International Journal of Scientific Research and Management (IJSRM)
||Volume||12||Issue||11||Pages||1639-1647||2024||
Website: https://ijsrm.net ISSN (e): 2321-3418
DOI: 10.18535/ijsrm/v12i11.ec02

Mapping Research Themes and Trends in Ergonomics within Industry 5.0: A Bibliometric Analysis

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Abstract:
Industry 5.0, the next stage of development after Industry 4.0, centers around the seamless integration of individuals and technology inside industrial processes to foster innovation that prioritizes human needs and experiences. Industry 5.0 diverges from Industry 4.0 by placing greater emphasis on the collaborative partnership between humans and machines rather than solely focusing on automation and advanced technologies like IoT and AI. The study employs bibliometric analysis to delineate the subjects and research areas in ergonomics within the context of Industry 5.0. The study analyzed literature from the Scopus database to identify trends and gaps in implementing ergonomic principles across different industrial sectors. The study addresses two distinct research inquiries: identifying overarching research subjects and emerging research themes. The results indicate the existence of four primary research clusters: the interaction between humans and advanced technology, the safety of work and collaboration between humans and robots, the optimization of multiple purposes and sustainable development, and the application of augmented reality in industrial design. The report emphasizes the growing importance of human-robot collaboration and artificial intelligence while acknowledging a decline in emphasis on user experience and virtual reality. The findings thoroughly analyze the present condition and development of ergonomics research in Industry 5.0 while providing significant recommendations for future investigations and real-world implementations.

Keywords: Artificial Intelligence, Bibliometric Analysis, Ergonomics, Human-Robot Collaboration, Industry 5.0.

1. Introduction

Industry 5.0 is an evolution of Industry 4.0 that emphasizes the integration of man and technology into production process. If industry 4.0 focuses on automation and utilizing advanced technologies such as the internet of things (IoT), artificial intelligence (AI), and big data.

Intelligence machines and automation system in industry 4.0 are essential to optimizing production processes, minimizing costs, and improving operational efficiency. In industry 4.0, integrating tools and technologies hass proven to bring advantages such as sustainability, flexibility, and cost optimization [1]. This integrated approach focuses on data processing, communication, and automation to simplify operations and improve overall efficiency. However, these methods often ignore the humanistic element of the work process, which can affect workers'health.

Industry 5.0 emerged to answer this problem by taking the idea of human-tech collaboration. The industry 5.0 concept is in line with the idea that major technologies in various field, such ass production engineering, material science, and human factors are integrated to produce science based solution [2], which means that technology is no longer just a tool that replaces human functions, but rather a working partner that supports and enhances human abilities.

The human factor and ergonomics (HFE) principle is crucial in spreading artificial intelligence technology to optimize usability and interaction in workflows [3]. Furthemore, applying ergonomic principles is essential to assess and avoid ergonomic risks affecting health, safety, and labor productivity [4]. To enlarge opportunities and overcome obstacles, it is essential to harmonize human-centric approaches and methods with the application of digital technology in work systems that support Industry 4.0 [5]. Regarding supply chains, investments in ergonomics at the workplace can create more sustainable system designs from a technological, economic, and social point of view, ultimately improving overall efficiency [6].

Ergonomics in Industry 5.0 are crucial in many ways, as adaptive workplace designs adapt to employees' physical and cognitive needs. It includes optimal lighting, adjustable tables and chairs, and aids designed to reduce physical load [7]. Technological advances such as cobots and augmented reality allow employees to connect to systems and machines more easily and naturally. Ergonomic interaction is not only efficient but also a safe desire [8]. Using wearable technology and sensors can improve occupational safety and health, monitor the physical condition of workers in real-time, and help prevent work-related injuries and illnesses. Ergonomics help make the workplace safer [9]. Psychological well-being is when an ergonomically designed working environment takes care of employees' mental and physical health. Mental health and job satisfaction can be assisted by meaningful job design, social support, and flexible work arrangements [7], [8].

