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Quality 4.0 Trends and Application: A Systematic Literature Review

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Abstract

This study investigated the trends in quality 4.0 and what they mean for various industries. Scopus was the main database used in the systematic literature review. Only papers written in English that directly addressed the study's research objectives and were published between 2017 and 2023 were included in the analysis. The number of papers on quality 4.0 has increased exponentially over the years. The majority of papers came from the TQM Journal, followed by the International Journal of Quality Research and Sustainability Switzerland. In our investigation into what quality 4.0 means for industries, we used a sample of 14 papers. We used qualitative data analysis known as thematic coding, and through inductive thematic coding, we were able to identify 99 codes that were associated with quality 4.0. The study found that quality 4.0 is a broad term encompassing nearly all aspects of quality management, including big data, digital quality management, connectivity, cybernetics, managing disruptions, simulation, and more. According to the study, quality 4.0 is unlikely to change the traditional quality management strategy; rather, it will make things smarter, faster, and more intelligent. The study's findings were consistent with previous research and had both reliability and validity.

Keywords
Big data, Quality management, Quality 4.0, Thematic coding

1. Introduction

Quality management has evolved in line with technological and industrial revolutions over the years (Broday 2022; Makhanya et al. 2022). The focus has always been on meeting customer expectations, from quality inspection to total quality management (Gejo-García et al. 2022; Makhanya et al. 2022). As a result of the increased complexity of machine-to-machine and human-to-machine communication brought on by the Fourth Industrial Revolution, quality managers and engineers are facing several new challenges. One of the problems is dealing with the large amounts of data created by the network of human and machine interactions, which are more than people can handle. Scholars coined the term "quality 4.0" to describe the unique challenges and approaches to quality management in the Industry 4.0 era (Balouei Jamkhaneh et al. 2022; Broday 2022). However, quality 4.0 is still seen as a muddled term with little understanding of what it entails (Psarommatis *et al.* 2022). Others look at quality 4.0 as a digital version of total quality management (Thekkoote 2022). As demonstrated in (Broday 2022), the term quality 4.0 does not have a universal definition. Some argue that, unlike other forms of quality development, quality 4.0 is driven by marketing and information technology rather than manufacturing and engineering.

Thekkoote (2022), conducted a systematic literature review to investigate the key variables that contribute to the success of implementing quality 4.0 effectively. The author (Ibid.) identified leadership support, accessibility of information, connectivity, analytics, training, and scalability as critical success factors for quality 4.0 implementation. In a study by Sureshchandar (2022), the critical dimensions of quality 4.0 were determined by combining the results of a literature review, expert judgment, and an analytical hierarchy process. The findings of the study identified 12 essential components that make up quality 4.0. The factors that were considered were leadership, quality culture, customer orientation, an effective quality management system, compliance, professionalism, analytical abilities, data-driven decision, innovation, and efficient implementation of quality among others. There is a very good understanding in the

literature of what should be in place and what should remain in place for the effective implementation of quality 4.0. Hence, Maganga and Taifa (2022), developed a transition model from traditional quality management approaches to quality 4.0. Interestingly, the findings show that manufacturing companies were ready to embrace quality 4.0 in Tanzania. However, the authors (Sureshchandar 2022 2023; Maganga and Taifa 2023) agree that quality 4.0 is a new concept that creates interest in understanding the trends and application of the concept of quality 4.0.

1.1 Objectives

The research was designed to meet two objectives:

a. To determine the trends in the adoption of quality 4.0.,
b. To find out what quality 4.0 is all about in industries.

3. Research Method

To conduct an efficient search for a comprehensive analysis of the relevant literature, it is necessary to take into consideration the period, the topic that is going to be researched, the information source, the search method, and the inclusion and exclusion criteria.

3.1 Time Span

In the age of Industry 4.0, technology like artificial intelligence and machine learning has led quality practitioners to want to rethink how they manage quality (Sony, Antony and Douglas 2020; Balouei Jamkhaneh et al. 2022). The evidence in Broday (2022) shows that the number of papers written about quality 4.0 has grown rapidly from 2013 to the present. In this study, we looked at papers from 2017 to 2023. We believed that papers from this period would be able to inform us about the trend and use of quality 4.0 in industries.

3.2 Subjects and Databases

The papers used in this study were obtained from the Scopus database, and the papers focused on quality management and quality 4.0. To search for relevant papers, we used the search term ("quality management in industry 4.0" or "management excellence" and "industry 4.0" or "quality 4.0"). We used the limits shown in Figure 1 to find relevant papers. The initial search yielded 209 results.

