

Pilot Error in Aviation from a Human Factor Perspective: A Bibliometric Approach

Nil KONYALILAR¹

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Abstract

This study aims to examine scientific publications on pilot error in aviation using bibliometric analysis. The Scopus database was searched using the keywords "pilot error" and "aviation" at the title, abstract, and keyword levels; only studies published in English were considered. Data was collected as of September 2025 using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) method. The findings indicate a significant upward trend in publications on pilot error from 1946 to the present. Particularly since the 2000s, the increasing academic interest in human factors, flight safety, and automation has led to a notable increase in the number of publications. Most of these publications appear in sources such as SAE Technical Papers, Human Factors, and International Air Safety Seminar Proceedings, demonstrating the interdisciplinary nature of the topic. When examined by the author, Baker, S.P., and Li, G. were identified as the most productive researchers. Institutional distribution was highlighted by Johns Hopkins Bloomberg School of Public Health, Northern Illinois University, and NASA Langley Research Center, while national productivity was largely centered in the United States. This demonstrates the US's leadership in pilot error research and its strong academic infrastructure. Document type analysis revealed that most publications were articles (57.5%) and conference proceedings (33%). This finding demonstrates that the topic is actively addressed in both academic and applied research. Overall, the results demonstrate that pilot error research continues to receive increasing interest in the 21st century and has matured as an interdisciplinary field within human factors and aviation safety.

Keywords: Pilot error, Aviation, Bibliometric

JEL Code: R41, R49, D81, L93

1.Introduction

The aviation industry is a complex system characterized by high safety standards and advanced technology, yet the human factor still plays a critical role (Başdemir, 2020). Examining the causes of aviation accidents reveals that, in addition to technical malfunctions, human error accounts for a significant portion (Reason, 1990). Pilot error stands out as a fundamental issue directly affecting flight

¹ Assoc. Prof. Dr., Istanbul Topkapi University, nilkonyalilar@topkapi.edu.tr,
<https://orcid.org/0000-0002-7310-7779>

safety and has long been debated in aviation safety literature (Dismukes et al., 2017). Factors such as the pilot's decision-making processes, situational awareness, workload, training level, and interaction with automation are among the critical elements determining the safety of flight operations (Hart & Staveland, 1988).

The concept of pilot error is considered not merely as an individual failure but because of the interaction between humans, machines, and the environment. In line with this approach, studies in the fields of human factors, ergonomics, and system safety have increased, especially since the second half of the 20th century (International Air Transport Association, 2024). With the widespread adoption of flight automation, advancements in cockpit technologies, and increased operational complexity in the 2000s, academic interest in research on pilot error has further intensified. In this process, pilot error has become a mature research area addressed within an interdisciplinary framework encompassing disciplines such as aviation safety, human factors, automation, and risk management (Civil Aviation Safety Authority, 2021).

Presenting the scope, development, and trends of studies on pilot error in the scientific literature is of great importance for the systematic evaluation of the existing body of knowledge. Bibliometric analysis is a powerful method for identifying research trends, prominent authors, institutions, countries, and publication sources by examining the quantitative and qualitative characteristics of publications in a specific research area (Donthu et al., 2021). Through this method, the historical development and interdisciplinary nature of the field can be revealed more clearly.

This study aims to examine scientific publications dealing with pilot errors in aviation using bibliometric analysis methods, revealing publication trends, leading authors, institutions, countries, and publication types in the field. In this context, studies published in English and included in the Scopus database were examined, and the findings were analyzed to evaluate the current state of pilot error research and future research trends. This study aims to provide researchers in aviation safety and human factors with a comprehensive literature review and to contribute to the body of knowledge in these fields.

2. Literature Review

Aviation Safety and Pilot Error: Basic Concepts

Aviation safety is a fundamental concept encompassing all activities aimed at preventing accidents and incidents in the aviation sector (Kaspers et al., 2019). Safety does not simply mean preventing accidents altogether; rather, it refers to the process of identifying risks in advance, controlling hazards, and systematically managing potential errors (Reason, 2016). Indeed, aviation accidents often do not occur by chance; there are usually numerous warning signs and weaknesses that could have been foreseen in the process leading to an accident.

