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Enhancing Aviation Safety: The Role of Mentorship and Coaching in Developing Skilled Pilots and Ground Crew

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Abstract

Aviation safety is heavily influenced by the quality of human resources, particularly pilots and ground crew. Although technology has advanced significantly, human error remains the primary cause of aviation accidents; therefore, strengthening both technical and non-technical competencies through effective human resource development strategies is essential. This study aims to explore the role of mentorship and coaching in improving aviation safety by enhancing the technical and non-technical skills of pilots and ground crew. The study employed a systematic literature review (SLR) approach based on PRISMA guidelines. Of the 194 studies initially identified, 34 articles met the inclusion criteria and were analyzed in depth using VOSviewer and Biblioshiny for thematic mapping and bibliometric visualization. The findings indicate that mentorship is effective in fostering a culture of safety, confidence, and professionalism, while coaching enhances technical performance through structured feedback and simulation-based approaches. Approximately 35% of the reviewed studies reported improvements in non-technical skills, while 26% demonstrated positive impacts on safety outcomes. The integration of mentorship and coaching forms a holistic competency framework that positively influences operational safety. This study concludes that mentorship and coaching are strategic instruments for enhancing aviation safety and should be systematically integrated into formal aviation training programs. This research contributes to the aviation safety literature by synthesizing evidence-based mentorship and coaching practices and providing practical guidance for developing integrated human resource development frameworks within the aviation industry.

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INTRODUCTION

Aviation safety is a critical priority in the global aviation industry, as public confidence in air transportation relies heavily on the system's ability to ensure passenger safety (Kim & Lee, 2022). Although aircraft technology has experienced rapid advancements, the human factor continues to be one of the primary contributors to aviation incidents (Deshmukh & Majumdar, 2025; Kaya & Göçmen, 2025; Lázaro et al., 2024). Both pilots and ground crew carry significant responsibility in executing flight operations safely, making continuous skill development essential to meet increasing operational complexity (Darmawan et al., 2025; Folke & Melin, 2024). In practice, pilots must master

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decision-making, emergency response, and advanced technical skills supported by simulation-based training (Lopes et al., 2025; Zhang et al., 2025), while ground crew must perform tasks such as inspections, refueling, and baggage handling with high precision to prevent safety risks (Bor et al., 2025; Firlej, 2025).

The aviation sector also has a strategic role in supporting global connectivity, economic growth, and technological innovation, aligning with SDG 8 and SDG 9 (Cele & Zou, 2025; Nguyen, 2024). This context demands enhanced competencies across human resources. Mentorship and coaching have therefore emerged as promising approaches for improving both technical and non-technical skills, contributing to professional character formation, situational awareness, and adaptability to operational demands (Cordova, Parsons-Daisley, et al., 2024; Rouco & Sousa, 2024; Tinoco-giraldo et al., 2022). Several studies highlight the positive impact of structured mentoring on pilot performance and retention (Cordova, Captain, et al., 2024), while coaching has been shown to strengthen leadership, teamwork, and task-specific competencies, especially in maintenance and ground operations (Littlepage et al., 2016).

Despite the growing evidence supporting mentorship and coaching, existing literature reveals several persistent challenges. Many studies tend to examine pilots and ground crew independently rather than adopting an integrated human factors approach (Rodriguez, 2024; Sant'Anna & Hilal, 2021). Other studies tend to focus on descriptive outcomes, such as general improvements in safety culture or teamwork, without evaluating long-term impacts, reductions in operational incidents, or systematically standardized program designs (Okine et al., 2025;Terzioğlu, 2024). In addition, research indicates that disparities in training quality across regions are influenced by variations in organizational resources, cultural factors, and limitations in training standardization. National culture has been shown to affect safety-related behaviors, including communication, teamwork, and decision-making, suggesting that training models developed within one cultural context may not be equally effective when applied in different cultural settings (Liao, 2015; Pratama & Caponecchia, 2025). Furthermore, qualitative comparisons among pilots from diverse cultural backgrounds demonstrate that cultural dimensions such as power distance and social norms significantly shape perceptions of safety culture and training outcomes (Liao, 2015). These gaps show the need for more comprehensive frameworks that integrate mentorship and coaching for both pilots and ground crew while addressing contextual variations in implementation.

In addition, several studies indicate that effective mentorship and coaching require organizational commitment, resource allocation, and supportive safety governance structures to achieve sustainable results (Lestari et al., 2025; Li et al., 2021; Wijaya & Puterisari, 2025). Variations in institutional culture, supervisory quality, and workload distribution often influence how well aviation personnel can internalize the competencies gained from these programs (Li et al., 2021; Pratama & Caponecchia, 2025; Teperi et al., 2023). Furthermore, prior research highlights that inconsistencies in instructor expertise and feedback practices, together with the lack of harmonized evaluation standards, can weaken the overall effectiveness of mentorship and coaching initiatives in aviation training (Hong et al., 2016; Shamsiev, 2022; Szawranskyj & Choudhury, 2025). These limitations suggest that the aviation industry still requires a more integrated, data-driven approach to workforce development one that links human factors training directly with measurable safety performance outcomes.

Given these challenges, this study aims to analyze and evaluate the role of mentorship and coaching in developing skilled pilots and ground crew by examining their contributions to technical competence, non-technical skills, decision-making, and adherence to safety protocols. This analysis includes a systematic literature review to synthesize existing evidence, assess program effectiveness, and identify areas requiring standardization and long-term evaluation.

The novelty of this research lies in its dual focus on pilots and ground crew within a unified mentorship–coaching framework, supported by empirical evidence from international cases, and grounded in SDG principles. This approach advances the scientific understanding of aviation human resource development and provides practical insights for improving safety innovation, reducing human error, and strengthening workforce competencies. Furthermore, this research emphasizes the urgent need for harmonized training strategies that incorporate both interpersonal learning and technical skill-building, ensuring the consistent development of aviation personnel across diverse operational contexts.

METHOD

Research Design

SLR Approach

This study uses a systematic review approach to examine the role of mentorship and coaching in developing the competencies of pilots and ground crew, as well as their contribution to improving aviation safety. In this context, the systematic review refers to a structured method of collecting, selecting, and synthesizing previous empirical studies related to mentorship and coaching in the aviation sector. The goal is to identify consistent patterns, impacts, and gaps regarding how these training approaches influence safety outcomes (Szawranskyj & Choudhury, 2025). This approach follows the **Prism** (Preferred Reporting Items for Systematic Reviews) guidelines which have proven to be effective in ensuring that the literature selection and synthesis process is carried out in a transparent and structured manner (Page et al., 2021; Rethlefsen et al., 2021; Tricco, 2018). The data is visualized using the VOSviewer application, which displays relationships between articles, authors, and topics in the form of Overlay Visualization and Network Visualization(Eck & Waltman, 2010; Husaeni & Husaeni, 2022) . This visualization is very helpful in understanding the patterns of linkages in the literature analyzed. As a complement, the data was also analyzed using Elicit AI, a web-based platform that supports the process of drafting research questions, literature reviews, and evidence-based decision-making. Before using Elicit AI, the previously cleaned CSV file is filtered back using Microsoft Excel to identify the articles available in PDF format. As a complement, the data was also analyzed using Elicit AI, a web-based platform designed to support automated evidence extraction and synthesis. In this study, Elicit AI was used to (1) automatically retrieve key information from each article, such as research questions, methods, findings, and conclusions; (2) assist in grouping studies based on thematic similarity; and (3) enhance the consistency of data extraction by reducing human error and ensuring that relevant evidence was captured systematically. Before processing the data through Elicit AI, the cleaned CSV file was filtered using Microsoft Excel to ensure that only articles with accessible full-text PDF files were included in the analysis. The figure 1 shows the Systematic Literature Review (SLR) process used in this study to select and filter articles according to predetermined criteria.

To ensure methodological clarity and alignment with systematic review standards, the literature search was conducted using structured Boolean keywords across several academic databases. Keywords related to aviation safety, human factors, mentorship and coaching, pilot and ground crew training were combined to capture comprehensive and relevant studies. The search was restricted by publication year, language, and document type to maintain focus on recent and high-quality evidence. All retrieved records underwent an initial screening of titles and abstracts, followed by full-text evaluation based on predetermined inclusion and exclusion criteria to ensure that only methodologically sound and thematically relevant studies were included in the final dataset.To strengthen the rigor of the review process, a multi-step validation and reliability procedure was implemented. A subset of articles was independently reviewed by more than one evaluator to assess consistency in screening and data extraction. Differences in interpretation were discussed until consensus was achieved, and the coding framework was refined where necessary. Quality appraisal tools were also applied to assess methodological robustness, ensuring that the findings synthesized in this review are grounded in credible and reliable evidence.

