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Human resources management 4.0: Literature review and trends

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ABSTRACT

Digitalization across a range of industry and service sectors is transforming the workplace and human resources. The adoption of disruptive technologies associated with the Fourth Industrial Revolution, also known as Industry 4.0, is reshaping the way people work, learn, lead, manage, recruit, and interact with each other. The aim of this study is to contribute to the theoretical development of human resource management (HRM) in the context of Industry 4.0, promoting directions for the sector and HRM professionals, organizations, and the workforce that are required to face the challenges of Industry 4.0. To achieve this objective, this study performs a systematic literature review and content analysis of 93 papers from 75 journals. The main results of the research show that digital trends resulting from Industry 4.0 affect the field of HRM in 13 different themes, promoting trends and challenges for HRM, the workforce, and organizations. This paper seeks to promote insights for studies on the interference of digitalization in HR for the evolution of the digital age, as well as for companies that want to become more productive, human, and digital.

1. Introduction

The development of digitalization and robotics has led to the emergence of Industry 4.0 in the manufacturing environment (Matt et al., 2020; Sony & Naik, 2019). This phenomenon is known as the interconnection of physical and cybernetic environments through the use of digital technologies (Liu & Xu, 2017). The use of technologies such as artificial intelligence (AI), cyber-physical systems, big data, and the Cloud have caused disruptive changes for the workforce, and has been characterized as a socio-technical revolution (Fareri et al., 2020; Sony et al., 2020).

Despite the revolution caused by technologies in work processes, digital transformation requires intrinsic human skills to ensure usability and efficiency for the application of digital technologies (Cimini et al., 2020; Galati & Bigliardi, 2019; Pacaux-Lemoine et al., 2017; Pontes et al., 2021; Ramzi et al., 2019; Romero et al., 2020; Sakurada et al., 2020). In this sense, the labor market needs to adapt to the related demands (Liboni et al., 2019; Stachová et al., 2019) because the increase in intelligence in the technological system and generation of complex data requires more qualified workers to make decisions in very different areas of work (Cagliano et al., 2019; Jerman, Pejić Bach, et al., 2020).

Considering the importance of the workforce in the success of digital transformation, it is necessary to understand the vision of digital technology with respect to achieving changes to aspects of human resource management (HRM). Traditional HRM is the process of managing people in organizations, and includes all of the techniques employed to manage people and keep them up to date, qualified, and aligned according to the expectations of stakeholders; there is also focus on activities related to the professional qualification, learning, and training of individuals (Gooderham et al., 2019; Hecklau et al., 2016; Liboni et al., 2019). It also includes outlining the organizational structure, improving communication, and developing ethical and social principles.

From the transformations caused by Industry 4.0, it is necessary to understand how its changes affect HRM, including the application of

Abbreviations: HRM, human resource management; AI, artificial intelligence; KPIs, key performance indicators; RQs, research questions; SLR, systematic literature review; QDAS, qualitative data analysis software; IoT, Internet of Things; VR, virtual reality; AR, augmented reality.

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digital technologies to their tasks, introducing the concept of Human Resources Management 4.0 (HRM 4.0 - Smart HR 4.0). A new concept was developed through the application of technologies arising from Industry 4.0 (Sivathanu & Pillai, 2018) in the HR sector, making it more agile, ensuring the welfare of workers (Mazurchenko & Maršíková, 2019) before the labor market, and extracting the human potential for new tasks. Therefore, HRM 4.0 currently needs to create a digital culture of digital people trained with digital tools, that is, with the right skills to increase productivity (Kumar, 2018).

The World Economic Forum (2020) reported that 84% of respondents will accelerate the digitalization of work (e.g., remote working and video conferencing) and 50% will accelerate the automation of jobs, thus increasing the use of digital technologies. This outlook is expected to bring challenges for the workforce as the Deloitte (Deloitte Company, 2021) survey states that less than 33% of workers are prepared for technological changes, especially remote work, which is a major challenge for HRM.

It is important to note that some actors are essential in the digital transformation process to understand the link between people and digital technologies. This allows us to understand how changes occur in HRM 4.0 and the need for human capital to meet current and future market demands (Liszka et al., 2019), consolidated by the use of key performance indicators (KPIs) for decision-making. In this configuration, engineers represent a category of professionals with a high degree of importance in technological advancement (Lantada, 2020).

In this digital transformation process, these professionals need to be qualified to work collaboratively between people and machines, in the digitalization process, and in technological and HRM (Jerman et al., 2018), and are known as multidisciplinary professionals with the greatest impact on digital transformation. In this sense, an engineering and technology perspective in the face of digital transformation can assist in the process of transforming the labor market and people. Among such collaborations between people and technology, industrial engineers can assist in the integration of people, materials, and information within the industrial environment (Sackey & Bester, 2016), thus possessing the ability to manage employees in the digital transformation process.

The new paradigms regarding HRM 4.0 will have important consequences for training in competencies required for Workforce 4.0 and new job profiles (Ana et al., 2019). The new talents of the future will require the development of more strategic, coordinated, and creative activities, and fewer repetitive and easy activities, enabling people to demonstrate their skills in activities that add more value (Becker & Stern, 2016; Fareri et al., 2020; Flores et al., 2020). Therefore, tasks that would traditionally be done manually and with individual analysis can become automated, and a large volume of data can be analyzed quickly, intelligently, and precisely.

Digital technologies coming from Industry 4.0 are used by industries that operate in the Digital Age. In this context, such technologies are used in HRM tasks to improve the management process. Big data and AI assist in resume selection, as well as the selection of profiles with a high probability of fulfilling job requirements, which were previously

Table 1
Research steps.

Steps	Activities	Results
Step 1: Problem Definition	(i) gap identification.(ii) Formulation of the research question.	(i) need to understand how digital trends of Industry 4.0 affect workforce and HRM;(ii) Research Question definition: What are the main trends brought by Industry 4.0 to Human Resource Management area?
Step 2: Systematic Literature Review	PRISMA Methodology (Fig. 1), according to the 3 main stages:(i) Identification: (a) Structuring the keyword tree from the thematic axes "Human Resource Management" and "Industry 4.0″; (b) Definition of the research protocol (search strategy, Boolean research logic, definition of databases, publication type and language); (c) Use of Mendeley software to catalog papers; (d) Deletion of duplicate papers; (e) Inclusion of papers by the snowball method;(ii) Screening: (a) Reading the title and abstract of papers to identify those that are not aligned with the objective of the papers and should be excluded from the portfolio; (b) Reading the full article to exclude papers that did not discuss HR in the context of Industry 4.0;(iii) Included: Description of the final portfolio of articles along with the papers included by snowball	Final portfolio com 93 papers that explicit discuss for portfolio about transformations, challenges and trends of themes related to Human Research Management in the context of Industry 4.0.
Step 3: Bibliometric Analysis	(i) Exporting the database to Excel and VOS viewer;(ii) Compiling information from papers and cleaning/refinement of the database;(iii) Development of table and graphs for descriptive analysis/characterization of the portfolio;(iv) Network generation in Vosviewer.	Characterization of the paper portfolio (evolution of publications over time, main authors, and main journals) and network analysis (citation of papers in the portfolio, authors' countries of affiliation and keywords).
Step 4: Content Analysis	(i) Importation of the portfolio articles into the Nvivo software;(ii) Preliminary analysis of the main themes addressed in the portfolio from the generation of the list of most frequent words, word-tree representation of the main concepts and the automatic coding performed by the NVivo software;(iii) Preliminary mapping of the thematic axes;(iv) Reading and interpreting the documents for coding according to the structure of nodes created in the software;(v) Analysis of the possibility of grouping the nodes that did not have many codifications and/or dividing those that had many codifications, to organize the content in the best ways;(vi) Discussion among the researchers regarding the final nomenclatures to be used.	Thematic analysis of the portfolio 93 papers and creation of 04 macro groups and their respective subgroups, being:(i) HR-Digitalization: Future Trends in HRM and Workforce, HRM and Technology, Human-Robot Collaborative and New Ways of Working;(ii) HR-Management: Learning and Training, Recruitment and Selection, Rewards and Performance Management and Talent Management;(iii) HR-Strategy: Diversity and Inclusion, Leadership, Organizational Change and Organizational Culture(iv) HR-Competence: Competence for Industry 4.0.
Step 5: Construction of the Framework	(i) Compilation of the results of previous steps, allowing the generation of insights by the research team from the mapped knowledge;(ii) Diagramming of the relationships between the macro-groups and groups created.	Consolidation of the results in a theoretical framework to identify the main trends related to Human Resources in the context of Industry 4.0

performed manually. KPIs can be aided by AI to evaluate workers and indicate promotions, which were previously determined based on the duration of a worker's tenure in a role and training needs (Abdeldayem & Aldulaimi, 2020). Functions such as career plan development, which aims to identify the right skills and ways of keeping the workforce developed, qualified, and motivated, are some of the benefits of the use of AI as a management and learning system (Abdeldayem & Aldulaimi, 2020; Nair, 2019). However, despite this shift towards the application of digital technologies in HRM, it is important to understand the trends resulting from Industry 4.0 in the HRM area, which can impact the workforce and other important actors within the labor market, such as universities, recruitment and selection companies, or even in-company training.

Considering the study on HRM in the context of Industry 4.0, there are still gaps in the literature on how the evolution of HRM is affected by Industry 4.0, as well as the changes in people management in the face of the challenges imposed by the implementation of smart technologies. Thus, studies are needed to verify HRM trends by considering the application of digital technologies in the industrial environment. The objective of this paper is to explore the following research questions (RQs): What are the main trends brought by Industry 4.0 to the field of HRM?

In doing so, we aim to contribute to the theoretical development of HRM in the context of Industry 4.0, promoting directions for the sector and HRM professionals, organizations, and the workforce that are needed to face the challenges of Industry 4.0. To this end, a theoretical framework is presented to identify the main trends related to HRM and their relationships. As a result, this study intends to show trends in management, competencies, strategies, and aspects related to digitalization in HRM.

The rest of the paper is organized as follows: Section 2 presents the methodology used, the systematic literature review (SLR), bibliometric analysis, content analysis, and the development of the framework process. Section 3 presents the results of the bibliometric analysis of the paper's portfolio, characterizing the state-of-the-art literature. In this section, we present an analysis of the themes raised by means of content analysis and a discussion pertinent to the identified themes. These two analyses allowed the construction of the framework, as discussed in Section 4. Section 5 presents the implications of this study. Finally, Section 6 presents the conclusions and limitations of the study.

2. Research method

To map the contributions and determine trends and challenges in the field of HRM in the context of Industry 4.0, Table 1 presents the research structure.

The problem definition (step 1) allowed us to clarify the research question: "What are the main trends brought by Industry 4.0 to the field of HRM?".

An SLR was carried out using the PRISMA methodology (Page et al., 2021) in order to identify relevant literature and address the issues raised. The analysis of the results was based on two methods: bibliometric analysis and content analysis. The former enables the mapping of the state-of-the-art on the subject, allowing sprite trends of Industry 4.0, which are related to HRM. Content analysis allows the identification of important topics on the subject, and checks what has already been discussed as well as the challenges that need to be addressed in a theoretical framework about digital trends of Industry 4.0, which affect HRM.

2.1. Systematic literature review

An SLR (Step 2) was conducted on HRM in the context of Industry 4.0. This method aims to analyze relevant evidence and perform a systematic process to find literature relevant to the topic of interest (Kitchenham, 2004). The mapping of academic contributions is essential to identify research gaps (de Campos et al., 2018) and transform knowledge, especially in emerging topics such as HRM in the context of Industry 4.0. The main feature of the systematic literature is that it is replicable and transparent, and all of its stages must be documented.

Table 2
Research protocol.

Search Term (Title, Abstract or Keywords)	**Group 1 (Industry 4.0)** ("Industry 4.0″ OR "Industrie 4.0″ OR "Fourth Industrial Revolution" OR "4th Industrial Revolution" OR "Smart Industry" OR "Smart Manufacturing" OR "Smart Factory" OR "Digital Transformation") **Group 2 (Human Resource Management)** ("Human Resource Management" OR "HRM" OR "Smart Human Resource" OR "SHR 4.0″)
Search Strategy	AND among groups
Database	Scopus (314 documents), Science Direct (3 Documents), Web of Science (27 documents) and other sources (2 documents)
Publication Type	Research Paper and Review Paper (Considering classification of the database)
Language	English
Search Period	Not Specific

The PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyzes) (Page et al., 2021), which aims to help authors to improve the construction of systematic literature reviews, was adopted. This method addresses questions that have not yet been answered by individual studies, identifying research issues and evaluating theories (Page et al., 2021). Furthermore, it is a method that has been adapted from studies on databases, such as Scopus and Web of Science. This methodology is illustrated using a three-phase flow diagram, namely identification, screening, and inclusion. These steps are necessary to bring the final portfolio of the paper closer to the defined objectives and are widely used across different research fields to guide the development of systematic reviews.