An aviation accident rarely results from a single direct error. In most cases, it occurs because of various causal factors accumulating over time, triggered simultaneously when existing defense mechanisms prove insufficient. In this process, a single error or negligence passing through incomplete, ineffective, or failed safety barriers forms the final link in the chain. Therefore, the fundamental aim of safety management is to prevent an undesirable and unsafe outcome by breaking the link at any stage of this chain leading to the accident (Wiegmann et al., 2005).

In the aviation sector, safety management aims to prevent loss of life and injury, reduce environmental damage, and prevent financial losses (Leveson, 2011). As in any environment involving the human element, safety is of vital importance in aviation (Moghimi Esfandabadi et al., 2023). However, in aviation, safety is a decisive factor for the sustainability of the sector. Aviation is an extremely complex system involving the interaction of numerous stakeholders, from manufacturers and maintenance personnel to ground services, air traffic control, flight crews, and passengers (International Civil Aviation Organization, 2018). The safe take-off and landing of a flight depend on the harmonious and error-free operation of all elements within this system.

This necessitates the existence of procedures aimed at preventing errors and negligence, as well as processes aimed at detecting potential deviations promptly. Aviation activities are carried out under equipment and working conditions that inherently involve certain risks (Janic, 2000). Therefore, aviation safety encompasses not only the safe operation of aircraft but also the protection of the health and safety of all personnel working behind the scenes of operations.

Definition and Classification of Pilot Error

Pilot error is defined as a situation where an action or decision made by the pilot directly causes or contributes to an aviation accident or serious incident (Kowalsky et al., 1974). In addition, the pilot's failure to take the necessary and correct action on time or to make the appropriate decision is also considered within the scope of pilot error. In this context, pilot error is considered not only as an individual failure but also because of the interaction between humans, machines, and the environment (Shappell & Wiegmann, 2003).

Pilot errors often stem from incorrect practices related to basic flight skills. Incorrect control of the aircraft, failure to properly execute basic maneuvers, or incorrect assessment of weather conditions are among the factors that negatively affect the safe conduct of flight. Such errors are generally related to the pilot's level of knowledge, experience, or attention, and can become more pronounced, especially under heavy workloads (Arnold, 2015; Zhu et al., 2024).

Furthermore, disruptions in communication processes also constitute a significant aspect of pilot error (Thorpe et al., 2022). Incomplete, erroneous, or misunderstood communication between pilots or between pilots and air traffic

controllers can pave the way for operational errors (McMillan, 1998). Incorrect frequency usage, incomplete or incorrect interpretation of instructions, and failure to share critical information on time are among the situations that directly threaten flight safety.

Another significant source of pilot error is problems in decision-making processes. A pilot's misjudgment of factors such as weather conditions, fuel status, aircraft performance, or operational limitations can lead to inappropriate decisions (Orasanu & Martin, 1998; Akbaba, 2025). Especially in emergencies or unexpected situations, incorrect decisions made under time pressure and stress can accelerate the process, leading to an accident (Ozel, 2001). Such errors are often associated with decreased situational awareness and increased cognitive load.

Finally, pilot errors can also occur within the context of teamwork (Helmreich, 2000). In multi-crew operations, the inability to effectively manage cooperation, communication, and task sharing among flight crew members poses serious safety risks. Lack of intra-crew coordination, imbalances in authority, and inadequate crew resource management practices can allow individual errors to go unnoticed, ultimately jeopardizing flight safety (Helmreich & Foushee, 1993; Akbaba, 2024).

Human Factors and Causes of Pilot Errors

A significant portion of aviation accidents stems not only from technical malfunctions but also from pilot errors and human factors (Maurino et al., 2017). Although modern aviation systems possess high technological reliability, the fact that these systems are operated by humans makes human factors a critical element in flight safety. Therefore, understanding the causes of pilot errors is of great importance in preventing accidents and increasing safety levels (Süzer, A. S. 2025).

Stress and fatigue experienced by pilots are among the fundamental factors negatively affecting human performance in aviation operations (Stokes & Kite, 2017). Long flight hours, shift work, time zone changes, and operational pressures can reduce the physical and mental capacity of pilots (Caldwell et al., 2009). Pilots working under fatigue and stress experience a decrease in attention levels, which negatively affects their decision-making processes. It is known that, especially under time pressure, stressed pilots become more susceptible to misleading information and tend to make quick but erroneous decisions.

