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REVIEW

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Accelerated Digital Transformation of Higher Education in the Wake of COVID-19: A Systematic Literature Review

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Abstract: The COVID-19 pandemic has accelerated digital transformation (DT) across various industries, including higher education (HE). In response to the dynamic demands of contemporary society, higher education institutions (HEIs) must swiftly adapt and transform. However, existing research has revealed a prevalent lack of strategic vision regarding DT in HE, often limited to the mere integration of technology. This study employs a systematic literature review (SLR) as a methodological framework to identify and categorize DT challenges and strategies within HE accelerated after the pandemic event. Findings from this SLR highlight four distinct categories of challenges and strategies in DT: Strategic-Administrative, Teaching-Learning, Technical-Technological, and Social-Cultural. Notably, the literature tends to focus more on identifying challenges, revealing an unbalanced emphasis compared to analyzing how HEIs are actively progressing in their DT efforts. Furthermore, there is a significant absence of impact analysis regarding these DT strategies within HE. To address these gaps, recommendations for future research are proposed, including (i) Exploration of strategic processes in HE toward DT, (ii) Empirical analysis of the Digital Maturity of HEIs, and (iii) Assessment of the impact of the strategic responses of HE toward DT. In conclusion, this study underscores the urgency for a more strategic approach to DT in HE, emphasizing the need to shift the focus from technology integration toward holistic, effective, and outcome-driven strategies. These recommendations aim to guide future research toward a more interdisciplinary and comprehensive understanding of DT within the realm of HE.

Keywords: digital transformation, higher education, Education 4.0

1. Introduction

1.1. Background

Over the last decade, the global phenomenon of digital transformation (DT) has required industries, including the educational sector, to adapt to new dynamics generated by the Fourth Industrial Revolution (4IR). The COVID-19 pandemic has further accelerated DT in higher education (HE) [1], highlighting that change in the industry is not only urgent but also feasible [2]. DT demands that higher education institutions (HEIs) address new forms of communication, behavior, and learning styles arising in society due to technological advancements [3]. Despite this, research indicates that HEIs are not sufficiently effective in developing the skills needed for individuals to cope with uncertainty and meet current DT industry needs [4].

To remain a key element for social development, HEIs must evolve comprehensively [5]. Addressing DT in HEIs requires a broader vision and innovative institutional approach. Unfortunately, many institutions focus narrowly on digitizing services and automating teaching tasks, overlooking the broader DT challenges [6, 7]. Some HEIs concentrate solely on technological modernization, lacking a strategic view of DT that is flexible enough to adapt to constant change and positively impact their context [8].

Radical institutional approaches are needed to transcend rigid organizational and academic structures and establish new work schemes that promote meaningful change and lifelong learning [9]. Although technological appropriation often initiates DT, it must quickly evolve toward a holistic organizational transformation [10]. Nevertheless, the literature highlights a lack of strategic, systemic, and interdisciplinary understanding of DT across all organizational branches and the need for an innovation-based management style [11].

Despite the complexity of DT, few studies examine how HEIs respond to its challenges [12–14]. Existing literature provides fragmented insights, primarily focusing on integrating new technologies into educational processes and the digitalization of services [15–18]. These studies tend to narrow their focus on specific types of challenges rather than offering a comprehensive analysis that encompasses the wider social relations involved in adopting technology in education [9].

Furthermore, while the literature includes extensive compilations of the challenges and barriers HEIs face concerning DT [19–21], there has been insufficient exploration from a strategic standpoint that connects and measures these findings in relation to HEI performance.

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Although progress in DT has been analyzed through research measuring digital maturity in organizations, this aspect lacks in-depth study in the educational sector [22].

The contribution of this literature review is to connect recent findings regarding current conceptualizations, challenges, and strategies implemented by HEIs, as well as how their performance is being measured. This comprehensive view of DT will be useful for leaders and decision-makers to strengthen their DT strategies and for researchers as a basis for future studies in the strategic management of education.

1.2. Research questions

To guide the research, the questions of this study are the following:

1) **RQ1:** What are the primary conceptualizations of DT in the context of HE?
2) **RQ2:** What challenges do HEIs face in adapting to the rapidly changing landscape of DT?
3) **RQ3:** To what extent do the strategies implemented in HE align with the challenges posed by DT?

The research questions outlined above aim to achieve a comprehensive understanding of DT within HE. This will be accomplished by (i) identifying the primary conceptualizations of DT within HEIs (**RQ1**); (ii) acknowledging the significant challenges associated with DT (**RQ2**); (iii) examining the domains of application and strategies employed by HEIs to address DT, along with an analysis of the methods used to assess their effectiveness and their outcomes (**RQ3**).

2. Methods

In search of a comprehensive analysis, the study was conducted through an SLR as a strategy to identify and analyze relevant contributions that allow for responding to the research questions. A SLR is a research methodology to synthesize scientific evidence following explicit, rigorous, and accountable methods [23–25]. To ensure reliability and recall, the specific research methods employed in this study are elaborated upon below.

2.1. Data sources

The search was carried out in four databases: the multidisciplinary scientific platforms Scopus and Web of Science, ERIC (Education Resources Information Center), a database specialized in educational sciences, and Business Source Complete by EBSCO, which specialized in business and management studies.

2.2. Search query

The automated search was conducted on February 26, 2023. The query was designed to address the research questions by using relevant terms regarding the topic of interest as follows:

"Digital Transformation" AND ("Higher Ed*" OR HEI OR "Education 4.0" OR Universit* OR Colleg*) AND (Conceptualization* OR Theor* OR Challenge* OR Barrier* OR Strateg* OR Measur* OR Assess*OR Outcome* OR Result*).

2.3. Study selection

Considering the purpose of the study, the following selection criteria were defined:

2.3.1. Inclusion criteria

1) Only peer-reviewed articles and conference papers were included in the study.
2) Papers identified using the snowballing technique one level deep (backward and forward) were also included as part of the study.

2.3.2. Exclusion criteria

1) As the study is focused on recent and current events and considers the effects of the COVID-19 pandemic in accelerating the DT of education [1, 2], the articles published before 2020 and/or research studies executed before 2020 were excluded.
2) Studies merely related to the specific pandemic phenomenon were also excluded.
3) Due to the constraints of the researchers, the articles not written in English or Spanish languages were discarded.