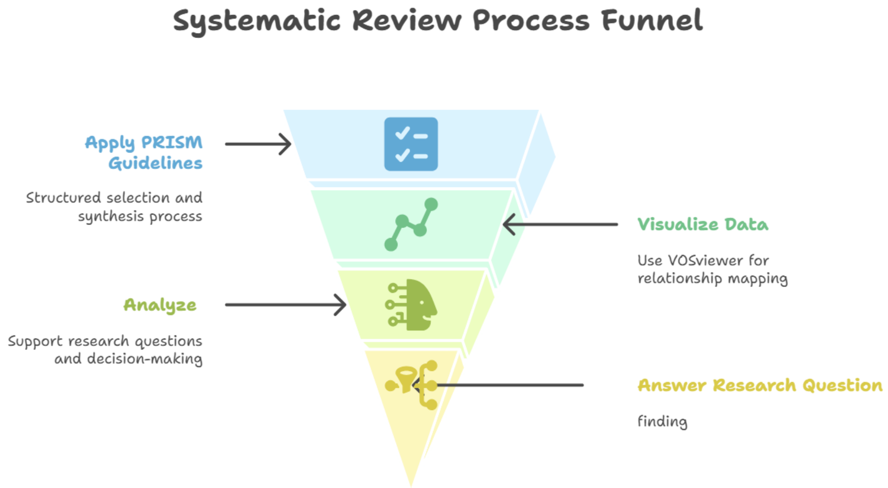

Figure 1. SLR Process

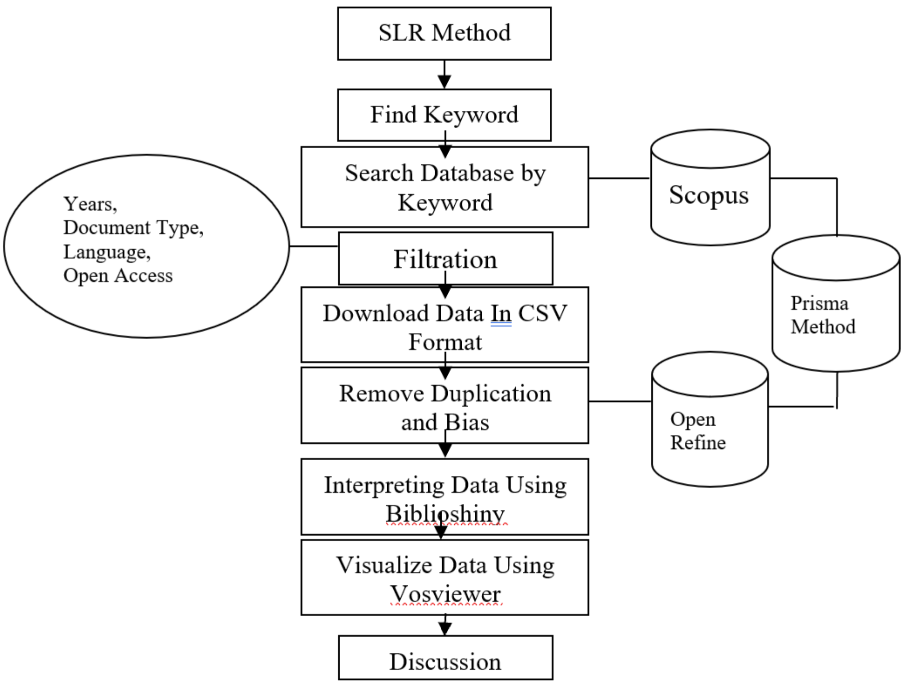

Figure 2. Research Method Flow Diagram

As part of this method, a prism flowchart will be used to illustrate the article selection process, from the number of articles found to the number that is ultimately included in this review.This diagram helps to show transparency in the selection process and provides a clear picture of how the literature has been screened based on established criteria.

The following figure shows a PRISMA chart that explains the stages of identification, screening, and inclusion of articles in this literature review.

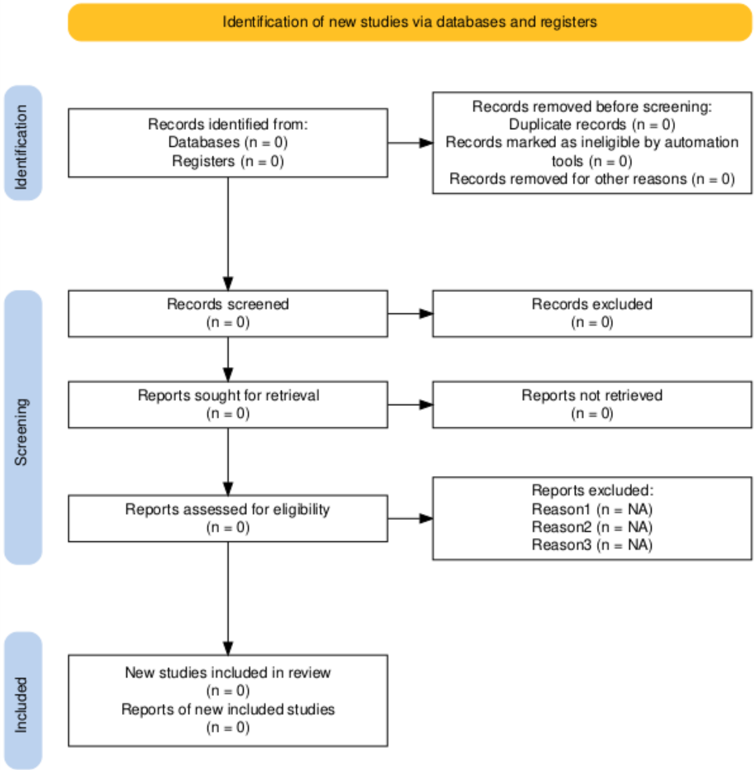

Figure 3 Prisma Systematic Literature Review Method

The PRISMA flowchart in this study serves to document the actual screening stages conducted during the systematic review, including the number of records identified, removed as duplicates, screened, excluded, and finally included in the analysis. Rather than explaining the PRISMA framework in general, this flowchart reflects the specific decisions made in this study's selection process. Each exclusion at the abstract and full-text stages was based on predefined criteria such as methodological clarity, thematic relevance, and availability of full-text access. This ensures transparency and allows readers to clearly trace how the final set of articles was obtained.

RESULTS AND DISCUSSION

Results

Bibliometric Analysis

In the bibliometric analysis, the search strategy used used Scopus data sources related to this research theme. From several keywords selected, 3 keywords were chosen, namely keywords for a broad search for digital literacy, a focus on digital literacy in online learning, and keywords for articles that discuss the influence of literacy on learning outcomes. The following table presents the search topics, keywords used, and the number of articles found for the 2015–2025 period based on Scopus data searches for the bibliometric analysis in this study.

Table 1. Search Topics and Keywords in Bibliometric Analysis

Search Topics	Keywords	Number of Articles (2015-2025)	Total Articles
Aviation Safety	" Aviation Safety Culture" AND	9	184
	" Human Factors in Aviation Safety"	1	
Pilot Training	"Crew Resource Management (CRM)" AND "Ground Crew Training"	1722	

Reduce duplicate data

With the use of data from the 4 files of the search results of the keywords above that are exported, it is compressed zip and then entered into open refine. This application is used to filter data, especially to see whether or not there is data obtained from search results. In addition, this application can also be used to eliminate keyword bias contained in the data obtained where initially the data was obtained as many as 184 articles, when entered into open refine to 168 articles. This image presents the results of the processing of keyword-related metadata (DE/Keyword) used in bibliometric analysis.

Metadata	Description	Missing Counts	Missing %	Status
AB	Abstract	0	0.00	Excellent
DT	Document Type	0	0.00	Excellent
SO	Journal	0	0.00	Excellent
PY	Publication Year	0	0.00	Excellent
TI	Title	0	0.00	Excellent
TC	Total Citation	0	0.00	Excellent
AU	Author	1	0.60	Good
DI	DOI	1	0.60	Good
C1	Affiliation	4	2.38	Good
CR	Cited References	7	4.17	Good
RP	Corresponding Author	32	19.05	Acceptable
ID	Keywords Plus	41	24.40	Poor
DE	Keywords	54	32.14	Poor
LA	Language	168	100.00	Completely missing
WC	Science Categories	168	100.00	Completely missing

Figure 4. The meta data on DE/Keyword is good

Furthermore, the process of interpreting bibliometric data can be carried out using the Biblioshiny application as follows. The main information data as a whole is the information obtained in the following image. The following table displays key information from the bibliometric data analyzed, including the number of documents, sources, and the level of author collaboration.

Table 2. Key information on the data sheet

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1993–2025
Sources (Journals, Books, etc)	103
Documents	168
Annual Growth Rate %	5.16
Document Average Age	11.3
Average Citations per Doc	38.24
References	5170
DOCUMENT CONTENTS	
Keywords Plus (ID)	1000
Author's Keywords (DE)	366
AUTHORS	
Authors	562
Authors of single-authored docs	17
AUTHORS COLLABORATION	
Single-authored docs	22
Co-authors for Doc	4.08
International co-authorships %	10.71
DOCUMENT TYPES	
Article	168

The data shown in Table 2 above includes bibliometric information from the documents analyzed in the period from 1993 to 2025. There are a total of 168 documents spread across 103 sources such as journals, books, and others. Publication growth showed an annual growth rate of 5.16%, which indicates an increase in interest in topics discussed consistently during the period. The average age of the document is 11.3 years, which means that most references have a fairly long time setting, reflecting the use of sources that are not only new but also established.

Each document has an average of 38.24 citations, a fairly high number and reflects the relevance and influence of these publications in their field. The total number of references recorded was 5,170, indicating the breadth of the literature used in these studies. In terms of content, there are 1,000 Keywords Plus (ID) and 366 Author's Keywords (DE) used, reflecting the diversity of themes and keywords relevant to the document being analyzed.

In the aspect of author collaboration, 562 authors were identified who were involved in the publication. However, only 17 authors wrote the document alone, while the rest were the result of collaboration. There were 22 papers written by one author, with an average of 4.08 authors per document, indicating a tendency for teamwork in scientific publications in this field. In addition, 10.71% of the total collaboration was international collaboration, reflecting the existence of cross-border work networks in the production of science.

In terms of document type, all recorded publications are scientific articles (168 documents), with no other types of documents such as proceedings or books, which indicates that the main focus of the analysis is on peer-reviewed scientific works. Overall, this data illustrates that the analyzed research topics have a stable development, a significant influence in their fields, and involve strong author collaboration both nationally and internationally. This figure shows the growth trend in the number of publications per year during the study period.

