

## Authors' correspondence

<sup>1</sup> Universidade Federal de Pernambuco, Recife, PE - Brazil  
tairineferraz1@gmail.com

<sup>2</sup> Universidade Federal de Pernambuco, Recife, PE - Brazil  
diogo.hhelal@ufpe.br

## Informational resilience: a literature review

Tairine Vieira Ferraz<sup>1</sup> Diogo Henrique Helal<sup>2</sup>

## ABSTRACT

**Introduction.** The term 'informational resilience' represents an emerging academic concept that ranges from notions of adaptation and permanence of information to procedural notions of transition and coping, with wide-ranging applications in various fields of knowledge. Its wide range of use makes it important to understand the roots of its development and its fundamental concepts. **Objective.** The objective of this study is analyze the thematic evolution within the research field of informational resilience. **Methodology.** A systematic literature review was undertaken, employing bibliometric analysis through the Web of Science database. The analysis operationalization was supported by software tools StArt, citnetexplorer, and VOSviewer. **Results.** 34 articles were analyzed and the data point to a diffuse, emerging and ambiguous research field. The computer science and information science areas are the majority productive and relevant in publications on the topic. Theoretical tensions arising from multiple understandings of the concept and an excessively optimistic bias in the approaches that use it are also highlighted. **Conclusion.** The study contributes to comprehension of the research field's development through an analysis of key publications, most cited authors, addressed topics, and the underlying foundations of its evolution. The analysis suggests that future research should focus on the inherent paradoxical nature of the concept.

## KEYWORDS

Information resilience. Systematic reviews. Concept analysis.

## Resiliência informacional: uma revisão da literatura

## RESUMO

**Introdução.** O termo 'resiliência informacional' trata-se de um conceito acadêmico emergente que envolve desde noções de adaptação e permanência da informação até noções processuais de transição e enfrentamento, com aplicações abrangentes em diversos campos do conhecimento. Sua grande amplitude de utilização, torna importante compreender as raízes de seu desenvolvimento e seus conceitos fundamentais. **Objetivo.** O objetivo deste trabalho foi analisar a evolução temática do campo de pesquisa sobre resiliência informacional. **Metodologia.** Foi realizada uma revisão sistemática da literatura por meio de um estudo bibliométrico utilizando a base de dados *Web of Science* e o apoio dos softwares *StArt*, *citnetexplorer* e *VOSviewer* para sua operacionalização. **Resultados.** Foram analisados 34 artigos e os dados apontam para um campo de pesquisa difuso, emergente e ambíguo. As áreas de ciência da computação e ciência da informação são as mais produtivas e relevantes nas publicações sobre o tema. Também são destacadas as tensões teóricas decorrentes de múltiplas compreensões

do conceito e um viés excessivamente otimista nas abordagens que o utilizam. **Conclusão.** O estudo avança na compreensão sobre o desenvolvimento do campo de pesquisa, analisando as principais publicações, autores mais citados, temas abordados e as bases de sua evolução, sugerindo que pesquisas futuras devam se concentrar no caráter paradoxal intrínseco ao conceito.

#### **PALAVRAS-CHAVE**

Resiliência informacional. Revisões sistemáticas. Análise de conceito.

#### **CRedit**

- **Reconhecimentos:** Não aplicável
- **Financiamento:** Este estudo foi parcialmente financiado pela Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES), através do Programa de Demanda Social - Código financeiro 001, sob o Processo nº 88887.668545/2022-00.
- **Conflitos de interesse:** Os autores certificam que não têm interesse comercial ou associativo que represente um conflito de interesses em relação ao manuscrito.
- **Aprovação ética:** Não aplicável.
- **Disponibilidade de dados e material:** Não aplicável.
- **Contribuições dos autores:** Conceitualização, Análise formal, Investigação, Metodologia, Escrita – revisão & edição: FERRAZ, T. V.; HELAL, D. H.; Software, Escrita – rascunho original, Redação – revisão & edição: FERRAZ, T. V.; Administração do projeto, Supervisão: HELAL, D. H.

**JITA:** FJ. Knowledge management

**ODS:** 4. Quality Education

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Article submitted to the similarity system

Submitted: 31/10/2023 – Accepted: 08/03/2024 – Published: 26/03/2024

Editor: Gildenir Carolino Santos

## 1 INTRODUCTION

In what has been called the Information Society or the Knowledge Society (Masuda, 1980; Toffler; Toffler, 1995), in which a large part of social, commercial and governmental relations are based on information flows and information technology networks (Castells, 2002), information has gradually become one of the most important objects of study and analysis in contemporary times (Kobashi; Tálamo, 2003).

Issues related to individual, organizational, and technical capacity in the accessibility, distribution, effective, and secure use of information assets, as well as the challenges associated with balancing their processing, management, and understanding of information demands, constitute a large part of the concerns of governments, public and private organizations, researchers, and citizens (Sadiq *et al.*, 2022; Damarad, 2020). In this sense, the term "information resilience" or "information resilience" (Lloyd, 2013; Al-Naday *et al.* 2014) emerges as a rather elastic umbrella concept, in which information, its need, availability, integrity, and usage practices are central to promoting adaptation and multiple adjustments.

When dealing with issues of a technical nature, information resilience aims to overcome physical limitations in the storage, availability, and distribution of information in failure scenarios (Sourlas *et al.*, 2015; Rak; Jonsson; Vinel, 2016; Chai; Sourlas; Pavlou, 2017; Wu; Chai, 2021). From a management perspective, it refers to the ability to process and analyze heterogeneous data sources in decision-making, as well as to predict and reduce vulnerabilities that may affect the quality of available information (Shi *et al.*, 2019; Blay *et al.*, 2020). From a human and societal perspective, the term is generally considered in light of a set of factors and conditions that contribute to uncertainty reduction, adaptation, and adjustment (Yu *et al.*, 2014; Lazarenko *et al.*, 2022).

Thus, it can be seen that information resilience is a term that can take on various aspirations and applications. In this context, it is important to understand the evolution of this field of study to offer preliminary ideas about its central concepts, main research, approaches, and needs for further study.

To this end, a systematic literature review was carried out using a bibliometric study, with the general objective **of analyzing the thematic evolution of the field of information resilience research**. Specifically, [1] to identify the main approaches and themes of research on the topic, as well as [2] its main areas, authors, and publications.

To achieve these objectives, a cross-section of studies without time limitation was employed, using the main collection of Web of Science, a globally relevant and reliable database (Dzikowski, 2018; Rossetto *et al.*, 2018). Although it is recognized that the choice of a single data repository can be considered a limitation of the work, the database in question was chosen because it supports the combined use of the bibliometric data analysis software CitNetExplorer and VOSviewer, which were used to support the operationalization of the analysis.