The primary objective of our research is to analyze bibliometrics to map the themes and topics of existing research on ergonomics in Industry 5.0. This research will provide a clear overview of how ergonomics is used and applied in various industries, as well as research trends that need improvement. By looking at the current references, we cand find best practices and create more efficient methods to implement ergonomics in the era of industry 5.0. To this goal, we have created two specialized research question (RQ):

RQ1 : What is a general reseach topic in ergonomics in industry 5.0?

RQ2 : What new research topics are e,erging in ergonomics in industry 5.0?

By addressing this RQ's new research topic of what is currently emerging in ergonomics in industry 5.0, our research seeks to offer an explicit and comprehensive overview of the current status and evolution of research. Furthermore, though the integration of bibliometric analysis, we strive to identify potential areas for future research and provide valuable insights to researchers and practitioners in the field of ergonomics in industry 5.0. The combination of these methods enables a deeper understanding of the existing knowledge set and paves the way for further exploration in this important field of study [10]. terials and Methods

2. Materials and Methods

To limit the data and fields generated from some databases, we restrict the use of the Scopus database, renowned for its comprehensive coverage, for our literature searches. Furthermore, the database has more articles and quotations that will offer ample information for comprehending scientific abstracts, research centers, and other associated data. The process of gathering this study data involves multiple stages. Figure 1 depicts the data-collecting procedure, which encompasses the selection of themes and the inclusion of bibliographic material for bibliometric analysis [11], [12], [13].