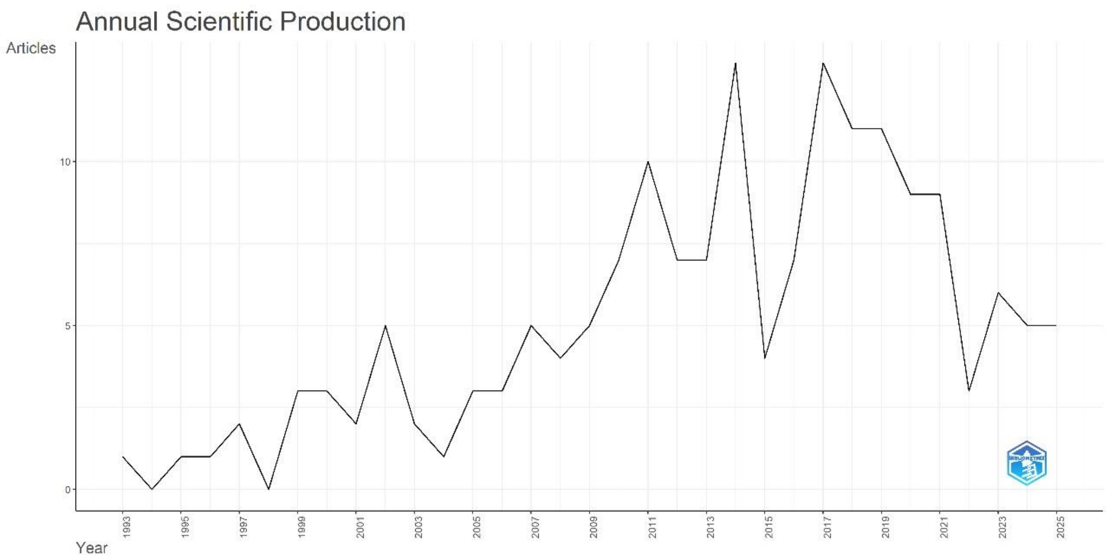

Figure 5. Year-over-year growth chart

The graph in figure 4 above shows the annual trend of scientific production (number of articles published per year) in the time range 1993 to 2025. In general, it can be seen that the production of scientific articles has been on an upward trend since the early 1990s until it reached its peak in the mid-2010s. In early years such as 1993–1998, article production was still relatively low and fluctuating, even in some years, the number of publications was close to zero. However, starting in the 2000s, there was a gradual increase, which indicated a growing interest or attention of researchers to the topic being analyzed.

A significant increase was seen from 2009, where the graph showed a spike in the number of articles to more than 10 articles per year. The peak point occurred in 2014 and 2017, which were the years with the highest scientific production throughout the observed time span. This can indicate that there is a great push from the scientific community or institution towards a particular issue/topic that is relevant at that time.

After 2017, the trend began to show a gradual decline, with a fairly sharp decline occurring in 2022, where the number of articles dropped significantly. Despite a slight increase in 2023, the trend still did not return to the highest levels as in previous years. This decline can be caused by several factors, such as changes in research focus, funding constraints, or shifts in priorities in the academic world.

Interestingly, although the graph covers the years to 2025, data in recent years (2024–2025) show that the number of publications has not seen a significant increase. This can be because the data for those years have not been fully accumulated or are still predictive.

Overall, this graph reflects that despite fluctuations, scientific production experienced positive growth in the long term, with the highest productive phases occurring between 2011 and 2019. This information is important as a reference in seeing the development patterns of scientific literature, identifying important moments in research, and evaluating the direction of scientific policy in the future. The following table presents data on the number of scientific publications per year analyzed in the initial period of the study.

Table 3. Growth every year.

Year	Articles
1993	1
1994	0
1995	1
1996	1
1997	2
1998	0
1999	3
2000	3
2001	2
2002	5

The data shown in table 3 above illustrate the annual production of scientific articles during the period 1993 to 2002. At the beginning of the period, namely 1993, there were 1 published articles. However, there was a sharp decline in 1994 with no publication at all. The following years, namely 1995 and 1996, each showed a steady increase with 1 article published each year. This trend continued into 1997, which showed an increase to 2 articles, although it briefly stagnated again in 1998, where no articles were published.

A significant increase began to be seen in 1999 and 2000, where each year recorded 3 published scientific articles. This indicates a growth in interest in the topic being researched or an increase in productivity from the researchers or institutions involved. The year 2001 saw a slight decline with only 2 articles published, but the trend increased again quite sharply in 2002 with the highest achievement in this period, which was 5 articles.

Overall, the trend of scientific production over this decade shows a pattern that fluctuates but tends to increase at the end of the period, especially after 1999. This development may reflect the growing interest and awareness of certain research topics, increased research capacity, or the availability of support for scientific publications. Although still relatively low in quantity, this pattern is an early indication that scientific production in the related field is starting to show positive growth. This figure illustrates the trend of average citations per year against scientific publications on the research topic.

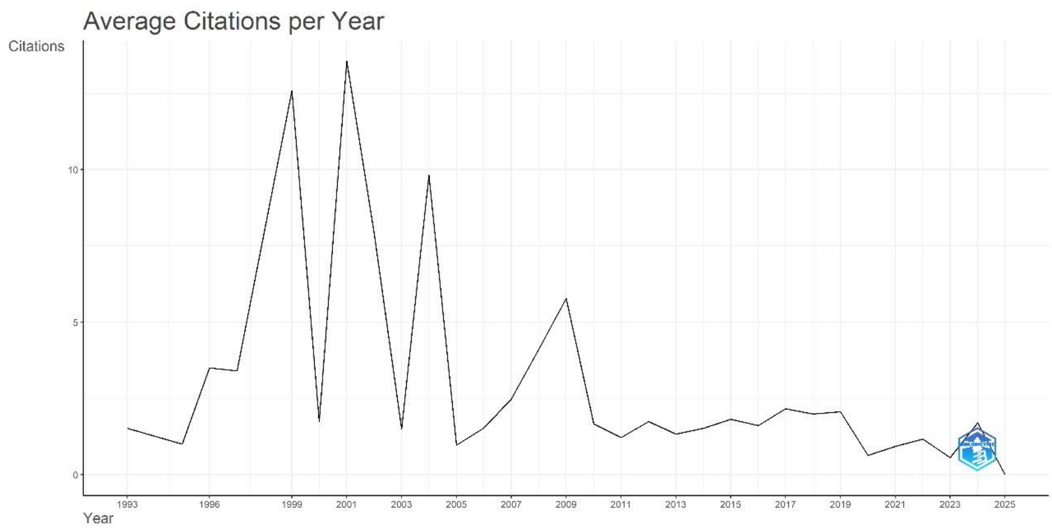

Figure 6. Graph of citations per year

The graph above shows the trend of average citations per year against published scientific papers in the time range of 1993 to 2025. In general, the graph shows that the average citation fluctuates sharply, especially in the period between the late 1990s and the early 2000s. The highest point occurred around 2002, with an average citation of more than 12 citations per document, indicating that the documents published at the time had a high academic impact and were widely referenced by other studies.

However, the graph also shows a drastic decline after the peak, particularly from 2004 onwards, where the average citation began to decline significantly and was relatively stable at low levels. After 2010, the citation trend remained low, averaging between 1 and 3 citations per year, although there was a slight variation in the ups and downs that were not very significant. This may indicate that documents published after the initial period did not receive as much attention or academic impact as previous documents. The factors that cause these fluctuations can be very diverse, ranging from the quality and relevance of research content, the number of publications in certain years, to changes in trends in research topics that may shift the attention of the scientific community. In addition, the publication time also has an effect, because older documents have more time to cite than newly published documents.

Thus, this graph shows that despite the initial phase with a high academic impact, the citation trend tends to decline in the long run. This can be an indicator of the need to improve the quality, visibility, and dissemination of research so that future scientific results can again make a strong contribution to the development of science. The figure below shows the relationship between the cited source, author, and keywords used in the relevant literature.

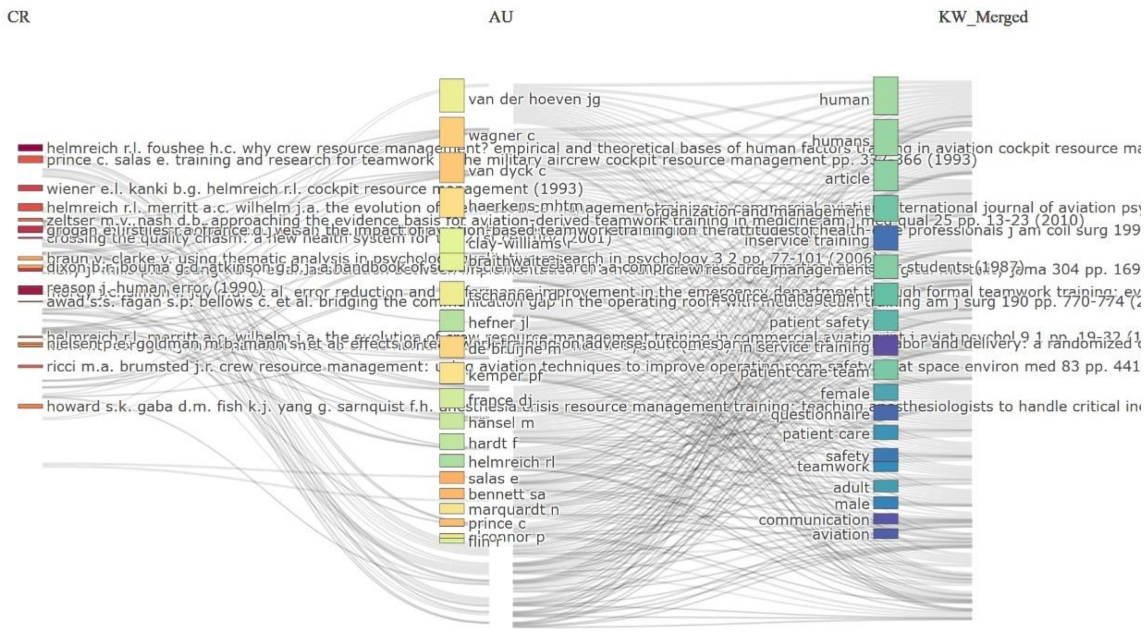

Figure 7. Diagram Three-Field Plot

Figure 7 above shows a visualization of the relationship between the citation source (CR), author (AU), and combined keyword (KW_Merged) in the form of a Sankey diagram. This diagram maps the flow of linkages between frequently cited documents or references, who the authors are involved, as well as the main topics covered in the relevant literature, indicated through combined keywords.

On the left side (CR), it appears that the name helmreich r.l. appears predominantly in some references, indicating that his works are often used as references in related research. This signifies Helmreich's important role as a central researcher in the field of crew resource management or topics related to safety and teamwork. Some other references such as the works of Wiener e.l. and Howard S.K. are also quite prominent.