The level of training and experience also plays a decisive role in the occurrence of pilot errors. Pilots who have received inadequate training or lack sufficient experience to handle complex and unexpected situations may struggle to make correct decisions during flight. In unusual circumstances, incorrect application of procedures or inappropriate maneuvers can accelerate the process leading to an accident (Dismukes et al., 2017). This highlights the importance of continuous training and scenario-based practice for aviation safety.

Communication deficiencies are also a common cause of pilot errors. Communication problems within the flight crew or misunderstandings between pilots and air traffic control can lead to incorrect decisions at critical moments (Alharasees et al., 2023). Incomplete, delayed, or incorrect information transmission reduces situational awareness and increases operational errors. These types of communication problems are particularly pronounced in multi-crew operations.

Pilots' decision-making processes become even more complex in stressful and emergencies (Craig, 1998). Incorrect decisions made under time pressure, high workload, and uncertainty can seriously threaten flight safety. Decision-making errors often do not occur in isolation; they manifest themselves in conjunction with factors such as stress, fatigue, lack of communication, and insufficient experience. Therefore, understanding pilot errors requires considering cognitive processes as well as individual performance.

Aviation accidents demonstrate that human error is not a singular event, but often the result of a chain of errors. Human error models explain that accidents occur as a result of sequential errors (Dekker, 2006). Factors such as distraction, perceptual errors, and delayed responses play a role at different stages of this chain. The Human Factors Analysis and Classification System (HFACS), developed by Shappell and Wiegmann (2000), addresses these types of errors within a systematic framework, making it possible to analyze the human factors underlying accidents more comprehensively.

Finally, the interaction between human factors and technical and operational elements also plays a significant role in the emergence of pilot errors. Inadequate or incorrect responses to technical malfunctions, incorrect application of procedures, or disregard of operational limitations can increase the impact of human error. Especially in multi-crew flights, incompatibility between technical systems and human performance can pave the way for accidents. As O'Hare and Wiggins (2004) also emphasize, ensuring flight safety requires a holistic approach encompassing human factors, technology, and operational processes.

Table 1. The Impact of Human Factors on Piloting Errors

The Human Factor	Types of Pilot Errors	Impact Level (Scale: 1-5)
Fatigue	Incompatible Landings	4
Stress	Wrong Route Tracking	3
Education Level	Communication Deficiencies	2
Experience	Late Departures	4
Communication Issues	Reporting Errors	3

In this context, Table 1, prepared to demonstrate the impact of human factors on pilot errors, shows the effects of fatigue, stress, training and experience level, and communication problems on different types of pilot errors, along with

the relative levels of these effects. The table clearly reveals the decisive role of human factors in flight performance and underlines the necessity of considering these factors in aviation safety studies.

3. Methods

For the research, a comprehensive search of the Scopus database was conducted using titles, abstracts, and keywords. The keywords "pilot error" AND "aviation" were used. In selecting relevant concepts, it was determined that both terms were the most widely used and established expressions in the research field (Exp. Dismukes et al., 2017; Li et al., 2001). Therefore, the research process was conducted based on these two fundamental concepts. To eliminate studies not directly related to the research method or content, certain document types were excluded from the scope of the study. Furthermore, only studies published in English were considered.

Bibliometric analysis is a research approach based on the examination of academic studies produced in a specific field using qualitative, quantitative, and statistical methods, and the identification of relationships and differences between these studies (Hoffman & Holbrook, 1993). This method is frequently used for comprehensive analysis of scientific production and the identification of the development dynamics of research fields, particularly in the social sciences (Verma & Gustafsson, 2020). Bibliometric data were obtained from the Scopus database, which covers a wide range of publications (Knani et al., 2022).