The automated search retrieved 626 results in the specified databases (Table 1). From these results, 120 duplicated documents were removed using the Covidence tool.

Upon the removal of duplicate papers, a pool of 506 articles was available for the subsequent phase of initial title and abstract screening. Utilizing the Covidence tool, this stage led to the exclusion of 383 studies, while prompting the retrieval of 123 articles for further evaluation. Following an exhaustive review of the 108 papers that were retrieved (15 remained unobtainable), a preliminary list of 40 selected articles was compiled. Additionally, two more papers were incorporated into the selection via the snowballing technique.

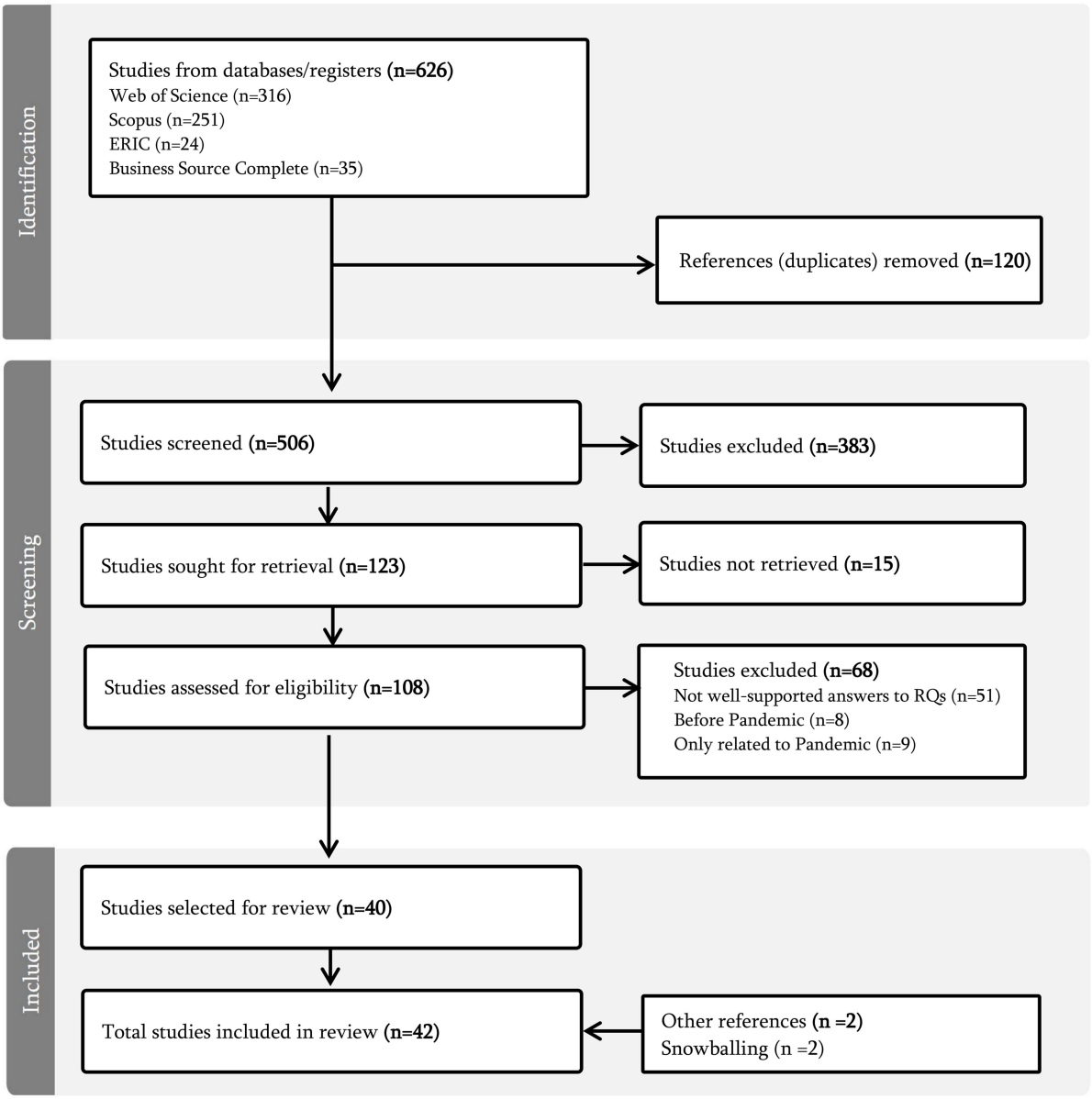
The quality assessment criteria for selecting the articles included in the study are as follows:

1) A clear and consistent research design.
2) A consistent theoretical background.
3) Detailed and well-supported answers to at least one of the research questions.

Table 1
Search results

Database	Results	Search type	Filters used
Scopus	251	Title+Abs+Key	Type: Journal articles and Conference papers Year: 2020–2023 | Languages: English and Spanish
Web of Science	316	Title+Abs+Key	Type: Journal articles and Conference papers Year: 2020–2023 | Languages: English and Spanish
ERIC	24	All fields	Type: Peer-reviewed Journal articles Year: 2020–2023 | Languages: English
Business Source Complete	35	Title+Abs+Key	Type: Peer-reviewed academic journals Year: 2020–2023 | Languages: English

Figure 1
Selection process



The selection process is illustrated using the PRISMA diagram as presented in Figure 1 [26].

2.4. Data extraction

The metadata were automatically collected from the search results. Subsequently, the findings were manually extracted after reading and assessing the selected papers. After the analysis, the extracted data were classified in an accessible spreadsheet considering the research questions:

1) Conceptualizations of DT in Higher Education.
2) Challenges faced by HEI in the context of DT.
3) Strategies implemented by HEIs and their performance, either if the paper presents a model or method to measure the performance of HEIs or the outcomes achieved by them.

2.5. Data synthesis

The data were tabulated and synthesized to present the main conceptualizations of HE towards DT, challenges faced, and strategies implemented by HEIs in relation to DT. Thematic synthesis [25] was used as a tool to facilitate the exploration of possible relationships between the research questions. As presented in Table 2, a series of four categories and 16 areas of application (or sub-themes) were defined by identifying patterns and merging complementary findings. This allowed for a more comprehensive interpretation of the results to connect and contrast the strategies implemented by HEI with the challenges identified by the literature.