The first stage includes identifying the literature by searching the selected databases. For this work, Web of Science, Science Direct, and Scopus were selected owing to their relevance in publications related to the topic of Industry 4.0 (Bueno et al., 2020; de Paula Ferreira et al., 2020).

The survey started by combining the search terms that represent the two axes of the research "Industry 4.0″ and "Human Resource". Owing to the variety of terms that can translate the search axes, the Boolean index "AND" was used to connect the search axes and "OR" for returns of synonyms or alternative terms in the same search axis. As reported by (Aliyu 2017), the use of Boolean indices increases the probability of searching for relevant documents.

The initial data entry was represented by a search in the databases, according to the filters used, and based on other sources (paper references). The survey was conducted in July 2020, and did not have a specific time duration. Table 2 presents the search protocol used, search terms, search strategy, database, publication type, language, and search period.

To complete the identification stage (344 papers), the papers were combined using Mendeley® software, allowing for the removal of duplicates (22 papers). In addition, papers were identified using the snowball technique to determine additional relevant references (two papers), and included articles that were not returned in the database searches. The snowball technique allows the development of systematic review studies using references from analyzed papers (Wohlin, 2014).

The screening stage was included to select the papers by reading the title and abstract and by verifying the adherence of the paper to the aim of the study. In this phase, we verified whether the terms Industry 4.0 and Human Resources were mentioned, in addition to their synonyms, reducing the portfolio to 120 papers. Papers that were selected were those that discussed only Industry 4.0, with mention of HRM being very vague, in addition to papers that discussed only human resources, but which did not consider the context of Industry 4.0, and a total of 91

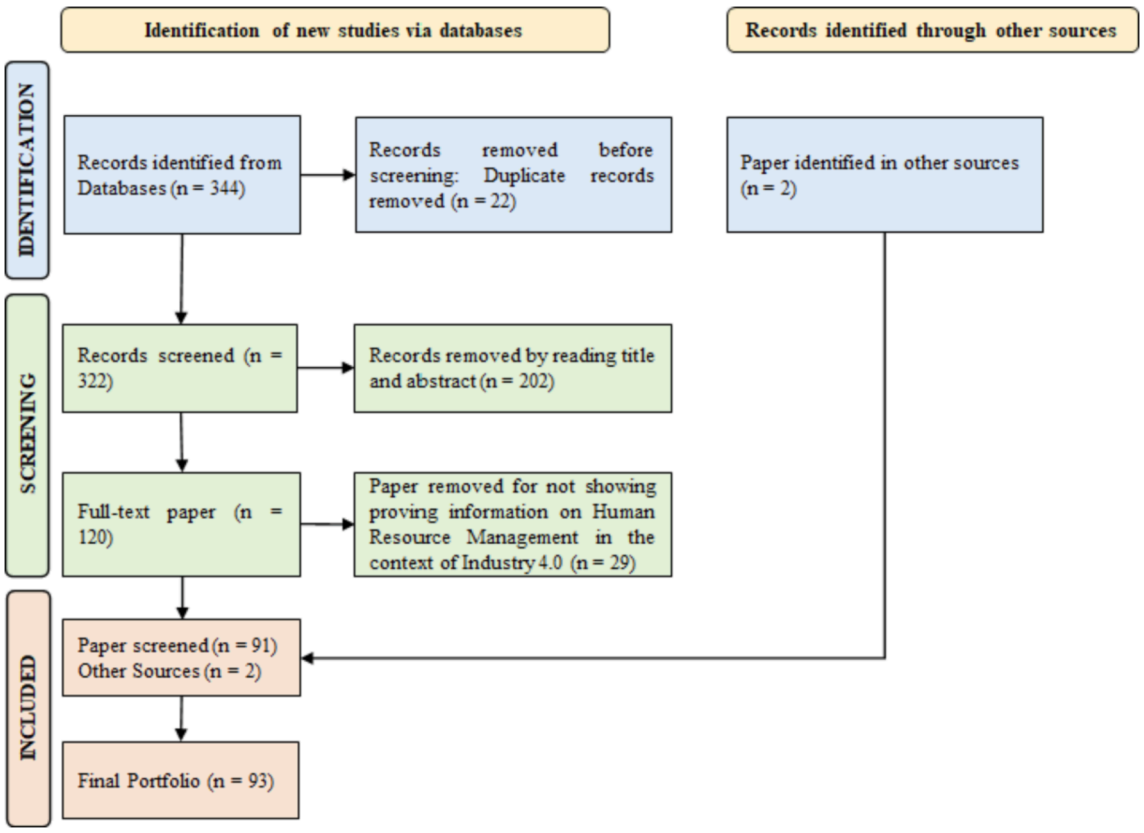

Fig. 1. Results of applying PRISMA to the Systematic Literature Review.

papers were selected.

Note that this is in addition to the papers found using the snowball method. Therefore, papers that explicitly discuss the theoretical development of HRM in the context of Industry 4.0 were included in the final portfolio. Fig. 1 illustrates the flow of information files, showing the quantitative data from the insertion and exclusion files according to the steps of the PRISMA methodology.

Therefore, after applying the PRISMA methodology, the final portfolio was based on 93 papers. The cataloged papers presented discussions on aspects related to HRM and Industry 4.0, enabling the analysis of contributions and identifying themes and trends on the analyzed subject. These papers were eligible for bibliometric analysis, content analysis, and framework construction.

2.2. Bibliometric analysis

Regarding the generation of results to be analyzed, one of the analyses performed is bibliometric analysis, which involves the quantitative analyses of publications (Ellegaard & Wallin, 2015), enabling us to determine the state of the art on the subject. Bibliometric analysis is defined as the identification of what has been produced by the scientific community, thus evaluating the main trends in the subject area (Treinta et al., 2014).

The analyses were performed based on the 93 papers collected through a systematic literature review. These references were compiled in electronic spreadsheets and VOSviewer software (Van Eck & Waltman, 2010) using data extracted from the Scopus database. Scopus was chosen because more than 95% of the papers' portfolios are indexed in it, and publications not indexed on that basis were extracted from the information and manually incorporated.

The analyses that were performed considered the distribution of papers over the years, main authors with published works, and main journals that have published on the subject. The citation analysis of the papers, country analysis, and keyword analysis were performed using VOSviewer software.

2.3. Content analysis

One approach to building knowledge, generating theories, and developing models based on the organization of qualitative data is to perform content analyses. The objective of this type of analysis is to conduct a systematic data study to integrate, interpret, conceptualize, establish relationships, and synthesize research findings (Bringer et al., 2004). However, one of the gaps found in qualitative analyses is the clear description of the procedures followed or the transparent conduction of steps, causing doubts about the legitimacy of the results (Chandra & Shang, 2017).

Thus, the portfolio of papers reported through the application of the PRISMA methodology was submitted for content analysis, and was carried out using Nvivo® software. There is an increasing number of studies that use qualitative data analysis software (QDAS) as a support tool for qualitative research because this kind of software functions as a facilitator for research, thus ensuring greater transparency, rigor, and traceability for the studies conducted. The NVivo® software (Woods et al., 2016) is among the most widely used software in publications with qualitative analysis.

Initially, the 93 papers in the portfolio were imported into the NVivo software tool and organized in a standardized manner to ensure quick and effective access to the information in the following steps. Subsequently, three main functionalities of the software were used (word-tree representation of the main concepts, listing of the most frequent words, and automatic coding) to enable a preliminary analysis by the researchers of the main themes addressed in the article portfolio.

The next step is related to reading the sources of information, which in this case involves reading papers for greater affinity with the subject, so that researchers have broad knowledge of the content of the papers.

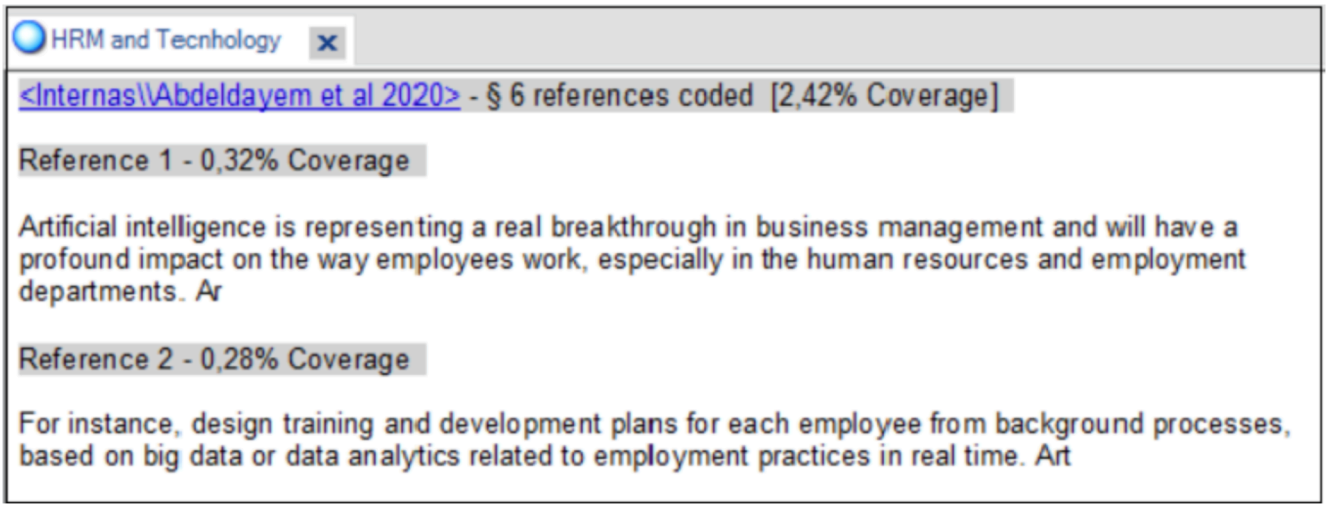

Fig. 2. HRM and Technology node example.

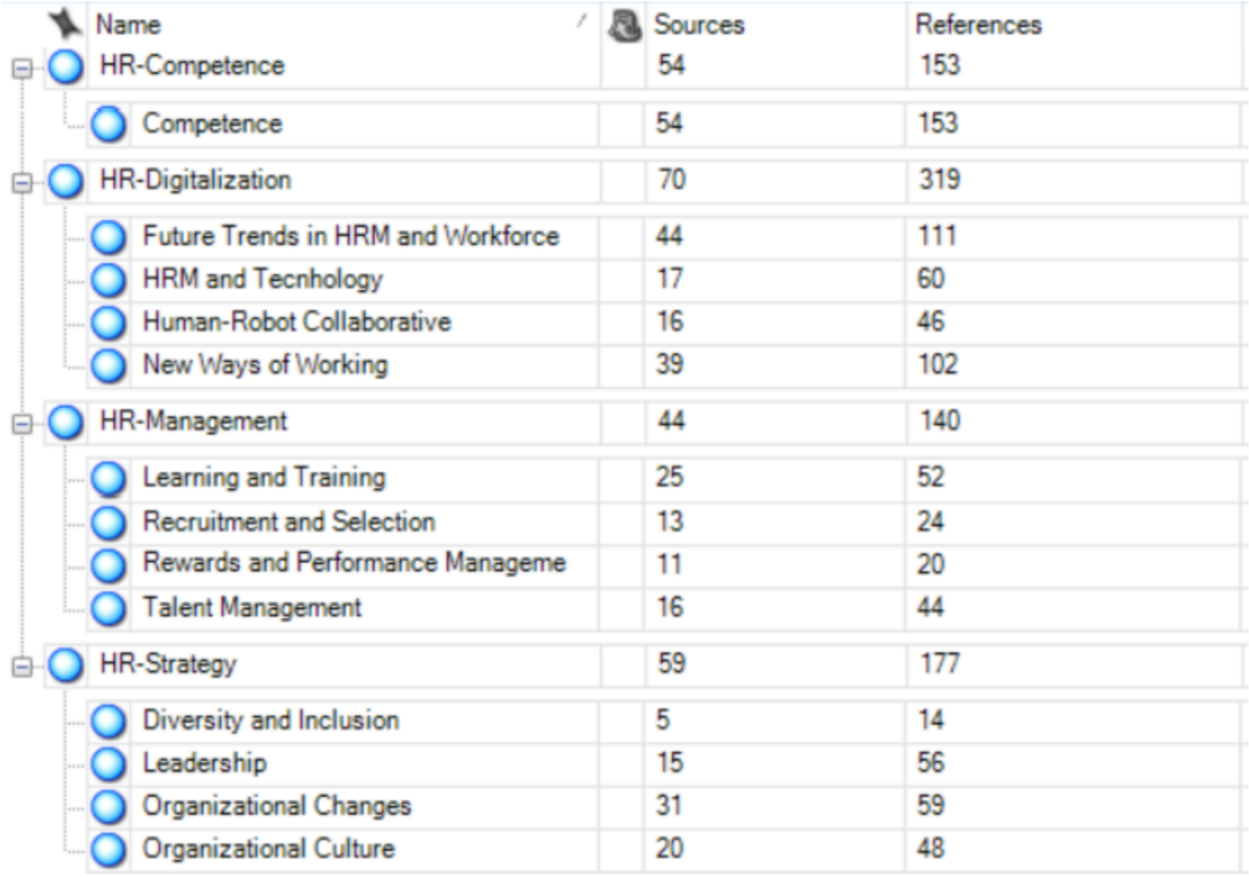

Fig. 3. Screen NVIVO Software.