Data collection began in September 2025. In the first stage, a total of 257 publications were accessed. Studies not directly related to the topic were eliminated, and 247 publications were retained for analysis. Since this stage focused on research on pilot errors in the aviation sector, publications included within the scope of the keywords were used. In the second stage, document types such as notes, revisions, conference reviews, short surveys, retractions, and editorials were excluded, and the focus was on 238 publications. This was because the research specifically focused on articles that had undergone peer review and addressed the topics specifically. In the final stage, publications not directly related to the topic were manually reviewed and individually classified. The final analysis was performed using these selected publications (n=233). For the data collection phase, the Preferred Reporting Elements for Systematic Reviews and Meta-Analyses (PRISMA) method developed by Moher et al. (2009) was adopted. This method consists of four stages: identification, screening, suitability, and inclusion. The PRISMA scheme is shown in Figure 1. During the analysis process, studies were evaluated in terms of publication year, author, institutional affiliation, country, document type, and subject area.

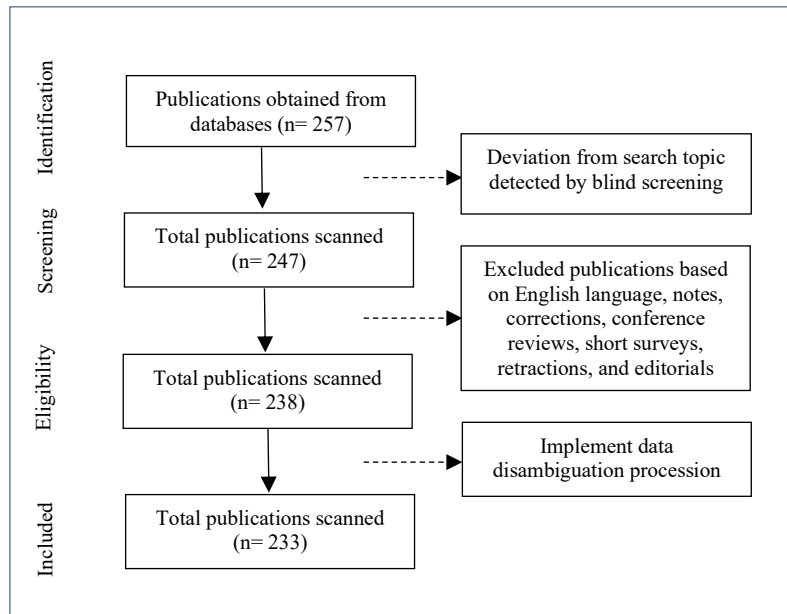
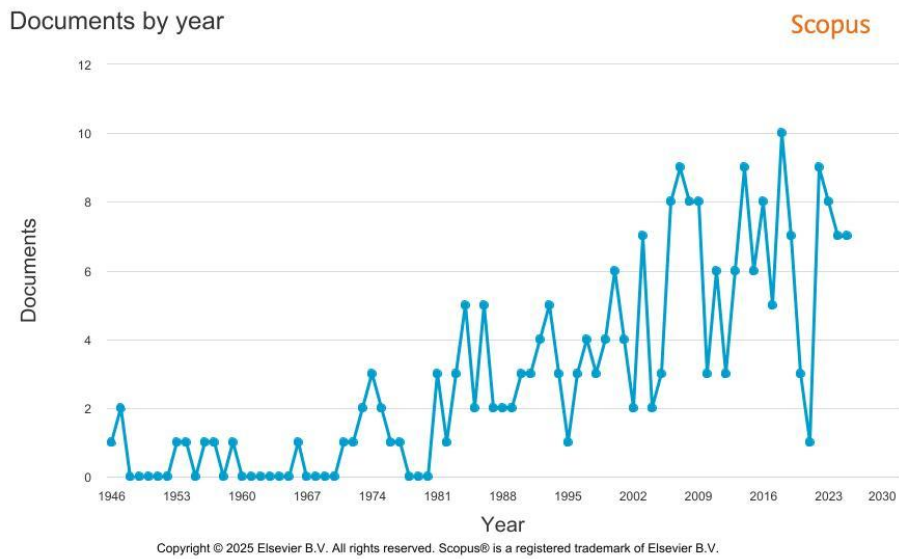