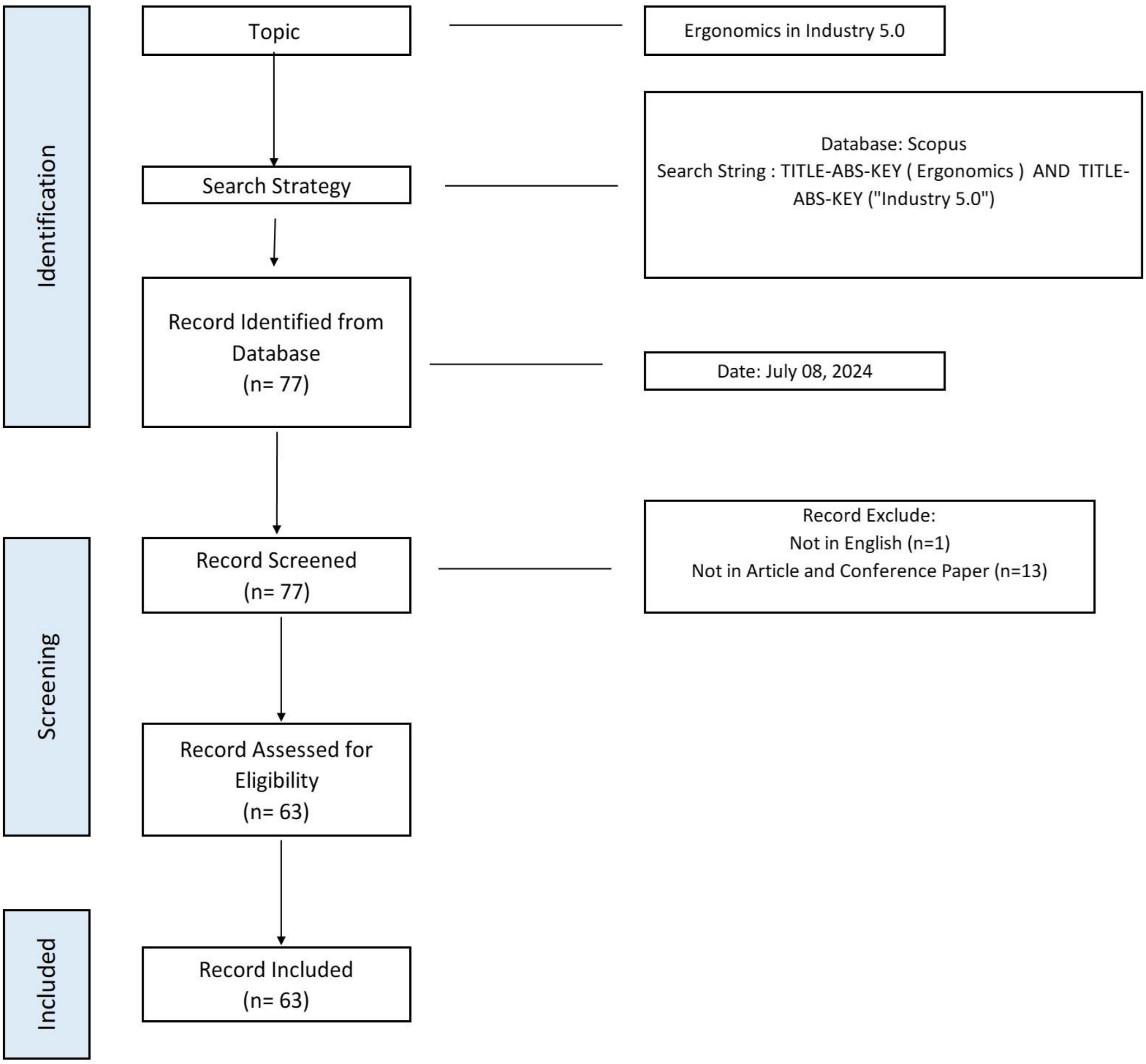

Figure 1: PRISMA Flowchart

The data collection procedure used in this investigation is based on and modified from the PRISMA flow diagram [14], as shown in Figure 1. On July 8, 2024, Scopus provided the data used. Ergonomics and "Industry 5.0" are two blocks of search terms used. This search is done based on the title, keyword, and abstract, which contain both search phrases. This research is limited to a maximum of 2024 due to the publication time limit. The type of article document and conference paper are other applied filters. The data collected is limited to English-language papers only. Eventually, two software programs, VOSviewer and BibliometriX, were used to process 63 bibliographic data successfully taken from Scopus [15], [16]. All the software is available for free download and useful for bibliometric analysis [17]. Projections of research status are made using bibliometrical analysis [18], [19]. Future purposes and work are described and explored through content analysis, an extension of cluster analysis derived from bibliometric analysis.

3. Result

This study use bibliometric analysis to provide an overview of the current research status on ergonomics in Industry 5.0. In order to offer a precise and quantitative overview of the most recent research on Ergonomics in the context of Industry 5, the descriptive findings will be presented initially. Subsequently, the modeling outcomes of network analysis derived from the combined event analysis and theme maps in relation to the study topics will be showcased.

To address RQ1 regarding the present level of research on general themes in ergonomics in Industry 5.0, visualizations generated by VOSviewer can be utilized. A joint event analysis graph illustrates the relationship between a research subject, its level of popularity, and the emergence of a cluster of related subjects. Joint events analysis is a method that can be employed to examine significant themes, subjects, or concepts identified in a publication [20]. The process of collaborative event analysis generates a network representation, as shown in Figure 2, that exposes the presence of four distinct clusters of subjects.