The complete dataset used in this literature review, which outlines the contribution of each examined study to the respective categories, can be found in Data Availability Statement.

Table 2
Structure for thematic analysis

Categories	Areas of application
Strategic-Administrative	Strategy and governance
	Business Model
	Operational processes
	Financial issues
Teaching-Learning	Pedagogical approaches
	Curriculum
	Academic quality
	Industry demands
Technical-Technological	Digital skills
	Technological infrastructure and digital resources
	Technical support
	Data Management
Social-Cultural	Organizational culture
	Health issues
	Changes in society
	Social and environmental contexts

3. Results

3.1. Conceptualizations of DT in HE

The literature shows several conceptualizations of DT from HE. Approaches related to innovation in the business models of HEIs, technological adoption to improve academic services, and pedagogical innovations to address industry needs are the most outstanding. Table 3 presents a total of 12 conceptualizations found in this review:

Table 3
Conceptualizations of DT in higher education

Conceptualization of DT in higher education	References
"Evolutionary process" that impacts and transforms key activities (teaching, research, administration) enhancing their effectiveness and removing physical barriers through digitalization.	Rof et al. [27]
The primary aim of DT in HE is "to redesign educational services and to redevelop the operational processes".	Kuzu [28]
Transforming current teaching and learning models for "survival and sustaining the competitive position of HE in the long term". Goals of DT in HE: "to improve the students' learning environment, increase operational efficiency, increase computing power for cutting-edge research, and stimulate innovation in education".	Alenezi [29]
Approaches: (i) "AI in Education: using AI technologies to educate students in various fields. (ii) Education (Teaching) of AI: training students with AI skills.	Cantú-Ortiz et al. [30]
Implementing digital technology across all organizational areas that involves key factors: "(1) digital culture, (2) digital strategies, (3) management process, (4) organization leaders, (5) digital technologies, (6) staff".	Laorach and Tuamsuk [31]
Education 4.0 is defined as an integration of elements that build new educational models, aligned with digital transformation needs in the sector.	Labanda-Jaramillo et al. [32]
Defines Education 4.0 as a combination of emerging technologies with innovative pedagogical practices that includes four key components: "competencies, learning models, information and communication technologies, and technological infrastructure".	del Castillo Castro et al. [33]
"Education 5.0 involves the use of new technologies to provide more humane teaching, with a focus on learner's social and emotional development and solutions that improve life in society". Key trends: personalized education, lifelong learning, reduced concentration of learner's attention, focus on acquiring soft skills, use of new technologies.	Skitsko and Osypova [34]
DT from an institutional standpoint, is seen as a strategy to anticipate stakeholder needs "and to provide education, research, and social services", aligned with the evolving demands of students.	Valdés et al. [35]
"DT is understood as the application of technology to improve processes" . . . "Implementation of technology in educational and administrative processes, improving class experience".	Maluche et al. [36]
"To explore unique digital technologies to enhance students' experience in learning". This involves transforming operations that impact portfolio, delivery, integration, and structure. From this perspective, the aim of HEIs is to increase revenue, improve productivity, generate innovative value, and develop reputation.	Mohamed Hashim et al. [37]
"Marked by a dynamic, independent, active, innovative, and self-directed learning (Education 4.0)", leveraging current and future technologies under the 4IR framework.	Chaka [38]

3.2. Main DT challenges within HEIs

The complexity of the new digital paradigm implies a change of direction and an integral and agile evolution of educational models [39–41]. Consequently, recognizing the DT challenges faced by the HE sector is the first step in addressing them. A total of 93 challenges and barriers faced by HEIs in relation to DT were found in the literature. Using thematic synthesis, the findings presented below were merged and organized into the following four categories: (i) Strategic-administrative; (ii) Teaching-Learning; (iii) Technical-Technological; and (iv) Social-Cultural.

3.2.1. Strategic and administrative challenges

Most of the challenges identified in this area are related to strategy and governance. The lack of a strategic vision, policies, and planning with respect to DT [29, 42–44] is the main concern found in the literature, along with decision-making and implementation of strategies and projects [27, 29, 45]. Similarly, the need for leadership [44, 46], organizational alignment [47], external collaboration [27], and rapid adaptation of organizational resources and capabilities [21] are matters of concern.

Other challenges are related to the need for innovation in the business model to create, capture, and deliver value from a global perspective [27, 48]; adaptation of operational processes to new technological and social realities [21, 27]; and financial issues due to the imbalance between the incremental investments and costs of DT and the lack of strategies for new sources of revenue [27, 29, 42], all as presented in Table 4.

Table 4
Strategic and administrative challenges faced by HEIs in the context of DT

Areas of application	Challenges	References
Strategy and governance	Delays in DT strategy definition and implementation of large-scale projects due to decentralized and lengthy decision-making.	Alenezi [29], Bucăţa et al. [49], Rof et al. [27]
	Strategic deployment to quickly mobilize "organizational capabilities and strategies for promoting flexibility of work and learning".	Nurhas et al. [21]
	"Make the right decisions regarding IT investments".	Sliep and Marnewick [45]
	Lack of a clear, holistic, and shared vision of DT.	Aditya et al. [42], Marks et al. [43], Rima Aditya et al. [44]
	"Lack of institutional plan and policy regarding DT".	Aditya et al. [42]
	Organizational leadership skills to deal with Digital Transformation.	Rima Aditya et al. [44], Rocha et al. [46]
	"Misalignment between teachers and administrators" (to develop digital strategies).	Alhubaishy and Aljuhani [47]
	"New partners for new relationships".	Rof et al. [27]
	Lack of strategic planning and proper prioritization.	Aditya et al. [42], Alenezi [29], Rima Aditya et al. [44]
	"Digital needs to be recognized as a strategic asset and as a way to help deliver the university's mission".	Pilege and Živitere [50]
Business model	"Difficult capture of new sources of revenues".	Rof et al. [27]
	"Self-limited regional focus due to traditional offering" and "global competition".	Rof et al. [27]
	"Uncertainty about new offerings, due to evolving students' preferences".	Rof et al. [27]
	"Evaluate which organization, business model will be the most suitable".	Pilege and Živitere [50]
Operational processes	"Growing demands of technology for a flexible work"	Nurhas et al. [21]
	"Lack of clear and standardized processes and protocols" for managing digital technologies.	Rof et al. [27]
	"Process and structure changes: cost and resistance".	Rof et al. [27]
Financial	"Cost escalation and technological dependence" and "Process and structure changes".	Rof et al. [27]
	"Insufficient funds".	Aditya et al. [42]
	"Reduction of old sources of revenues".	Rof et al. [27]
	"Narrow View of ROI" (when it comes to investments in technology).	Alenezi [29]

3.2.2. Teaching and learning challenges

The literature's main emphasis on teaching and learning challenges is on the pedagogical aspect. Following the Education 4.0 approach, the demands for flexibility, collaboration, lifelong learning, and personalization are some of the key skill sets and competencies required by the industry in need to be addressed by the HE sector [12, 20, 21, 48, 51]. Consequently, the rigid academic structures within HEIs are also challenging the implementation of these learning approaches [13].