With this, it was possible to perform a preliminary mapping of the thematic axes of the research because the knowledge acquired enables the identification of the initial themes focused on HRM in the context of Industry 4.0, and identifies research areas of interest, such as learning and training, organizational culture, and HRM and technology.

Then, the portfolio documents were read and interpreted, and text excerpts were encoded according to the themes found. Encoding can be used to reduce the amount of data and gather information related to the same research area. In this case, text excerpts were organized into themes according to their reading coherence (Savage, 2000). As an example of how coding was performed, Fig. 2 presents an example of the HRM and technology node. By reading the paper, it is possible to verify text excerpts that present a discussion of the topic analyzed. This snippet was coded in the existing node, as shown in Fig. 2.

It should be noted that as the coding is completed, the researchers consolidate and group themes into content boxes called nodes. This is a dynamic and interactive process, and at every moment, the possibility of grouping the nodes that did not have many encodings and/or splitting those that had many encodings was analyzed in order to organize the content in the best way.

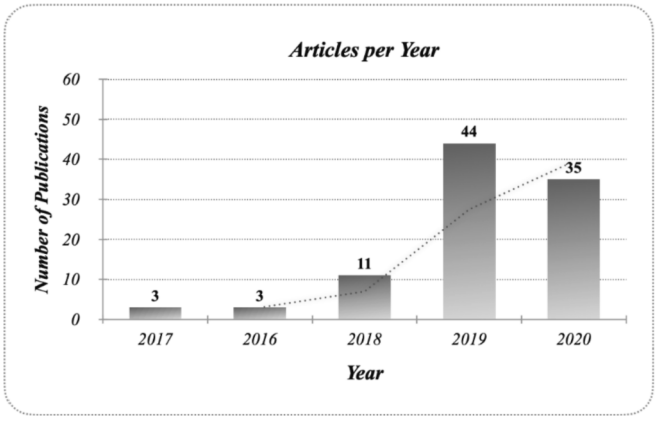

Fig. 4. Evolution of Publications about HRM and Industry 4.0.

Finally, after all the regroupings were performed and the nodes were structured, a discussion was held among the researchers regarding the final nomenclatures to be used, giving rise to the macro groups and groups presented in this research. The final organization of themes is shown in Fig. 3.

Fig. 3 presents information about the number of sources (paper portfolios) and references (text snippets). As an example, a group related to talent management was identified in 16 papers with 44 coded text excerpts. Therefore, from this structure, themes were analyzed to transform the coded data into information. This step was important to analyze what was built of knowledge and to observe trends on the theme of HRM in the context of Industry 4.0.

2.4. Construction of the framework

A theoretical framework synthesizes related concepts and empirical research to provide a basis for further theoretical development (Rocco & Plakhotnik, 2009).

Thus, from the compilation of the results of the previous steps, it was possible for the research team to generate insights from the body of knowledge that was mapped. These results were initially diagrammed according to the relationships between the macro groups and groups created, and subsequently gave rise to the theoretical framework that identifies the main trends related to HR in the context of Industry 4.0, as presented in the Results section.

3. Results

3.1. Bibliometric analysis

The first publications related to Industry 4.0 were released in 2013 (Muhuri et al., 2019). Subsequently, they discussed technological applications and changes in the industrial environment. Regarding the HR theme in the context of Industry 4.0, as shown in Fig. 4, the first publications appeared in 2016, with three papers, and the number of publications peaked in 2019 with 40 papers. In 2020, 35 papers were published up to July 2020, and the search was carried out using the databases of this study.

The first publications presented initial discussions on the impact of people on intelligent production systems. Becker and Stern (2016) discuss how people influence the project for the implementation of cyber-physical systems, and they should be inserted since its conception. The work of Hecklau et al. (2016) presented discussions related to the competencies and skills that are important in the context of Industry 4.0, demonstrating the role of HRM in preparing people to face challenges. Do et al. (2016) discussed the culture of the flexibility of HR. A flexible culture helps people to adapt more easily to the challenges that are imposed on them.

Regarding productivity, the 93 publications analyzed were prepared by 173 authors and co-authors, 18 of which had authors who had published at least two papers. Therefore, almost 89.6% (155 authors) have only one article in the bibliographic portfolio, indicating that studies on HR in the context of Industry 4.0 are not representative of most authors.

Table 3 presents the authors of three or more published papers, with only one author publishing four papers. The table contains information regarding the country, affiliation, H-index, and keywords for the publications used. The data were searched based on the Scopus classification. The H-index is available for each author based on the number of articles and quotes received by the author.

Among the cited authors, it should be noted that they do not have a link related to country and affiliation. Sony, M. and Naik, S. are authors of the same publications, with Sony, M. having one more, and Jerman, A. and Pejich Bach, M. are authors of two papers in common, and each of them co-authored a separate paper with different authors.

Table 4 presents the main journals with three or more papers. The 93 papers were published in 75 journals or proceedings. The table presents information regarding the number of papers, main keywords of papers, subject area and category, aim and scope, and Journal Citation Reports 2019 (JCR).

The journal with the most published papers is Computer and Industrial Engineering, with five publications in the portfolio of analyzed papers. In addition, the table shows the frequency of keywords related to Industry 4.0 and HRM, and the Computer Science field is common to the

Table 3
Main authors.

Author	Quantity	Country	Affiliation	H-index	Keywords
Sony, M.	4	Namibia	Namibia University of Science and Technology	9	Critical Success Factors; Cyber-physical System; Industry 4.0; Internet of Things; Automation; Behavioral Operations Management; Socio-Technical Systems Theory; IoT; Quality 4.0; Quality Management; Organizations Readiness; Literature Review.
Jerman, A.	3	Slovenia	University of Primorska Koper	4	Competencies; Industry 4.0; Job Profile; Slovenia; Smart Factory; Future Competences; Human Resource; Automotive Industry; Conceptual Key; Competency Model.
Naik, S.	3	India	Sanjay Gandhi Postgraduate Institute of Medical Sciences Lucknow	23	Critical Success Factors; Cyber-physical System; Industry 4.0; Internet of Things; Automation; Behavioral Operations Management; Socio-Technical Systems Theory; Organizations Readiness; Literature Review.
Pejić Bach, M.	3	Croatia	University of Zagreb	12	Competencies; Industry 4.0; Job Profile; Slovenia; Smart Factory; Future Competences; Human Resource; Automotive Industry; Conceptual Key Competency Model.

Table 4
Main journals.

Journal	Number of Papers	Main Keywords of Papers	Subject Area and Category	Aim and Scope	JCR
Computer and Industrial Engineering	5	Industry 4.0; Cyber-physical System; Human Resource Management; Personnel Training; Production System; Smart Factory; Human-centric Manufacturing; Smart Operators.	Engineering; and Computer Science	Publications related to Computerized Methodologies for solving problems in the field of Industrial Engineering	4.13
Computers in Industry	3	Human Resource Management; Industry 4.0; Job Description; Job Profile; Skills; Technology 4.0; Work and Skills; Industry 4.0 barriers.	Engineering; and Computer Science	Publish original works that point out new trends in Information and Communication Technology in the Industry	3.95
International Journal of Supply Chain Management	3	Strategic Human Resource Management; HR Practice; Human Factor; Industry 4.0; Smart Manufacturing; Cyber-physical System; Challenges in Implementation of Industry 4.0.	Decision Science; Business, Management and Accounting; and Computer Science.	Publications related to Supply Chain Management with high impact on theory and practice.	N/T
Sustainability Switzerland	3	Industry 4.0; Sustainability; Sustainable Business Model; Organization; Enterprise 4.0; Sustainable Human Resources; innovation; Employee Education.	Social Science; Environmental Science; and Energy.	Research related to sustainability in all spheres and sustainable development	3.2

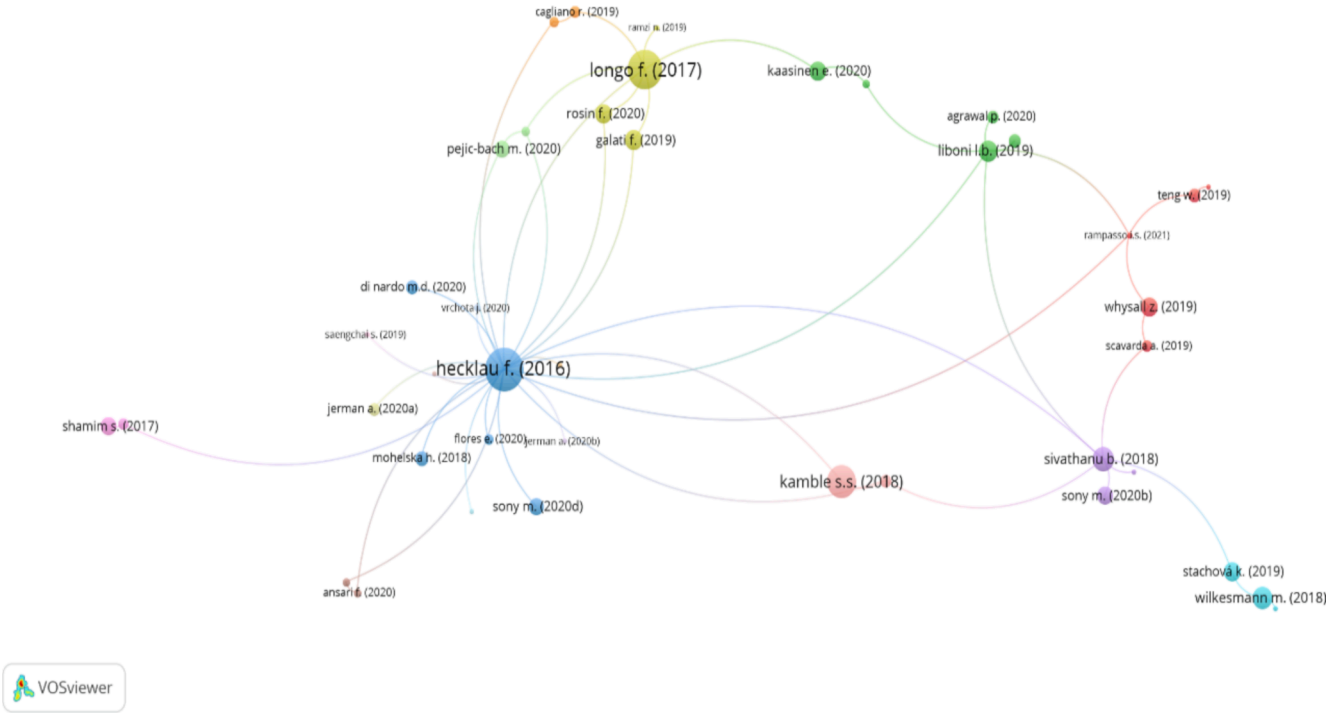

Fig. 5. Evolution of Publications about HRM and Industry 4.0.

three journals that were analyzed. This refers to the current theme related to Industry 4.0, which is the focus of most publications.

A relevant discussion relates to the number of citations received by the papers in the final portfolio. A total of 947 studies were cited based on the Scopus database. Among these, 18 papers (19.35%) were not cited in any study and 13 papers (13.97%) were cited once. In another analysis, 67.75% of papers (63 studies) received 10 or fewer citations, and there was a higher concentration in the remaining 32.25% (30 papers). The analysis of the most cited papers was performed using VOSviewer software, and the citation network of the papers is presented in Fig. 5.

The most frequently cited paper, which accounts for 17.31% of the citations, is the study by Hecklau et al. (2016), identified by the blue cluster, and is a seminal paper that discusses the competencies required for Industry 4.0. The publication of Longo et al. (2017) presents an approach reported that intelligent operators and humans are at the center of smart factories; it also discussed future competencies, and is a relevant publication presented by the yellow cluster. (Kamble et al., 2018) presented an analysis of the barriers to the adoption of Industry 4.0, and the human factor is discussed and identified by the pink cluster. Although the portfolio of studies is recent, some publications have already been used as precursors to discussions on HR in the digital age.

