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SECURITY AND SAFETY FOR SUSTAINABILITY IN AVIATION INDUSTRY

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Abstract

In the advancing technology era, air transportation has become a preferred mode of transport due to its efficiency. This development carrying the aviation safety and security become relatable issues in the aviation industry. Hence, the implementation of Standard Screening Requirement (SSR) This requirement is extracted from ICAO's finding (25 ICAO USAP) about unestablished screening processes. The fulfillment of standard safety equipment can contribute to the overall aviation industry, especially for security and safety. Therefore, this study has several objectives: (i). To analyze the impact of implementing the SSR towards security aspects; (ii). To analyze the impact of implementing SSR for the economy; and (iii). Describing the rate of violation before and after the implementation. This study uses a Systematic Literature Review (SLR) based on the Web of Science (WOS) database with several criteria. This study finds that technology is an important aspect for enhancing security. Using the advance and updating the technology will help to increase the safety and security in the aviation industry through better screening processes. The other findings also reveal that human capital skills and sustainability of Airlines are the most important aspect to support the security aspect. This study elaborates the findings that when the technology, human capital, Airlines industry are fully integrated, the aviation industry will enhance its global competitiveness.

Keywords**:** *Aviation Security & Safety, SSR, Human Capital, Technology, SLR.*

1. INTRODUCTION

Air transportation plays a crucial role for society in various activities to reach destinations more quickly. It offers the fastest, efficient, and most comfortable mode of transportation, making this highly favoured in modern life. Koti (2019) identified the determinants influencing the preference for air transportation modes. The results of the study indicated that the primary factors influencing airline choice are related to price and the safety factors offered. Comfort and safety are two key aspects that are of primary concern to passengers and stakeholders in the aviation industry (see Wahyudono, 2023). Aviation is governed by strict safety standards, including thorough security checks, crew training, supporting technology, and regular aircraft maintenance. These efforts aim to ensure passenger safety and minimize operational risks. These activities are designed to prevent threats to aircraft, passengers, and crew. However, Oster Jr. et al. (2013) argue that the challenges to enhance aviation security include: (i). Balancing the focus between identifying terrorists and detecting the tools they might use; (ii). Do in the appropriate response to terrorist threats; and (iii). Delineating the roles of public and private sectors in ensuring aviation security. Moreover, intervention in the industry can be done from public spending. In the context of security and safety, governments can play a crucial role through their budget and monetary policy. Lohman (2014) in his study found that the subsidies given by the government can affect the managerial decision to implement the R&D projects among airlines. This government spending will indirectly affect the sustainability of their aviation industry through increasing the rate of aviation security. On the other hand, government spending can affect the airline's financial performance by controlling money supply growth and exchange rate where both variables can affect the inflation rate economically. So, the rate of inflation will support the airlines through the loans rate for the aviation industry (Mwangi, 2013). Moreover, high inflation can severely negatively impact airlines,

such as: (i). Operational cost of airlines such as average fuel price, maintenance cost, and wage. The airlines might be facing the two conditions – constraint to aircraft maintenance that can affect security or bankruptcy for airlines because of severe profitability and market demand; (ii). Airlines' investment; and (iii). Airfare. Therefore, there are many aspects of government (rules, equipment, airport, airlines, support stations and others) that can intervene through their policy.