In terms of curriculum updates, the complexity and broad conceptualizations of DT make it difficult to reach consensus and

agility in integrating digital competencies into disciplinary programs [51, 52]. The literature presents too little concerning quality of education and teaching and learning performance are tangentially approached [47]. In addition, the need for digital collaboration with internal and external stakeholders and the demands of the industry are more widely considered [4, 21, 52], all as shown in Table 5.

Table 5
Teaching and learning challenges faced by HEIs in the context of DT

Areas of application	Challenges	References
Pedagogical approaches	Increasing demands of flexibility to support a "learning approach (independent of place and time management)".	Nurhas et al. [21]
	"Providing personalized feedback at-scale"	Nunez Avila et al. [12]
	Improving learning practices with innovative educational strategies focused on "collaborative, genuine, project-based learning".	Fleaca et al. [51]
	The rigidity of HEIs' academic structures as a "barrier to the new adaptable learning approaches required by Generation Z students".	Caratozzolo et al. [13]
	Incorporation of a lifelong learning approach considering diversity and heterogeneity of learners.	Ahel and Lingenau [20], Aslam et al. [48]
Curriculum	"Integration of digital competence into the disciplinary curriculum".	Fleaca et al. [51]
	Achieving a shared understanding of required competences among stakeholders due to the complexity of digital transformation.	Lindner et al. [52]
Quality	"Teaching performance".	Alhubaishy and Aljuhani [47]
	"Learning performance".	Alhubaishy and Aljuhani [47]
Demands of the industry	"An increasing need for open and cross-functional (cross-disciplinary) digital collaboration".	Nurhas et al. [21]
	Changing qualification demands on human work in an Industry 4.0 and digital transformation context.	Goulart et al. [4], Lindner et al. [52]

3.2.3. Technical and technological challenges

When it comes to DT in the context of HE, one of the main concerns highlighted in the literature is the insufficiency of digital skills among academic and administrative communities [14, 27, 29, 43, 44, 47, 51–53]. Along with generational gaps between the faculty and students [29] and a lack of experience with digital environments, resources, and processes [47], most authors emphasize the importance of developing a digital culture based on the mastery of new technologies by all members of university communities.

Likewise, some of the most prominent challenges in the literature are related to implementing new technologies and using digital resources. Limitations regarding technological infrastructure [27, 43, 54], the need for implementing technology in the classroom, the incorporation of 4IR technologies to develop e-learning environments [19, 21, 37, 44, 54], and technological modernization of academic and administrative processes [43, 53–55] are widely considered. Other challenges related to technological infrastructure are less frequently discussed such as the lack of access to resources for vulnerable populations [20] and sustainable campus infrastructure [55].

Challenges related to the need for proper technical support to implement DT are also highlighted [44, 48]. Regarding data management, data governance structures, processes, and policies are also emphasized as being of great importance in the context of DT [43, 44, 47, 54, 56], all as seen in Table 6.

3.2.4. Social and cultural challenges

Table 7 presents social and cultural challenges related to the implementation of DT in HEIs. Concerning organizational culture,

Table 6
Technical and technological challenges faced by HEIs in the context of DT

Areas of application	Challenges	References
Digital skills	Development of competences in terms of knowledge, skills, attitudes, and values toward DT (Teachers, students, and administrative staff).	Alenezi [29], Alhubaishy and Aljuhani [47], Fleaca et al. [51], Lindner et al. [52], Marks et al. [43], Rima Aditya et al. [44], Rodríguez-Abitia and Bribiesca-Correa [53], Rof et al. [27], Viñoles-Cosentino et al. [14]
	"Lack of digital competence among staff".	Pilege and Živitere [50]
	"Generational disparities between students and technology-adopting faculty".	Alenezi [29]

(*Continued*)

Table 6
(*Continued*)

Areas of application	Challenges	References
	"Lack of experience" (with digital environments, resources, and processes).	Alhubaishy and Aljuhani [47]
Technological infrastructure and digital resources	Increased "use of emerging technologies and social media" including "online collaborative platforms to support learning and working".	Nurhas et al. [21]
	"Increasing investment in innovative technological advancement" (for sustainability).	Mohamed Hashim et al. [55]
	Limited IT infrastructure.	Chituc [54], Rima Aditya et al. [44], Rof et al. [27]
	Create content that is compatible with and accessible in offline environments for those that lack permanent access to Internet.	Ahel and Lingenau [20]
	Redundant systems and lack of integration and interoperability.	Chituc [54], Marks et al. [43], Mohamed Hashim et al. [37], Rodríguez-Abitia and Bribiesca-Correa [53]
	"Investments in infrastructure".	Pilege and Živitere [50]
	"Difficulties to keep up with technological changes" and "lack of time to incorporate digital technology".	Rima Aditya et al. [44]
	Embedding ICT such as cloud computing and AI methods and algorithms into Higher Education.	Aditya et al. [19], Chituc [54], Mohamed Hashim et al. [37], Rima Aditya et al. [44]
Technical support	"Lack of IT support service".	Rima Aditya et al. [44]
	"Support the teachers in designing and developing courses online for a different type of student".	Aslam et al. [48]
Data management	Data structure, procedures and operations, and IT strategy, IT governance.	Marks et al. [43], Tungpantong et al. [56]
	IT risks, privacy concerns, and security data.	Alhubaishy and Aljuhani [47], Chituc [54], Rima Aditya et al. [44]
	"Third-Part Reporting Systems" and "the existence of several external reporting agencies/systems that require different data sets, formats, and requirements".	Marks et al. [43]
	"User infoxication and spamming"	Rof et al. [27]

resistance to change is a significant challenge. Commitment, digital mentality, motivation, and quality relationships given the excessive use of digital environments are also considered social and cultural challenges in the literature [21, 27, 29, 42, 47]. In addition, health issues due to the adverse effects of technology [21, 27]; lifestyle changes related to technology use such as greater workloads, technological dependence, loss of social skills, and excessive use of technology [21, 27, 47]; and social and environmental trends and pressures are part of the challenges of DT in HE [21, 55].