It is believed that this approach strengthens the robustness of the study, as the visualizations provided by these tools, both in aggregate and individualized form, complement each other (Van Eck; Waltman, 2017). The article is structured as follows: first, general considerations on the scope of the concept of resilience and, in particular, information resilience are presented. Next, the methodological procedures used are described in detail. Finally, the results and preliminary considerations are presented.

## 2 INFORMATIONAL RESILIENCE: A BROAD CONCEPT

The concept of resilience has its origins in a complex web of history, from ancient times to the present. According to Saladini (2021 apud Ionescu, 2016), its first occurrence dates back nearly two thousand years and was used in an incident involving a vestal priestess who was condemned to be thrown off a cliff for violating her vow of chastity. However, by appealing to her divinity, the priestess survived the fall, sparking an intense debate over her right to return to her priestly duties due to her "resilience" in the face of punishment. During this debate, the Roman senator Gaius Julius Bassus is said to have used the word resilience to describe the return of the condemned priestess.

It is also in this context of jumping and leaping that the term is found in ancient texts such as those of Ovid, Quintilian, and Pliny (Saladini, 2021 apud Ionescu, 2016).

Etymologically, according to the Infopédia Dictionary of the Portuguese Language<sup>1</sup>, the word comes from the Latin *resilire*, retaining the same idea of jumping back, sharply refusing. In English, its use is attributed to the philosopher Francis Bacon in 1626 to describe the way in which the echo reverberates, causing the sound to return to its point of origin (Saladini, 2021 apud Ionescu, 2016).

Academically, before the focus shifted to the information field, the term resilience was used in the fields of physics, materials engineering, and mechanics. It is associated with the ability of a given material to recover, adapt, return to its original form, or transform itself after exposure to intense stress. From the outset, the term proved to be conducive to the development of interdisciplinary dialogue and was quickly incorporated into the fields of ecology, psychology, and psychiatry (Toyoda, 2021).

From an ecological perspective, resilient systems would be those that can absorb change and persist, incorporating concepts of renewal and reorganization as elements that facilitate ecosystem adaptation to new conditions (Colavito, 2017). In contrast, research on resilience in the fields of psychology and psychiatry addresses the links between resilience and positive psychological adaptation to adversity experienced by individuals or those close to them, such as serious diagnoses and stressful situations (Cho; Kim, 2023; Wang *et al.*, 2022; Li *et al.*, 2022).

A common focus of debate in the mental health field is whether resilience should be understood as an intrinsic trait or characteristic of individuals or as a process (Gouzman *et al.*, 2015). When considered as a trait, studies focus on factors such as self-efficacy and positive thinking, among others, as useful cognitive mechanisms for coping with stress and adversity (Yu *et al.*, 2014).

When viewed from a process perspective, resilience is analyzed from a more interactional perspective, considering the individual in relation to the context, as well as social support and other psychosocial factors as possible facilitators of resilience (Li *et al.*, 2022). The term has been the subject of intense debate (Ionescu; Jourdan-Ionescu, 2010), and despite the lack of consensus on its definition, it has been explored by an increasing number of disciplines (Toyoda, 2021).

By extending the notion of resilience as an interactive process between people and changing environments, and by considering information as a socially constituted artifact and its practices as a fundamental resource for the development of resilience, Lloyd (2013) shifts the focus in the study of resilience to the field of information science and coined the term 'information resilience'.

In general, information resilience is considered a type of mechanism, logic, or process that involves the use, adaptation, availability, or survival of information. This process is

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<sup>1</sup> <https://www.infopedia.pt/dicionarios/lingua-portuguesa/resili%C3%Aancia>

catalyzed by a focus on change such as unavailability, failure, disruption, or uncertainty. Furthermore, it is usually understood as consisting of a network of actors or components, of which availability, access, and good practices in the use of information are some examples (Rak *et al.*, 2017; Lloyd, 2015; Blay *et al.*, 2020; Gouzman *et al.*, 2015; Yu *et al.*, 2014).

The concept of informational resilience, from the perspective of Lloyd (2013; 2014; 2015), extends the notion of adaptation from the exact domain to encompass the processes by which subjects connect to and experience new informational environments, highlighting the importance of informational practices in the search for, access to, and use of information. This perspective emphasizes subjects' motivations to access and use information in the face of a state of informational uncertainty through the sharing of meanings and sociomaterial arrangements that allow for the construction or reconstruction of a given understanding of the world.

Research based on this conceptualization focuses less on answering only what, how, and when subjects seek information, but mainly on why they seek what they seek or why they use information in one way and not another (Lloyd, 2015; Silva, 2022). Since the concept presented by Lloyd (2013; 2014), other studies have adopted this perspective. Especially in the context of migration, where the concept was initially developed (Lloyd *et al.*, 2013; Lloyd; Wilkinson, 2016; Lloyd, Pilerot; Hultgren, 2017; do Nascimento; Brasileiro, 2022). These studies have extended the analysis of migrants' informational resilience beyond Australian society, where the pioneering study took place, to the Swedish and Portuguese realities.

Specifically in Brazil, there is an information science research group (GEPSCI) that uses the informational resilience perspective conceptualized by Lloyd (2013; 2014) and has been studying the topic regularly since 2015. This group has expanded the use and application of the concept beyond the context of migration, using it to analyze different contexts, especially the context of health information and the implications of digital space in the reconstruction of the information base of subjects (Brasileiro; 2019, 2020; Pinto *et al.*, 2020; da Silva Rocha *et al.*, 2021).

Other fields such as management, computer science, and communication have also sought to expand the theorization of information as a central resource for resilience. In the field of management, information resilience has been associated with the ability of organizations to create and maintain data processes that are agile and transparent, while reducing the vulnerabilities that affect their quality throughout the value chain (Blay *et al.*, 2020; Sadiq *et al.*, 2022).

In the field of computer engineering, the term is more related to the ability to deliver or exchange information regardless of the location of the source or the connectivity conditions of a network (Chai; Sourlas; Pavlou, 2017). Initially, research in this area was associated with a paradigm focused on connecting physical machines, recalculating routes, delivering and protecting information infrastructure from adverse situations (Rak; Jonsson; Vinel, 2016).

Subsequently, the Information-Centric Networks (ICN) or Content-Centric Networks (CCN) paradigm emerged, shifting the focus from information resilience based on physical nodes to algorithmic solutions capable of naming, identifying, and evaluating the content circulating on the network (Wu; Chai, 2021). As an alternative or complementary approach to the traditional physical paradigm, CCN explores ways to give "consciousness to the network".

In other words, once content has been named and evaluated based on network requests, it can be identified and evaluated. This introduces a more efficient way to discover copies of information circulating on a given network. This new method, coupled with the possibility of exploiting distributed caching resources, increases the ability of a network to provide continuous access to information deemed important, even in the face of failures (Sourlas *et al.*, 2018; Rak *et al.*, 2017).