Security in aviation is closely linked to the role of technology and the human resources involved. Wahyudono (2023) in his study argues that technological aspects play a significant role in aviation safety performance. There is several equipment used to support the flight safety such as: Explosive material detector, organic & non-organic material detector, metal & non-metal material detector, liquid material detector, aircraft traffic, vehicle monitoring, cargo monitoring, crime deterrence, aviation security communication, and so on. Gupta & Kumar (2021) argue that technology can support the maintenance and reduce human error. Cordova (2022) and Degas et al. (2022) asserted the importance of technological aspects in aviation in his study. Furthermore, Biringkanae & Bunahri (2023) in their study elaborate on several types of technology used in aviation, as follows: (i). Air Traffic Management (ATM) as traffic management; (ii). Aircraft Maintenance to identify technical problems and reach the appropriate maintenance; and (iii). Customer Service. Moreover, the use of technology also extends to other activities such as aircraft landing at airports (see: Susanto et al., 2020; and Sabur et al., 2020) and air navigation (see Salsabila, 2020). Furthermore, Monika & Kumar (2021), using various examples of technology implementation such as 5G, Augmented Reality (AR), Aeronautical (AeroMACS), WAIC, Internet of Things (IoT), and System Wide Information Management (SWIM), also concluded similarly. The importance of technology usage underscores the necessity of digitization in aviation, which significantly impacts safety and security (see Kuisma, 2018). In addition to technology, other equipment supporting the operational safety of air transportation is also crucial. Ryapukhin (2023) also concluded that the rate of technology adopted in an economy can affects the development of standardization and certification of aviation equipment. However, it is essential that the existing equipment is standardized according to established standards.

In the global context, the event of 11th September 2001 when terrorists hijacked four commercial aircraft to attack the World Trade Center twin towers and the Pentagon, demonstrate the catastrophic consequences when terrorist plots succeed. By this event, Transportation Security Administration (TSA) reforms security screening strategies such as the policy of removing jackets and shoes, and the 3-1-1 liquid and gel policy for carry-on baggage. This process made an inconvenience for travellers due to longer screening times (see Lee & Jacobson, 2011). Therefore, the screening processes should not increase the expected time of passengers. Lee & Jacobson (2011) also stated that the security classes are composed of sets of screening devices, such as a magnetometer, an x-ray, and a millimeter-wave imaging machine. In Indonesia, the Ministry of Transportation compiles the strategic roadmap 2020-2024 (*Renstra 2020-2024*) to ensure the performance of flight safety and minimum setting of safety flight equipment detections. Here are several points discussed: (i). Aviation security facilities must be adapted to operational needs and technological advancements, considering the effectiveness of equipment, airport type, and threat and disturbance levels; (ii). The use of dual-view x-ray machines for inspecting cabin baggage and checked baggage at airports with A-F security systems; (iii). The use of dual-view x-ray machines for inspecting cargo at airports with D security systems; and (iv). Restrictions on the usage period of aviation security facilities. This roadmap using 5 priorities: (i). Enhancing the risk awareness and responses; (ii). Developing security culture and human capital competencies in aviation safety; (iii). Maximizing the technology resources; (iv). Enhancing the monitoring and quality control; and (v). Stakeholder integration. According to Minister of Transportation Decree Number 211 of 2020 about the Standard Screening Requirements (SSR) for Aviation Security. This decree is attempting to address ICAO's audit findings about unestablished screening activity. On the other hand, Malicang & Puspitasari (2023) indicate that Apron Movement Control (AMC) performance