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(TITLE-ABS-KEY("QUALITY MANAGEMENT " OR "MANAGEMENT EXCELLENCE" AND "INDUSTRY 4.0" OR "4IR") AND
( LIMIT-TO ( SUBJAREA,"ENGI" ) OR LIMIT-TO ( SUBJAREA,"BUSI" ) OR LIMIT-TO ( SUBJAREA,"COMP" ) OR LIMIT-TO (
SUBJAREA,"DECI" ) OR LIMIT-TO ( SUBJAREA,"SOCI" ) )  AND ( LIMIT-TO ( LANGUAGE,"ENGLISH" ) )  AND ( LIMIT-TO (
SRCTYPE,"J" ) OR LIMIT-TO ( SRCTYPE, "P" ) ) )
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Figure 1. Summary of study parameters

3.3 Inclusions and Exclusions

Only papers written in English that directly address the study's research objectives and were published between 2017 and 2023 were included in the analysis. All non-peer-reviewed articles, articles that don't directly relate to the research question, and articles published before 2017 were disregarded. The Scopus database, which includes articles from journals, conferences, and other publications, was a primary database for this study. In addition, the study followed the quality assessment strategy proposed by Mathuthu, Marnewick and Nel (2017) and Makhanya, Nel and Pretorius (2019), which recommends checking the completeness of each paper that was included. The criteria of yes, no, and partially were proposed for evaluating the quality of study designs, methodologies, and conclusions. In other words, members of the research team would evaluate each paper selected for inclusion on a scale of 0 (no) for a feature that does not meet the requirements, 0.5 (partially) for a feature that meets the requirements partially, and 1 (yes) for a feature that meets the requirements completely. The paper with an aggregated score of less than two was deemed to not meet quality standards and it was excluded from further analysis.

3.4 The search method

There is an exponential increase in the number of papers and work related to quality 4.0 and reading every paper from the Scopus database was not feasible. As a result, we chose the systematic process depicted in Figure 2. The first step was the identification of relevant papers which was followed by screening and eligibility assessment. The initial search

with the keywords identified 209 papers. We then narrowed the papers down to those about engineering, business management, decision-making, and social science; the language was restricted to English; and we only selected peer-reviewed journal papers. After the initial screening phase of the research, 105 papers were discarded, leaving 60 papers for abstract review and structural assessment. The abstract screening process ruled out 26 papers because they didn't fit the study's goals. This left us with 34 articles to evaluate for quality and suitability for further analysis. As described in section 3.3, the quality assessment procedure eliminated 20 papers with an overall quality score of less than two. Then, to understand the application of quality 4.0 in industries, we used a total of 14 articles.