Pertaining to the countries' citation networks, an analysis was performed using VOSviewer software, and presented the countries with the highest number of citations. The network is presented in Fig. 6, with a minimum indication of one citation.

From the formed network, it can be observed that two large clusters were formed in the citation network in relation to the countries. The cluster in red highlights Italy, with citations in France, Canada, and South Africa. Germany presented a network of citations with the United States, Italy, and India. Small clusters, such as those represented by yellow, are still formed, with an emphasis on India, whereas green represents Malaysia, and violet represents Croatia.

Finally, an analysis of the co-occurrence of keywords was performed using VOSviewer software to understand the use of keywords by the papers in the analyzed portfolio. The main words are represented by the

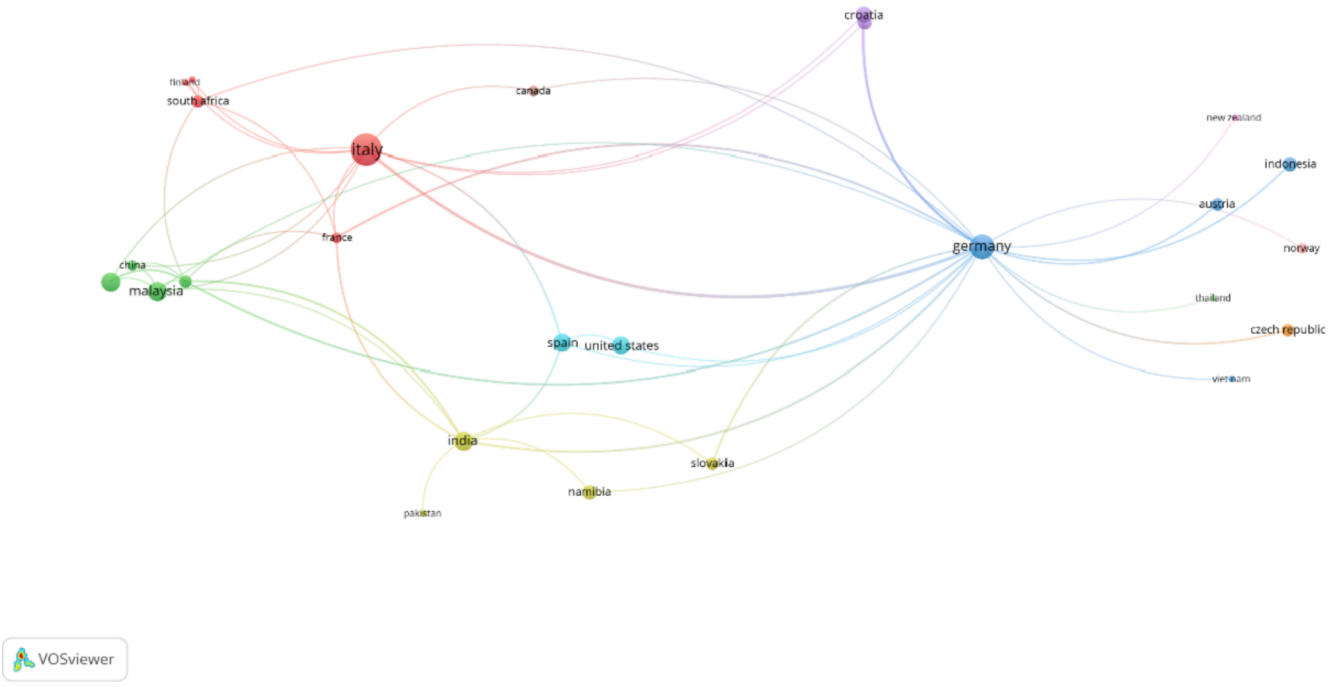

Fig. 6. Affiliation Countries.

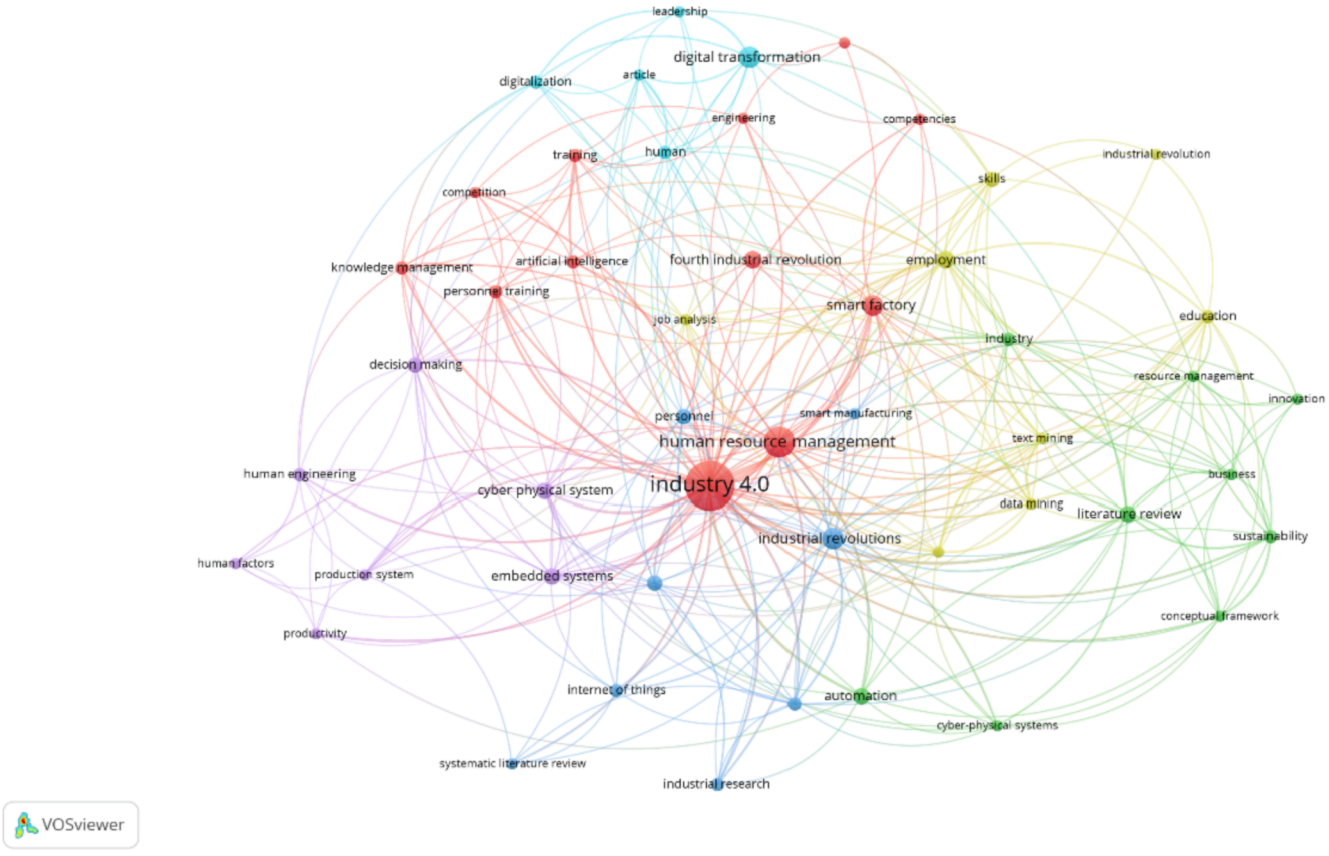

Fig. 7. Co-occurrence of keywords.

terms Industry 4.0 and HRM. Fig. 7 shows the constructed network, where the minimum number is defined as three occurrences of the word.

The formation of a maximum Industry 4.0 red cluster can be seen, with 73 links, which is related to the other themes, being identified. In addition, Fig. 7 also presents the importance of the cluster related to HRM, with 34 links. This demonstrates the affinity of the paper portfolio to the research topic.

Furthermore, it is possible to verify the formation of the violet cluster with technologies from Industry 4.0, such as the cyber-physical system, with a blue cluster representing the industrial revolution, and light blue representing digital transformation. The cluster highlighted in yellow indicates employment. The formation of these clusters and the keywords that represent them will direct future research in this area.

3.2. Main themes found

Content analysis was based on the identification of themes that are pertinent to the field of HR and the identification of information capable of analyzing what was built as knowledge. Owing to the large number of groups identified, the information was divided into nodes and sub-nodes or macro groups and groups of specific themes.

These groups were subdivided into macro groups based on their contributions. The macro group of **HR-Digitalization** addresses issues related to future trends in HRM and the workforce, HRM and technology, human-robot collaboration, and new ways of working. This group presents discussions pertinent to the applications of digital technologies, which are the basis for the transformation of organizations in the digital age.

Macro group **HR-Management** represents the main HRM areas, namely learning and training, recruitment and selection, rewards and performance management, and talent management. This group presented pertinent discussions on the main HRM areas.

The HR-Strategy is the macro group that represents diversity and inclusion, leadership, organizational changes, and organizational culture groups. This group discusses the formulation of HR-related strategies and how people have adapted to this new era.

Finally, **HR-Competence** is a macro group that presents discussions related to competence for Industry 4.0. Owing to the notoriety of the discussed theme, this group was created because it was perceived to be influenced by the other macro-groups that were formed. It discusses each macro group and its specific groups.

3.2.1. HR-Digitalization

Trends in HRM and discussions concerning the world of work are discussed in the group **Future Trends in HRM and Workforce.** It is important to understand that machines and people are complementary (Ansari, 2019), and that robotics, widespread automation, and computerization have serious effects on the labor market (Ana et al., 2019). Despite the technological applications, people are an important factor in realizing the transformation (Agrawal et al., 2020; Ansari et al., 2020), as machines need to respond to the needs of the people, and not the opposite (Erro-Garcés, 2019).

Therefore, it is necessary to have an HR department that deals especially with issues related to digitalization (Butschan et al., 2019). The HRM professionals need to have knowledge of the terminologies and applications of technology related to Industry 4.0 (Kohnová & Salajová, 2019; Mazurchenko & Maršíková, 2019), such as the Internet of Things (IoT), AI, cloud computing, big data and virtual reality (VR). This knowledge needs to be applied in the recruitment of candidates (Jerman, Pejić Bach, et al., 2020) who meet the need for skills related to digital technologies. Therefore, it is necessary for human capital monitoring strategies to assess the existing status and assess their needs (Matt et al., 2020; Ziebell et al., 2019).

Thus, HRM has strategic value within organizations to understand the challenges in relation to Industry 4.0 (Llinas & Abad, 2019), one of which is related to the imminent shortage of skilled workers, consequently extending the working life of older workers and taking advantage of their experience acquired over time (Caruso, 2018). Thus, organizations need to think about how to meet their demands, enabling a better work-life balance (Kaczmarek, 2019) and creating a more flexible culture (Mazurchenko & Maršíková, 2019; Sony & Naik, 2020).

Therefore, according to the discussions presented by this group, workforce trends need to be deepened, and should focus on themes such as Learning and Training, HRM and Technology, Human-Robot Collaborative, Diversity and Inclusion and Organizational Culture.

The application of digital technologies in HRM itself is discussed in the group **HRM and Technology**. Digital Technologies have the potential to transform HRM functions, creating new tasks and roles, driving transformation into HRM 4.0 or Smart HR 4.0 (Mazurchenko & Maršíková, 2019; Verma et al., 2020; Ziebell et al., 2019) with a range of skills to analyze real-time data, make decisions and use interactive platforms (Fareri et al., 2020; Kohnová & Salajová, 2019), implementing innovative solutions for productivity improvement.

AI, robotics, and machine learning can detect patterns in HRM functions, such as the need for more assertive recruiting and selection, retaining talent, and providing real-time guidance to professionals (Nankervis et al., 2019; Sivathanu & Pillai, 2018). Other functions such as performance evaluation and measurement, resource planning, training needs, job evaluation, and even predicting the need for competencies (Abdeldayem & Aldulaimi, 2020; Bogoviz, 2020; Geetha & Bhanu Sree Reddy, 2020) can be improved by using these digital technologies.

Virtual and augmented reality (AR) will facilitate remote team interactions (Sivathanu & Pillai, 2018) and training (Brocal et al., 2019) because of their ability to overlap the virtual and physical worlds, creating interactive (Bongomin et al., 2020) environments. Big data can assist in training plans for each worker based on data related to developed practices (Abdeldayem & Aldulaimi, 2020), enabling the development of human resources according to tasks performed at work.