In the field of communication, meanwhile, information resilience has been addressed by studies interested in how information is produced, controlled, mediated, and circulated in a network, and the implications of this. Issues of power and control, transparency, accessibility,

disinformation, and the expansion or restriction of discursive spaces have been central to such discussions (Raisio *et al.*, 2023).

Discussions in the field of communication highlight some of the ambiguities that exist in the concept. Since, in the research in this field, resilience can be linked, from a positive perspective, both to the possibilities of creating and accessing information resources that are important for life in society and to democratic disputes (Damarad, 2020). As for the challenges involved in this process, it should be emphasized that the increased availability of data and the facilitation of the information transmission process also lead to tensions associated with the increased risk of misinformation, segregation, dysfunctional adaptation processes and the expansion of the space for valid controversy based on biased, prejudiced and implausible information (Hopp; Ferrucci, 2020; Tabasso, 2019; Patent, 2022).

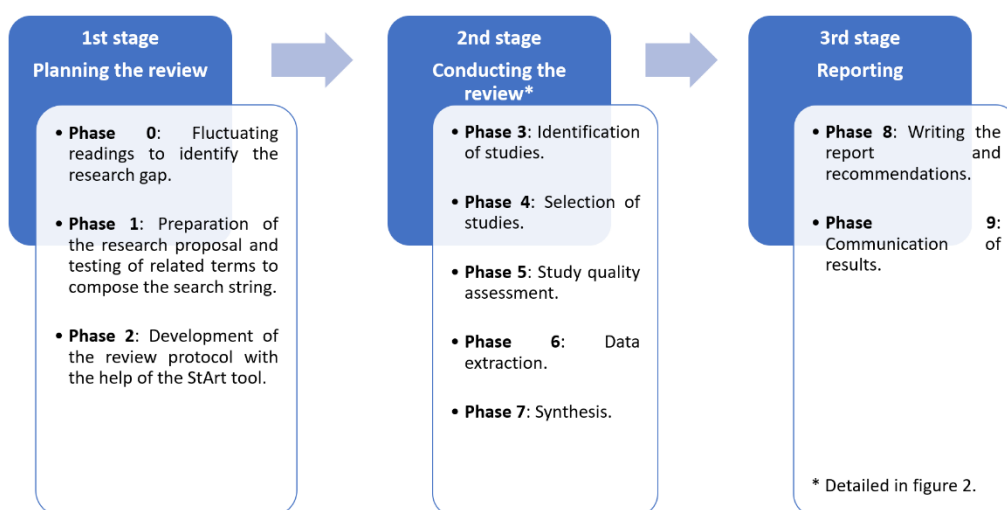
Observing the extent, diversity, and scope of the approaches to information resilience, it is possible to see that this is an emerging and diffuse theme, reinforcing the importance of analyzing the panorama of its main studies, themes, and directions. The methodological procedures adopted in this study are detailed below.

### 3 METHODOLOGY

The main objective of this study was to analyze, through a bibliometric study, the thematic evolution of the field of research on information resilience. To this end, a systematic literature review was carried out, a type of secondary source research that seeks to gather evidence to describe and synthesize scientific production relating to a focus question (Pollock; Berge, 2018). Among the essential characteristics of this type of review is the a priori establishment of explicit and reproducible methods for identifying, evaluating and synthesizing the literature of interest (Pollock; Berge, 2018).

The structuring of the review contained in this work followed the steps recommended by Tranfield, Denyer and Smart (2003), as shown in Figure 1.

Figure 1: Stages in the development of the review.



Source: Adapted from Tranfield, Denyer and Smart (2003).

In stage 1, the StArt reference management and protocol registration tool was used to help draw up the research protocol and operationalize the review process, as well as to ensure rigor and transparency in its execution. This choice was motivated by the fact that StArt<sup>2</sup> is a

<sup>2</sup>[http://lapes.dc.ufscar.br/tools/start\\_tool](http://lapes.dc.ufscar.br/tools/start_tool).

free and open access tool, allowing it to be used and verified by any interested party, as well as offering support functions ranging from the inclusion of the protocol to the review process itself and the organization of the information retrieved.

In stage 2, the identification of relevant literature was carried out on May 14, 2023, through an automated search in the main collection of the Web of Science database. This database, provided by the company Clarivate Analytics, covers all areas of knowledge and is one of the most widely used databases in the world of scientific research<sup>3</sup>, recognized for its reliability (Dzikowski, 2018).

Access to the database is granted by subscription to the main universities in Brazil, enabling institutional access to more than 171 million records, according to Clarivate's own data. Although the choice of a single database is a limitation of this study, the use of Web of Science allows the use of bibliometric software such as CitNetExplorer and VOSviewer to explore the bibliographic material returned to the search, expanding the possibilities of operationalization in the data analysis process (Van Eck; Waltman, 2017; Rossetto *et al.*, 2018).

Articles returned in accordance with the following search string were submitted to the eligibility criteria: ("information resilience" OR "informational resilience" OR "information resilience" OR "informational resilience" OR "resiliencia de la informacion" OR "resiliencia informacionale" OR "resiliencia en informacion"), with no restriction on the time period for the search and taking into account the title, abstract and keywords fields.

In total, 36 records were returned. Two of these papers were excluded for the following reasons: one because it was not yet published (early access) and the other because it had been flagged as withdrawn from the journal upon proof of a breach of the publication principles. The remaining 34 papers were read in full and subjected to a quality assessment using the Methodi Ordinatio methodology for classifying articles (Pagani; Kovaleski; Resende, 2015).

The evaluation proposed by Pagani, Kovaleski and Resende (2015) uses elements such as impact factor, year of publication of the research and number of citations to assign a quality index to the articles returned in a systematized bibliographic review, according to the following equation:

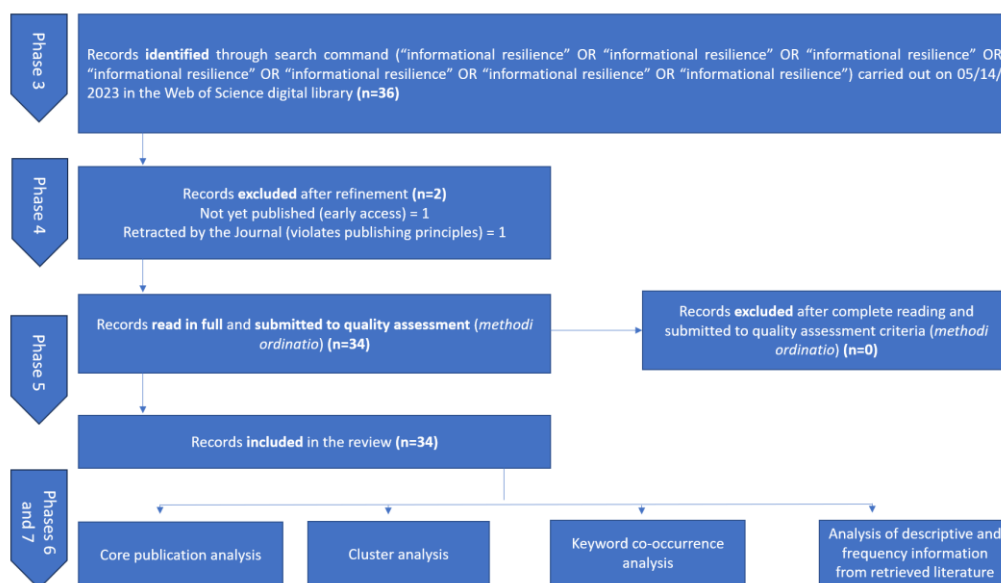
$$\text{InOrdinatio} = \left( \frac{\text{IF}}{1000} \right) + \alpha * [10 - (\text{ResearchYear} - \text{PublishYear})] + (\Sigma\text{Ci})$$

Where the impact factor (IF) is divided by 1000 to normalize its value in relation to the other criteria. The weighting factor ( $\alpha$ ), ranging from 1 to 10, is assigned by the researchers according to their perceived relevance. 'ResearchYear' represents the year of development of the review in question, while 'PublishYear' indicates the year of publication of the article evaluated. Finally,  $\Sigma\text{Ci}$  corresponds to the number of citations of the article under analysis (Pagani; Kovaleski; Resende, 2015, p. 2120). All 34 articles resulting from the first refinement obtained a positive InOrdinatio index and, therefore, were included in the analysis (detailed in Appendix A). The stages of the review are shown in Figure 2.

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<sup>3</sup><https://clarivate.com/webofsciencegroup/campaigns/web-of-science-base-de-dados-de-citacao-global-independente-mais-confiavel-do-mundo/>

Figure 2. Breakdown of the stage of conducting the review.



Source: Own elaboration (2023).

In addition to the overall objective, two specific objectives were defined: to identify the main approaches and topics of research on information resilience, and to identify the main areas, authors, and publications on the topic. To achieve the first specific objective, the analysis strategy focused on core publication analysis, clustering (CitNetExplorer) and the keyword co-occurrence network (VOSviewer) to highlight relevant topics on the subject.

To achieve the second specific objective, descriptive information was considered, as well as the relationship between other components of the retrieved literature, trying to represent the impact of the publications and the importance of the authors in the subject under analysis. The results obtained were systematized in step 3 and made it possible to visualize the scope of research on information resilience, identify traditions, the evolution of the concept over time, and emerging themes that inform the results and preliminary considerations presented.

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## 4 RESULTS

### 4.1 Historiography and main themes in information resilience research

Based on the survey conducted, the historiographical analysis begins with the first studies on information resilience published since 2013. As this is an emerging and interdisciplinary topic, the most important publications, the so-called core publications (Figure 3 - all circles in the figure in the time plane), present research on information resilience that is quite diverse from the point of view of the theoretical approaches used.

The clustering analysis reveals two main groupings of articles by year and proximity (Figure 3 - blue and green circles), which explore information resilience from different perspectives: a social aspect and a technical aspect, as the main streams of approach to the topic.

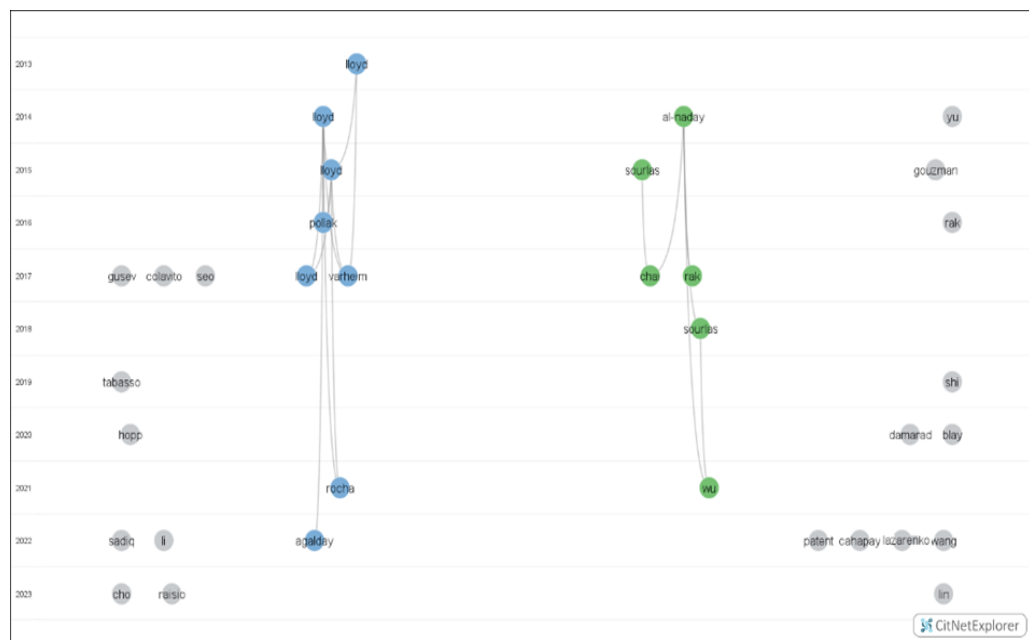
The strand that we have called the "social dimension of information resilience" focuses largely on the socio-informational processes that people develop in shaping their information bases in order to satisfy their information needs through complex social practices. These practices are based on the use and exchange of information as a fundamental resource for navigation and orientation in the contemporary world. Typically, studies that adopt this approach emphasize the actions and performances of individuals and their interactions with environments, devices, and other people.



In contrast, what we call the "technical dimension of information resilience" focuses efforts on the development of computational mechanisms that enable the maintenance, distribution, and delivery of information whenever users request it, even in degraded connectivity scenarios. The technical dimension emphasizes the transformation from the logic of local storage to the logic of information flow diluted in a network, in all its multiple possibilities.

In the historiography of publications, Lloyd's article (2013), which explores the relationship between information literacy and the development of information resilience in the workplace, was the forerunner of a series of studies that adopt the perspective of practice-based studies to examine information literacy and information resilience itself as contextual, social, and collective activities, in an information sociological strand of analysis.

Figure 3 - Visualization of core publications and clusters.



Source: Prepared using CitNetExplorer software (2023).