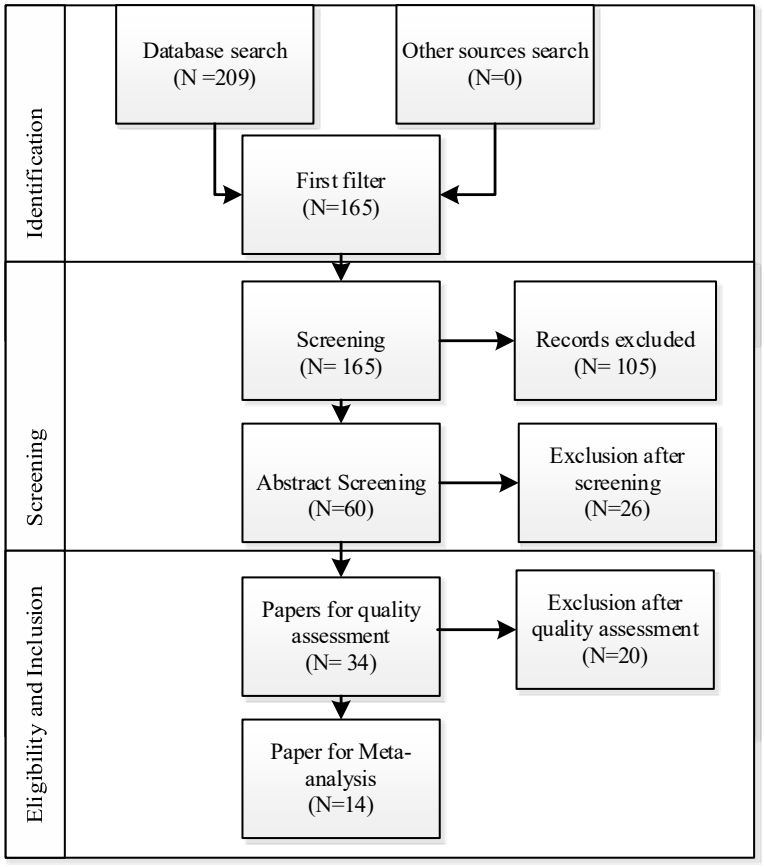

Figure 2. Identification of included papers

4. Results and Discussion

4.1 Most recent articles

The research about quality 4.0 has been published in a variety of journals, which can be seen in the second column of Table 1. In support of the research (Broday 2022), the majority of the papers were discovered in the TQM Journal. It looks like the authors are still trying to figure out what quality 4.0 means. This is because the idea hasn't been fully developed in industries yet. For example, Maganga and Taifa (2023), did a systematic literature review to establish how industries understand quality 4.0 and what quality 4.0 models are available. The uniqueness of the idea of quality 4.0 is also shown in studies (Broday 2022; Thekkoote 2022) that look at the important elements for companies that want to use quality 4.0 as their quality management strategy. The systematic literature review appears to be the most popular approach to research in this field (Sony, Antony and Douglas 2020; Balouei Jamkhaneh et al. 2022 Broday 2022; Thekkoote 2022; Maganga and Taifa 2023).

There were papers like that of Gejo-García et al. (2022) that used modeling to show the relationship between business processes and how changes in one process affect other processes. These models can easily be used to make digital twin s(Winkler, Gallego-García and García-García, 2022). Scholars generally agree that the successful implementation of quality 4.0 is dependent on organizational culture, leadership, knowledge of big data, artificial

intelligence, competency, and collaboration (Ranjith Kumar, Ganesh and Rajendran 2022; Sureshchandar 2022; Maganga and Taifa 2023). The motivation and barriers to quality 4.0 are documented in Sony et al. (2021).

It was discovered that the high cost involved and the difficulties in estimating the return on investment were some of the barriers to the implementation of quality 4.0. Other barriers included a lack of resources required to roll out quality 4.0 initiatives, a lack of a standardized approach to implementing quality 4.0, and the barriers associated with the organizational attitude toward quality 4.0. The adoption of quality 4.0 was motivated by the desire to improve the accuracy of the information, implement a quality management program that was driven by big data, save money on operating costs, increase customer satisfaction, and reduce time spent on non-value-adding activities that have an impact on productivity. Companies in Tanzania view quality 4.0 as a vehicle to improve customer satisfaction, product improvement, and waste reduction. Infrastructure issues such as high-speed internet and stable electricity supply are seen as the main obstacles affecting the adoption of quality 4.0 (Maganga and Taifa 2022).

It is also important to note that the challenges of maintaining stable electricity and access to high-speed internet, which are required to support quality 4.0, may not be unique to Tanzania on the African continent. As a result, further research is required to investigate the level to which the infrastructure on the African continent is prepared to support the implementation of quality 4.0. Although the investigation of critical success factors in the implementation of quality 4.0 and barriers was not one of the primary goals of this study, we needed to highlight those to bring the reader up to date because this paper is a literature review.

Table 1. Most recent articles

Authors	Source title and Digital Object Identifier	Title	Objectives and method	Main Findings
Gejo-García J., Reschke J., Gallego-García S., García-García M.	Applied Sciences (Switzerland) (10.3390/app12042095)	Development of a System Dynamics Simulation for Assessing Manufacturing Systems Based on the Digital Twin Concept	To evaluate the health and efficacy of manufacturing processes, this study set out to create an integrated modeling strategy.	For equipment manufacturers, service engineering providers, and manufacturers and assemblers alike, the case study demonstrates how applied simulation can improve decision-making throughout the manufacturing asset lifecycle.
Balouei Jamkhaneh H., Shahin A., Parkouhi S.V., Shahin R.	TQM Journal (10.1108/TQM-01-2021-0030)	The new concept of quality in the digital era: a human resource empowerment perspective	Quality 4.0 drivers were discussed in depth, as well as the roles of human resources. For data collection, the study combined a literature review and a questionnaire.	Some of the elements identified as important for the success of quality 4.0 were learning orientation, job rotation, innovation capabilities, teamwork, and rewards and recognition.
Maganga D.P., Taifa I.W.R.	TQM Journal (10.1108/TQM-11-2021-0328)	Quality 4.0 conceptualization: an emerging quality management concept for manufacturing industries	The research investigates the concept of quality 4.0 and the models that are related to it. The research method that this paper employed was a systematic review of the literature.	The management of big data and digitalization were the defining characteristics of quality 4.0. The capability to work together, supportive leadership, and the ability to work with large amounts of data were discussed as the enablers for quality 4.0.
Thekkoote R.	International Journal of Quality and Reliability Management (10.1108/IJQRM-07-2021-0206)	Enabler toward successful implementation of Quality 4.0 in digital transformation era: a comprehensive review and future research agenda	The study looked into the various aspects that are necessary to implement quality 4.0. The paper was based on a comprehensive review of the previous literature.	The leadership support, accessibility of information, connectivity, analytics, training, and scalability were identified as critical success factors for the implementation of quality 4.0.
Broday E.E.	International Journal of Quality and Service Sciences (10.1108/IJQSS-09-2021-0121)	The evolution of quality: from inspection to quality 4.0	The paper examines the transition of quality management from traditional total quality management to quality 4.0. The research methodology of the paper	The study finds that quality 4.0 will not replace traditional quality management, but it will make things faster and smarter thanks to big data and artificial intelligence.