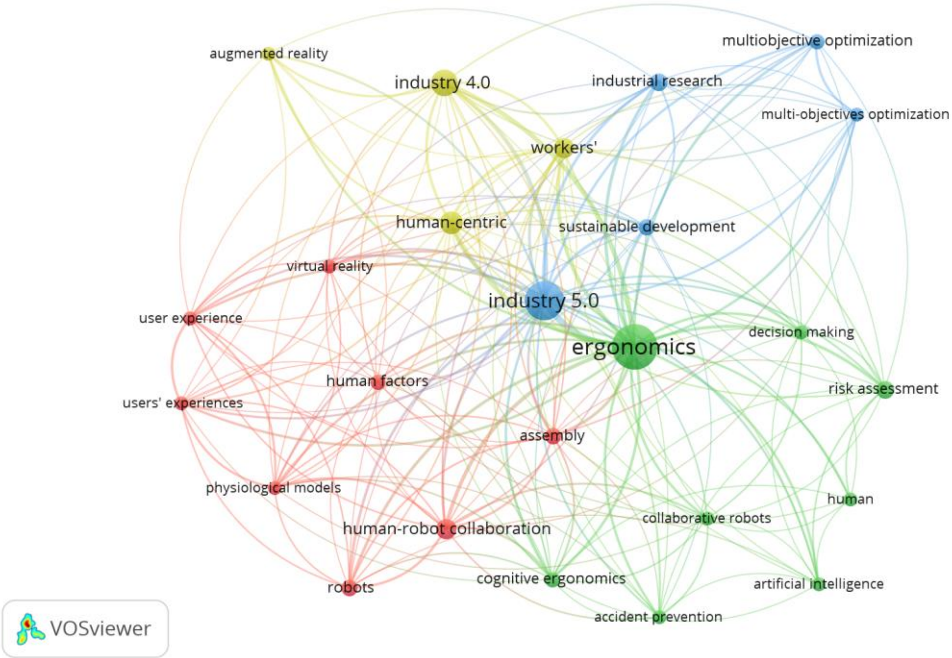

Figure 2: Four Clusters Created by Network Visualization from Co-Occurrence Analysis

The red cluster, discusses human interaction with advanced technology in an industrial context. Human-robot collaboration is the most popular topic in this cluster. Ergonomics in Industry 5.0, robotic collaboration, is an important research topic for optimizing workplace employee safety, efficiency, and wellbeing. Some studies have published that ergonomics in human-robot collaboration (HRC) increases workers' productivity and wellbeing [21], [22], [23]. The ergonomic workstation design is very useful for improving the physical ergonomy of operators and production efficiency [24]. Besides, the relationship between ergonomy, human-robotic collaboration, and lean manufacturing remains an active research topic that emphasizes the importance of considering factors related to human-robot collaboration [25]. Studies have shown collaborative robots can improve human ergonomic work by utilizing posture optimization and user monitoring techniques [26], [27]. Furthermore, it is essential to develop safe, ergonomically sound, and efficient methods of control for human-robot cooperation to the main objectives of HRC in the industrial environment, such as improving safety, wellbeing, profitability, and productiveness [28].

Green cluster to discuss occupational safety, decision-making, and human-robot collaboration in industrial contexts. Ergonomics is the most popular topic in this cluster. Ergonomics is at the heart of the theme, describing the need for modern industry today. In Industry 5.0, ergonomics is connected to human-centered concepts, workers, and sustainable development. Ergonomics emphasizes the creation of systems that integrate humans effectively, emphasizing workers' welfare and sustainability principles [29]. Multi-objective optimization is also important, as it links industrial research and multi-object optimization. Human-robot collaboration is key in discussing relationships with robots, cognitive ergonomics, artificial intelligence, and occupational accident prevention. Research has shown the importance of collaborative control systems based on human-robot dialogue as a choice of traditional control methods [30]. In addition, combining artificial intelligence with robots is thought to enhance capabilities and influence various field lines [31], [32]. Ergonomics are crucial to ensuring good collaboration between humans and robots, especially in areas such as construction that increasingly use human robots [33]. It is crucial to increase workers' safety and productivity. Imagination, human factors, virtual reality, user experience, physiological models, decision-making, and risk assessment are other elements of ergonomics.

Industry 5.0 is the most popular topic in blue cluster. This cluster focuses on industrial research, multi-objective optimization, and sustainable development in Industry 5.0. The core of Industry 5.0 is ergonomics, which is represented by several human-centric themes, sustainable development, and workers. According to recent research, ergonomic designs are very useful for improving productivity and safety at work. Their research on robotics and computer-integrated manufacturing stressed that ergonomics can improve workers' productivity and well-being [21]. Human-robot collaboration is also a major concern, as it is linked to various factors, such as robotics, cognitive ergonomics, artificial intelligence, and accident prevention. Mechatronics researches human-robot collaboration in the industry, focusing on safety, intuitive interface, and collaborative applications [34]. Ergonomics designs combine human factors and physiological models to ensure human-robotic collaboration runs safely and efficiently. Furthermore, technologies such as virtual reality in industry 4.0 and industry 5.0 show progress in creating a more interactive and user-friendly work environment. In general, the interrelationship of various elements describes how ergonomics became an important part of producing secure, efficient, and comfortable collaborative systems in the industry 5.0 era, with the support of sophisticated technology and a human-centric approach.