Therefore, for investment in digital technologies to be leveraged by HRM, HRM workers must be able to exploit the benefits of these technologies (Caputo et al., 2019). As the workforce becomes dependent on technology, the role of HRM will also change (Ra et al., 2019). This will require organizational structure, culture, and leadership focused on innovation and learning, and training related to the skills needed to use digital technologies.

The group **Human-Robot Collaborative** explores the interaction between people and machines. The Human-Robot Collaborative group refers to collaborative assembly cells that are a hybrid of manual and fully automated cells that perform the execution of work tasks (Bruno & Antonelli, 2018). This interaction has advanced owing to some of the pillars of Industry 4.0, such as big data, AR, autonomous vehicles, additive manufacturing, and cyber-physical systems (Cagliano et al., 2019; Di Nardo et al., 2020; Flores et al., 2020; Kamble et al., 2018).

For a work cell to be collaborative, in addition to collaborative robot and safety measures, it is necessary to redesign the work cell and work organization methods, especially with respect to task assignment (Bruno & Antonelli, 2018; Ramingwong et al., 2019). To increase productivity, collaboration between robots and humans is inevitable (Maisiri et al., 2019; Rosin et al., 2020), and it is necessary to allay the fears associated with the substitution of people by machines. These systems need to be designed as a support for human work and not as rivals (Rauch et al., 2020; Wilkesmann et al., 2018). Therefore, during the implementation phase, people must be familiarized with the robot functions, and should have the freedom to apply their knowledge to the application of collaborative robots.

Thus, people who work in collaborative environments with robots will work as an intersection between the organization and machines, and should have very high technical skills that are related to computational tools, as well as soft skills, such as communication and relationships (Tirabeni et al., 2019). Therefore, topics such as learning and training are crucial for a system to work and adapt to changes. In

Table 5
Topics discussed HR-digitalization.

Groups	Keywords	Topics discussed	Main Authors
Future Trends in HRM and Workforce	People Analytics; Smart HR 4.0; Digital Work; Digital Innovation; Human; Workforce; Automation; Employment; Human Capital.	Importance of people for digital transformation; HRM professionals with knowledge about digital technologies; and HRM with strategic value.	(Agrawal et al., 2020; Ansari, 2019; Ansari et al., 2020; Butschan et al., 2019; Erro-Garcés, 2019; Fareri et al., 2020; Jerman, Pejić Bach, et al., 2020; Matt et al., 2020; Mazurchenko & Maršíková, 2019; Nair, 2019; Sony & Naik, 2019; Ziebell et al., 2019)
HRM and Technology	Artificial Intelligence; Machine Learning; Human Factors; Cyber-physical System; Virtual Reality; Big Data; HRM; Human Resource.	Technology-related competences for HRM professionals; Use of Artificial Intelligence, Virtual and Augmented Reality and Big Data in HRM; Changing HRM functions due to digital technologies.	(Abdeldayem & Aldulaimi, 2020; Bogoviz, 2020; Brocal et al., 2019; Caputo et al., 2019; Geetha & Bhanu Sree Reddy, 2020; Mazurchenko & Maršíková, 2019; Nankervis et al., 2019; Ra et al., 2019; Sivathanu & Pillai, 2018)
Human-Robot Collaborative	Human-Robot Collaborative; Man-Machine Systems; Productivity; Human-Centered Production; Anthropocentric.	Use of robots in collaborative environments to increase productivity; People familiarized with the robots; High level of Technical Skills; Training of people and machines.	(Bruno & Antonelli, 2018; Maisiri et al., 2019; Ramingwong et al., 2019; Rauch et al., 2020; Rosin et al., 2020; Stein & Scholz, 2020; Wilkesmann et al., 2018)
New Ways of Working	Human Work; Future Jobs; Human Factors; Cyber-physical System; Digital Tools; Automation; Workforce; Job Profile.	New ways of work due to technological applications of Industry 4.0; Resistance to changes arising from Industry 4.0; Importance of Reskilling and Upskilling for the digital economy; Job restructuring.	(Ana et al., 2019; Becker & Stern, 2016; Cagliano et al., 2019; Cortellazzo et al., 2019; Fantini et al., 2020; Maisiri et al., 2019; Marnewick & Marnewick, 2020; Meske & Junglas, 2020; Pereira et al., 2020; Ra et al., 2019; Romero et al., 2020; Thun et al., 2019; Wilkesmann et al., 2018)

addition, training can be applied to machines (Stein & Scholz, 2020) as the modern communication network implies that machines can teach people in the same way that people can teach machines by employing technologies such as machine learning, which allows machines to learn autonomously based on their experience and the tasks developed.

The group **New Ways of Working** was created to facilitate discussions related to the new ways people work in the labor market. Industry 4.0 involves a complex interaction between people and machines, making it necessary to study new ways in which people work (Galati & Bigliardi, 2019). Easier, repetitive (Fantini et al., 2020), and lower-skilled tasks are more likely to be replaced by technology (Cagliano et al., 2019; Ra et al., 2019; Wilkesmann et al., 2018). This trend needs to be considered from the conception of a cyber-physical system, where the tasks and people assigned to the system should be considered in the design phase (Becker & Stern, 2016; Cortellazzo et al., 2019).

Digital transformation in the workplace is a phenomenon that causes significant changes in how workers perform tasks, processes, engage in social relationships, and workplace experiences (Meske & Junglas, 2020; Pejic-Bach et al., 2020; Romero-Gázquez & Bueno-Delgado, 2018), and the incorporation of technological applications creates uncertainty owing to the possible replacement of human labor by digital technologies. Therefore, the authors propose that new technologies arising from the Fourth Industrial Revolution should be investigated, analyzed, and adapted by companies' knowledge management to ensure the inclusion of digital jobs (Ana et al., 2019; Marnewick & Marnewick, 2020). This may decrease the resistance to change (Cheng & Hahm, 2019) and prepare companies for a consolidated digital culture (Molino et al., 2020).

In addition, it is important to address topics such as reskilling and upskilling for the digital economy (Maisiri et al., 2019; Thun et al., 2019), which prepare people to take on more complex and advanced tasks (Cagliano et al., 2019). The importance of people in these systems is owing to their ability to adapt to the environment, flexibility, and variability of behavior, which are qualities not possessed by machines (Chang & Yeh, 2018; Meske & Junglas, 2020), enabling them to manage the complexity of productive systems.

Despite previous discussions about the adaptation of people to new productive systems and the need for reskilling, there remains little consensus in literature with respect to the consequences of the application of digital technologies, in terms of determining whether there will be more job creation or extinction (Ana et al., 2019; Bejaković & Mrnjavac, 2020; Jerman, Pejić Bach, et al., 2020). Some studies indicate that digital technologies are not mature enough to replace human knowledge but are needed mainly for maintenance work, troubleshooting, and adjusting equipment parameters (Chang & Yeh, 2018). One study reports that Industry 4.0 has the potential for job loss and human replacement by technological innovation (Ana et al., 2019). However, (Jerman, Bertoncelj, et al., 2020) emphasize that the discussion is not about job loss or gain, but about job restructuring and the ability of people to adapt to new digital technologies.

Therefore, this group interfaces with other macro-groups such as HR-Management, HR-Strategy, and HR-Competence because the strength of HRM is that it focuses on how people are managed and how they serve the stakeholders in their assignments and work tasks performed. Table 5 presents a summary of the discussion addressed by this macro group and its specific groups.

3.2.2. *HR-management*

The **Learning and Training** group seeks to discuss issues related to learning and training, whether in the workplace or educational institutions. Training programs will require adaptation to the transformation of job profiles (Tirabeni et al., 2019), not only in the activities performed, but also in increasing competencies among workers (Chang & Yeh, 2018; Shamim et al., 2017; Stachová et al., 2019) to ensure that they effectively use digital technologies (Molino et al., 2020).

Industry 4.0 introduces challenges for university education (Kohnová & Salajová, 2019). In addition to imparting knowledge about technologies and applications (Chang & Yeh, 2018), instructors are required to teach skills such as problem solving, communication, responsibility, ethics, values, and entrepreneurship (Chang & Yeh, 2018; Maisiri et al., 2019; Teng et al., 2019). That is, soft skills should be incorporated into the academic curriculum in addition to hard skills (Liboni et al., 2019; Ra et al., 2019; Rampasso et al., 2020; Teng et al., 2019), preparing future professionals to develop safe and efficient (Lantada, 2020).

University graduates represent a great potential in innovation, and thus play an important role in introducing Industry 4.0 (Vrchota et al., 2020). Therefore, it is necessary for educational organizations to be open to change (Jerman, Bertoncelj, et al., 2020; Jerman, Pejić Bach, et al., 2020) and to partner with the government (Matt et al., 2020) and industry to train a workforce with the required skills.

Digital technologies can also be used in learning environments. VR is presented in a virtual world that is built and managed by a computer (Bongomin et al., 2020), enabling the creation of virtual environments and working together with AR. Consequently, training can be offered without risk to worker safety (Brocal et al., 2019) in a flexible and

Table 6
Topics discussed HR-management.

Groups	Keywords	Topics discussed	Main Authors
Learning and Training	Learning; Lifelong Learning; Education; Training; Skill; Competence; Flexibility; University.	Training Programs for adapting job profiles; Learning environments using digital technologies; Teaching key competencies; Need for lifelong learning	(Brocal et al., 2019; Cezarino et al., 2019; Chang & Yeh, 2018; Jerman, Bertoncelj, et al., 2020; Jerman, Pejić Bach, et al., 2020; Kohnová & Salajová, 2019; Maisiri et al., 2019; Matt et al., 2020; Ra et al., 2019; Rampasso et al., 2020; Teng et al., 2019; Vrchota et al., 2020)
Recruitment and Selection	Automation; Recruitment; Selection; Job Profile; Work; Assessment; Talent.	Talent captures competent in digital technologies; Attributes that facilitate implementation of Industry 4.0 sought in recruitment processes; Understanding of requirements to be sought in recruitment	(Abdeldayem & Aldulaimi, 2020; Butschan et al., 2019; Geetha & Bhanu Sree Reddy, 2020; Mazurchenko & Maršíková, 2019; Nair, 2019; Nankervis et al., 2019; Pejic-Bach et al., 2020; Shamim et al., 2017; Sivathanu & Pillai, 2018)
Rewards and Performance Management	Remuneration; Rewards; Performance Management; Job Satisfaction; Productivity.	Rewards based on competencies and performance; Performance measurement based on indicators; Incentives based on performance.	(Abd Razak & Ismail, 2018; Llinas & Abad, 2019; Nair, 2019; Shamim et al., 2017; Sivathanu & Pillai, 2018)
Talent Management	Talent Management; Talent Need; Recruitment; Selection; Digital Technology; Human Capital; Employer; Personal Development.	Attracting and retaining talent for Industry 4.0; Analyzing the employee profile to take proactive measures; Talent development; Attractive company image to attract and retain talent.	(Abdeldayem & Aldulaimi, 2020; Chang & Yeh, 2018; Kaasinen et al., 2020; Longo et al., 2017; Matt et al., 2020; Mazurchenko & Maršíková, 2019; Nangoy et al., 2020; Sivathanu & Pillai, 2018; Whysall et al., 2019)

reconfigurable environment (Chang & Yeh, 2018). Therefore, this technology is a strong ally in an environment where change requires lifelong learning, which is strengthened by the ability to perform reskilling and upskilling (Ra et al., 2019).

As such, this group has a strong relationship with the other topics covered in this study. The learning and training issue ensures that human resources remain up-to-date. Therefore, it is related to other HR management groups, such as HR digitalization and HR strategy. Furthermore, learning and training is responsible for the development of people's HR competence to develop their activities at work.

Recruitment and Selection is a group that discusses new traits should be desired in job candidates. In order to attract competent talent in digital technologies, recruitment must be adapted in order to be able to identify professionals according to the real needs of the organization (Shamim et al., 2017). In addition, digital tools that can themselves assist in this process, including big data and AI, help to automate the resumption of candidates in relation to the position, selecting only those with a high probability of fulfilling the requirements (Sivathanu & Pillai, 2018).

Many organizations use artificial intelligence in their recruitment process, such as selection, assessment, and recruitment, thus increasing efficiency in obtaining talent with the required skills (Abdeldayem & Aldulaimi, 2020; Nankervis et al., 2019), unlike focusing primarily on qualifications (Mazurchenko & Maršíková, 2019). This technology can help remove inaccurate data and automate the evaluation of resumes and manual tasks (Geetha & Bhanu Sree Reddy, 2018).

Social networks have become an ally for recruiters because they can obtain information shared voluntarily by people (Mazurchenko & Maršíková, 2019). In order for recruiters to use them, it is necessary to know the data that can be extracted and understand the requirements to be sought, turning social networks into new channels of digital talent acquisition (Nair, 2019). In addition, the job advertisements themselves are sources of information about which skills are in demand (Pejic-Bach et al., 2020), enabling candidates to search for qualifications more accurately and in line with the needs of the industry.