Subsequent studies by Lloyd (2014, 2015), Lloyd, Pilerot and Hultgren (2017), and da Silva Rocha *et al.* (2021) extend the theorizing on informational resilience begun in Lloyd (2013) to refugee contexts (Lloyd, 2014; 2015; Lloyd; Pilerot; Hultgren, 2017) and mothers whose children have been diagnosed with microcephaly (da Silva Rocha *et al.*, 2021). Broadly, these articles explore how the informational needs of a situated experience are met through social interactions that shape and reconstruct the informational landscapes interrupted in the liminal moments of diagnosis or migration. This process of orientation, adjustment, and re-signification would be operated by social practices of informational literacy (a kind of informational practice) that enable the emergence of informational resilience as a way of learning to read a new informational landscape (Lloyd, 2014).

In line with a social scope, it is also worth highlighting the work of Pollak (2016), Vårheim (2016), and Ağalday and Özdemir (2022), who expand the frontiers of research on information resilience (initiated by Lloyd). They include in the debate related concepts such as information poverty, informal information micro contexts (Pollak, 2016), social capital (Vårheim, 2016), and institutional communication (Ağalday; Özdemir, 2022) as important concepts and factors in the analysis of what the development of the information resilience process entails.

The second cluster shows the research of Al-Naday *et al.* (2014) as a pioneer in the stream of studies that approach information resilience from a technical dimension. The works related to this cluster understand information resilience as a computational function derived from the ability to deliver or make information available when its source is fragmented, inaccessible, or when connectivity is impossible or intermittent. Most of the studies in this cluster are based on the simulation of critical situations - disasters - where information must be made available to first responders or government agencies regardless of the physical location of the node or source from which the information originates.

The work in this area seeks technical alternatives to support or overcome the current logic of content distribution, which is based on the interconnection of physical machines (network nodes) and usually includes mechanisms for protection and redistribution of information at physical layers. The focus of these studies is to develop traffic engineering solutions that support the availability and delivery of relevant information when the physical nodes or the origin of the information fail (Rak *et al.*, 2017; Al-Naday *et al.*, 2014), shifting the support of information traffic from the nodes to the information content itself (Sourlas *et al.*, 2015). The goal is to provide location-independent information retrieval and availability (Chai; Sourlas; Pavlou, 2017).

To this end, the works included in the cluster make a technical effort to explicitly name the information circulating in the network and assign a value to it. Valuation measures are created, for example, based on the interest and popularity of the content and information circulating on a network (Wu; Chai, 2021; Sourlas *et al.*, 2015). Techniques for identifying "natural" communities and assigning value to information are being explored, allowing networks to gain "awareness of the information being carried" and allowing the network flow itself to decide what relevant information to retain (Chai; Sourlas; Pavlou, 2017).

This logic, combined with techniques for storing and distributing information in flux, which is constantly fed back by requests (interest and popularity), using, for example, the caching resources of routers or end users, makes it possible to extend the useful life of information that becomes resilient to interruptions in connectivity in disruptive scenarios (Sourlas *et al.*, 2018). It is worth noting, however, that none of the studies on the technical dimension mention ethical issues related to the valuation of circulating content.

The other works are diluted and do not form clusters. The recent conceptualization of the term implies, in addition to the recognition of two main strands of analysis, evidence that research using the concept covers a wide range of fields of knowledge. In general, the research that is not grouped into clusters is concerned with the elements that can support or hinder information resilience.

The works of Rak, Jonsson, and Vinel (2016), Gusev *et al.* (2017), Seo (2017), and Shi *et al.* (2019) also start from an understanding of information resilience in its technical dimension. In common with the cluster, these works seek computer engineering solutions to ensure that circulating information has guaranteed integrity, availability, and reliability. And they can be activated whenever needed, even under distortions, interruptions, constraints, and stress. However, they are fundamentally different from technical cluster studies in that they do not use the logic of CCN architectures, but are still tied to the physical layers of a network.

Other approaches to information resilience have been proposed to develop policies that can guarantee not only the delivery and retrieval of requested information, but also its quality and scope. This is a concern in the field of management and other fields that use information systems to support their processes, such as construction and ecology. For Colavito (2017), Blay *et al.* (2020) and Sadiq *et al.* (2022), information resilience is related to the process of information articulation and the reduction of vulnerabilities that affect the quality of information in the system. It is derived from the ability of organizations to create, detect failures and information risks, protect, and maintain agile, useful, and transparent data processes. These

works illustrate how the identification of information needs, their articulation, and the identification of vulnerabilities can be integrated into the study of information resilience in the field of management.

Also prominent, but not clustered, are studies in the fields of psychology and psychiatry that do not directly address informational resilience. Rather, they approach resilience as a personality trait, a set of characteristics intrinsic to the individual, a mechanism, or dynamic cognitive process of adaptation and adjustment that helps overcome stress, uncertainty, and adversity, as an indicator of psychological health. These studies consider information as a resource that people use to reduce uncertainty and aid decision-making, and also emphasize the importance of social interaction and support (Gouzman *et al.*, 2015; Yu *et al.*, 2014; Wang *et al.*, 2022; Lazarenko *et al.*, 2022; Li *et al.*, 2022; Lin *et al.*, 2023; Cho; Kim, 2023).

At the frontiers of psychology, Patent (2022) and Cahapay (2022) explore the importance of information in human resilience processes. Although they also understand it as a process of cognitive adaptation that can lead to certain attitudes and behaviors, these authors raise questions about bias, prejudice, trust, and access to complete, safe, appropriate, and high-quality information that enables uncertainty reduction and functional decision-making. Information resilience in this context refers to the development of cognitive, affective and emotional capacities to consciously filter and weigh the information that makes up the decision-making process that may or may not have functional outcomes.

In this sense, it is important to know how access to implausible information and misinformation can operate dysfunctional processes (Patent, 2022), such as the vaccine hesitancy documented during the COVID-19 pandemic (Cahapay, 2022). In this sense, works that understand the sociotechnical nature of informational resilience are dedicated to exploring, from perspectives apart from psychology, how information itself is a central asset in today's social and democratic disputes. And how certain kinds of information are constructed, made possible or impossible, adapt, persist, and influence the sociotechnical processes of contemporary society.

Works by Tabasso (2019), Damarad (2020), Hopp and Ferrucci (2020), and Raisio *et al.* (2023) aim to overcome a strictly positive view of informational resilience by showing the paradoxical and ambivalent nature that information (which acquires this "resilient property") can take on. These authors argue that in a society with increased informational control, information resilience can be framed as the possibility for a population to create, access, distribute, and monitor information as a terrain of democratic contestation (Damarad, 2020). The stealthy and emergent nature of virtual and informal social organizations suggests that there is a constant tension between the benefits of increased information availability and ease of data transfer and the risk of misinformation, the viral spread of inaccurate information, and the consequent generation of panic or fear (Raisio *et al.*, 2023).