Authors	Source title and Digital Object Identifier	Title	Objectives and method	Main Findings
			was a systematic literature review.	
Winkler M., Gallego-García S., García-García M.	Applied Sciences (Switzerland) (10.3390/app12020811)	Design and Simulation of Manufacturing Organizations Based on a Novel Function-Based Concept	The goal of this study was to come up with a systematic way to look at manufacturing organizations so that their functions could be modeled. Using a system dynamic model would make it possible to evaluate, plan, manage, and keep track of operations and performance, as well as find ways to make things better.	The study presented a digital model of the manufacturing organization and demonstrated how each component influences performance.
Tambare P., Meshram C., Lee C.-C., Ramteke R.J., Imoize A.L.	Sensors (10.3390/s22010224)	Performance measurement system and quality management in data-driven industry 4.0: A review	The paper discusses smart manufacturing, quality 4.0, and the challenges associated with these concepts in the manufacturing sector.	Industry 4.0 is still a new concept, so there is a lot of ambiguity, a lack of information, and a lack of published material on performance and quality measurement and management. Industry 4.0's many technologies are still confusing manufacturers.
Psarommatis F., Sousa J., Mendonça J.P., Kiritsis D.	International Journal of Production Research (10.1080/00207543.2021.1987551)	Zero-defect manufacturing the approach for higher manufacturing sustainability in the era of Industry 4.0: a position paper	The paper criticizes quality 4.0 and argues that Zero Defect Manufacturing is the best way to handle quality.	Widely used in the manufacturing industry, quality management methods like Six Sigma, Lean, Lean Six, the Theory of Constraints, and Total Quality Management are incompatible with the technological advancements introduced by the Industry 4.0 framework.

4.2 Publications distribution

Table 2 presents the distribution of papers by country gained from the first database search. Most papers were produced in Germany, which is not surprising given that the idea of industry 4.0, which is the foundation for quality 4.0, originated in Germany (Wagner, Herrmann and Thiede 2017). The Russian Federation had the second-most papers, with 17 papers. India had the third-most papers, with 15 papers. The United Kingdom had the fourth-most papers, with 11 papers. Japan only had two papers in the search from the Scopus database, which was surprising since most of the ideas and changes in quality management come from Japan (Foster 2013).

Table 2. Publication per country

Country	No. Doc	Country	No. Doc	Country	No. Doc	Country	No. Doc
Germany	19	South Africa	6	Austria	3	Saudi Arabia	2
Russian Federation	17	Spain	6	Norway	3	Slovenia	2
India	15	China	8	Switzerland	3	South Korea	2
United Kingdom	11	Hungary	5	Finland	2	Thailand	2
Brazil	10	Slovakia	5	Japan	2	Turkey	2
Portugal	9	France	4	Malaysia	2	Vietnam	2
Czech Republic	8	Indonesia	4	Mexico	2	other	12
Italy	8	Morocco	4	Namibia	2		
Poland	8	Serbia	4	Nigeria	2		
United States	7	Taiwan	4	Romania	2		

4.3 Trends in Publishing

Over the years, the number of papers about quality 4.0 has grown at a rate of about 28 papers per year, which is a very fast rate as seen in Figure 3. Given the number of papers published on the topic before 2016, it's fair to assume that very little was known about the concept before 2016. Interestingly, our results are consistent with those reported by other authors, who also find that the number of papers addressing quality 4.0 has grown exponentially(Broday 2022; Maganga and Taifa 2023). Figure 4 shows the concentration of papers around the world. Areas with a lot of papers

are shown in deep red, while areas with a small number of papers are shown in green. The highest concentration of papers was in Germany and Russia, followed by India.