3.3. DT strategies and areas of application in HE

In contrast to the challenges identified, strategies toward DT are much less researched. The literature presents a wide range of theoretical proposals to manage the digital environment, and although there are plans and strategies developed by HEIs [28, 36], there is not much evidence explicitly linked to DT about how they are performing in the face of this context. To analyze how HEIs are addressing DT challenges, the strategies found in

Table 7
Social and cultural challenges faced by HEIs in the context of DT

Areas of application	Challenges	References
Organizational culture	Resistance to change.	Aditya et al. [42], Alenezi [29], Alhubaishy and Aljuhani [47], Nurhas et al. [21], Rof et al. [27]
	"Existing governance structures and college-specific cultures . . . that make organizations sluggish and resistant to change".	Bucăţa et al. [49]
	"Lack of quality employee relationships" (when remote work) and "loss of contact and socialization routines" (in both students and employees).	Nurhas et al. [21]
	Lack of "doing it all digital mentality".	Rof et al. [27]
	"Lack of commitment".	Aditya et al. [42]
	"Lack of motivation".	Alhubaishy and Aljuhani [47]

(*Continued*)

Table 7
(*Continued*)

Areas of application	Challenges	References
Health issues	"A "24-h-accessibility" syndrome (e.g., teleworking)".	Rof et al. [27]
	"Adverse effects of technology on mental health" (such as technostress, anxieties, sleeping disorder, negative emotions, and frustration among others).	Nurhas et al. [21]
Changes in society	"Greater workloads using new technologies, resources . . . ".	Nurhas et al. [21]
	Technological dependence	Nurhas et al. [21], Rof et al. [27]
	"Blurring the boundaries of personal and work-related (as employee or student) activities to use technology".	Nurhas et al. [21]
	"Lack of social awareness" (about the importance and implications of DT).	Alhubaishy and Aljuhani [47]
	"Poor social skills" (due to the use of digital environments).	Alhubaishy and Aljuhani [47]
Social and environmental contexts	Pressing sustainable practices and rapid macro-environmental changes.	Mohamed Hashim et al. [55]
	Emerging social e-trends.	Mohamed Hashim et al. [55]
	Reduce of e-waste.	Mohamed Hashim et al. [55]
	"Guiding technology to promote diversity and inclusion "location infrastructure, different technology experiences, interaction at home, technology for vulnerable groups".	Nurhas et al. [21]

the literature that were carried out after the disruption caused by the Pandemic are categorized below.

3.3.1. Strategic and administrative strategies

In terms of strategy and governance (see Table 8), evidence of a few DT institutional plans was presented, as well as the use of information technology for decision-making [28, 36]. Regarding HEI business models, the literature exhibits some strategies related to the creation of online programs [36], new academic offers oriented to develop digital skills [57], and cooperation for leading IT with the external sector [28]. The digitalization of processes and the use of social media to improve communication channels with students [28, 36] are also emphasized as strategies affecting operations. Regarding financial issues, no concrete strategies other than new academic offers as potential sources of new revenue were identified [36]. Additionally, no results from any of the presented strategies were analyzed in the reviewed articles.

3.3.2. Teaching and learning strategies

Table 9 highlights pedagogical approaches as one of the most addressed issues when it comes to DT in HE. Evidence of new active challenge-based learning experiences, meaningful learning, and application of technologies and resources are usually presented as empirical research within the context of a classroom or small groups of students [12, 13, 33, 58]. The analyzed studies support the positive impact of technology-based learning experiences in

Table 8
Strategic and administrative strategies implemented by HEIs in the context of DT

Areas of application	Strategies	Results	References
Strategy and governance	Definition of a "formal DT plan, with digital culture adoption, technology for new learning experiences, change management, virtual university".	Not presented	Maluche et al. [36]
	"Use of information technology in management, corporate communications, and performance evaluation".	Not presented	Kuzu [28]
Business model	"Diversification of the academic offering, represented in the expansion of the portfolio of virtual programs and continuing education".	Not presented	Maluche et al. [36]
	New "Courses and training to acquire new skills or reinforce knowledge".	Not presented	Teixeira et al. [57]
	"University-sector cooperation" and "leading IT services competition".	Not presented	Kuzu [28]
Operational processes	"Redefine the services through a new and advanced digital in-house process . . . (student admission, registration, examination system, quality assurance system, course plan/ hour, syllabus/module and academician employment)".	Not presented	Kuzu [28]
	"Use of information technologies in communication with students".	Not presented	Kuzu [28]
	"Digitalization of processes".	Not presented	Maluche et al. [36]
Financial issues	"Diversification of the academic offering".	Not presented	Maluche et al. [36]

improving the development of competences and skills demanded by current industry needs.

On the other hand, fewer strategies were identified regarding curriculum and educational quality. In the first case, without presenting concrete results, curricular redesigns toward a transdisciplinary [59] and AI approaches [30] were found. In both approaches, these experiences are developed in the context of engineering programs, reinforcing the idea that DT is still conceived in relation to hard science instead of as a phenomenon affecting all areas of human life and fields of knowledge. Regarding the quality of education, only HE institutional plans including the use of technological support to achieve accreditation were identified [28].

Finally, with no evidence of effectiveness, the literature allows for identifying two strategies to attend to the industry needs: cooperation with the external sector to strengthen academic capabilities [28] and the formulation of new programs and courses to attend to their needs, according to the school emphasis [57].

3.3.3. Technical and technological strategies

In terms of technical and technological strategies (Table 10), research supports progress in the development of digital skills [14, 58] and the use of new technologies in university communities [30] as a result of training programs which were significantly reinforced and prioritized during and after the pandemic [39].