Figure 1. PRISMA diagram

4. Results

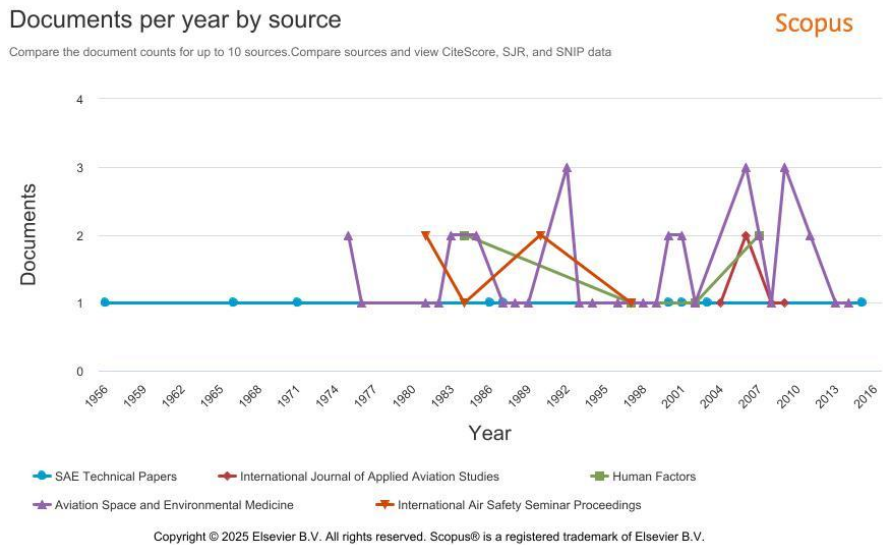
When Graph 1 examines the distribution of scientific publications on pilot error in the aviation field by year, it is seen that a limited number of studies have been published since 1946, but a significant upward trend has emerged since the 2000s. A relatively low number of publications were produced between 1946 and 1980, which can be attributed to the lack of systematic development in the field of human factors. As human error, ergonomics, and flight safety gained academic prominence from the 1980s onward, a gradual increase in the number of publications was observed. In the post-2000 period, publication productivity reached its highest levels, particularly between 2010 and 2020, with an average of 7–10 studies published annually. This increase can be explained by increased awareness of the association between human error and aviation accidents, research on the effects of flight automation on pilots, and scientifically grounded studies of applications such as Crew Resource Management (CRM). While minor fluctuations in the number of publications have been observed since 2020, it appears that the topic remains an active and relevant area of research.



Graph 1. Documents by Year

Secondly, the research examined the publication sources of pilot error publications. Chart 2 shows the publication sources on pilot error in aviation by year. The data shows that studies in this field are scattered across journals and conference resources, but some resources are more influential than others. From the 1980s onward, there was a notable increase in publications on pilot error, particularly in the journals "International Air Safety Seminar Proceedings" and "Aviation Space and Environmental Medicine". This demonstrates the increasing importance of applied research on aviation safety and human performance from this period onward. In the 1990s, in addition to these two sources, a significant increase in publications was also observed in the journal *Human Factors*, demonstrating that the subject was beginning to be scientifically addressed within the human factors discipline.

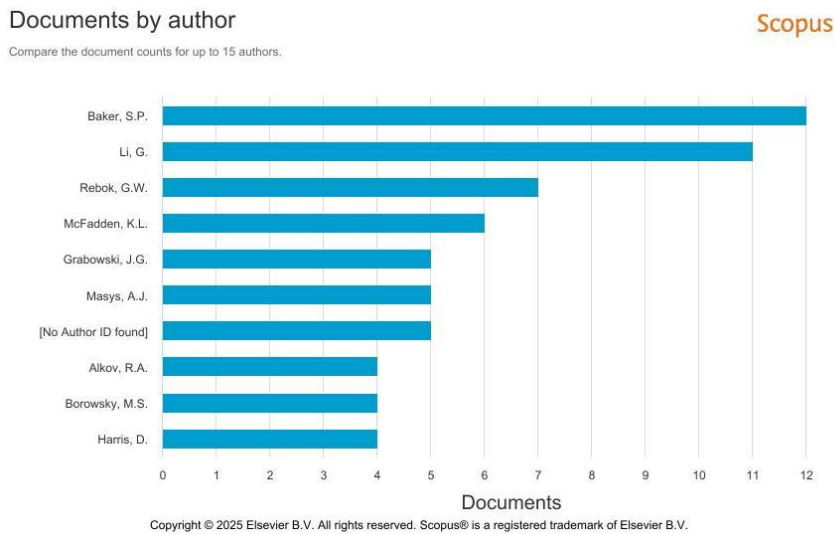
After the 2000s, the distribution of publications became more balanced, with fewer but consistent publications, particularly in sources such as *SAE Technical Papers* and the *International Journal of Applied Aviation Studies*. This demonstrates that the topic has reached a certain level of maturity and has spread across numerous academic journals. Overall, the graph shows that pilot error research is not concentrated in a single journal or conference series; instead, it is published across multidisciplinary fields such as aeronautical engineering, human factors, and safety studies. This demonstrates that the topic has become an interdisciplinary field of research, addressing both technical and behavioral dimensions.