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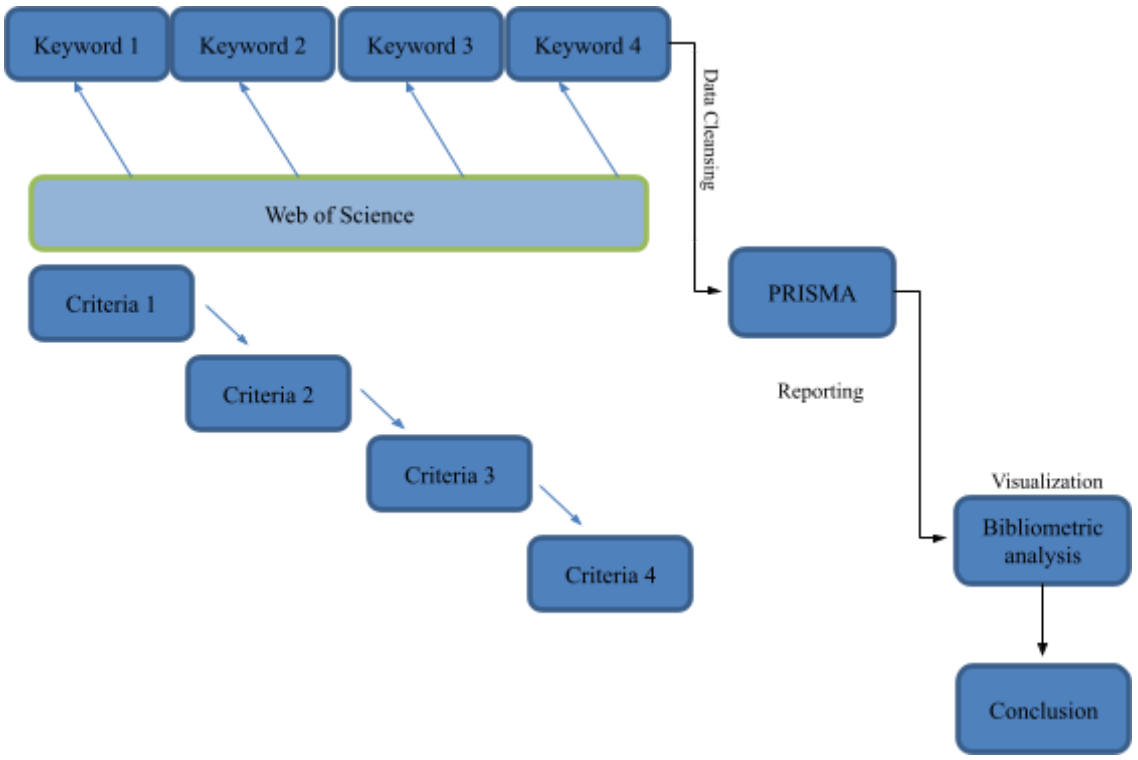
impacts the safety performance of Sultan Babullah Airport in Aceh. Aviation Security (AVSEC) also plays a crucial role in flight safety (see Widiarto & Endrawijaya, 2023). However, it is observed that equipment conditions and HR expertise remain suboptimal at airports in Indonesia (see Syamsudin, 2010; Arti et al., 2016; and Novita et al., 2020). Therefore, aviation security facilities include the equipment used to achieve flight security. Therefore, meeting the standard will contribute to the creation of security in the aviation world, extending to several other aspects, particularly within the industry as a whole. Additionally, some equipment conditions remain inadequate in supporting airport operations (Syamsudin, 2010; Arti et al., 2016; and Novita et al., 2020). Hence, the purpose of this study is to analyze: (i). The impact of implementing the SSR towards security aspects; (ii). The impact of implementing SSR for the economy; and (iii). The rate of violation before and after the implementation.

2. IMPLEMENTATION METHOD

Khan et al. (2003) describe a Systematic Literature Review (SLR) as a type of research that identifies relevant studies, assesses their quality, and summarizes existing studies using a scientific approach. This study will involve 4 Keywords to search the data. The database used in this study is Web of Science (WOS). Based on the general research topics and objectives, there are 4 keywords involved in this study (i). Aviation Security; (ii). Aviation Safety + Economic; (iii). Aviation + Violation; and (iv). Aviation Security + Screening. Furthermore, data cleansing is the next important step to ensure only qualified data are included (eligible articles) for further analysis. Therefore, there are several criteria used to clean the data, such as: (i). Years of publication – 2019-2024; (ii). Document types – articles; (iii). Language – English; (iv). Research areas – Transportation, Operation Research Management Science, Environmental Science Technology, Telecommunication, Business Economics, Instrument & Instrumentation, Social Science Other Topics, Science Technology Other Topics, Government Law, and Engineering.