Attributes linked to innovative behavior, knowledge management practices, and technology acceptance are critical success factors that must be sought in recruitment and selection processes (Butschan et al., 2019). These attributes can facilitate the implementation of Industry 4.0 as they promote innovative capacity and lifelong learning (Shamim et al., 2017; Sivathanu & Pillai, 2018).

The **Rewards and Performance Management** group discusses changes in the reward systems and performance management. Rewards are an important HRM function that pertains to the system of remuneration in relation to the work performed (Abd Razak & Ismail, 2018). As the work is related to the knowledge and skills of the worker with respect to technological applications, compensation systems need to remain in line with the changes (Sivathanu & Pillai, 2018), and the compensation is now based on performance (Llinas & Abad, 2019). Therefore, there is a tendency for workers to have a career plan that is independent of the company, as opposed to the company taking care of the career plan.

The increase in globalization proposed by the Fourth Industrial Revolution, that is, greater integration between culture and values, stimulated by globalized work practices, encourages employers to change compensation systems to systems that are based on performance, skill, knowledge, competence, and productivity (Abd Razak & Ismail, 2018; Sivathanu & Pillai, 2018). To do this, KPIs are required as a means of measuring performance, unlike seniority-based pay (Abd Razak & Ismail, 2018; Shamim et al., 2017).

Formal and structured employee performance evaluation mechanisms are important for future development, performance-based promotions and incentives, and the proactive management of underperforming employees (Llinas & Abad, 2019). In addition, HRM must create monetary and non-monetary incentives for workers who proactively acquire necessary skills (Nair, 2019) and competencies, thus decreasing training costs and increasing job performance. Therefore, the interfacing of the group with other HRM in substantial areas, such as competence, learning, and training.

The **Talent Management** group is characterized by managing the supply, demand, and flow of talent in organizations (Dries, 2013). Owing to the shortage of skills important for Industry 4.0, companies must change some parameters to attract and retain talent (Whysall et al., 2019).

The demand for talent to implement Industry 4.0 has resulted in the need for companies to change their talent development practices (Chang & Yeh, 2018) because the greater the complexity of the system, the greater is the need for skilled talent for implementation (Longo et al., 2017). The opportunities offered to new talent in the digital age include greater autonomy and self-development (Kaasinen et al., 2020).

By using predictive analysis tools that are based on technologies such as AI, managers can determine the competencies that need to be developed (Abdeldayem & Aldulaimi, 2020) according to the activities performed. In addition, the intention to leave the company can be predicted by analyzing employees' profiles, enabling HRM to take proactive measures to retain high-performing talent and to provide better opportunities (Sivathanu & Pillai, 2018).

By identifying talent, companies can allocate resources to develop

technologies (such as the IoT, big data, and the cloud) more efficiently, so the identification of talent has become a high priority (Chang & Yeh, 2018) as digitally minded talent is critical to the success of digital transformation (Nair, 2019). One tool for developing digital talent is e-learning, which can ensure qualification without offering risks to workers (Mazurchenko & Maršíková, 2019). AI predicts the need, and VR and AR offer support for training that can be conducted using virtual platforms.

Companies must promote their employer brand to attract and retain talent (Whysall et al., 2019), and should promote an attractive image, value-oriented, personal and strategic marketing (Matt et al., 2020). With this approach, there will be a change in the way that strategic HR functions are perceived (Nangoy et al., 2020). As such, topics such as recruitment and selection, HRM and technology, rewards, and performance management and competence interact with talent management. Table 6 presents a summary of the discussions in each group and the keywords that represent them.

3.2.3. HR-strategy

The group **Diversity and Inclusion** addresses this theme in the workforce. Features of Industry 4.0, such as the globalization of work, which are facilitated by digital technologies, are the creation of multidisciplinary and multi-variant groups where specific features can be absorbed. For example, owing to high life expectancy, the inclusion of older workers should be considered, taking advantage of their experience and knowledge of the process (Calzavara et al., 2020). Besides companies, educational systems (Ana et al., 2019), need to adapt to the characteristics, support, and guide them adequately for their adaptation or re-adaptation to their work profiles (Calzavara et al., 2020; Matt et al., 2020), besides transferring knowledge and experience to younger workers (Matt et al., 2020).

Furthermore, there are issues related to the diversity of people working in a productive environment, taking advantage of their characteristics in tasks that are more specific to their skills. An example is people with a mild degree of autism who have visual and spatial abilities, a combination of high demand for functions such as software testing, data analysis, and cyber security because of their ability to recognize patterns (Carrero et al., 2019).

Therefore, organizations that develop recruitment and selection systems that enable diversification in their workforce based on elements at which they excel are more integrated into the digital context. In addition, it is necessary to consider the redesign of workstations and environments that are suitable for people who may have some motor difficulties (Carrero et al., 2019) or some specific characteristics that need to be considered to enable their adaptability to the productive environment (Carrero et al., 2019).

Therefore, issues such as diversity and inclusion are allocated to the HR-Strategy group because it is responsible for the development of strategies for the inclusion of people with the most diverse characteristics. In addition, this group addresses topics such as recruitment and selection, learning and training, and new ways of working.

Leadership is the competence to inspire, motivate, and channel activities to achieve organizational goals, and it is the focus of the group **Leadership**. Leaders achieve their desired objectives by using an appropriate leadership style according to the situation (Sony & Naik, 2020). It is necessary to understand the changes related to leadership because traditional leadership is not compatible with interconnected humans and machines (Cortellazzo et al., 2019; Zakaria et al., 2019). Traditional styles are being replaced by ambidextrous leadership, showing flexibility of behavior (Rosing et al., 2011), which creates positive change through transformation (Marnewick & Marnewick, 2020; Sarwono & Bernarto, 2020). For the digital culture to be consolidated by companies, this transformation is a challenge that must be overcome (Zakaria et al., 2019). Without the digital transformation proposed by ambidextrous leadership, it would be more difficult to systematize these changes.

Industry 4.0, which requires a leadership style designed for learning and knowledge management, leads to innovation (Sivathanu & Pillai, 2018). Therefore, knowledge-oriented leadership is required to stimulate high-performance teams by referring to the transformational style. This type can facilitate organizations and workers to accelerate Industry 4.0 strategies, with more learning, knowledge, innovation, and technology acceptance (Shamim et al., 2017; Zakaria et al., 2019).

Leaders perform roles that cannot be easily replaced by machines (Schwarzmüller et al., 2018) as they are responsible for shaping cultures and guiding people's behavior (Alos-Simo et al., 2017; Zakaria et al., 2019); in this new era, leaders seek to prevent conflict between generations (Sivathanu & Pillai, 2018) and encourage requalification (Fareri et al., 2020). In addition, the role of the leader is to integrate the other groups discussed in this article because the leader will need to deal with diversity, inclusion, multi-or multiculturalism, new talents, generations, structural changes in the company, and competencies, and is responsible for integrating and incorporating digital talents in the teams. Consequently, leaders must improve their ability to deal with multigenerational teams, including understanding their strengths and weaknesses, work culture, and aspirations (Nair, 2019; Sarwono & Bernarto, 2020; Schwarzmüller et al., 2018).

In addition, digitalization opens up new possibilities, such as virtual teams and smart work (Schwarzmüller et al., 2018), introducing new communication tools, increasing the speed and access to information, influencing power structures, and increasing efficiency and standardization. To guide organizations and help them reap the benefits of this kind of digital transformation, leaders need to develop a variety of different competencies (Cortellazzo et al., 2019), such as ethics, emotional intelligence, systems thinking, supportive behavior, and knowledge capability (Zakaria et al., 2019).

The **Organizational Changes** group focuses on organizational issues. In situations of change, organizational structure can play a vital role in developing a climate of innovation and learning (Do et al., 2016; Van der Sluis, 2004). Therefore, it is necessary to know the impact of Industry 4.0 on the organizational structure and how it can help the implementation of digital technologies.

Transition strategies must be developed during the application of concepts and technologies in Industry 4.0, and technical organizational structures must be prepared (Cimini et al., 2020; Sony & Naik, 2019). In this context, the direct involvement of employees is key to the transformation from traditional organizational models to innovative models (Flores et al., 2020).

Another major change expected in Industry 4.0 is the decentralization of decision making. The responsibility and authority for decision-making is generally transferred to more operational levels, as it is believed that these employees have greater knowledge of the activities than the administrative level, making decisions more agile (Shamim et al., 2017). However, for this to occur, communication and collaboration are essential competencies (Schwarzmüller et al., 2018).

Therefore, organizational changes need to be understood to enable the spread of the digital age. Themes such as organizational culture, new ways of working, leadership, learning, and training speak to this issue.

Organizational culture is defined as a complex set of values, beliefs, assumptions, and symbols that define how a company conducts business (Alos-Simo et al., 2017; Mohelska & Sokolova, 2018). HRM is responsible for the cultural changes that should take place in the context of Industry 4.0 (Ziebell et al., 2019), creating a culture of commitment to technological change (Agrawal et al., 2020). Therefore, matters pertaining to this topic have been organized in an **Organizational Culture** group.

Management must create a culture of commitment (Agrawal et al., 2020; Stacho et al., 2020) because the transition to new business paths also depends on this behavior. The dissemination of this culture needs to occur at all hierarchical levels, especially at the operational level. This level is one that most needs support from technological improvements because it requires the greatest amount of information (Thun et al.,

Table 7
Topics discussed HR-strategy.

Groups	Keywords	Topics discussed	Main Authors
Diversity and Inclusion	Human; Autonomy; Ageing Workforce; Collaborative Technologies; Diversity and Inclusion; Recruitment; Selection.	Multidisciplinary and multi-skilled work groups; Inclusion of workers; Aging workforce; Taking advantage of specific characteristics; Adapting jobs.	(Ana et al., 2019; Calzavara et al., 2020; Carrero et al., 2019; Matt et al., 2020)
Leadership	Leadership; Management Practices; E-Leadership; Competence; Job Profile; Organizational Performance; Work; Transformational Leadership; Adaptive Culture	Leadership style aimed at innovation; Role of leaders for digital transformation; Influence of leadership for the implementation of Industry 4.0.	(Alos-Simo et al., 2017; Cortellazzo et al., 2019; Fareri et al., 2020; Nair, 2019; Sarwono & Bernarto, 2020; Schwarzmüller et al., 2018; Shamim et al., 2017; Sivathanu & Pillai, 2018; Zakaria et al., 2019)
Organizational Changes	Organizational Changes; Organizational Challenges; Organizational Structure; Organizational Level; Organizational Performance	Changes in organizational structure due to impacts of Industry 4.0; Decentralization of decisions; Core competencies such as communication and collaboration.	(Cimini et al., 2020; Flores et al., 2020; Schwarzmüller et al., 2018; Shamim et al., 2017; Sony & Naik, 2019; Thun et al., 2019)
Organizational Culture	Organizational Culture; Innovative Culture; Process Innovation; Human Resource Flexibility; Adaptability Culture.	Culture of Commitment to Industry 4.0; Culture of easy adaptation; Support at the operational level.	(Agrawal et al., 2020; Butschan et al., 2019; Do et al., 2016; Mohelska & Sokolova, 2018; Stacho et al., 2020; Tirabeni et al., 2019)

2019).

A company with an already deep-rooted culture must carefully set goals to introduce a flexible production model. This would enable it to retain new and old talent, and to spread the paradigms of smart production among workers (Tirabeni et al., 2019). A culture characterized by high inertia and difficulties in change can see the inhibition of digital transformation (Butschan et al., 2019).

Implementing innovation depends not only on people's skills, but also on the organizational culture (Mohelska & Sokolova, 2018). An organization with an easily adaptable culture is able to more dynamically meet market demands (Do et al., 2016). Thus, Industry 4.0 depends directly on the development of a good strategy for organizational behavior for technology transition. Therefore, this group discusses themes related to organizational changes, leadership, new ways of working, talent management, and competence, enabling people to commit to technological changes. Table 7 presents the topics discussed in each group related to HR strategy.

3.2.4. HR-competence

The group related to **HR Competence** presents a discussion related to changes in Competence for Industry 4.0. Competence is the combination of a person's attributes, skills, knowledge, and experience, which are necessary to perform life roles at work (Flores et al., 2020; Hecklau et al., 2016; Jerman, Pejić Bach, et al., 2020). Owing to changes in Industry 4.0, new skills are required for the development of work (Rampasso et al., 2020), causing companies to focus on skilled labor to ensure the effective use of the technologies that are employed (Kamble et al., 2018; Rasiah et al., 2019). Therefore, it is necessary to know the changes that arise from Industry 4.0 related to the competencies, skills, and attitudes that are required (Flores et al., 2020), identifying the job profiles of the future.