Table 9
Teaching and learning strategies implemented by HEIs in the context of DT

Areas of application	Strategies	Results	References
Pedagogical approaches	Implementation of active and challenge-based learning experiences (focus on collaborative learning to solve problems)*.	High improvement when comparing with students of the control group. Use of design thinking and art design methodologies tools helps abilities and disposition to creative thinking in students.	Caratozzolo et al. [13]
	"Use of summaries, mind maps, case studies, and discussions in their classes supported by technological tools and infrastructure, and thus improve the learning of the course . . . enhancing the achievement of significant learning".	The levels of significant learning are improved from regular (43.6%) to good (82.1%).	del Castillo Castro et al. [33]
	"Development of teaching and learning experiences, in real classrooms, aimed to develop technical, social and cognitive skills defined by Education 4.0" (with a focus on sustainability).	All skills (soft skills and hard skills) stimulated in the experience were evaluated positively in the students' self-assessment.	Oliveira and de Souza [58]
	Use of "Learning Analytics feedback tools to improve Self-Regulated learning skills".	Not presented.	Avila et al. [12]
Curriculum	"Empirical-based redesign of a lecture for the transdisciplinary education".*	Not presented.	Ralph et al. [59]
	"The design of an AI curriculum with an emphasis on the AI capabilities that the Higher Education Institution desires to develop"	Not presented.	Cantú-Ortiz et al. [30]
Quality	"Technological support" (aimed to achieve national and international quality accreditation).	Not presented.	Kuzu [28]
Demands of the industry	"Strategy of HEIs varies according to their school typology . . . engineering schools train people with high digital skills who are able to innovate and program, whereas the function of business schools is to improve business models and add value to the digital".	Not presented.	Teixeira et al. [57]
	"University-sector cooperation".	Not presented.	Kuzu [28]

Note: *Strategies focused on Engineering programs

Table 10
Technical and technological strategies implemented by HEIs in the context of DT

Areas of application	Strategies	Results	References
Digital skills	Training for digital skills in the academic community and management body.	Better perceived self-efficacy to integrate technologies into teaching practice, increase in digital culture in the classroom.	Kuzu [28], Maluche et al. [36], Teixeira et al. [57], Viñoles-Cosentino et al. [14]
	"Trained professors in the main technologies of AI and the principal approaches to AI".	Not presented.	Cantú-Ortiz et al. [30]
Technological infrastructure and digital resources	Creation of digital learning environments (focused on the use of tools such as LMS, software, and digital libraries).	Not presented.	Henseruk et al. [60], Kuzu [28]
	"Create new educational programs as well as digitization of the programs offered by the old method . . . massive open online courses – MOOC – are enriched with new methods".	Not presented.	Kuzu [28]
	Investments to acquire or develop e-learning technologies to improve educational processes.	Not presented	Kuzu [28], Maluche et al. [36]
	Applications of Big Data as Learning Analytics (LA) for performance prediction, intelligent feedback, course recommendations, etc.,	Not presented.	Nunez Avila et al. [12], Klishin et al. [61], Maluche et al. [36], Najdawi and Stanley [62], Vatolkina and Cardoso [63]
	Implementation of an "AI-supported Smart Learning Environment" which consists of the integration of technologies such as "applying AI in facial recognition, image and behavior recognition, data visualization, and educational chatbots".	Higher academic performance and smaller standard deviation. (Teachers can collect students' learning behaviors and entrust chatbots to help provide accurate care and guidance in self-adjustment of learning).	Hu [64]
	"Investments in technological infrastructure".	Not presented.	Maluche et al. [36]
	"Digitalization of research infrastructure" and "Technological equipment of laboratories".	Not presented.	Kuzu [28]
	Initiatives oriented to develop a "smart, sustainable and unobstructed campus".	Not presented.	Kuzu [28]
Technical support	"Support students and staff in the implementation of e-learning and digital technologies. Providing sufficient professional instruction, through learning, supporting structures for students and academic workers, making the limits of space, time and distance no longer complex problems".	Not presented.	Vatolkina and Cardoso [63]
Data management	"Automation-software" (Software/data/server; Automation systems).	Not presented.	Kuzu [28]
	Implementation of data government practices, which includes "create an effective functional team for data governance tasks", "have an internal audit for data governance", and "evaluate and follow-up the legal and regulatory requirements of data governance practice".	Support of the effective role data governance can play in the implementation of DT processes.	Omar and Almaghthawi [39]

With respect to technological infrastructure and digital resources, several strategies are presented to tackle DT. Research infrastructure improvement, sustainable campus initiatives [28], digitalization of administrative processes [36], and application of Big Data, AI, and digital tools to learning environments [12, 28, 36, 60–63] are the most outstanding. Regarding this, some evidence is presented about the positive effect of learning environments supported by technology [64].

In terms of technical support, HEIs have provided students, faculty and staff with professional training and supporting resources for a flexible, integrated, and sustainable learning environment [63]. In terms of data management, the implementation of data governance practices has proved to be effective in the implementation of DT processes [39] and the implementation of technology to secure data and system automation is also considered [28].

3.3.4. Social cultural strategies

Finally, Table 11 evidences that there is not much research explicitly linking DT and HE strategies that address the social and cultural challenges of this phenomenon. Some institutional strategic

Table 11
Social and cultural strategies implemented by HEIs in the context of DT

Areas of application	Strategies	Results	References
Social and environmental contexts	"Relationship with external stakeholders and society" (Socio-cultural and social responsibility; promotion of university services; international networks).	Not presented.	Kuzu [28]

plans present the importance of the relationship with external stakeholders by leveraging DT in order to promote services, networks, and social goals.

4. Discussion

4.1. How do HEIs understand/conceptualize DT?

The global phenomenon of DT represents an inevitable and permanent trend significantly affecting HEIs. New technologies have revolutionized access to information and knowledge, challenging the traditional role of HE in society [29]. Within this context, many conceptualizations of DT and its implications have emerged. A review of the literature reveals three main approaches to DT in HE (**RQ1**):

The first one is a technology-based approach that presents two perspectives [30]. The first perspective involves using new technologies in educational processes to enhance the teaching-learning experience and improve administrative processes [28, 30, 36]. This is arguably the most common and narrowly focused view of DT in education. The second perspective focuses on developing the competencies and skills needed to apply AI and navigate the digital context [30]. Although traditionally centered on engineering students and related fields, this perspective can be broadened to emphasize that individuals in all disciplines should strategically understand technology to leverage its potential and manage it effectively. This broadening focus presents significant curricular challenges for HEIs.