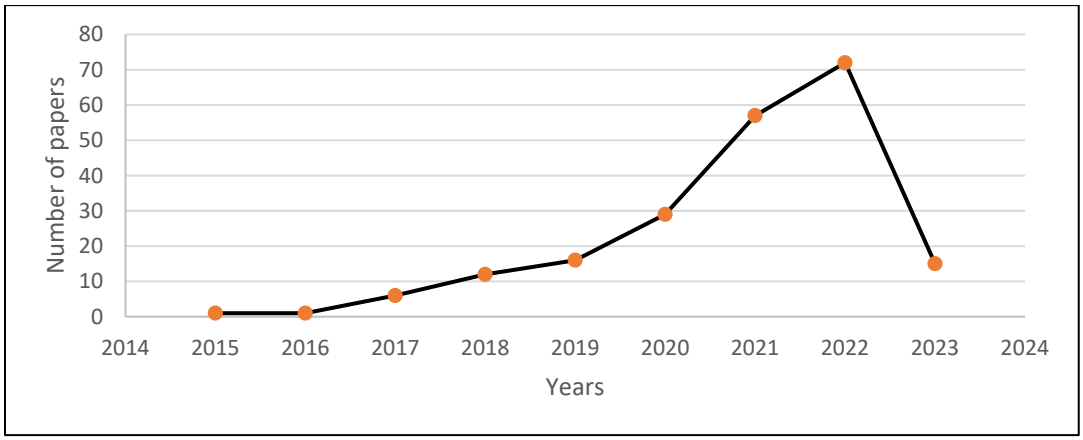

Figure 3. Trends in publishing

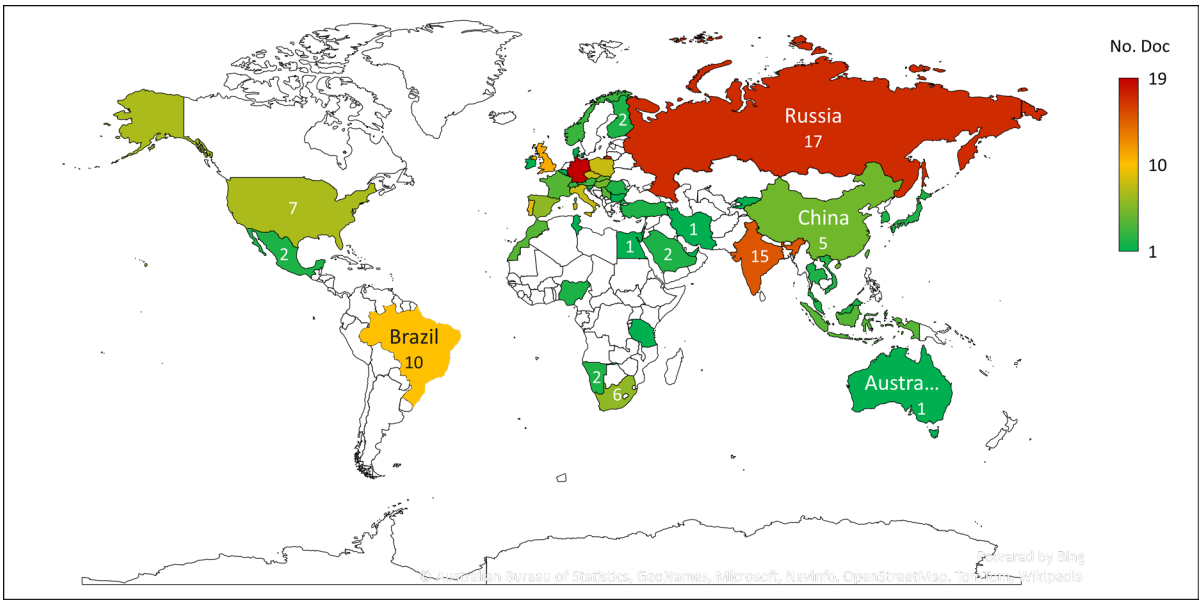

Figure 4. Concentration of papers

Figure 5 shows the number of papers from different sources. Most papers were from the TQM Journal (11), then the International Journal for Quality Research and Sustainability Switzerland, each with 7 papers.