Figure 1 Research Design



Source: Authors (2024)

Using only one database (Web of Science) will help the authors from redundant issues. Using too many bibliographic databases can lead to redundant data, requiring authors to filter through the same results multiple times and also time consuming. By focusing on a high-quality database like Web of Science, the research process can remain focused and efficient. Web of Science (WOS) and Scopus are the two main worldwide bibliographic databases for publication metadata (Pranckute, 2021). Therefore, the credibility of these two databases will simultaneously reach the need for validity and reliability of results. However, most users of these databases lack the expertise in bibliometrics or are unwilling to spend the extra time required for such evaluations (see Pranckute, 2021). That's why the authors only choose one of them to avoid the redundant. Web of Science was developed by Thomson Scientific, a part of the Thomson Corporation. Related records can be found and sorted by latest date, times cited, relevance, author, publication year, country/region, document type, source title and so on. According to Figure 1, the following steps included in this study are: (i). Searching the data through several keywords in Web of Science database with several criteria and will be saved in BibTeX extention; (ii). The cleansing process will be reported in Preferred Reporting Items for Systematic reviews & Meta-Analysis – (PRISMA); (iii). The eligible articles will be analysed by bibliometric techniques that included several visualisation; and (iv). Generate a conclusions. Bibliometric analysis is conducted in three stages: data compilation; software and data cleaning; and analysis, interpretation, and visualization (Nobanee et al., 2021). Such visualization is referred to as bibliometric mapping, which allows for the observation of connections within the structure of scientific fields in terms of authors, countries, documents, keywords, and other elements of scientific production (Briones-Bitar et al. 2020; Nobanee et al. 2021). Moreover, this study will use R software to generate bibliometric analysis. The package in R software let the authors to save their time in conducting Systematic Literature Review efficiently. The authors using R Studio and R software to run a specific package for bibliometric analysis (Biblioshiny). The visualization used in this study are: Annual Scientific Production; Most Relevant Words, and Most Relevant Authors. Annual Scientific Production will explain the performance of the topics. Furthermore, Most Relevant Words and Author will respectively visualize the most frequent words and prolific authors in particular research domain.

3. RESULTS AND DISCUSSION

As mentioned before, there are 3 keywords involved in the searching processes: (i). Aviation Security; (ii). Aviation Safety + Economic; (iii). Aviation + Violation; and (iv). Aviation Security + Screening. This following table will show the intended information:

Table 1. The Eligible Article

Keywords	Records	Excluded Items	Included Items
Aviation Security	474	442	32
Aviation Safety + Economic	64	54	10
Aviation + Violation	59	43	16
Aviation Security + Screening	156	142	14
Total	**753**	**681**	**72**

Source: Data Processed (2024)

The different sub-criteria are involved in the processes for each keyword:

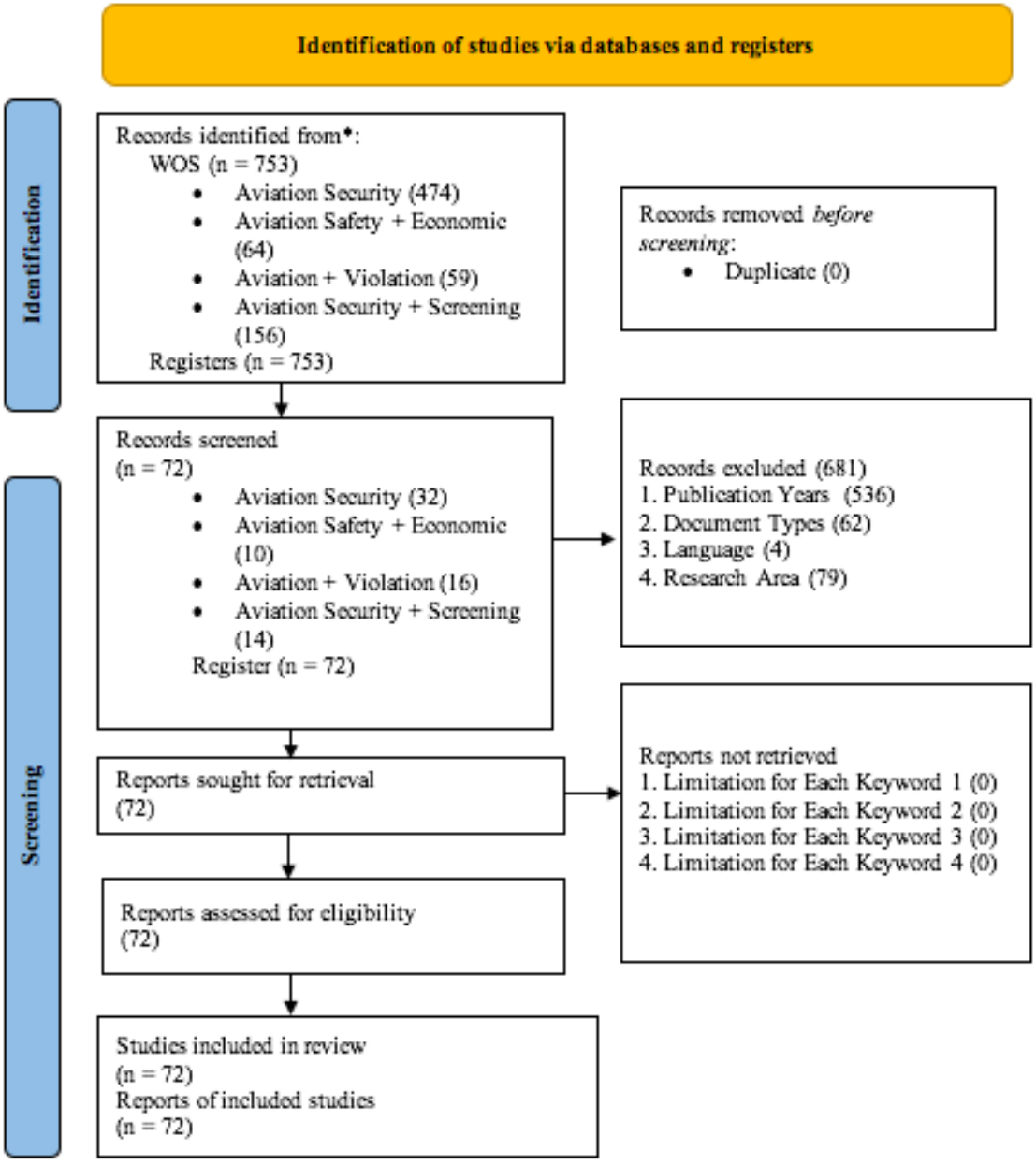
1. **"Aviation Security**" yields 32 data included with following criteria: (i). Years of 2019-2024; (ii). Document Types – Article; (iii). Language – English; and (iv). Research Areas – Transportation, Operation Research Management Science, Business Economics, Social Science Other Topics, Government Law, and Environmental Science Technology.
2. There are 10 articles included in **"Aviation + Economic"** keyword with following criteria: (i). Years of 2019-2024; (ii). Document Types – Article; (iii). Language – English; and (iv).

Research Areas – Transportation, Operation Research Management Science, Business Economics, and Social Science Other Topics.