Advanced technologies require advanced competencies (Ana et al., 2019; Maisiri et al., 2019), and companies must support workers in the upskilling process (Do et al., 2016; Fantini et al., 2020; Sony & Naik, 2019). The main difference between traditional workers and Industry 4.0 workers is related to the skill and knowledge gap (Hudáková et al., 2019). Although the former is considered to lack experience and skills, the latter is considered to be someone who will deal with management and not only with production (Di Nardo et al., 2020), and who has knowledge about digitalization and digital technologies, such as robotic and AI (Galati & Bigliardi, 2019). Therefore, skills and qualifications are critical success factors for Industry 4.0.

For better clarity about the study of skills, it is necessary to know the subdivisions to ensure an understanding of the subject. Among these subdivisions, soft skills are linked to personality traits, enabling people to control their interactions and be more adaptable, interdisciplinary, and open to continuous learning (Flores et al., 2020; Ra et al., 2019). Flexibility, problem-solving, leadership, collaboration, and resilience are some important soft skills (Kaczmarek, 2019; Maisiri et al., 2019; Matt et al., 2020; Ra et al., 2019). In Industry 4.0, job profiles require candidates to exhibit strength in soft skills (Ana et al., 2019; Jerman, Pejić Bach, et al., 2020; Prifti et al., 2017), and owing to their increasing importance, there is the need to know how to train and improve them because they are differentiation factors between men and machines (Cimini et al., 2020; Fareri et al., 2020). Further, there is the need for new ways to train and educate people for Industry 4.0, such as project-based learning, university/industry partnerships, multidisciplinary teamwork, and flipped classrooms (Yoshino et al., 2020).

Hard or technical skills are competencies related to specialized knowledge for a specific occupation (Flores et al., 2020). Process understanding, data security, programming, and the operation of new technologies (cyber-physical system, big data, IoT, and the cloud) are among some important hard skills that are required for the Industry 4.0 context (Jerman et al., 2018; Liboni et al., 2019; Matt et al., 2020). Digital literacy, which in the Third Industrial Revolution was a strategic advantage (Sakurada et al., 2020), has now become a necessity for workers, especially for those who need reskilling. Lifelong learning is a daily theme in companies because of the constant need to learn new competencies needed by the company and the labor market (Bejaković & Mrnjavac, 2020; Vrchota et al., 2020), requiring training programs to keep up with this trend (Jerman, Pejić Bach, et al., 2020).

Industry 4.0 will be known for its multidisciplinary skills and knowledge (Jerman, Pejić Bach, et al., 2020; Liboni et al., 2019). Therefore, leaders need to invest in the qualification of their workers to support and motivate them to continue to increase the learning curve (Cortellazzo et al., 2019). From a management perspective, the presence of incorrect competencies leads to poor company performance (Fareri et al., 2020). For example, studies show that industrial engineers must have skills related to production, digital systems such as AR, collaborative human robots, and simulation and modeling (Pejic-Bach et al., 2020), observing multidisciplinary knowledge for Industry 4.0.

This discussion about competencies plays an important role in HRM as it influences the company, and is an important discussion for Industry 4.0. Therefore, HRM plays an important role in determining what competencies are needed for a company and how they are developed (Meddour et al., 2020). Competency development involves identifying the competencies that need to be developed, identifying the critical gaps (i.e., the level between the actual and required competency), and closing those gaps with appropriate and targeted qualifications (Ana et al., 2019; Hecklau et al., 2016). This allows the organization to align its workforce to meet the challenges imposed by Industry 4.0 (Abdeldayem & Aldulaimi, 2020; Jerman et al., 2018). Table 8 presents a summary of the topics discussed by this macro group, which also organizes directing keywords on the theme.

Table 8
Topics discussed HR-competence.

Groups	Keywords	Topics discussed	Main Authors
Competence	Competence; Employment; Job Profile; Skill; Digital Literacy; Workforce; Human Capital.	Changes arising from Industry 4.0 requires new competences; Features in relation to competences of 4.0 worker; Importance of Soft and Hard Skills; Digital Literacy essential for new revolution.	(Ana et al., 2019; Cimini et al., 2020; Fantini et al., 2020; Fareri et al., 2020; Jerman et al., 2018; Jerman, Pejić Bach, et al., 2020; Maisiri et al., 2019; Meddour et al., 2020; Sony & Naik, 2019)

4. Discussion

Through bibliometric analysis and the construction of macro-groups and organized groups, a content analysis framework was built in relation to the theme of HRM in the context of Industry 4.0. Fig. 8 illustrates the proposed framework.

The base of the pyramid is the macro group of **HR-Digitalization**. This group presented relevant discussions about digital technology applications, which are the basis for the transformation of organizations to the digital age. In this group, we note the importance of HR in the application of digital technologies in the work environment and their importance to the workforce.

The application of digital technologies in manufacturing environments presents several challenges. With regard to their application in HR, tasks are transformed. Meetings and interactions previously held in person have evolved to remote modality, and are aided by interactive digital platforms, AI, and virtual and AR; they also help during health crises such as COVID-19. However, despite this physical distance, environments need to be planned to safeguard the mental health of workers, especially the quality of life at work, which will be impacted by digitalization.

The main challenge of this macro group is the dissemination of digital technologies and the transformation of people, mainly to promote the training of skills needed to use the technologies, including those used by HRM. As was observed, people will continue to be key players, and their expertise is necessary for the implementation and use of digital technologies, verifying the importance of understanding issues such as the trends caused by digitalization. In addition, this

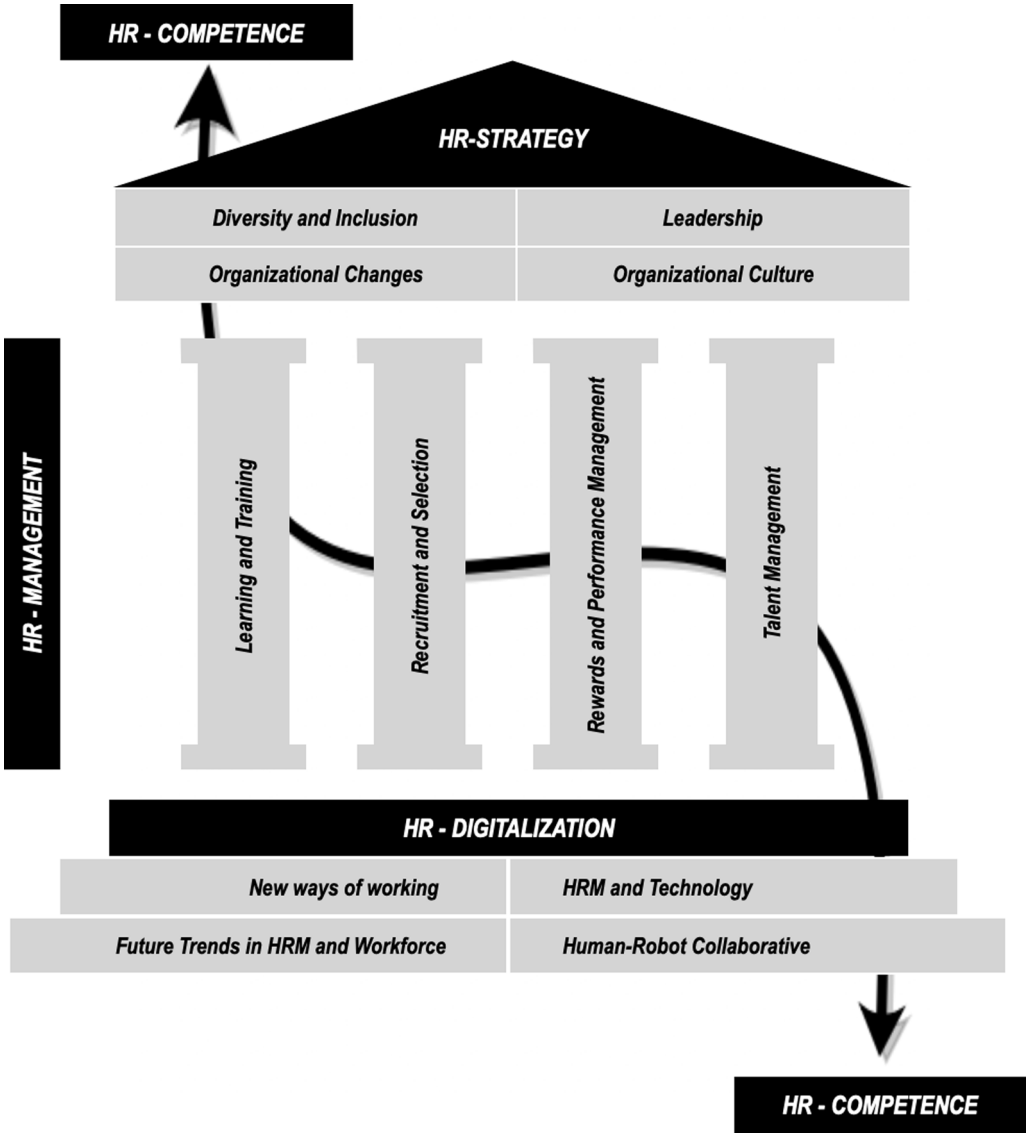

Fig. 8. Theoretical Framework for Human Resource Management 4.0.

understanding can help managers to monitor the need for new job profiles and to develop a digital culture.

This macro group is also responsible for highlighting the need for providing digital literacy, learning, and training to different actors, including senior professionals, autistic professionals, and those with special conditions. Furthermore, new work profiles can be created from the application of digital technologies, enabling a dynamic environment and safety, with role definitions for people and robots as well as and codes of conduct that ensure the principles and values that will be disrupted and will need to be organized and reflected in the digital age organization.

The pillars of support are known as the macro group **HR-Management**. This group presented relevant discussions pertaining to the main areas of HRM, which were identified in the literature review, as support for the organization's HRM.

The areas identified by HRM change as the organization enters the digital age. Recruitment, training, and performance management tasks were performed manually with little data and information. However, with technologies such as big data, a larger database can be used, and profiles can be cross-checked, assisting actors, including managers, in the management and life-cycle management of the workforce in areas such as operations and supply chain. For example, AI can help improve job posts and minimize selection errors and dismissals. In this approach, AI leverages big data technologies to mobilize the widest variety of datasets regarding performance and evaluation, competence development, and educational testbeds aided by continuous learning and real-time data. In addition, it is necessary to verify trends in the use of some technologies, such as machine learning, for the recognition of soft skills in recruitment processes and talent management in the organization.

One of the challenges being faced is related to the reward system. It is necessary to reflect on which reward mechanisms will engage people to develop lifelong learning, which is an important theme for updating workers' skills in Industry 4.0, as well as to consider how this can change labor legislation and career planning and development within the organization.

Thus, the changes in activities developed by HRM with knowledge from Industry 4.0 are verified. For knowledge of the workforce, topics such as reskilling and upskilling in Workforce 4.0 are a challenge for the future to ensure that people continue to fully utilize digital technologies.

The ceiling is represented by the macro group **HR-Strategy**. This macro-group is capable of formulating strategies related to HR and how people adapt to this new era. These strategies must be disseminated to the workforce, which is part of the organization, so that they adapt to the changes arising from Industry 4.0.

The challenges for this macro group are in relation to determining the strategies that require focus to enable organizations to take advantage of the benefits of Industry 4.0 technologies more efficiently, especially in relation to the multidisciplinary competencies required using a range of digital technologies. A more decentralized decision structure gives workers more autonomy to make decisions, creating a culture of self-management and greater importance of people for digital transformation. This only happens if the culture promotes changes, forming a set of behaviors and knowledge aimed at Competencies 4.0.

Diversity of people that make up Organizations 4.0, regardless of gender, color, race, age, or health condition. Managing diversity is one of the greatest challenges, particularly in terms of its peculiarities. Understanding how to define diversity and how people can deal with it in the workplace is crucial. Moreover, the use of collaborative technologies in digital collaborative environments can help bring people together, regardless of their physical or other differences related to the concepts of diversity and inclusion, making the culture truly diverse, creative, inclusive, welcoming, flexible, human, and digital.

Preparing leaders to take on more strategic roles and managing people is also a part of the series of challenges to be overcome. These new leaders also need to be concerned with outlining talent retention strategies and improving the quality of life in people's work, as this is a major concern today. With respect to digital work, this macro group is responsible for developing strategies regarding the preservation of mental health and understanding that people need to differentiate between the physical and digital worlds, maintain their creativity, and develop codes of conduct in collaborative virtual environments.

Therefore, in helping to develop strategies for inclusion, leadership, and understanding organizational change and culture, this macro group is of great importance for strategies to be disseminated throughout the company, such as decentralizing decisions, and understanding people's particular competencies and their multiple plurality.