In the middle (AU), you can see a number of authors such as van der hoeven jg, wagner c, helmreich rl, salas e, and prince c, who are important points of connection because they contribute to more than one work that is connected to various keywords. This reflects the multidisciplinary collaboration between researchers and their contribution in shaping the understanding of the topic being researched.

Meanwhile, the right side (KW_Merged) shows the keywords or themes that appear most often in the literature. Words such as human, teamwork, patient safety, communication, and aviation stand out as dominant topics. This indicates that topics related to patient safety, teamwork in aviation and medicine, and human factors are the main focus of these studies.

Overall, this visualization provides an in-depth view of the relationship between the document, the author, and the main topic of the research. The diagram is also very helpful in identifying key figures, important literature, as well as keyword trends that are frequently discussed in specific fields, particularly in the context of crew resource management, flight safety, and team training in professional environments such as aviation and medical. This image shows the most relevant journals or publication sources based on the number of documents related to the research topic.

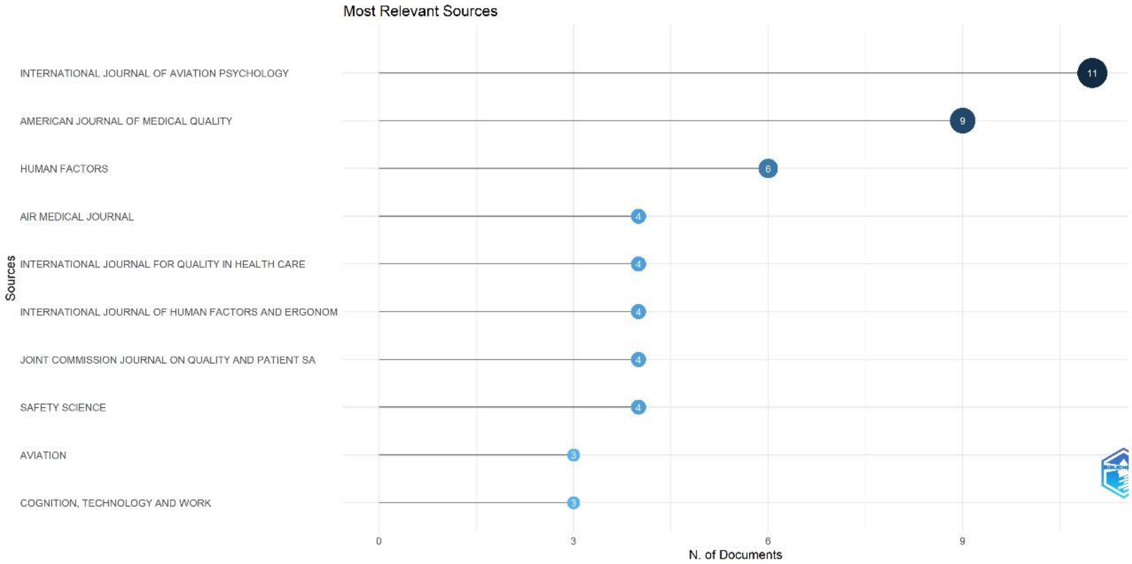

Figure 8. most relevant Source

Figure 8 above is a visualization of Most Relevant Sources or the most relevant journal sources used in a scientific literature review. This chart shows the top ten journals based on the number of documents or articles published related to the topic being researched. The horizontal axis shows the number of documents (N. of Documents), while the vertical axis shows the name of the journal or scientific source (Sources). The size of the circle reflects the number of documents published by each journal, the larger the circle, the more it contributes.

From the image, the "International Journal of Aviation Psychology" is the most dominant source with 11 documents, showing that this journal has the largest contribution and is the main reference in the field of research related to aviation psychology and human factors. Followed by the "American Journal of Medical Quality" with 9 documents, indicating a close relationship between the topics studied and the quality of medical services.

Furthermore, the journal "Human Factors" occupies the third position with 6 documents, showing the importance of ergonomic and human behavior aspects in the study. The other seven journals, such as the "Air Medical Journal", the "International Journal for Quality in Health Care", and "Cognition, Technology and Work", each contributed 3–4 documents, which, although smaller, still showed an important contribution in enriching the literature and multidisciplinary perspectives on research topics.

Overall, this figure shows that the literature review conducted is interdisciplinary, involving journals from the fields of aviation psychology, patient safety, health service quality, and human factors. This illustrates that the issues being researched are not only relevant in the context of aviation, but also in the medical and occupational safety world at large. This image shows the publication productivity of the top authors throughout the study period.

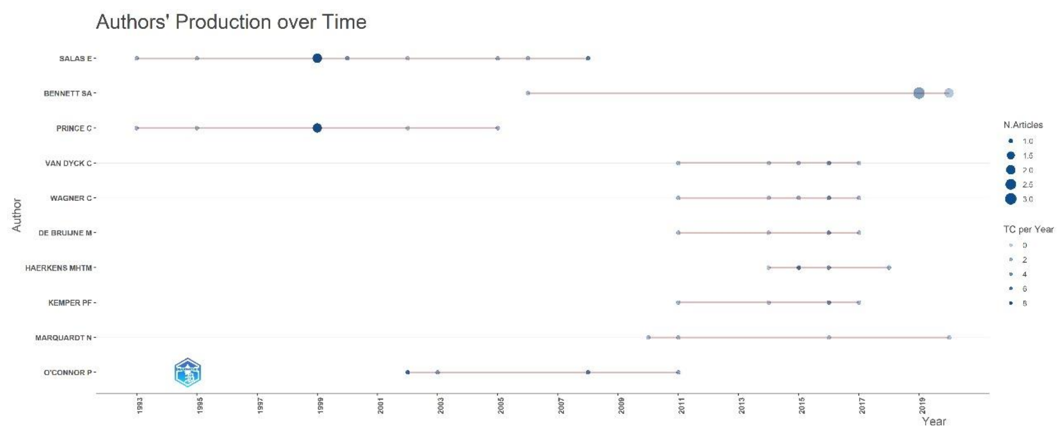

Figure 9. authors Production over Time

Figure 9 above is titled "Authors' Production over Time" and shows a visualization of the publication performance of the ten most prolific authors in a given research topic over the time span between 1993 to 2020. This graph presents information about the number of articles written by each author per year (indicated by the size of the circle), as well as the temporal distribution of their publications (shown by a horizontal line connecting the points of the year).

Authors SALAS E. and PRINCE C. were early contributors to this field, with publication beginning in the mid-1990s. SALAS E. stands out with consistent production for more than a decade, while PRINCE C. was active until the mid-2000s. SALAS E. also appears to have a large circle, which indicates more article contributions in a given year, as well as a possible high rate of citations (TC per year).

Author: BENNETT SA., being one of the authors with the most recent and continuous publications, starting from 2006 to 2020, and showing a large circle at the end of the graph, which means that his contribution rate has been getting higher in recent years.

Meanwhile, other authors such as VAN DYCK C., WAGNER C., DE BRUIJNE M., and HAERKENS MHTM. It has been active since the 2010s, with a number of publications that tend to be stable but more limited when compared to the original authors. They appear to be engaged in this topic contemporaneously, contributing to recent developments in research.

The size of the circle indicates the number of articles published in a given year (the larger the circle, the more articles), while the intensity of the blue color indicates the number of citations per year (Total Citations per Year/TC per Year), with darker colors representing a higher number of citations.

Overall, this graph illustrates the dynamics of the contribution of key authors to the topic being studied, both in terms of article volume and academic impact, and shows a shift in the generation of researchers from the 1990s to new post-2010 writers.

Countries

The following is the Author's correspondence by country. This figure shows the distribution of publications by country of correspondent authors, differentiated between domestic publications and international collaborations.

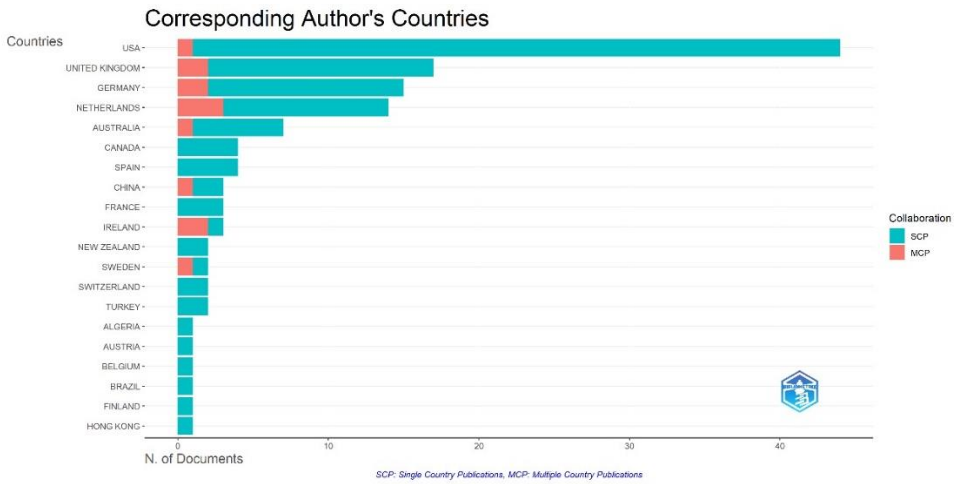

Figure `10. Author's Coreesponding by country

Figure 10 above shows data entitled "Corresponding Author's Countries" which describes the distribution of the number of documents based on the country of origin of the corresponding author in a particular field of research. This horizontal bar chart not only shows the number of publications per country, but also distinguishes between two types of collaborations: SCP (Single Country Publications) shown in turquoise green and MCP (Multiple Country Publications) shown in pink.

From this visualization, it can be interpreted that the United States (USA) dominates the publication contribution with the highest number of documents, far surpassing other countries, with most of its publications coming from domestic internal collaboration (SCP). This shows that researchers in the United States are active and productive in publishing scientific papers independently without much cross-border involvement.

In the next position, the United Kingdom (United Kingdom), Germany, and the Netherlands (Netherlands) also show a fairly high level of contribution, with a more significant proportion of cross-border collaboration (MCP) than the USA, indicating their tendency to cooperate in international research networks.