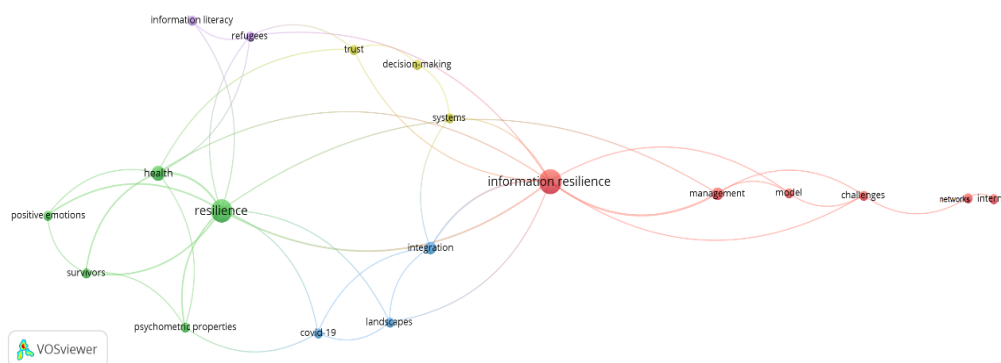
The researches of Tabasso (2019) and Hopp and Ferrucci (2020), on the other hand, are dedicated to the study of how certain types of information acquire resilient properties, as well as to the ability of resilient information to form the informational bases on which the decision-making process is based, regardless of whether its content violates social norms or not. Tabasso (2019) comes closer to those who understand the resilience of information from a technical perspective, relating it to the notion of permanence of information on the network and simulating epidemiological models to explore how viral information spreads and survives.

The work of Hopp and Ferrucci (2020), on the other hand, is closer to the body of research that prioritizes the sociotechnical nature of information resilience, investigating information resilience as the adaptation or persistence of beliefs, ideas, and movements that are capable of satisfying people's information needs. However, they can produce not only positive adaptations, but also conspiratorial and deviant information landscapes.

In addition to the research themes identified, a survey of the co-occurrence of keywords used by the studies included in the analysis was conducted to gain a deeper understanding of

the main research foci in the field. In this way, it was possible to identify the most interesting topics in the identified research. To avoid a polluted visualization and to exclude potentially insignificant results, keywords that did not meet the minimum co-occurrence frequency of 2 were excluded. Out of a total of 256 keywords, 19 met this threshold. Figure 4 shows the results of the visualization of the global keyword co-occurrence network.

Figure 4 - Keyword co-occurrence network.



Source: Prepared using VOSviewer software (2023).

A brief analysis of the figure shows that, given the plurality of approaches to the concept, there is also a plethora of topics. This indicates that the idea of information resilience itself, introduced by Lloyd (2013) and extended to psychological, technical, ecological and organizational domains, continues to expand.

As expected, 'information resilience' is the keyword with the highest frequency, appearing 11 times. This is followed by the keyword 'resilience' alone, with 10 occurrences. The keywords fell into five main groups: [1] **Digital networks and their management challenges** ('management'; 'model'; 'challenges'; 'networks'; 'Internet'); [2] **Psychological and emotional adaptation factors** ('resilience'; 'health'; 'positive emotions'; 'survivors'; 'psychometric properties'); [3] **pandemic implications in the information landscape** ('integration'; 'landscapes'; 'COVID-19'); [4] **informed decision-making processes** ('systems'; 'decision-making'; 'trust'); [5] **information literacy in liminal situations** ('refugees').

| 12

These findings suggest that research should be aimed at understanding how it is possible to develop management mechanisms for information phenomena that have an emergent and fluid nature, what factors influence individuals' information attitudes and behaviors, as well as the implications of the pandemic for the formation of today's information landscapes, the development of processes capable of generating trust in information and ensuring informed decision-making, in addition to the importance of information literacy for contemporary social processes, highlighting the transdisciplinary nature of the concept under analysis.

#### 4.2 Relevance of areas, publications, and citations in information resilience research

In all, this study identified 34 articles published from 2013 to April 2023, involving a total of 107 authors linked to 65 institutions in 24 countries, distributed in 31 journals or conferences. Given the recent appearance of the term in the literature, as far as we know, no previous bibliometric studies have been carried out. Among those who have published the most on the subject, Annemaree Lloyd stands out, with 4 publications. In addition, George Pavlou and Vasilis Sourlas have jointly published 3 papers, of which Ioannis Psaras is co-author on 2. Wei Koong Chai, co-author of 1 of these papers, has published a total of 2 research papers on the subject. Jacek Rak and Magnus Jonsson complete the list of authors with more than one publication on the subject, with 2 papers published together. The incidence of co-authorship in

the papers indicates that in 10 of the 34 studies retrieved, there is at least one of these seven authors, responsible for 29.4% of the total publications on the subject.

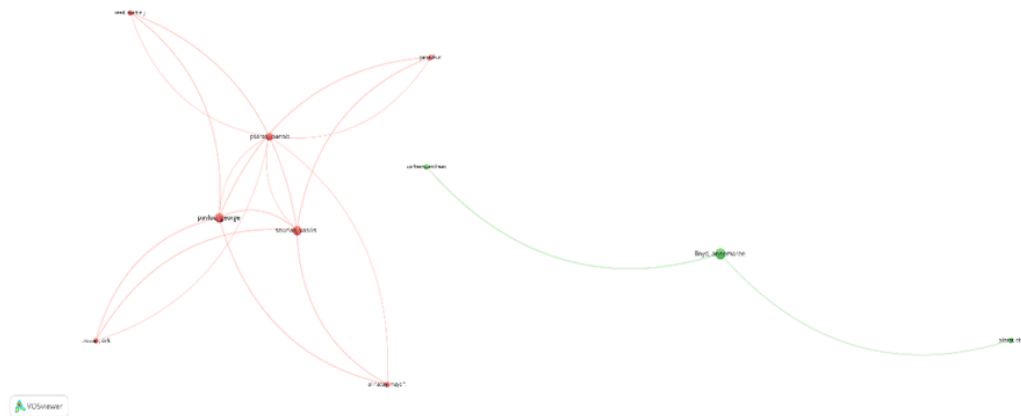
**Chart 1.** Ranking of authors with the most publications

Authors	No. of records
Annemaree Lloyd	4
George Pavlou	3
Vasilis Sourlas	3
Wei Koong Chai	2
Ioannis Psaras	2
Jacek Rak	2
Magnus Jonsson	2

Source: Prepared by the authors using VOSviewer software (2023).