Graph 2. Documents per Year by Source

Third, the study examined authors publishing in this field. Chart 3 shows the distribution of authors in publications on pilot error in aviation. The data show that Baker, S.P., is the most productive author in this field, followed by Li, G., Rebok, G.W., McFadden, K.L., Grabowski, J.G., and Matsys, A.J. The ranking in the chart indicates that the first two authors (Baker and Li) have significantly more publications than the other researchers, indicating the presence of pioneering researchers who have shaped the pilot error literature. In particular, the collaborative work of Baker, S.P., and Li, G. on human factors, aviation safety, and accident causal analysis can be considered significant contributions that form the foundation of the literature in this field.

Researchers such as Rebok, McFadden, and Grabowski generally stand out with their work on team performance, human-machine interaction, and organizational safety culture. This demonstrates that pilot error research does not focus solely on individual errors but also encompasses systemic and environmental factors. While the contributions of lower-ranking authors such as Alkov, Borowsky, and Harris are more limited, they appear to have made valuable contributions to different subfields of the topic (e.g., training, simulation, or operational safety). Overall, the graph reveals that pilot error research developed under the leadership of a core group of authors, but over time, numerous other researchers contributed, transforming the field into a multi-authored and collaborative structure.



Graph 3. Documents by Author

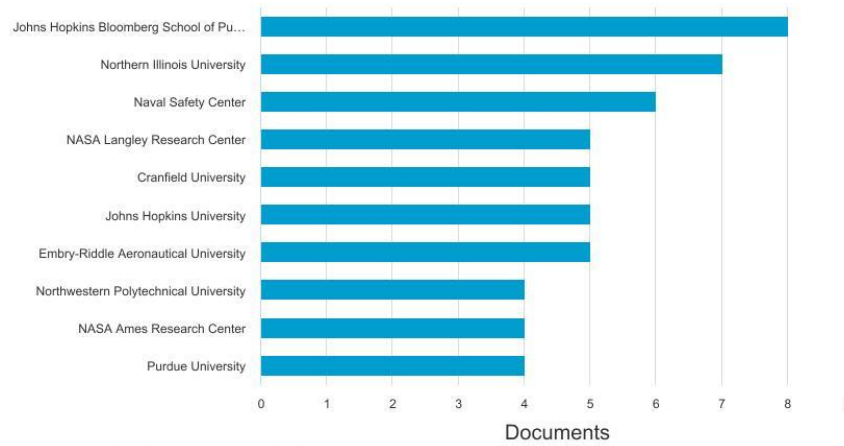
Fourth, the study examined the distribution of institutions producing relevant publications. Chart 4 shows the distribution of publications on pilot error in aviation by affiliation. According to the data, the institution with the highest number of publications in this field is the Johns Hopkins Bloomberg School of Public Health. This institution stands out with its work on aviation safety, human error, and accident analysis from a public health perspective. It is followed by Northern Illinois University and the Naval Safety Center. This distribution demonstrates that pilot error research is conducted not only at engineering-based institutions but also by institutions operating in the health, safety, and behavioral sciences fields. The dominance of Johns Hopkins University-affiliated units in literature reflects academic leadership in human factors and safety culture.