The macro group related to **HR-Competence** is related to all of the other macro groups and is a determining factor for the success of Human Resource 4.0. Competencies are essential for the development of this study. In the context of Industry 4.0, they are essential because of the application of advanced technologies, which is an essential feature for the transformation to Human Capital 4.0.

For this macro group, the main challenge is to identify, map, and develop the necessary competencies for worker performance using digital technologies. Competencies, especially soft skills, are differentiating aspects of people and machines in an industrial environment. Therefore, it is necessary to understand their importance in organizations, especially how the workforce can develop soft skills through training programs.

Competencies are inputs that influence all macro groups of human resources because they can be considered a strategic advantage for the organization; they are managed and must be considered for aspects such as recruiting and training, and they are fundamental aspects to guarantee the digitalization of the industries. Therefore, it is important for this group to focus on developing competencies because this macro group will provide the basis for change in the other macro groups. Knowledge, training, and consolidation of 4.0 competencies by the industry's competencies are fundamental for improving digitalization, management, and strategy, helping to promote the digital transformation of the industry as a whole.

To illustrate the evolution of HRM in the context of Industry 4.0, Fig. 9 (Appendix 1) presents the behavior of the macro groups prior to Industry 4.0, presenting their difficulties. This study addressed how these difficulties were overcome, allowing the evolution of Industry 4.0. The previous period was marked by tasks performed manually without intelligent systems assisting in decisions and performing work tasks. Industry 4.0 allows intelligent systems to digitalize not only the productive environment, but to also support areas such as HRM, allowing tasks to be assisted by digital technologies and the area to support the development of people, helping them to face the challenges imposed by digital transformation.

5. Implications of the study

5.1. Implications for human resources management

An understanding of how Industry 4.0 transforms HRM is necessary to drive digital transformation. As digital technologies are incorporated by companies, changes in how people do their jobs must be understood in order for HRM to support initiatives such as reskilling, performance management, skills development, and employee inclusion.

In addition, the application of technologies such as AI, big data, and virtual and AR transform HRM's own tasks. Screening of resumes uses big data according to the competencies required for a vacancy training with the aid of VR and AR. Predictive analysis of talent, foreseeing the possibility of turnover. These are some of the tasks transformed by digital technologies for an area of the company previously known as "non-technological.".

Thus, the theoretical framework indicates the relationship between the areas delimited by this study, demonstrating their objectives within the organization. Moreover, an understanding of how this framework

Table 9
Future research questions.

HR-Digitalization
RQ 1: How can AI help improve HRM processes?
RQ 2: What learning and training needs do HRM professionals have?
RQ 3: What are the ethical challenges between the human and robot relationship?
RQ 4: How to preserve the physical and psychological integrity of the workforce in the digital age?
RQ 5: What investments to make in digital technologies applied to HRM?
HR-Management
RQ 1: How to adapt learning and training according to workforce 4.0?
RQ 2: What the structure of new recruitment models for workforce 4.0, based on the identification of soft skills?
RQ 3: How do interactive digital platforms can better support training programs?
RQ 4: What are the new changes in reward legislation and how to change them to promote lifelong learning?
RQ 5: How to use machine learning for selection processes to identify soft skills?
HR-Strategy
RQ 1: What are the ways to diversify the workforce and know the point characteristics of people?
RQ 2: What means to form digital culture within the company in the context of Industry 4.0?
RQ 3: How to measure performance and update career and development plan in the digital age?
RQ 4: What are the competencies and the role of the leader 4.0 in Industry 4.0 context?
RQ 5: What ways to attract and retain workforce 4.0?
HR-Competence
RQ 1: How to map important competencies for Industry 4.0?
RQ 2: What are ways to measure competencies levels of workers from the use of digital platforms?RQ 3: What are the main Key Performance Indicators (KPI) based on competencies 4.0?

works allows HRM professionals, leaders, and team managers to verify the importance of people within organizations for the creation of a digital culture and the creation of strategies to ensure the company's readiness for Industry 4.0.

5.2. Implications for workforce and university

For the workforce, it is necessary to understand future HR transformations and trends in order to remain prepared and up-to-date. In addition, the article provides insights for the future workforce on the competencies required in the context of Industry 4.0, and these qualifications are provided by universities.

The main trends involve the development of soft skills in addition to hard skills. Engineers in the future need a high degree of hard skills, such as programming and digital tools, in addition to a set of soft skills such as emotional intelligence, critical thinking, and communication (Maisiri et al., 2019). This balance is known in the professional profile of industrial engineers, and is a highly investigative professional with the necessary competencies for resource management, including HR.

To achieve this, new teaching methodologies are required, allowing co-creation through partnerships between universities and companies. To train an innovative workforce, teaching methodologies must evolve, such as the use of interactive digital platforms. This allows for better student monitoring and familiarization with digital technologies. However, this is possible with the support of senior university management to understand the needs of professionals based on the trends required by the industry.

5.3. Implications for research

The knowledge generated about HRM in the context of Industry 4.0 was consolidated, and the analysis results present some opportunities for future research.

- To provide more conclusive results on the identified groups, specific systematic reviews on these groups may be useful for the identification of more specific trends in the field of HR. For example, the research performed by (Liboni et al., 2019) addressed implications for the supply chain. Studies addressing mainly job profiles were conducted by (Jerman, Bertoncelj, et al., 2020; Pejic-Bach et al., 2020). However, further investigations are required.
- The challenges reported in the discussions can be validated and addressed by a panel of experts to be directed to researchers in the field of HR and Industry 4.0. Besides verifying the validity of these challenges, other challenges not identified by the authors of this paper may be found, enabling the advancement of the state-of-the-art on this theme.
- An investigation was performed to determine how the HRM 4.0 area can help the Institute for Education to develop training programs oriented to Industry 4.0. With respect to workforce training, universities should align their training with industry needs, providing a future workforce according to the right skills to face the challenges imposed by Industry 4.0.

Thus, Table 9 highlights some research questions for direct future studies. In addition, the keywords addressed in Tables 5–8 can be used in future research directed at the macro groups and groups addressed in this article.

6. Conclusion and limitations

Over the course of several industrial revolutions, many changes have occurred in industries such as production systems, services, and the HR involved in the processes. Since the start of the Fourth Industrial Revolution, digital technologies have reshaped the way people work, learn, lead, manage, recruit, and interact with each other. In this sense, it is necessary to understand the main changes and trends in HR from the use of digital technologies, the main issues and disruptive groups in HR that will achieve this change, and the relationship between these issues identified by the literature. It is important to understand how technology can change HRM processes.

Thus, a theoretical framework was presented in which the main trends related to HRM 4.0 were identified. Some macro groups were identified as trends for people management in the Industry 4.0 context, namely HR-Digitalization, HR-Management, HR-Strategy, and HR-Competence. From these macro groups, trends were verified in relation to the strategic value of people, digital technologies that drive HR (AI, big data, VR, and AR), trends for training people and machines, lifelong learning, changes in the company's image to retain talent, the inclusion of autistic and elderly people, new adaptations in the workplace, digital leadership, adaptable culture, and new competencies for Workforce 4.0.

With this, the paper showed the trends and possible challenges for areas facing the new workforce of the digital age, thus assisting the strategy, management, and digitalization of the HR of companies to ensure more assertive decision making about the recruitment and selection of people, organizational culture, talent management, leadership, organizational performance, diversity, training and lifelong learning, and other changes that have occurred, with a strong relationship between the competencies of the new workforce and the other themes and groups verified in the literature. This shows the importance of investment in Competencies 4.0 by companies so that HRM is strengthened and promotes Culture 4.0, which involves qualified people committed to the digital age, and enabling the preparation and direction of Workforce 4.0. From this, the study sought to promote new theoretical insights for studies in the field of HR in the Digital Age, as well as for companies that intend to become more productive, human, and digital.

The present study sought to provide an overview of HRM in the context of Industry 4.0, seeking to establish the main trends and challenges. Despite the review protocols and methods used, these studies have limitations. According to (Liao et al., 2017), some initiatives for Industry 4.0 around the world, such as the Industrial Internet in the United States of America (USA) or the Future of Manufacturing in the United Kingdom (UK), are terms that could be considered in the paper search.

According to the research protocol used for this review, only research and review papers could have considered other types of documents and languages. In the field of HR, trends such as sustainable HRM were not considered as keywords because this study focused on unveiling HRM 4.0.

This research presented useful insights and directions for future research, enabling us to determine what knowledge has already been acquired pertaining to the study of HRM in the context of Industry 4.0.

CRediT authorship contribution statement

L.B.P. da Silva: Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft, Writing – review & editing. **R. Soltovski:** Conceptualization, Methodology, Formal analysis, Visualization, Writing – original draft. **J. Pontes:** Conceptualization, Methodology, Formal analysis, Validation, Visualization, Supervision, Writing – original draft, Writing – review & editing. **F.T. Treinta:** Conceptualization, Methodology, Formal analysis, Visualization, Validation, Supervision, Writing – original draft, Writing – review & editing. **P. Leitão:** Conceptualization, Methodology, Validation, Visualization, Supervision, Writing – review & editing. **E. Mosconi:** Conceptualization, Methodology, Supervision, Writing – review & editing. **L.M.M. de Resende:** Conceptualization, Methodology, Supervision, Writing – review & editing. **R.T. Yoshino:** Conceptualization, Methodology, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

See Fig. 9.

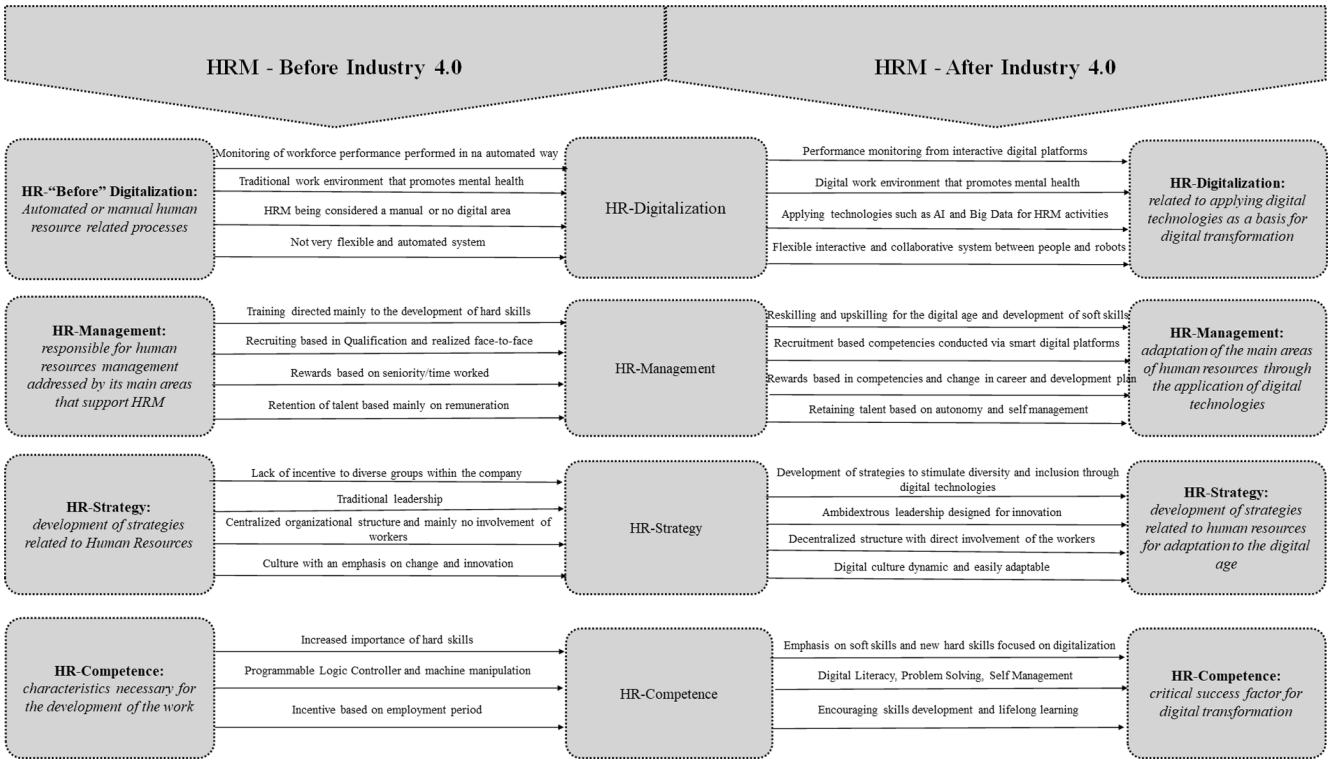

Fig. 9. Transformation of HRM macro group.

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