Countries such as Australia, Canada, Spain, and China are in the middle position with a relatively balanced number of documents between single country publications and international collaborations. Interestingly, China and some European countries such as Ireland and the Netherlands have a sizable portion of MCPs, showing their tendency to build global collaboration.

Other countries such as Sweden, Turkey, Austria, and Hong Kong have smaller document contributions, but still show participation in scientific publications, both independently and collaboratively. Some countries such as Belgium, Brazil, and Finland are only recorded with SCP, signaling more local research activities.

Overall, this graph shows that although large countries such as the USA and the UK lead in the number of documents, the trend of international collaboration (MCP) is important, especially in countries with academic systems that are open to global networks. Cross-border collaboration plays a significant role in increasing the visibility and scientific impact of publications.
The following is the data of the top 10 Countries' Scientific Production. The following table shows the ten countries with the highest number of scientific publications on the research topic.

Tabel 4. top 10 Countries' Scientific Production.

Country	Freq
Usa	261
Germany	92
Netherlands	78
Uk	50
Australia	17
France	16
China	15
Canada	14
Sweden	14
Switzerland	13

The data in the table shows the frequency of involvement or contribution of ten countries to a given activity or phenomenon, with the highest score coming from the United States (USA) as many as 261 times. This number is particularly prominent compared to other countries, indicating a much greater dominance or participation than the USA in the context studied. A fairly significant distance is seen in the second position occupied by Germany with 92 frequencies, followed by the Netherlands with 78, and the United Kingdom (UK) with 50. The top four countries overall show high levels of engagement, but there is still a striking gap between the USA and other countries.

Furthermore, Australia ranks fifth with 17 frequencies, followed by France (16), China (15), Canada and Sweden with 14 each, and Switzerland (13). These countries are in the medium to low frequency category when compared to the top four countries. The numerical differences between the upper group (USA to UK) and the lower group (Australia to Switzerland) indicate an uneven distribution of contribution or participation among the countries analyzed.

Overall, the interpretation of this data shows that there is a significant disparity in frequency between countries. The USA plays the role of the main actor with a contribution of more than double that of the country in second place. This may reflect the USA's greater resource superiority, capacity, or attention to the object of study. Meanwhile, the contribution of countries such as Switzerland and Sweden is relatively small, which can be caused by factors such as the scale of activities, national priorities, or other constraints. This interpretation indicates the need for further analysis to understand the background of differences in contributions between countries and the potential for collaboration that can be improved to create a more equitable distribution of participation.

Countries' Production over Time

The following is the data on Countries' Production over Time. The data can be seen in the Figure 11. This image shows the development of the number of publications from several selected countries throughout the research period.

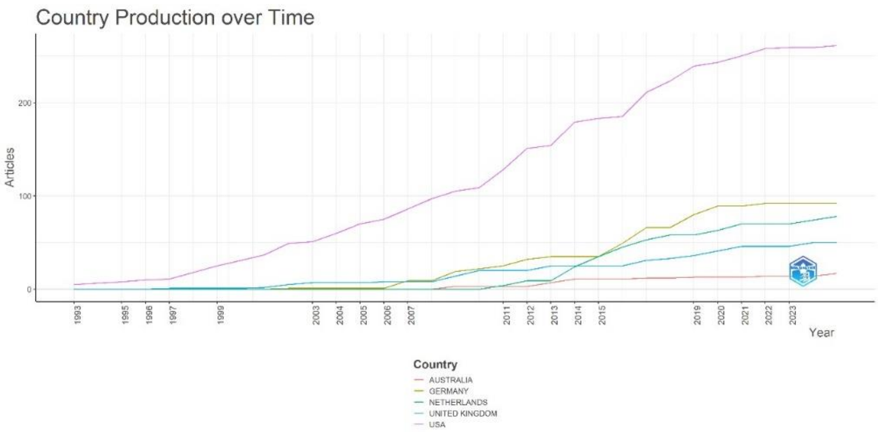

Figure 11. Grafik Countries' Production over Time

This graph shows article production trends from five countries (Australia, Germany, the Netherlands, the United Kingdom, and the United States) over the period 1993 to 2023. The vertical axis describes the number of articles produced, while the horizontal axis shows the time range in years. In general, this graph shows the accumulated number of articles from each country over the past three decades.

The United States (USA), depicted with a light purple stripe, showed a particularly striking dominance in article production from the beginning to the end of the period. Since 1993, the USA has had a steady initial contribution and began to increase significantly after 2000. A sharp increase was seen mainly in the 2010–2015 and 2017–2019 periods, until finally the USA production chart approached 270 articles in 2023 and seemed to be starting to slope, indicating a phase of stability or saturation.

Germany, shown by the yellow line, is in second place. The increase in article production from Germany began to be seen around 2007 and continued to rise slowly but consistently, especially between 2012 and 2020, before finally approaching a flat point of around 90 articles in 2023. This shows good growth although not as fast as the USA.

The Netherlands, with its turquoise line, has shown a steady growth trend since 2005. Growth has begun to strengthen since 2012 and continues to increase until 2023, approaching 80 articles. This pattern shows consistency in publications, although it remains below Germany.

The United Kingdom, depicted in light blue, has seen a significant increase since 2013. Its article production showed rapid growth between 2013–2017, then increased more slowly to reach around 60 articles in 2023.

Australia (with the pink line) is at the bottom of this chart. The production of articles looked very low and relatively stagnant from 1993 to 2023, with a very slow increase and reaching less than 20 articles by the end of the period.

Overall, this graph shows that the USA is consistently and significantly the most productive country in terms of article publication. European countries such as Germany, the Netherlands, and the United Kingdom also showed a marked increase in contributions, while Australia lagged far behind. These differences in production levels can reflect various factors such as research support, the number of academic institutions, research budgets, and different scientific publication policies in each country.

Most Cited Countries

Figure 11 shows the countries with the highest number of citations that their publications receive.

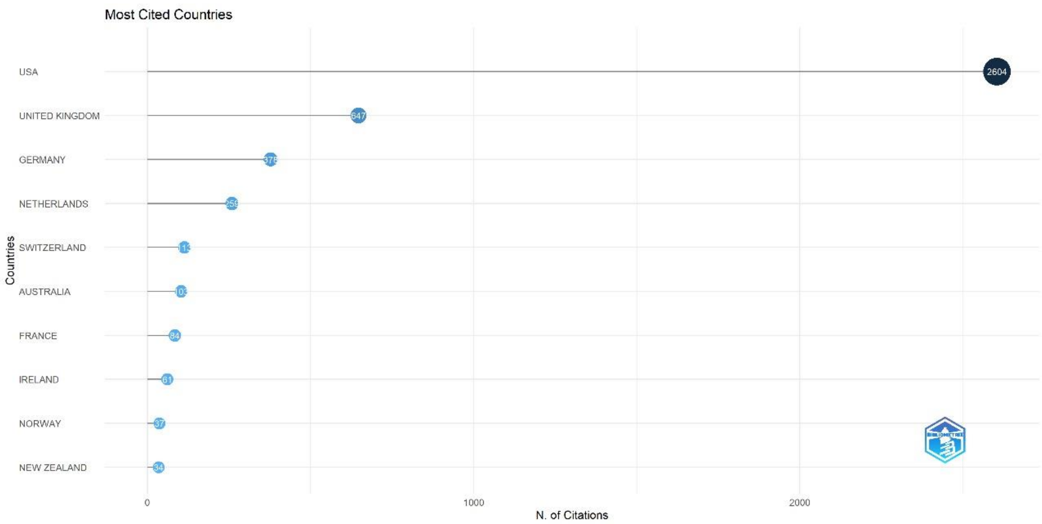

Figure 12. Most Cited Countries

This graph shows the highest number of citations received by publications from different countries, illustrating how much influence or scientific impact the scientific work of each country is based on the number of citations they receive. The horizontal axis represents the number of citations, while the vertical axis lists the name of the country. The blue circle shows the total quote, where the size of the circle also illustrates the magnitude of the number.

The United States (USA) dominates absolutely with a total of 2,604 citations, far surpassing any other country. This shows that scientific publications from the USA are not only more numerous, but also most referenced by other researchers, reflecting a very strong global influence in the academic and research worlds.

Second place is occupied by the United Kingdom with 647 citations, which although quite large, remains only about 25% of the total USA citations. Followed by Germany with 476 citations and the Netherlands with 359 citations, these two countries show a significant role in the scientific community, although they are still below the UK and far below the USA in terms of scientific visibility.

Other countries such as Switzerland (118 citations), Australia (108 citations), and France (94 citations) show intermediate citation rates, signaling a relevant contribution but not as large as the countries at the top. Meanwhile, Ireland (61 citations), Norway (37 citations), and New Zealand (34 citations) are at the bottom of this graph, indicating that although they have contributed to the scientific literature, their influence in terms of citations is still relatively limited.

Overall, this graph confirms a fairly striking imbalance in the level of scientific influence between countries. The United States leads overwhelmingly in terms of citation counts, showing that publications from this country are more often referenced by the global scientific community. Western European countries such as the United Kingdom, Germany, and the Netherlands continue to show important positions, while other countries have room for improvement in terms of visibility and scientific influence on the international scene.

Overlay visualization

This image shows a map of keyword linkage by year of appearance in publications related to the research topic.