As a second relevant approach, Education 4.0 is perhaps the most established view of HE within the DT context. Defined as a pedagogical approach responding to the demands of the 4IR [32], it aims to transform HE through a dynamic, independent, active, innovative, and self-directed teaching-learning perspective supported by new technologies [33, 38]. This approach advocates for adopting innovative pedagogies to develop essential skills in both professors and students, fostering lifelong learning capabilities in society [29]. More recently, some authors have presented an evolution of this approach (Education 5.0), emphasizing learners' social and emotional development [34].

Despite its comprehensiveness, Education 4.0 lacks a strategic perspective that encourages HEIs to develop a culture of innovation. This would involve fostering an administrative-academic vision capable of anticipation, leadership, and change management. The importance of innovation in HEIs is critical for their survival and success in dynamic environments [65] and as a crucial component of achieving high-quality education [66].

The third approach draws from the corporate world. Rof et al. [27] studied business model innovation (BMI) as applied to HEIs, comparing the challenges faced by universities to those faced by the business sector. The BMI approach offers a strategic and financial perspective, focusing on value creation, proposal, and capture by developing an innovation-centered culture and strategy. While not an ideal approach on its own for education purposes, it provides a complementary and significant vision to develop the potential of HE as an organization.

To effectively create, propose, and capture value, HEIs must transcend traditional practices to digitally transform their capabilities, processes, and resources [31, 37]. Building a more student-centered experience and continuously improving to become globally competitive is essential [27]. In this sense, incorporating digital technologies in education should be seen not merely as a tool for facilitating teaching but as a critical means of cultivating individuals capable of succeeding in modern society [7, 67]. Furthermore, the pervasive and exponential use of technology in society and its influence on education may lead to the adoption of a smart education approach [68], oriented toward creating smart environments and applying smart pedagogies to support the development of smart learners, thereby improving lifelong learning quality [69].

The reviewed literature suggests that HEIs have predominantly favored a technology-centered approach, alongside the pedagogical aspects emphasized by Education 4.0. Findings indicate that many institutions view DT primarily as the incorporation of technologies – often as late adopters – to improve and streamline educational and administrative processes. On the other hand, the BMI approach appears to be the least adopted among HEIs. Although a few have DT strategic plans, some institutions do not even mention DT in their strategic plans and lack a clear conceptualization of DT [28, 36]. Moreover, there is insufficient evidence to support the completeness of these institutional plans and their impact on HE performance.

The above denotes a lack of a holistic approach in navigating DT and underscores the necessity of incorporating digital innovation strategies [70]. These strategies are crucial for creating new value propositions and transforming organizational structures to foster an innovation culture. To effectively address DT and remain competitive in the current dynamic environment, HEIs must prioritize promoting an innovation culture that takes into account stakeholder needs and behaviors [35].

4.2. How do HEIs address DT challenges?

HEIs face substantial challenges in adapting to the rapidly evolving landscape of DT (**RQ2**). One significant issue is the lack of robust strategic and administrative frameworks [29, 42]. Many institutions incorporate technology into their educational processes without a coherent, overarching strategy that aligns technological adoption with long-term institutional goals [43, 45]. This fragmented approach limits the effectiveness of DT initiatives and prevents HEIs from fully capitalizing on the potential benefits of digital technologies.

Another major challenge for HEIs is the insufficient emphasis on social and cultural contexts within their DT strategies. Often, DT efforts focus narrowly on technological upgrades and digital skills development, overlooking the broader social and cultural dimensions crucial for successful transformation [4, 28]. For instance, fostering an innovation-centric organizational culture requires addressing the social dynamics and behavioral changes necessary for embracing new technologies [71]. Without acknowledging and integrating these social and cultural factors, DT initiatives are likely to face resistance or fail to achieve sustainable impact. HEIs must, therefore, adopt a holistic view of

DT that includes cultural change management and stakeholder engagement to foster an environment conducive to innovation [72]. Additionally, HEIs deal with insufficient measures of academic quality in the context of DT. Traditional metrics and evaluation frameworks often do not capture the nuanced impacts of digital initiatives on educational outcomes [73, 74]. To address this, HEIs need new assessment tools that effectively measure the quality and effectiveness of digital pedagogies, technological infrastructure, and the overall digital learning experience.

When examining the challenges encountered and strategies employed by HEIs in adopting DT (**RQ3**), an observable disparity in both quantity and scope emerges. Furthermore, there is a noticeable scarcity of studies that comprehensively evaluate the effectiveness of DT plans and strategies. As presented in Table 12, the alignment between identified challenges and corresponding strategies is mostly poor. Pedagogical approaches, digital skills, technological infrastructure, and technical support emerge as primary where DT is applied in HE. Conversely, there is a significant lack of focus on challenges related to social and cultural aspects, academic quality, and strategic and administrative concerns.

While the HE sector is actively grappling with the challenges posed by DT, this study aligns with previous observations regarding the sectors' struggle to adapt swiftly to rapidly changing environments [41]. Through a systematic analysis, this review unveils a substantial emphasis of HEIs on the adoption of technology to tackle DT, rather than prioritizing the development of comprehensive organizational strategies [7]. Furthermore, it underscores that many DT initiatives within HE are isolated endeavors rather than integrated institutional policies and strategies.

In the case of the most extensively investigated strategies (pedagogical methodologies, integration of technological infrastructure, and enhancement of digital skills), few studies assessing the outcomes of these approaches can be found. It is worth mentioning that the studies incorporating empirical evidence reveal positive results for the strategies under scrutiny. However, in many cases, these assessments are conducted on a limited, non-institutional scale, typically involving small groups as part of experimental research. Furthermore, there is a noticeable absence of impact analyses for these initiatives. The findings of this research allowed for identifying a lack of studies on the institutional effectiveness of DT strategies in HE.

Valdés et al. [35], Marks et al. [43], Rodríguez-Abitia and ribiesca-Correa [53] and Shindina et al. [75] have presented their theoretical adaptation to measure the level of digital maturity in HE. Nevertheless, none of these have been applied to comprehensively assess how HEIs are tackling DT challenges, leaving room for future empirical research.