This production data naturally reflects the prevalence of the most cited authors and the formation of the aforementioned clusters. Annemaree Lloyd has 123 citations, while Mays F. Al-Naday, Martin J. Reed, Dirk Trossen and Kun Yang have accumulated 20 citations of the same work in which they are co-authors. In addition, George Pavlou (17), Vasilis Sourlas (17), Ioannis Psaras (15), Andreas Vårheim (15) and Ola Pilerot have 10 citations in co-authorship with Lloyd. Figure 5 shows the networks of authors with the most citations on the topic.

**Figure 5:** Networks of authors with the most citations.



Source: Prepared using VOSviewer software (2023).

It was also found that the field of computer science has done the most research on this topic so far, accounting for 35.3% of the published articles. These studies focus on the development of computer architectures capable of providing resilience based on the availability and retrieval of information in disruptive scenarios. In second place is the field of information science and librarianship (17.6%), which links the topic to the social aspects of information search, use, and experience as social strategies of information orientation. This is followed by Psychology and Psychiatry, with 11.8%, which focuses on the cognitive aspects of resilience, treating it as a process or trait mobilized in coping with adverse situations and for which information is a resource.

**Chart 2.** Areas with the highest number of investigations.

Categories Web of Science	No. of records
<i>Computer Science</i>	12
<i>Information Science &amp; Library Science</i>	6
<i>Psychology &amp; Psychiatry</i>	4

Source: Prepared by the authors using VOSviewer software (2023).

Considering the records returned to the search, only three journals have published on information resilience on more than one occasion: the *Journal of Documentation and Information Research*, both interdisciplinary journals that publish work with an emphasis on disciplines related to librarianship and information management. And *Frontiers in Psychiatry*, which publishes basic and clinical research in the field of mental health. Each of these journals contains two articles on the subject.

Even in the area of computing, which has the largest number of publications on the subject, research appears to be quite diluted, indicating initially that the most productive journals are related to the area of librarianship and information. Unlike what was found in the number of publications by area, the identification of the most relevant journals corroborates the data on the most cited publications.

In order to analyze the main publications in the field, a ranking of the most cited articles was established. The first two are works by Lloyd (2014; 2015), reflecting the strength of the cluster already mentioned in the historiographical analysis and the citation index per author. In her work, the author explores the information experience and information practices operated in a context of access to the health system by resettled refugees. In this sense, the concept of information resilience is proposed as key to identifying the principles of access, organization, and use of information by refugees, focusing attention on the critical role that social practices of information literacy play as a strategy for reducing uncertainty in times of transition. Information resilience is associated with the ability to re-establish the social capital that provides support for navigating a strange and unknown land (Lloyd, 2014; 2015).

**Chart 3.** The most cited articles on the subject of information resilience

Order	Title	Author	No. of citations
01	<i>Building Information Resilience: How do Resettling Refugees Connect with Health Information in Regional Landscapes - Implications for Health Literacy</i>	Lloyd, 2014.	54
02	<i>Stranger in a strange land; enabling information resilience in resettlement landscapes</i>	Lloyd, 2015.	39
03	<i>Systematic Analysis of a Military Wearable Device Based on a Multi-Level Fusion Framework: Research Directions</i>	Shi et al., 2019.	30
04	<i>Resilience and Psychosocial Adjustment in Digestive System Cancer</i>	Gouzman et al., 2015.	26
05	<i>A Pilot Randomized Controlled Trial to Decrease Adaptation Difficulties in Chinese New Immigrants to Hong Kong</i>	Yu et al., 2014.	24
06	<i>Building Information Resilient Workers: The Critical Ground of Workplace Information Literacy. What Have We Learnt?</i>	Lloyd, 2013.	20
07	<i>Information Resilience: Source Recovery in an Information-Centric Network</i>	Al-Naday et al., 2014.	20
08	<i>Public libraries, community resilience, and social capital</i>	Varheim, 2016.	15
09	<i>To get or not to get: Examining the intentions of Philippine teachers to vaccinate against COVID-19</i>	Cahapay, 2022.	11

10	<i>The remaking of fractured landscapes: supporting refugees in transition (SpiRiT)</i>	Lloyd; Pilerot; Hultgren, 2017.	10
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Source: Prepared by the authors using VOSviewer software (2023).

The third most cited article, by Shi *et al.* (2019), seeks to extend the applications of algorithmic architectures centered on information processing to the context of battlefields. The framework developed by the authors aims to integrate various information-gathering devices, from wearable devices to decision support systems, in war scenarios. The modeling proposed by the authors transforms soldiers into the main points for collecting information and controlling critical information resources, i.e., nodes in the network. This structure would make it possible to merge a wide range of distributed information, with the aim of increasing the resilience of information and decision-making capacity under restrictions or contingencies in data transmission and analysis, situations common to battle scenarios (Shi *et al.*, 2019).

The fourth most cited article is by Gouzman *et al.* (2015), from the field of psychology and psychiatry, which studies resilience from the perspective of psychological adjustment. Although the work does not deal directly with information resilience, it appears as an important reference, as it informs theoretical changes in circulating understandings of resilience. The authors investigated the contributions of resilience, affective reactions and post-traumatic growth (PTG) to psychosocial adjustment and behavioral changes in patients with cancer of the digestive system.

Of particular relevance to the phenomenon of informational resilience is the authors' understanding that resilience is a dynamic process that encompasses affect (positive and negative), social support and other environmental factors, distancing it from the understanding of resilience as a personality trait. Among the findings, the (un)documented relationship between resilience and CPT raises the possibility of thinking that resilience, as an adaptive process, may not always lead to positive aspects such as improvement or growth, which opens up possibilities for thinking about the role of information resilience in dysfunctional processes.

The fifth article with the highest number of citations (Yu *et al.*, 2014) is a randomized pilot study that sought to test the effectiveness of two interventions used to reduce adaptation difficulties in immigrants. The interventions were composed of a didactic-informational arm and another arm acting on personal resilience, such as the trait concept. The results strongly suggested that both the informational intervention and the trait intervention were effective in reducing adaptation difficulties (Yu *et al.*, 2014), showing that information is crucial, but not the only way to positive adaptation.

The sixth most cited article, Lloyd (2013), is the author's precursor work that provides the basis for her subsequent theoretical proposition of approaching resilience from an informational perspective. The paper provides a theoretical overview of previous empirical work dedicated to understanding the role of knowledge formation, negotiation, and renegotiation in the workplace, and what information modalities workers use to develop readiness to learn continuously in a dynamic informational environment such as work. The research makes it possible to understand information resilience as a result of the social practices of information literacy, as a reflection of contextual and collective practices that arise in the routine activities that make up everyday life.

The seventh most cited article, by Al-Naday *et al.* (2014), seeks to quantify the benefits that the information-centered networks (ICN) approach can bring to resilience from information retrieval's perspective. It is one of the forerunners in this current. In the results, the authors demonstrate an improvement in the level of information retrieval and a reduction in the overall traffic load when compared to IP-type solutions (based on physical network nodes), when information resilience is tested in scenarios where the source of the information fails.