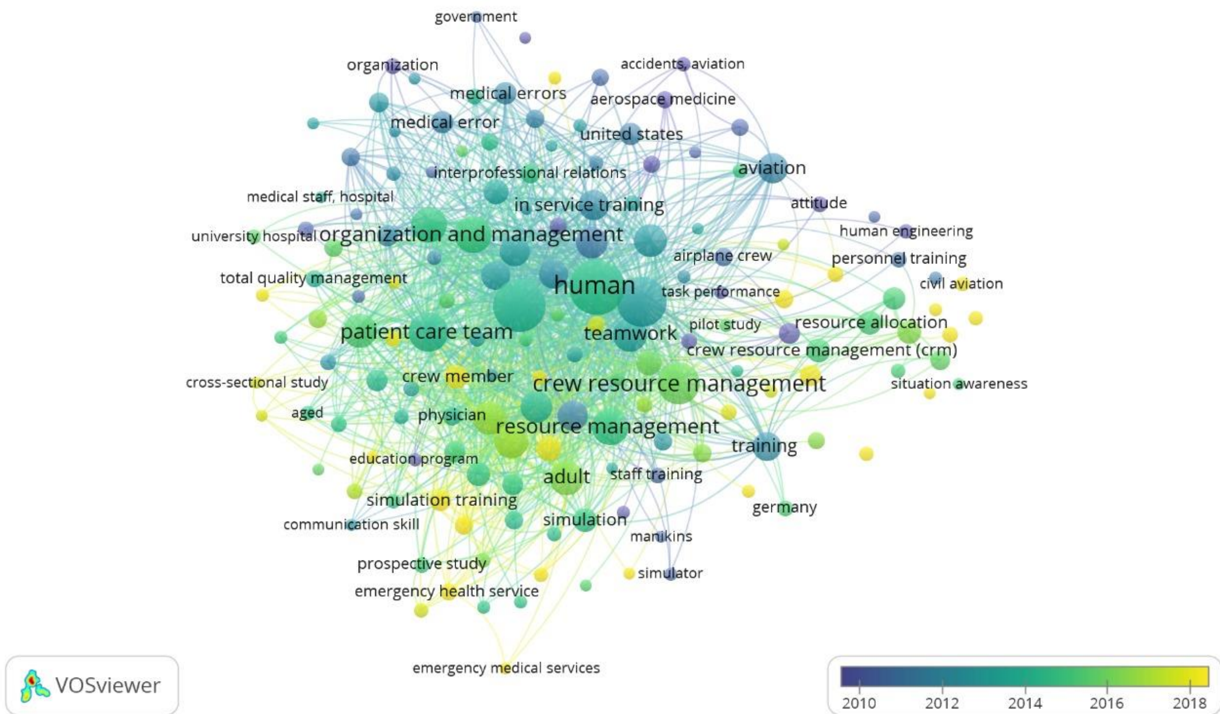

Figure 13. Overlay visualization

The image shows a visualization of the relationship between keywords (co-occurrence map) used in scientific publications, focusing on the theme of "crew resource management" and related fields. The size of the circle shows the frequency with which the keyword appears in the literature, while the color shows the average year of occurrence based on the color scale from dark blue (2010) to yellow (2018). The connecting line between nodes describes the interconnectedness or proximity between those keywords in the same document.

From this visualization, it can be seen that the terms "human", "crew resource management", "teamwork", "resource management", and "organization and management" are the center of the map and have the largest size. This shows that these words are a dominant topic and often appear in studies that discuss human resource management in the context of teamwork, especially in the medical and aviation fields. Words such as "patient care team", "crew member", "training", and "simulation training" also have a central position and are often closely related to the main topic.

It also appears that keywords such as "aviation", "medical error", and "simulation" are in interconnected but more specific clusters, indicating the field of application of human resource management—both in the medical and aviation worlds. This visualization also shows the close relationship between training, situational awareness, and teamwork, which are important components of a high-risk work system.

Judging from the color, we can observe that a number of keywords such as "simulation training", "situation awareness", "education program", and "emergency health service" are dominated by yellow, which means that they are widely studied in more recent publications (around 2016–2018). In contrast, terms such as "aerospace medicine", "government", and "aviation" are more dominant in blue or purple, indicating that the topic appears more frequently in older publications (circa 2010–2012).

The overall map shows that resource management and team training are key issues in the field of collaborative work, especially as it relates to safety and efficiency. The topics are also increasingly evolving in interprofessional and cross-sector approaches such as medical, military, and aviation. In addition, the increasing frequency and connectivity of newer keywords suggests that attention to simulation, education, and team management in critical systems continues to grow and become an active research area until recent years.

Network Visualization.

Figure 14 shows the network of connections between keywords used in the literature on the research topic.

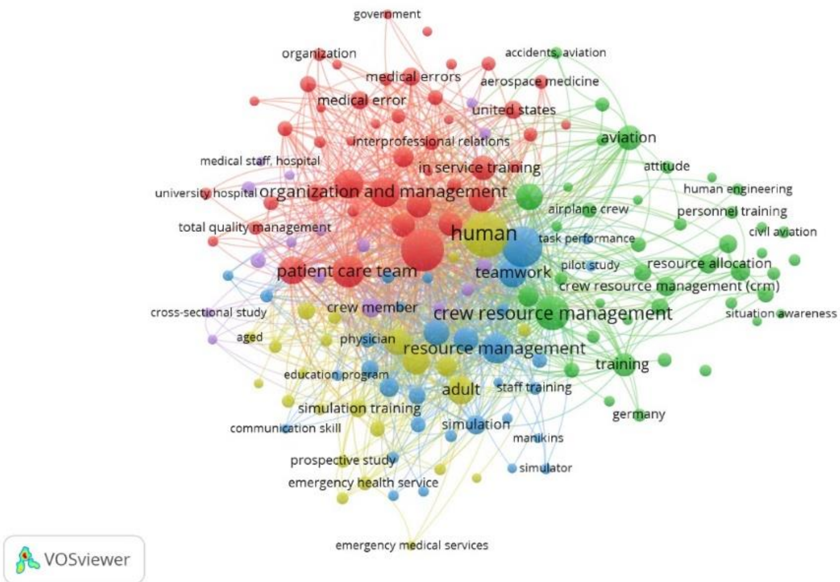

Figure 14. Network Visualization

This keyword network visualization image generated by VOSviewer shows the conceptual relationships between topics that often appear in the scientific literature, particularly as they relate to resource management, training, safety, and collaboration in the context of health and aviation. Each circle in this image represents a single keyword, with the size of the circle reflecting the frequency with which the word appears in publications, while the color indicates an interrelated cluster or group of themes. The inter-circle lines illustrate the strength of the linkage between one keyword and another, thus forming a complex and integrated topic map.

In this visualization, several colored clusters are seen that indicate a major theme in the literature. The red cluster dominates the upper left of the image and shows a strong connection between topics such as "organization and management", "medical error", "medical staff", and "interprofessional relations". This shows a great focus on organizational management issues in healthcare as well as the importance of team collaboration to prevent medical errors. In the top right, the green cluster displays keywords related to aviation, such as "aviation", "airplane crew", and "resource allocation". It illustrates the linkage between resource management and training in the context of the aviation industry, particularly in crew management and situational awareness enhancement.

Another cluster that is quite striking is the yellow and blue cluster that connects the concepts of "simulation training", "education program", and "communication skills", showing the importance of simulation and education methods in improving professional skills. The cluster is closely related to training in the emergency health sector and other public services. In addition, smaller purple clusters mark topics such as "cross-sectional study", "aged", and "university hospital" which place more emphasis on clinical research approaches and institutional settings.

Overall, the most central and biggest keywords in this visualization are "human", "crew resource management", "resource management", "organization and management", and "teamwork". This shows that the human aspect and team collaboration are the focus of much of the research analyzed. This visualization also indicates that there is a strong multidisciplinary relationship between the fields of management, health, training, and safety, where human resource management and teamwork development are the main themes connecting these fields. As such, the map reflects a holistic understanding that effectiveness and safety in various systems are highly dependent on human management, proper training, and solid coordination between personnel.

SLR Study.
Of the 168 data obtained, 122 will focus on the type of article. Table 5 presents the number of documents analyzed by the type of publication.

Table 5. Number of Documents by Publication Type.

In a	Kind	Sum
1	Article	122
2	Conference Paper	30
3	Reviews	16
	Total	168

Results of the prism method

Figure 15 shows a flow diagram of the results of applying the PRISMA method in the article selection process.

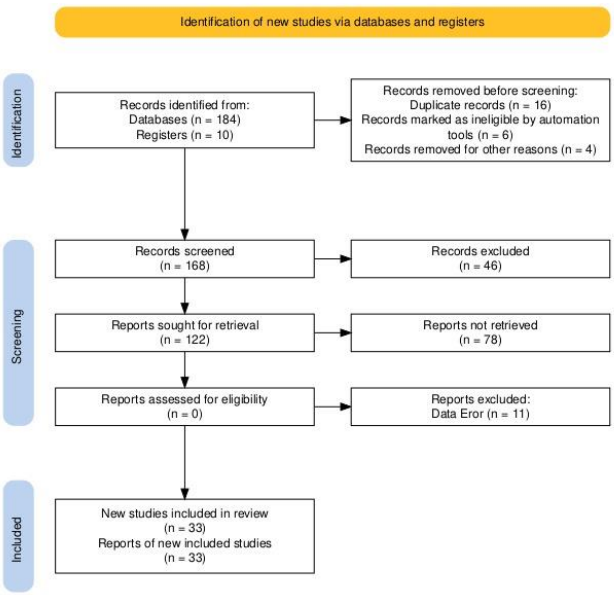

Figure 15. Results of the prism method.

Figure 15 shows a flow diagram of the study selection process used in a systematic review, with an approach based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol. This process is divided into three main stages: identification, screening, and inclusion.

At the identification stage, a total of 194 records or references were found, consisting of 184 records from the database and 10 from the registry. However, before further filtering, there were 26 records that were deleted: 16 due to duplication, 6 were flagged as inappropriate by automation tools, and 4 were deleted for other reasons. After this removal, a total of 168 records remained to be filtered.

Entering the screening stage, out of 168 records screened, as many as 46 records were issued because they did not meet the criteria. Then, a total of 122 reports were selected for retrieval, but 78 of them were not successfully retrieved or accessed. Of the remaining 44 reports, it turned out that none of the reports entered the eligibility assessment stage, because all of them (as many as 11) were issued due to data errors.

Although no reports were considered feasible, at the end of the diagram it can be seen that there were 33 new studies that were still included in the review. This indicates that the included study report may have come from a source or selection process that is separate from the formal feasibility assessment pathway, but is still eligible for review.

Overall, this diagram illustrates how rigorous and selective the screening process is in systematic studies, as well as showing a variety of common reasons why most records do not make it to the final stage of inclusion. Table 6 shows the classification of the research methods used in the studies analyzed.