The yellow cluster focuses on augmented reality (AR) technology, a human-centric approach to industrial design, and the worker-centered concept of industry 4.0. Industry 4.0 correlates with augmented reality, virtual reality, and human-robot collaborations, which focuses on integrating digital technology and automation into the survival of industrial processes. On the other hand, industry 5.0 prioritizes a more human-centric approach, focusing on human-machine collaboration to increase workers'productivity and well-being. Ergonomics is a key factor in industry 5.0 since it is closely linked to decision making, cognitive ergonomics, accident prevention, and artificial intelligence. This highlights the significance of designing work environments that consider the human element to enhance efficiency and safety. This exemplifies that Industry 4.0 and Industry 5.0 encompass not only technological advancements but also the integration of technology with a focus on human considerations in order to establish a work environment that is both more efficient and safer.

In order to address RQ2 regarding the latest developments in ergonomics in Industry 5.0, thematic maps generated by BibliometricsX can be utilized. Cobo initially introduced this thematic map utilizing a strategic graphic technique divided into four quadrants [36].

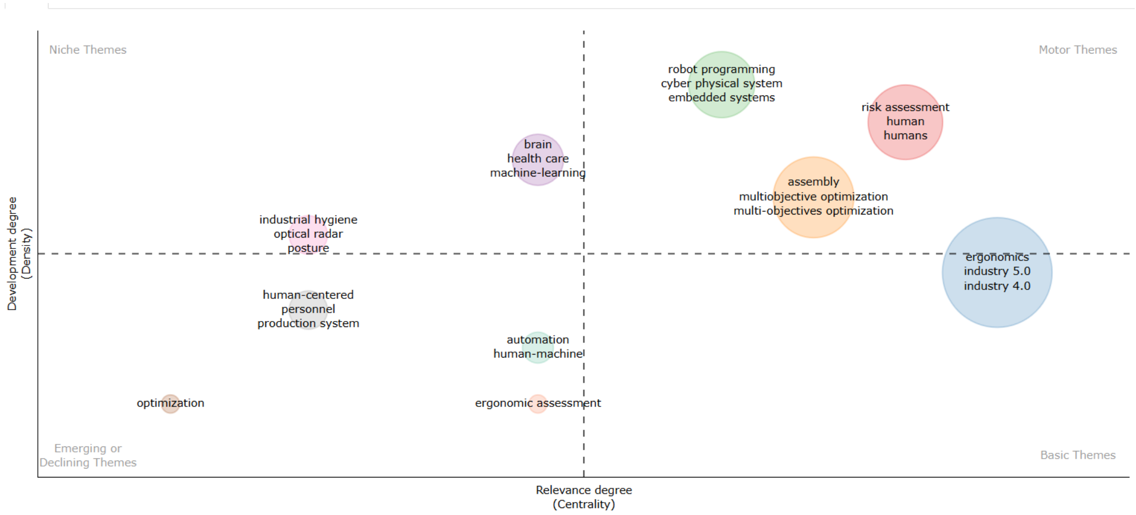

Figure 3: Strategic Diagram Showing 4 Quadrants With Their Respective Labels

This diagram classifies topics according to two dimensions: density and centrality. The dominant motifs exhibit greater elaboration, suggesting a strong internal coherence and an already established nature. The level of relevance or centrality denotes the significance or pertinence of an issue within the realm of inquiry. The themes on the right are more central, indicating their extensive interconnections with other themes and substantial effect.

The quadrant motor themes in the upper right quadrant are highly developed and serve as primary motifs. They possess significant influence and demonstrate a high level of maturity, driving the advancement of the scientific field. Some examples include programming robots, developing cyber-physical systems, and conducting risk assessments. The quadrant specialized topics on the top left are progressing satisfactorily without being overly centralized. They possess specific knowledge and exhibit robust internal growth, but their connection to other topics, such as industrial hygiene and optical radar, needs to be improved. The main concepts in the bottom right quadrant are of central importance, but they must be elaborated more. Although they possess fundamental characteristics and are closely linked, they require additional refinement.

An instance of this can be seen in the evaluation of ergonomics. Trends that are either growing or diminishing (shown on the bottom left) These topics encompass the expansion or contraction of sectors such as optimization and a personnel production system focused on human-centered approaches. To validate this, the results of the co-event analysis conducted with VOSviewer can be applied to the overlay visualization depicted in Figure 4. This overlay visualization illustrates the correlation between the occurrence of an event and the year of publication. It aids in determining whether a study area is experiencing growth or decline.