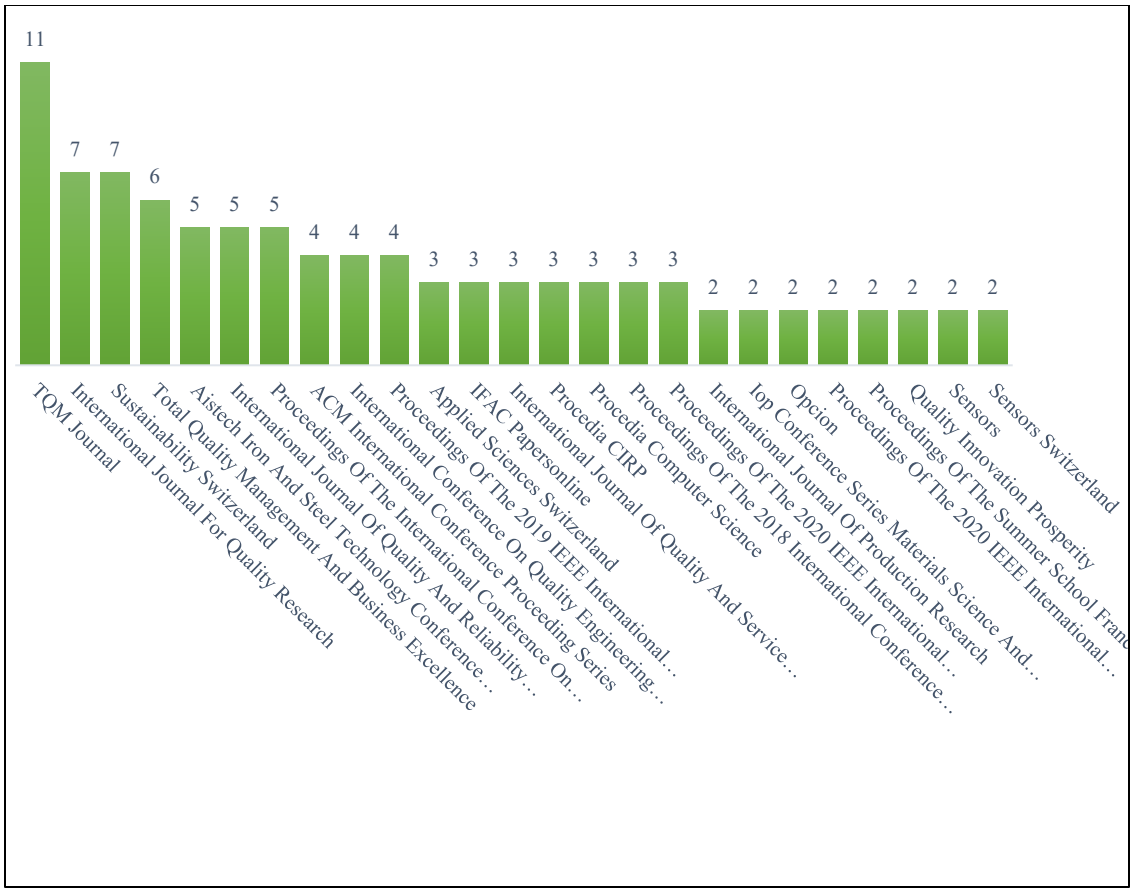

Figure 5. Source providers

4.4 What Quality 4.0 Means in Industries

Through discussions with researchers reading the 14 papers chosen for final qualitative analysis, we were able to determine what quality 4.0 meant to various industries. Since we used an inductive method of data analysis (Rajasekar, Philominathan and Chinnathambi, 2006; Saunders, Lewis and Thornhill, 2009; Sreejesh, Mohapatra and Anusree, 2014), we did not set off with a set of predetermined codes. For this study, we used the data analysis software NVIVO. The first step was to load the 14 papers into the program, and then we let the program generate the code structure on its own. We did this because we believe that doing so removes the researchers' subjectivity and yields insights that would have been impossible to gain through manual coding and thematic clustering. Even though the codes were made automatically, we had to go through the code structure again to make sense of them and get rid of the codes that we thought were not in line with the study's goals. In the end, we had 99 primary codes, which is what quality 4.0 is (see Figure 6 and Figure 7). Figure 7 shows that quality 4.0 in the industry seemed to be defined by a group of buzzwords like quality, management, data, research, product, technologies, process, system, and more.