Table 6. Classification of Research Methods

Category Methodology	Number of Papers	Percentage (of 34 Papers)
Randomized Controlled Trial (RCT)	3	~9%
Quasi-Experimental	4	~12%
Qualitative Study	5	~15%
Observational Study	8	~24%
Mixed Methods	3	~9%
Case Series / Quality Improvement	4	~12%
Descriptive / Analytical	7	~21%

Table 6 shows the classification of research methods from the 34 papers reviewed, based on the type of methodology used. The most widely used method is the Observational Study of 8 papers, which represents about 24% of the total. This suggests that the observational approach without direct intervention is most commonly used in the studies analyzed.

Furthermore, the Descriptive/Analytical method occupies the second position with 7 papers or about 21% of the total, indicating the importance of descriptive and analytical approaches in explaining phenomena based on available data. The Qualitative Study method was used in 5 papers (~15%), demonstrating the important role of qualitative approaches in understanding contexts, perceptions, and experiences that cannot be quantitatively measured.

The Quasi-Experimental and Case Series/Quality Improvement categories were used in 4 papers each, representing ~12% of the total. This indicates that the semi-controlled experimental approach and evaluation of service quality improvement have also received relatively balanced attention.

Meanwhile, the Randomized Controlled Trial (RCT) and Mixed Methods methods were used in 3 papers each, each contributing ~9%. RCTs are known as the gold standard in intervention research, but their low frequency of use suggests that there may be limitations in their application to the context of the studies being studied. Similarly, mixed methods that combine qualitative and quantitative data are still relatively rarely used.

Overall, the distribution of methods suggests that observational and descriptive studies are more dominant compared to purely experimental methods such as RCTs, which may reflect the more exploratory or contextual nature of the research topic. The choice of this methodology is likely to be influenced by the limitations of resources, the objectives of the study, and the complexity of the study context that is more suitable for the non-experimental approach. Table 7 presents a classification of the main findings from the studies reviewed in this study.

Table 7. Main Finding Classification

Key Findings Categories	Number of Papers	Percentage (of 34 Papers)
Improvement of Non-Technical Skills	12	~35%
Improved safety/quality of care	9	~26%
CRM Training Effectiveness	7	~21%
Increased teamwork	5	~15%
Impact on Patient Outcomes/Performance	4	~12%
CRM Implementation Challenges	5	~15%
No significant impact	2	~6%

Table 7 presents a classification of the main findings of the 34 papers analyzed in this study. The most dominant category of findings was "Non-Technical Skills Improvement", which was found in 12 papers or about 35% of the total. These findings suggest that most studies highlight the important role of improving skills such as communication, leadership, decision-making, and teamwork in the context of healthcare or crisis management (CRM) training.

The second category that appears most often is "Improved Safety/Quality of Care" with 9 papers or 26%. This suggests that the interventions studied in the paper contribute directly to improving patient safety standards and overall clinical service quality. Furthermore, "CRM Training Effectiveness" emerged as the main finding in 7 papers (~21%), signaling that CRM-based training is considered successful in achieving professional or organizational performance improvement goals.

The findings on "Improved Teamwork" and "CRM Implementation Challenges" were found in 5 papers (~15%) each, highlighting the importance of collaboration between professionals while underlining the existence of real barriers to the implementation of CRM training, such as resource limitations, cultural resistance, or structural issues.

A total of 4 papers (~12%) reported "Impact on Patient Outcomes/Performance", reflecting the direct influence of interventions on clinical output and work efficiency. Interestingly, there were also 2 papers (~6%) that noted that no significant impact of the intervention was found. It is important to note that not all programs or approaches are delivered as expected, and need further evaluation of the design and context of its implementation.

Overall, the interpretation of the data in this table shows that the majority of studies note positive benefits in the non-technical and safety aspects, but there are still a number of studies that face implementation challenges and insignificant results. This indicates the need for a more adaptive and contextual approach in implementing training programs or quality improvement interventions in the health sector. Table 8 displays the classification of research designs used in the literature analyzed.

Table 8. Classification of Study Desaign

Categories Study Design	Number of Papers	Presentase (%)
Randomized Controlled Trial (RCT)	4	11.8%
Quasi-Experimental	6	17.6%
Qualitative Study	5	14.7%
Observational Study	9	26.5%
Mixed Methods	3	8.8%
Case Series/Quality Improvement	4	11.8%
Descriptive/Analytical Review	3	8.8%

Table 8 presents the study design classification of the total 34 papers reviewed, based on the methodological approach used. From the data shown, the Observational Study design was the most dominant type, used by 9 papers or about 26.5% of the total. This suggests that most of the studies in this review use a more observational approach without direct intervention, which is often used to evaluate events in real contexts.

Furthermore, Quasi-Experimental became the second most widely used design, recorded in 6 papers (17.6%). This design is often chosen when intervention studies are conducted but without full randomization, usually due to ethical or logistical limitations in a clinical or educational setting. Qualitative Studies were also used quite significantly, namely in 5 papers (14.7%), which indicates the importance of in-depth exploration of perceptions, experiences, or processes in the context of this research.

The design of the Randomized Controlled Trial (RCT) and Case Series/Quality Improvement appeared in 4 papers (11.8%) respectively. RCTs are known as the most powerful methods of testing the effectiveness of interventions because they involve randomization and control, while Case Series/Quality Improvement tends to be used to describe the experiences or outcomes of quality improvement interventions in a practical context.

Finally, the Mixed Methods and Descriptive/Analytical Review designs were used in 3 papers (8.8%) each. Mixed Methods show a combination of qualitative and quantitative approaches in a single study, which allows for a more comprehensive understanding of a phenomenon. Meanwhile, Descriptive/Analytical Review tends to be used to present an analysis or overview of literature that is narrative or evaluative.

Overall, the distribution of these study designs shows methodological diversity in the reviewed studies. The trend in the use of Observational and Quasi-Experimental Studies suggests that many studies focus on field studies or hands-on practice, while the use of purely experimental methods, such as RCTs, remains but is not dominant. This design choice reflects the researcher's efforts to balance between scientific validity and practical limitations in the conduct of studies. Table 9 presents a classification of future research recommendations identified from the studies analyzed.

Table 9. Future Research Classification

Categories Future Research Recommendations	Number of Papers	Percentage (%)
Long-Term Impact Evaluation	12	35.3%
Transfer to Real Clinical Settings	9	26.5%
Training Method Optimization	7	20.6%
Standardization of CRM Programs	5	14.7%
Contextual Factors of Implementation	6	17.6%
More Objective Outcome Measurement	4	11.8%
Comparison of Different Methods	3	8.8%

The figure 16 shows a visualization of the distribution of future research recommendations based on the frequency of their occurrence.

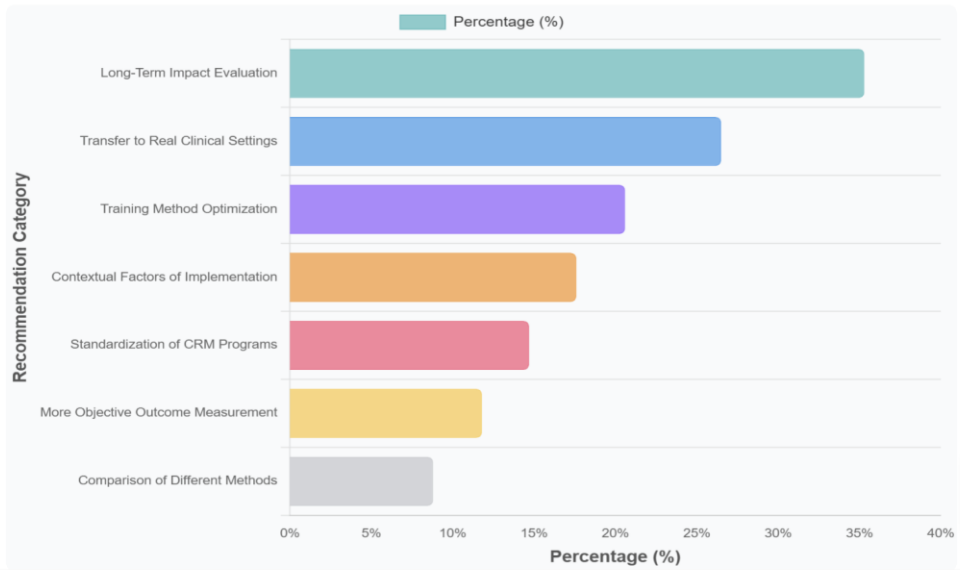

Figure 16. Future Research Classification

Table 9 and Figure 16 shows the classification of future research recommendations based on the 34 papers analyzed. From the table, the most emerging recommendation is "Long-Term Impact Evaluation", which is mentioned in 12 papers or about 35.3% of the total. This indicates that many researchers emphasize the importance of evaluating the effects of interventions over a longer period of time to assess the sustainability of benefits and their effectiveness as a whole.

The second most recommended was "Transfer to a Real Clinical Setting", which was mentioned by 9 papers (26.5%). This suggests that although many interventions have been tested under controlled conditions, the researchers assess the importance of implementing and evaluating these programs in real practice in the field so that the results are more relevant and applicable in the context of the complex clinical world.

Furthermore, "Optimization of Training Methods" was recommended by 7 papers (20.6%), reflecting the need to improve the quality, effectiveness, and efficiency of the training methods used, so that they can be more in line with the needs of participants and institutional conditions. Meanwhile, "Contextual Factors of Implementation" was a concern in 6 papers (17.6%), emphasizing the need for a deep understanding of the organizational context or work culture that can affect the success of program implementation, such as CRM (Crisis Resource Management) training.

"Standardization of CRM Programs" appeared in 5 papers (14.7%), highlighting the need for uniformity of standards in program implementation so that results can be compared and measured consistently. On the other hand, "More Objective Outcome Measurement" was mentioned in 4 papers (11.8%), which shows that researchers are aware of the need for improvement in the way of evaluating intervention outcomes, so that it is not only based on subjective assessments but also through measurable and standardized indicators.

The least emerging recommendation was "Comparison of Different Methods", with 3 papers (8.8%), which suggested that future research should also include comparative studies between training approaches or intervention models to find out which methods are most effective in a given context.