Institutions such as NASA Langley Research Center and Cranfield University are notable for their technical research focused on flight safety and human-machine interaction. Their work generally focuses on flight simulations, human performance assessments, and aviation system safety models. Additionally, aviation-focused education and research institutions such as Embry-Riddle Aeronautical University, NASA Ames Research Center, and Purdue University are also making significant contributions. These institutions generally conduct pilot training, operational safety, error management, and simulation-based research. Overall, the chart demonstrates that pilot error research is conducted in an interdisciplinary manner, with strong collaboration among both academic institutions and research centers. This demonstrates that scientific production in the field of aviation safety is approached not only from a technical perspective but also from a broad perspective encompassing human factors, psychology, and organizational behavior.

Documents by affiliation

Compare the document counts for up to 15 affiliations.

Scopus

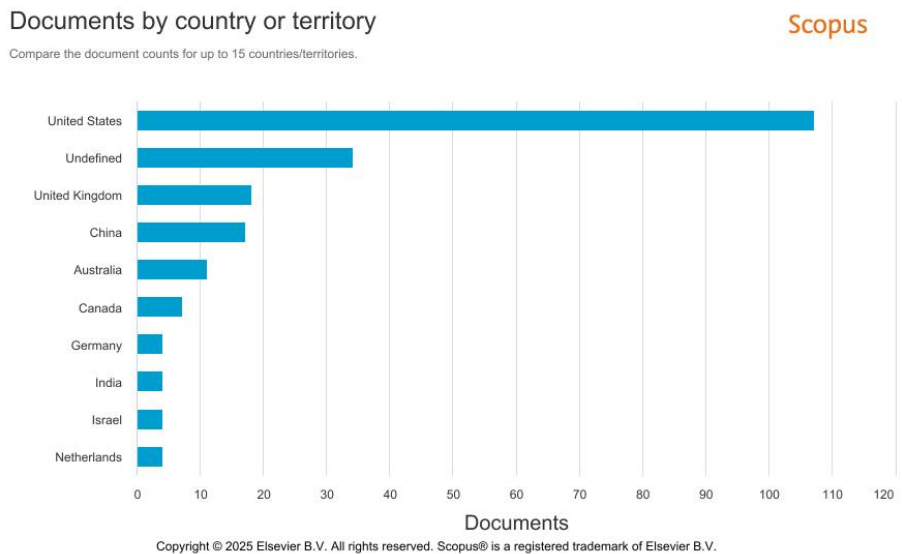


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Graph 4. Documents by Affiliation

Fifth, country distribution was evaluated. Chart 5 shows the distribution of publications on pilot error in aviation by country. According to the data, the United States (US) has by far the highest scientific production in this field. The US has over 100 publications, significantly outpacing other countries. This reflects the US's historical and structural superiority in aviation research, as well as its institutional research capacity in human factors, flight safety, and accident causation analysis. The "Undefined" group, second on the list, consists of studies with unclear institutional or geographical information in the database. This category typically arises from multinational research projects or reports with incomplete institutional identification.

The US is followed by countries such as the United Kingdom, China, Australia, and Canada. Research in these countries is generally based on collaborations between national aviation safety agencies, military research centers, and universities. The United Kingdom and Australia have strong academic backgrounds in human factors and flight psychology. Contributions from countries with lower publication numbers, such as Germany, India, Israel, and the Netherlands, are generally concentrated in specific thematic areas—for example, flight training, pilot performance assessment, or simulation technologies. Overall, the chart demonstrates the decisive leadership of the United States in pilot error research, while English-speaking countries (the United States, United Kingdom, Australia, and Canada) contribute significantly to academic production in this field. This is directly related to both the strong aviation industry and safety culture in these countries and the fact that English is the language of scientific publishing.