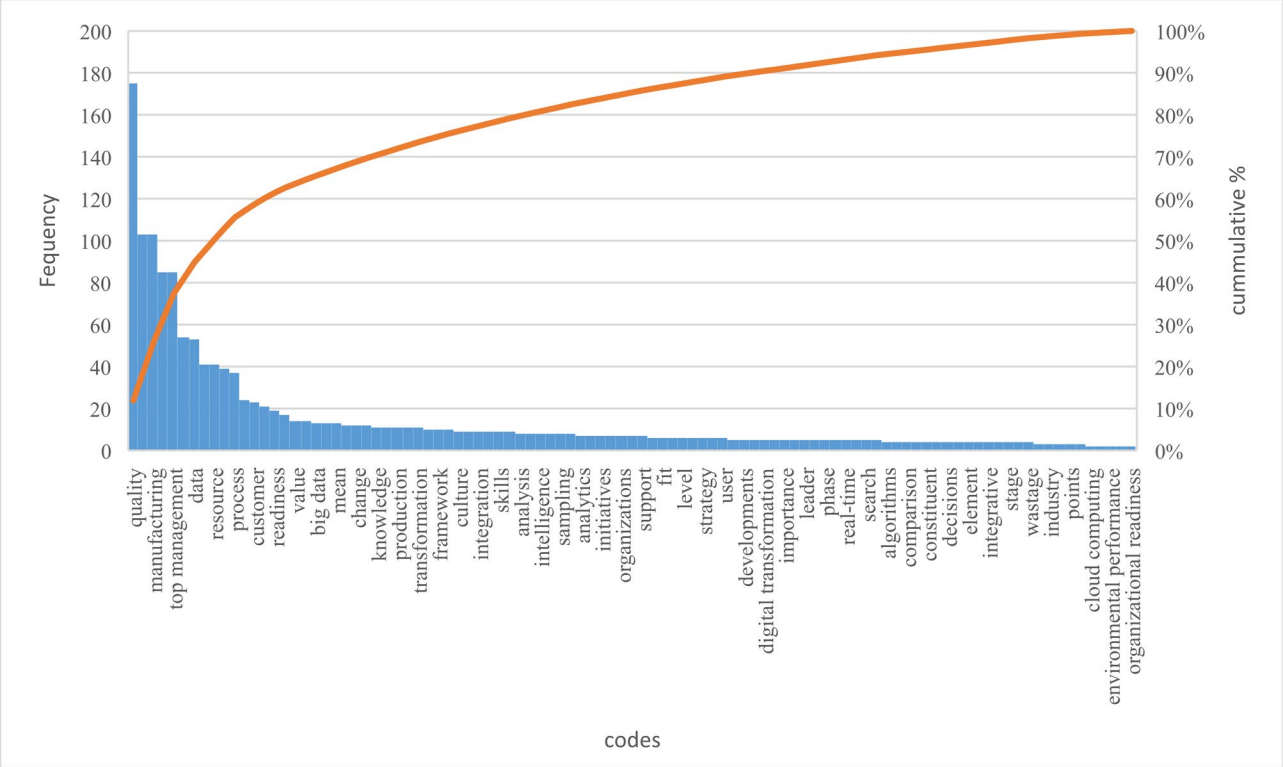

Figure 6. Thematic codes

Figure 7. What Quality 4.0 means in industries

We chose the top 20 themes for the top 5 codes and the codes we thought were most important for quality 4.0 (see Table 3). It seems as if the idea of "big data" is the most important part of "quality 4.0." Managers have to come up with plans for how to handle big data and electronic quality management systems. It seems like companies won't be able to make it in the quality 4.0 era if they don't learn how to deal with and learn from data.