Overall, the interpretation of the data in this table shows that the researchers strongly emphasize the need for more applicative, long-term, and contextual studies to improve the implementation and evaluation of training programs such as CRM. In addition, a more systematic and objective approach to measuring impact is needed, as well as improvements in program design to be more standardized and easily replicated. Table 10 provides a summary of the classification of the main topics discussed in related studies.

Table 10. Classification Summary

Category Summary	Number of Papers	Percentage (%)	Examples of Focus
CRM Effectiveness	15	44.1%	Impact of training on knowledge/attitudes
Security Enhancements	12	35.3%	Reduction of errors, safety culture
Improved teamwork	9	26.5%	Communication, multidisciplinary coordination
Specific Applications	7	20.6%	ICU, aviation, obstetric surgery
Implementation Challenges	6	17.6%	Cultural barriers, resources
Performance Impact	5	14.7%	Operational efficiency, patient outcomes
Policy Recommendations	4	11.8%	Training standardization

Table 10 presents a summary of the classification of a number of papers that discuss various aspects related to CRM (Crew Resource Management) in the context of professional services or training. The category with the highest number of papers is CRM Effectiveness, which includes 15 papers or 44.1%. The main focus in this category is the impact of training on participants' knowledge and attitudes. This suggests that most studies assess the extent to which CRM training is able to improve professional understanding and behavior towards teamwork, safety, and communication.

The second dominant category was Safety Improvement, with 12 papers (35.3%). The focus includes reducing errors and establishing a safety culture. This reflects the high attention to the impact of CRM training in preventing incidents and creating a safe work environment. This was followed by the category of Improving Teamwork (9 papers, 26.5%) which highlighted the importance of multidisciplinary communication and coordination, indicating that effective interpersonal interaction is essential in complex work systems.

Meanwhile, other categories, such as Specific Applications (7 papers, 20.6%) and Implementation Challenges (6 papers, 17.6%), show a focus on the context of CRM use in areas such as ICU, aviation, and obstetric surgery, as well as cultural and resource barriers in its implementation. The two categories with the least number of papers were Performance Impact (5 papers, 14.7%) and Policy Recommendations (4 papers, 11.8%), each discussing operational efficiency and patient outcomes, and the importance of standardization of training as a policy reference. Overall, this data provides an idea that training, safety, and teamwork are top priorities in CRM research, while implementation and policy aspects are still relatively underexplored.

Discussion

The Role of Mentorship in Aviation Safety

Mentorship plays a key role in shaping the professional skills and behaviors of pilots and ground crew, particularly those in the early stages of their careers. Based on the findings of the systematic review, several studies emphasize that effective mentor–mentee relationships enhance confidence, discipline, and the ability to cope with situational pressure, all of which are critical to aviation safety (Tinoco-giraldo et al., 2022). Experienced mentors also facilitate the internalization of safety culture and standard operating procedures (SOPs) through interpersonal approaches that cannot be fully achieved through formal training alone (Cahyo et al., 2025). This is further supported by the dominance of the themes "non-technical skills enhancement" and "safety improvement" in the analyzed literature (Table 7), indicating that mentorship effectively strengthens the cognitive and affective competencies essential for aviation personnel.

Previous studies also support these findings by demonstrating that mentorship contributes significantly to the development of situational awareness, error management capabilities, and adherence to safety procedures (Cordova, Parsons-Daisley, et al., 2024). In particular, structured mentor–mentee interactions have been shown to improve junior pilots' judgment in abnormal situations and to enhance safety-related communication within flight crews (Hariri et al., 2022). Moreover, mentorship accelerates the internalization of safety culture when mentors consistently model safe behaviors (Cahyo et al., 2025). Compared with earlier research, the present review provides stronger evidence by encompassing a broader range of operational contexts, including ground operations, maintenance activities, and multi-crew environments, thereby confirming the cross-operational impact of mentorship on aviation safety.

The Role of Coaching in Aviation Safety

Coaching, as a more structured and feedback-based approach to training, has proven to be effective especially in the context of ground crew training. Several studies have highlighted that coaching processes focused on strengthening technical skills (such as fuel management, aircraft inspection procedures, and emergency handling) significantly reduce work errors and improve operational efficiency(Dalkilic, 2017). Coaching also allows for a process of continuous reflection and improvement, which indirectly contributes to the formation of a solid safety culture. In this context, coaching is often a more applicable approach to address CRM (Crew Resource Management) implementation challenges, such as cultural barriers and resource limitations (Table 10). The impact of coaching on patient outcomes and surgical efficiency was also mentioned in the study's findings although it was not yet the main focus of the study.

Comparisons with previous studies indicate that coaching interventions are particularly effective when combined with structured performance feedback, simulation-based training, and standardized competency frameworks(Tuhkala et al., 2024). Earlier research found that coaching enhances procedural compliance and reduces operational deviations among maintenance and ground-handling personnel (Aktas & Kagnicioglu, 2023; Gunes et al., 2025). Meanwhile, other studies in related high-risk industries, such as healthcare and maritime operations, demonstrate that coaching significantly improves teamwork and minimizes human errors (Grogan et al., 2004; Liu, 2023). This review extends those findings by showing that coaching not only strengthens technical proficiency but also supports the reinforcement of Crew Resource Management principles, thus offering a more comprehensive understanding of its role in aviation safety.

The Interaction Between Mentorship, Coaching, and Aviation Safety

Although mentorship and coaching have different characteristics, they complement each other in forming the holistic competencies of aviation personnel. Mentorship excels in building a professional mentality and understanding of safety values in the long term, while coaching is more effective in improving task performance in a specific and real-time manner. The literature suggests that the combination of these two approaches can improve non-technical skills such as communication and teamwork, as well as technical skills through simulation-based training. Such skill improvements are directly correlated with improved flight safety, as shown in the findings that 35% of studies noted improvements in non-technical skills, and 26% noted improvements in safety/quality of service.

These findings are consistent with previous literature suggesting that integrated training approaches combining mentoring, coaching, and CRM principles lead to stronger behavioral improvements than single-method interventions(Liu, 2023; Salas et al., 2006). Earlier studies emphasize that mentorship enhances the cultural and interpersonal dimensions of safety, while coaching strengthens operational and task-based competencies (Cahyo et al., 2025; Liu, 2023; Sun et al., 2023; Tinoco-giraldo et al., 2022). However, few previous reviews have analyzed how these approaches interact within a unified safety framework. The present study contributes by showing how the synergy between mentorship and coaching accelerates competence formation and improves both technical and non-technical skills, confirming the multidimensional nature of aviation safety development.

Gaps in the Literature

Although the literature shows that mentorship and coaching are effective in improving flight safety, there are a number of research gaps. First, few studies have evaluated the long-term impact of mentorship and coaching programs (only 35.3% of studies have proposed long-term evaluations). Second, its application in real contexts such as low-cost airlines or developing countries is still poorly explored. Third, very few studies have discussed the standardization of mentorship and coaching programs that can be adopted globally. Finally, there is still a lack of evidence that objectively measures outcomes, such as reducing incidents or improving safety indicators. Therefore, future research is recommended to focus on longitudinal aspects, objectification of outcomes, and comparative effectiveness of different training models.

Several previous reviews have also reported similar gaps, particularly regarding inconsistent reporting standards, lack of longitudinal data, and the absence of global benchmarks for evaluating training effectiveness. However, most earlier studies focused on either mentorship or coaching independently, without examining how the two approaches complement each other across different aviation contexts. By synthesizing both dimensions together, this review highlights additional gaps such as the limited integration of behavioral outcome metrics, minimal comparative analysis across airlines, and inadequate evaluation of real-world safety impact. Addressing these gaps is essential for advancing evidence-based training policies.

Contribution

This study makes an important contribution in explaining that mentorship and coaching are not only relevant for individual learning, but also as systemic strategies in improving aviation safety. This research also emphasizes the need to strengthen non-technical skills-based training programs as a complement to conventional technical training. In practical terms, these findings can be used as a basis for designing a more holistic and sustainable pilot and ground crew training curriculum.

Compared with prior reviews, this study contributes a more consolidated understanding by bridging technological, behavioral, and organizational perspectives on aviation training. Previous studies often emphasized specific aspects such as CRM, simulation training, or error-reduction programs without fully connecting them to mentorship and coaching frameworks. The current review provides an integrated perspective that positions mentorship and coaching as central components of modern aviation safety strategies. This reinforces their relevance not only for individual competency development but also for broader systemic safety enhancement across aviation operations.

LIMITATION

This review has some limitations. First, not all documents identified in the PRISMA process are fully accessible, so the number of studies analyzed is limited (only 34 out of 168). Second, most studies use observational and descriptive methods, so the strength of the evidence is still not optimal when compared to RCTs. Third, the diversity of contexts (medical and aviation) can influence the generalization of findings.

CONCLUSION

The results of this systematic review show that mentorship and coaching play an important role in the development of both technical and non-technical skills of pilots and ground crew, which directly contributes to improving flight safety. Mentorship has been proven to be effective in building professional character, instilling a culture of safety, and increasing confidence and decision-making in emergency situations. Meanwhile, coaching plays a role in improving operational performance through feedback-based approaches, simulation exercises, and continuous skill evaluation. Overall, the literature supports that the combination of these two approaches can create a more competent aviation workforce and be prepared for complex operational challenges. For practice in the field, it is recommended that training programs in the aviation industry systematically integrate elements of mentorship and coaching into the pilot and ground crew training curriculum. The program should include ongoing mentoring by experienced mentors, coaching sessions with realistic-scenario-based live feedback, as well as simulation training that emphasizes aspects of safety, communication, and teamwork. In addition, management involvement and institutional support are essential to ensure the sustainability and effectiveness of the program. As for the next direction of research, more in-depth studies are needed on the long-term impact of mentorship and coaching on aviation safety, including objective measurements of operational incident reduction and improvement of safety indicators. Research also needs to focus on standardization of training program design, contextual adaptation across different types of airlines and countries, and comparison of effectiveness between different coaching and mentorship models. It is important to ensure that this approach is not only effective, but can also be replicated widely and consistently across the aviation sector.

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