to human life. However, monitoring specific indicators for the health sector is rather limited, despite the sector's relevance in responding to disruptions.

This research is preliminary and thus subject to several limitations related to non-systematic literature reviews. For instance, restrictions on the selection of database, keywords, timespan and subject areas may have excluded relevant results from the selection. Nevertheless, this work has shown promising avenues of future research that could be further investigated and strengthened through systematic research that goes beyond the current limitations, especially in terms of the keywords used and the formalised exploration process, following, for example, the PRISMA protocol and including a quality assessment process. Additionally, future research on this topic should focus on analysing the applicability and transferability in practical healthcare contexts of the proposed indicators, developing more indicators that consider the social impacts of disruption on people, and standardising the proposed indicators.

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