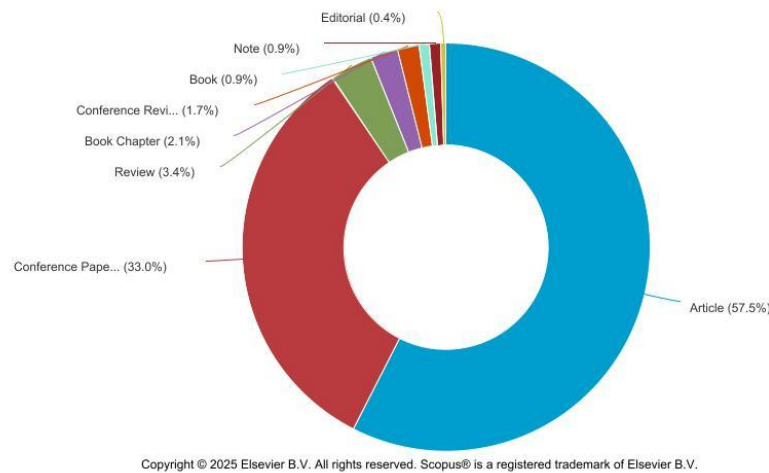
Graph 5. Documents by Country

The sixth most important publication type was examined. Chart 6 shows the distribution of publications on pilot error in aviation by type. According to the data, articles constitute the vast majority of studies in this field. Approximately 57.5% of the total publications are in the form of articles. This rate demonstrates that the subject of pilot error is primarily addressed through scientific research published in academic journals and that the theoretical foundations of the field have been strongly developed. Conference papers, which ranked second, account for 33% of total publications. This demonstrates that international conferences on topics such as aviation, safety, and human factors are important platforms for knowledge sharing. The high proportion of conference papers demonstrates that research in this field is practical, dynamic, and constantly evolving.

The proportion of publications in other types is quite low: 3.4% are reviews; 2.1% are book chapters; 1.7% are conference reviews; and 0.9% are books and notes. Editorial only accounts for 0.4%. This suggests that the field of pilot error is dominated by empirical and applied studies rather than reviews or theoretical discussions. Overall, the graph reveals that the majority of publications in the literature are produced in the form of scientific articles and conference proceedings, making the subject an academically active and research-based field. Furthermore, the limited number of publications in the form of reviews and books demonstrates that the field still needs to develop holistic theoretical frameworks.

Documents by type

Scopus



Graph 6. Documents by Type

5. Conclusion and Discussion

This study aims to reveal the historical development, current trends, and academic structure of the field of pilot error in aviation by examining scientific publications on the subject using bibliometric analysis. Analysis of studies published between 1946 and 2025 and included in the Scopus database shows a significant increase in pilot error research, particularly in the 21st century. This finding indicates that despite the technological advancements in aviation systems, the human factor retains its decisive role in flight safety and has even become more complex.

The results show that pilot error research was represented by a limited number of studies for many years; however, since the 2000s, there has been a significant increase in the number of publications due to the growing interest in topics such as human factors, automation, decision-making processes, and crew resource management (Dismukes et al., 2017; Reason, 2000). The increase in publication density, particularly between 2010 and 2020, suggests that large-scale aviation accidents and discussions on automation-human interaction during this period triggered academic research. This situation reveals that pilot error is no longer considered merely an individual problem but a systemic safety issue.

An examination of the distribution of publication sources shows that studies are not concentrated in a single journal; rather, they are spread across sources belonging to different disciplines, such as SAE Technical Papers, Human Factors, and International Air Safety Seminar Proceedings (Shanmugam & Paul Robert, 2015). This finding confirms that the topic of pilot error has become an interdisciplinary research area at the intersection of different fields such as engineering, psychology, ergonomics, and safety management. Similarly, an examination of publication types shows that articles and conference papers dominate, indicating that the field has both a strong theoretical and applied aspect.

Authors, institutions, and country analyses point to a significant academic centralization in the pilot error literature. The pioneering roles of researchers such as Baker S.P. and Li G. demonstrate the influence of certain core researchers in shaping the field. The prominence of institutions like the Johns Hopkins Bloomberg School of Public Health and the NASA Langley Research Center at the institutional level demonstrates that pilot error research is being addressed not only from an aerospace engineering perspective but also from public health and human performance perspectives (Thomas, 2016). On a national level, the United States' clear leadership can be explained by its strong academic infrastructure, the size of its aviation industry, and its advanced safety culture.

In conclusion, this study shows that pilot error research is being addressed with increasing interest, that the field is maturing, and that it has become interdisciplinary. However, since bibliometric analysis only provides a quantitative perspective, it is recommended that future studies delve deeper into the field using methods such as content analysis, thematic mapping, and comparative country analyses. Furthermore, investigating how the increasing role of automation, AI-powered cockpit systems, and remote piloting are transforming the concept of pilot error will make significant contributions to the literature. In this respect, the study provides both a systematic overview of the existing literature and a guiding framework for future research.

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