The eighth article (Vårheim, 2016) provides a theoretical overview to investigate the role of public libraries in community resilience. The paper suggests that there is theoretical

evidence that community libraries are relevant actors in the resilience of a community and that, in particular, the concepts of community resilience and information resilience, as well as their operative mechanisms of social capital and social trust, are central to understanding the role played by libraries.

The ninth most cited article (Cahapay, 2022) examined the COVID-19 vaccination intentions of Filipino teachers. The results revealed that lack of knowledge about the vaccine and concern about its possible side effects were the predominant reasons for vaccine hesitancy in the group surveyed. Higher income and education scores were positively associated with a greater intention to get vaccinated. In addition, a lower level of informational barriers significantly predicted vaccination intention: "it can be observed that for a unit decrease in barriers, there is an expected increase of 0.321 [...] in the odds of being at a higher level of intention to vaccinate against COVID-19" (Cahapay, 2022, p. 330-331). These data suggest that actions to favor favorable vaccination intention target behaviors should focus on vaccine information literacy, considered by the authors as an opportunity to promote informational resilience.

Finally, the article by Lloyd, Pilerot and Hultgren (2017) is the tenth most cited article. Extending their stream of studies with resettled refugees to other regions of the globe. In this work, in addition to the importance of the concept of social capital for the analysis, the notion of place that is contained in the author's earlier works is extended. Placemaking is described as a way of knowing that helps to reduce uncertainty in times of transition. Here, the notion of the reconstruction of place comes to recognize the digital environment as a central environment for the creation, search, and dissemination of information, experiences, and memories, and therefore an important social terrain for the analysis of informational resilience.

## 5 CONCLUSION

The aim of this paper was to analyze the thematic evolution of information resilience research, using bibliometric research, to improve our understanding of the development of the field by analyzing the main publications and topics covered. Based on the results presented, some trends and areas of research in information resilience stand out.

First, research on the topic mainly covers two strands: the social dimension and the technical dimension. The former focuses on socio-informational practices and strategies for coping with states of uncertainty from a transitional perspective, while the latter concentrates on the development of computational mechanisms to guarantee the availability and delivery of information in disruptive scenarios, in a logic of adaptation and permanence.

Some authors stand out, such as Annemaree Lloyd, George Pavlou, Vasilis Sourlas and Ioannis Psaras. Their influential publications reflect the established strands and address issues such as information literacy practices in specific contexts and algorithmic architectures for processing and making information continuously available. In addition to the dimensions favored in each strand, information resilience is ultimately explored in multiple fields, including ecology, management, communication, psychology, and psychiatry.

Common to all approaches are threshold situations as catalysts for the process of information resilience: serious diagnoses, migration, disasters, failures, stress, uncertainty, and difficulties in requesting or accessing information, arising from various causes: cognitive, emotional, social, political, health, and computational, as necessary for the operationalization of the concept. What will be radically different between them is the focus that each perspective favors as a constituent of the concept: computer architectures, social, cognitive, emotional, and contextual aspects, satisfaction of information needs in decision-making processes, among others.



These findings highlight the multidisciplinary and interdisciplinary nature of information resilience research, which also involves a variety of theoretical and methodological approaches. As a result of this diversity of existing approaches and interpretations, the establishment of a single concept is particularly challenging.

Historically, the predominance of the notion of resilience as adaptation and persistence has its roots in the concept of the exact sciences, which emphasize the ability of physical and biological systems to recover after disturbances. However, Lloyd's proposal introduces a crucial differentiation, highlighting informational resilience as more than just adaptation, incorporating the notion of transition based on informational practices and interaction with the sociotechnical context.

The analysis also revealed emerging areas of study dedicated to reflecting on the fluidity of digital networks and organizations and the associated management challenges, as well as pandemic implications in the constitution of the information landscape and informed but dysfunctional decision-making processes. In particular, an emerging theme, most likely inherited from the tradition of resilience research in the field of psychology as positive adaptation, deals with the overly optimistic view of transition and adaptation processes driven by information experiences.

Particularly, when this notion is confronted with empirical evidence documenting a series of political and democratic instabilities related to disinformation that have occurred around the world lately and the growth of anti-scientific and anti-democratic movements on digital networks, even though today's information resources make it easier than ever to access, confirm, or refute information. This underscores the fact that information, its constitution, and its use are now contested fields in and of themselves.

On the one hand, information resilience can be associated with a process of reducing uncertainty or adaptation, and also with the permanence of useful information based on availability and access. On the other hand, the evidence that the processes of uncertainty reduction, persistence, and adaptation can also operate on information bases characterized by bias and prejudice, resulting in the dysfunctionality of adaptation, or worse, the problematic diffusion and permanence of anti-democratic, racist, and xenophobic ideals, adds a level of complexity to the advancement of research on information resilience.

This means that both the collective confrontation with a state of informational uncertainty and the persistence and adaptation of certain information will not always be based on moral and ethical grounds. Therefore, it is important for the field to advance in understanding and identifying the processes that support the construction, adaptation, and persistence of dysfunctional or deviant informational landscapes that meet the informational needs of subjects.

In addition, the large number of papers not included in clusters indicates that the domains and frontiers to be explored in the field of information resilience research point to an interdisciplinary agenda that can recognize the technical and social aspects of valuing and persisting with information and how we do this in society. The theoretical implications of this study highlight the need to revisit established concepts of resilience in light of contemporary dynamics of increasing neoliberalism.

Furthermore, the possibility of thinking that resilience, as a process of persistence and the supply of information, may not always lead to improvement or growth, opens up various possibilities for future research into studies of informational resilience as a necessary articulation of current problems.

A significant limitation of this study is the use of a single database for the review, which resulted, for example, in the identification of only one article by Brazilian or Latin authors in the discussion on the evolution of the concept. This decision may imply a bias in the sampling of the works considered, and the attempt to minimize this bias involved the use of two bibliometric softwares in the exploration of the material retrieved. When used together, the

visualizations provided by these tools complement each other, displaying individualized and aggregated analyses.

In addition, quotes about GEPSI - the Sociology and Information Study and Research Group (an active Brazilian research group studying the subject) - were included as a form of contextualization. It is understood that future studies could broaden the search, including other databases, which could deepen the preliminary notions presented in this study, providing a more complete and diverse representation of the discussions.

In short, this study highlights the complexity, ambiguities, and challenges in a single definition of information resilience, the need for critical approaches to current views that are excessively positive, and the importance of sociotechnical perspectives for a more comprehensive understanding of the concept. Finally, the need to expand approaches to understanding the informational bases constituted in scenarios of democratic disputes is highlighted.

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