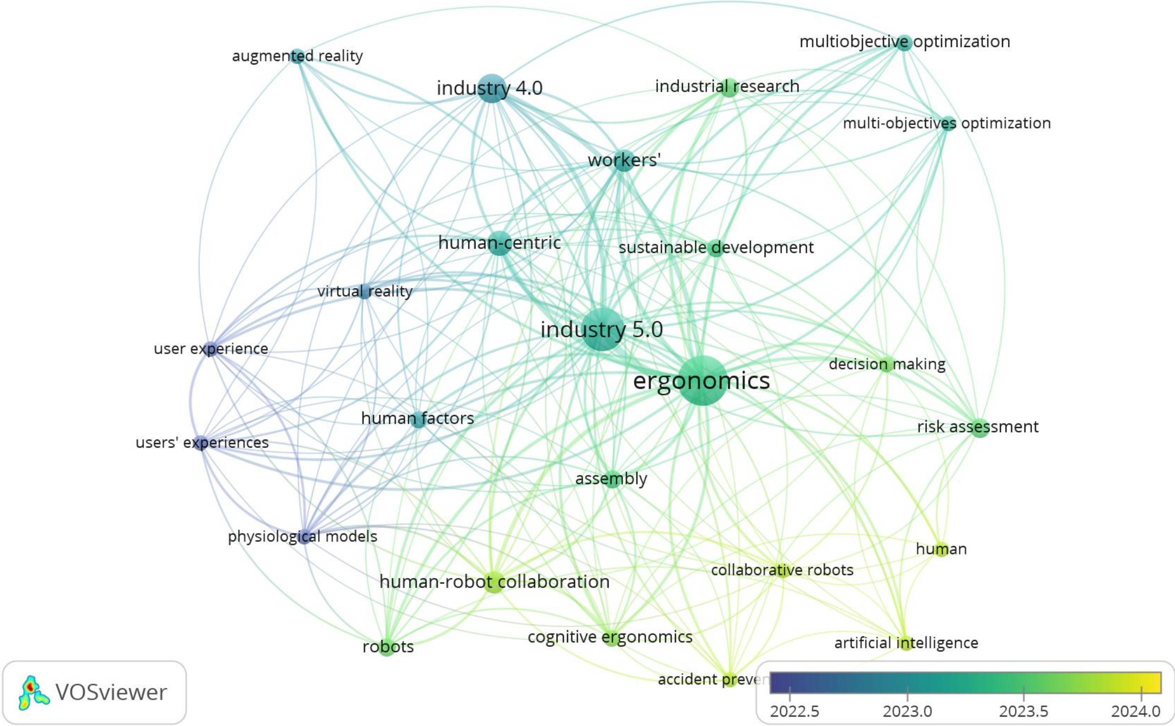

Figure 4: Overlay Visualization

The color node in data visualization is utilized to denote the mean age of publication of research topics. The transition from green to yellow signifies that the publication is recent, whereas the transition from green to blue signifies that it is outdated. Research topics associated with the green node are considered emerging topics, while topics with near-blue colors are considered declining themes. For instance, discussions regarding user experience, human aspects, and virtual reality are associated with shades of blue, suggesting that these topics are losing popularity. Human-robot collaboration, as a field of study, is associated with the burgeoning topic of artificial intelligence. This connection is symbolized by the color yellow.

4. Conclution

This study investigates the application of ergonomics in industrial 5.0 using bibliometric analysis.

1. This study categorizes research themes into four distinct groupings. Red cluster centers on the interplay between humans and advanced technology within an industrial setting. Green cluster, focuses on researching workplace safety, decision-making processes, and the collaboration between humans and robots in industrial settings. Blue cluster focuses on investigating industrial research, multi-objective optimization, and sustainable development within the industry. 5.0. Yellow clutter examines augmented reality (AR) technology, a human-centered approach to industrial design. Additionally, it explores the worker-centered notion of industry. 4.0.
2. Subsequent examination indicates that study areas about human-robot collaboration and artificial intelligence are progressing, but subjects such as user experience, human aspects, and virtual reality are experiencing a drop.

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