Table 3. Top 20 themes for the top 5 codes

Management	Quality	Technological	Systems	Data
Agile program management	Critical quality characteristics	Automation technologies	Automated quality systems	Accurate data
Big data management	Acceptable quality levels	Communication technology	Autonomous measurement test system	Data verification
Big-data-driven quality management plans	Accomplishing quality objectives	Connected technology	Business system	Big data
Built-in quality management	Achieving quality	Digital technology	Cyber-multi-minded system	Big data analytics
Business process management	Aid quality professionals	Disruptive technologies	Cyber-physical systems	Big data capability
Change management program	Aligning quality management	Leveraging technology	Enterprise system	Big data challenges
Closed-loop quality management	Appropriate supplier relationship management	Modern technologies	Establishing systems	Big data handling capacity
Conflict management	Automated quality checks	Nanotechnology	Existing quality management system standards	Big data management
Customer relationship management	Automated quality systems	New-age technologies	Hybrid fault diagnosis system	Connecting data
Data-handling quality management reliable data productivity	Basic quality evolution theories	Technological advances	Management systems	Cross-functional data governance committee
Developing management systems	Quality control	Technological age	Multi-minded system	Customer product usage data
Digital quality management systems	Big data-driven quality management initiatives	Technological aspects	Organizational systems	Customer usage data
Effective managers	Big-data-driven quality management plans	Technological changes	Paper-based system	Data security complex
Efficient quality management	Built-in quality management	Technological disruption	Personal messaging system	Data analysis process
Electronic quality management system	Called quality	Technological factors	Physical systems	Data analytics
Emerging quality management concept	Clear quality focus	Technological folks	Quality management system	Data analytics models
Enterprise-wide data management capabilities	Closed-loop quality management	Technological innovation	Quality system	Data analytics skills
Existing quality management system standards	Commodities quality	Technology adoption	Recognition system	Data collection
Familiarising quality management concepts	Contact quality professionals	Technology barcodes	Reward system	Data exchange
Human resource management	Conventional quality	Advanced technologies	Self-induced correction systems	Data governance structure

4.5 Proposed Improvements

Quality 4.0 doesn't change the way quality management has been done in the past, but the capabilities that come with industry 4.0 technology make things better and smarter. This means that companies don't have to stop doing what they do now to implement quality 4.0. Quality 4.0 focuses on digital quality management, enterprise-wide quality data management, quality management that is driven by big data, innovation, and, most importantly, the ability to collect, manage, and use big data (Tambare *et al.*, 2022). Companies should adapt to changes in technology and build the skills they need to handle big data. It's important to keep in mind that quality 4.0 depends a lot on a stable power supply and high-speed internet as highlighted in Maganga and Taifa (2022). The critical success factors in implementing quality 4.0 include leadership support, accessibility of information, connectivity, training, scalability, quality culture, customer orientation, an effective quality management system, compliance, professionalism, analytical abilities, data-driven decision, innovation, and efficient implementation of quality.

4.5 Validation

The study employed theoretical triangulation as a strategy for validating the study's findings(Hoque, Covaleski and Gooneratne, 2013). There are a lot of discussions in the literature about how to assess the reliability of a qualitative study(Hadi and José Closs, 2016). However, there is no agreed method for calculating the reliability of qualitative

research, in general, qualitative researchers do not calculate the reliability of the study. The authors agreed that the reliability of qualitative research is based on the systematic processes used to carry out the study(Queirós, Faria and Almeida, no date; Hadi and José Closs, 2016). Other researchers should be able to follow the logic of how the study was conducted and why certain discussions were held during the research. Similarly, we used a systematic research method to ensure that other researchers could easily follow the logic and replicate the process used to conduct this research and come to similar conclusions. The findings of this study were similar to those of previous studies. For example, the studies of Broday (2022), Maganga and Taifa (2023) found exponential growth in the publications related to quality 4.0 since 2016, which is similar to what we found. We found that most of the papers from the TQM Journal reflect the same finding (Broday, 2022). We are confident of the study's validity and reliability as its findings are consistent with those of other researchers who conducted similar research.

6. Conclusion

The purpose of this study was to investigate the trends in quality 4.0, as well as to determine what exactly that term means for various industries. For this study, a systematic literature review was performed, and the Scopus database served as the primary research tool. The period from 2017 to 2023 is covered by the papers that were included in this study, and the predominant language used in those papers was English. We made use of 14 papers in our investigation into what it means for industries to have quality 4.0. In the study, qualitative data analysis, known as thematic coding, was utilized. Through inductive thematic coding, we were able to identify 99 codes that were connected to quality 4.0. According to the published research, quality 4.0 is unlikely to change the conventional strategy for quality management; rather, it will make things smarter, quicker and more intelligent. The findings of the study indicate that quality 4.0 is a broad term that touches nearly all aspects of quality management. Some of the ideas that are beginning to predominate discussion under the quality 4.0 umbrella include big data, electronic quality management, digital quality management, connectivity, cybernetics, data management, managing disruptions, simulation, and more. This study's findings were consistent with previous research, and we concluded that the study had both reliability and validity. In reviewing this study, it is worth noting that the study relied on a literature review, which means that some of the findings may need to be tested in future studies through interviews or other forms of empirical research. Because this study benefited from work published all over the world, we believe that generalizing the findings of this study will not be one of the study's limitations.

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