4.3. Connecting findings: A comprehensive approach for DT from HE

The study reveals that HEIs conceptualize DT through three primary approaches: a technology-based approach focusing on the integration of new technologies and development of digital competencies, the Education 4.0 approach which emphasizes innovative pedagogies in response to the Fourth Industrial Revolution, and the BMI approach, which offers a strategic and financial perspective to develop an innovation-centered culture. Despite these conceptualizations, many HEIs primarily adopt a technology-centered view, often as late adopters, to streamline their educational and administrative processes without a comprehensive DT strategy (**RQ1**).

HEIs face significant challenges in adapting to the rapidly changing landscape of DT, including the lack of strategic and administrative frameworks, insufficient emphasis on social and cultural contexts, and inadequate measures of academic quality. The study suggests that while there are efforts in areas such as pedagogical approaches and technological infrastructure, these are often isolated initiatives rather than integrated institutional policies (**RQ2**). The strategies implemented by HEIs generally do not align well with the challenges posed by DT, with a notable gap in addressing strategic, financial, and cultural dimensions comprehensively. This indicates a need for HEIs to develop

Table 12
Integrated analysis of DT challenges and strategies in HE

Categories	Areas of application	Correspondence challenges/strategies	Measures of strategies' effectiveness
Strategic-Administrative	Strategy and governance	Poor	Non-existent
	Business Model	Poor	Non-existent
	Operational processes	Poor	Non-existent
	Financial	Non-existent	Non-existent
Teaching-Learning	Pedagogical approaches	High	Acceptable
	Curriculum	Acceptable	Non-existent
	Academic quality	Non-existent	Non-existent
	Demands of the industry	Acceptable	Non-existent
Technical-Technological	Digital skills	High	Poor
	Technological infrastructure and digital resources	High	Poor
	Technical support	High	Non-existent
	Data Management	Acceptable	Poor
Social-Cultural	Organizational culture	Non-existent	Non-existent
	Health issues	Non-existent	Non-existent
	Changes in society	Non-existent	Non-existent
	Social and environmental contexts	Poor	Poor

holistic DT strategies that incorporate innovation culture and strategic alignment to effectively navigate the DT landscape and enhance overall performance (**RQ3**).

Reviewing the conceptualizations, challenges, and strategies of HEIs concerning DT provides insights into the necessity for a comprehensive DT strategy in this sector. Technology should not be the primary driver of an organization's DT [76]. A change in priorities is crucial. First understanding the current challenges and then building a holistic view that leverages technology to address them [72]. While technology is indeed a key component of educational strategy and policy [67], there needs to be a shift from viewing it solely as a resource to recognizing the broader social dynamics that support its use in HE [9].

The core of the DT should be an organizational culture led by innovation rather than technology alone. By incorporating digital innovation strategies, institutions can transform their organizational structures to promote a culture of innovation [70] ensuring that all aspects of the institution are aligned to fully leverage technological advancements. Smart education strategies further enhance the DT framework by emphasizing the creation of smart environments and the application of smart pedagogies. These strategies are aimed at developing smart learners equipped with the skills and knowledge necessary for lifelong learning [69].

In light of this, a linkage between DT strategies, smart education strategies, and digital innovation strategies is essential for HEIs to effectively navigate the challenges and opportunities presented by the modern educational landscape. Consequently, the HE approach to DT requires a re-evaluation. Initially, there is a need to establish a clear DT vision that addresses the challenges posed by the DT landscape. Subsequently, the focus should shift to developing a digital and innovative organizational culture. Finally, strategies and actions should be formulated based on the core organizational values and capabilities, strategically aligning with the evolving digital environment and a smart education perspective.

5. Conclusion

This study underscores that while technology adoption is a major focus, there is a lack of emphasis on developing a comprehensive and strategic DT vision (**RQ1**). In addition, it reveals that HEIs face significant challenges, including inadequate attention to strategic planning and decision-making processes in response to DT (**RQ2**), and identify a disconnect between the strategies implemented by HEIs and the challenges posed by DT, indicating a need for more aligned and integrated approaches (**RQ3**). Overall, this research emphasizes the necessity for HEIs to adopt a more strategic and integrated approach to DT, ensuring that technological advancements are supported by robust institutional strategies and policies.

The implications of this review extend to both academia and practitioners, offering valuable insights into the misalignment between technological adoption and DT strategy in the HE sector. This research also provides guidance to HE leaders in the formulation of their DT strategies, facilitating a more effective and holistic approach to navigating the challenges and opportunities posed by DT.

6. Limitations

The limitations of this study include its exclusive focus on papers published in English or Spanish after the COVID-19 pandemic, potential researcher bias, and the selection of databases and queries. To partially mitigate these limitations, the researchers employed the snowballing technique to identify relevant papers that may have been overlooked during the initial selection process. Additionally, feedback from peers and subject experts was solicited. Given its emphasis on HE, the findings of this study may not be equally relevant or applicable to other educational levels or sectors.

Despite the abundance of identified DT challenges within HE and various approaches for assessing digital maturity levels in existing literature, there remains a need for further exploration, particularly in integrating organizational culture as a measure of DT performance within HE. Additionally, comprehensive documentation of strategies implemented in this context is necessary, spanning four key categories: Strategic-Administrative, Teaching-Learning, Technical-Technological, and Social-Cultural.

Moreover, there is a scarcity of empirical evidence regarding the DT within HEIs. To address this gap, future research should explore several avenues: (i) Strategic processes in HE toward DT, aiming to establish a more comprehensive approach to strategic planning, examining how HEIs can better align their strategies with DT objectives; (ii) Empirical analyses of the digital maturity of HEIs, enabling a nuanced understanding of their readiness and capabilities in navigating DT; and (iii) Assessment of strategic responses of HE toward DT, shedding light on the effectiveness and outcomes of DT initiatives within the sector. These research directions will contribute to a more thorough understanding of how HEIs can effectively implement and benefit from DT, ultimately enhancing their adaptability and resilience in a rapidly changing educational landscape.

Ethical Statement

This study does not contain any studies with human or animal subjects performed by any of the authors.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

The data that support the findings of this study are openly available in SLR Data selection and extraction.xlsx.

Author Contribution Statement

María Luisa Nieto-Taborda: Conceptualization, Methodology, Validation, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Rocci Luppicini:** Conceptualization, Validation, Writing – review & editing, Supervision.

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