3. **"Aviation + Violation"** yields 16 eligible articles included with same criteria as before and also types Research Areas: Business Economics; Transportation; Government Law, Science Technology other Topics, and Social Science Other Topics, Telecommunication, Instrument & Instrumentation, and Engineering.
4. "**Aviation Security" + "Screening**" yields 14 items included with different Research Area scopes: Business Economics, Transportation, Government Law, Science Technology Other Topics, Instrument & Instrumentation, and Engineering

Furthermore, for reporting matter, PRISMA are used in this study for doing a report because the diagram reveals the item excluded (n) for each criteria:

Figure 2. PRISMA Diagram

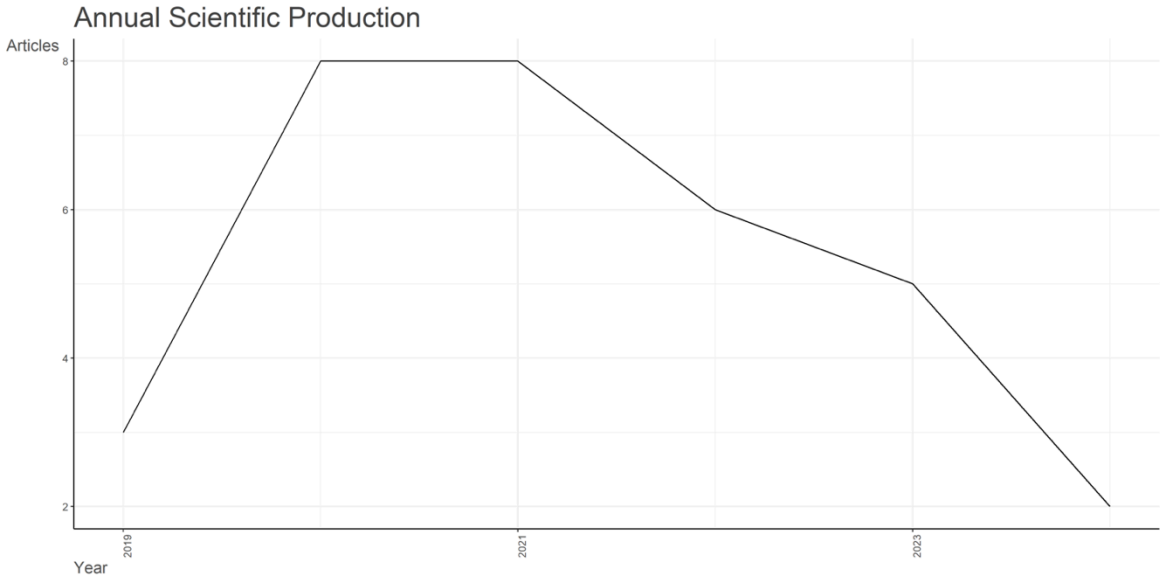


Source: Authors (2024)

According to the figure above, several criteria excluded the items or data, such as: (i). 536 items excluded for publication years of 4 keywords; (ii). 62 items excluded for Document Types of 4 keywords; (iii). 4 items for language of all keywords; and (iv). 79 items for research areas of all keywords. Therefore, 681 items are excluded in total. We subtract the Gross Record items with items excluded (753 – 681 = 72). Therefore, there are 72 items included (*eligible articles*) in this study for further analysis.

The development of the study (Aviation Security) has experienced a downfall trend with -7,79% in average. This can be interpreted that the study about aviation security has declined over the years, especially in WOS (Figure 3).

Figure 3. Annual Scientific Production of Aviation Security Keywords



Source: Data Processed (2024)

Based on figure above, it can be seen, that the declining trend in aviation security topic is happening. It might be caused by interdisciplinary shift or diversified topics. It causes aviation security topic might be increasingly viewed through interdisciplinary lenses, such as technology, logistics, emergency, and so on. The another thigs might be happened when there is a potential lag in publication (in pandemic of Covid-19 for example). Furthermore, considering that 2024 is not complete, hence the data may not fully reflect the trend of this year. The decline performance of this topic has several implications: (i). Lack of research could contribute to outdated policies and regulations; (ii). Experiencing a diminished effectiveness in security practices; (iii). Advancements in security technologies and strategies might slow down, affecting the industry's ability to respond to new challenges effectively; and so on.

Furthermore, there are several words associated in the context of Aviation Security. It can be seen from the figure below:

Figure 4. Most Relevant Words in Aviation Security Context

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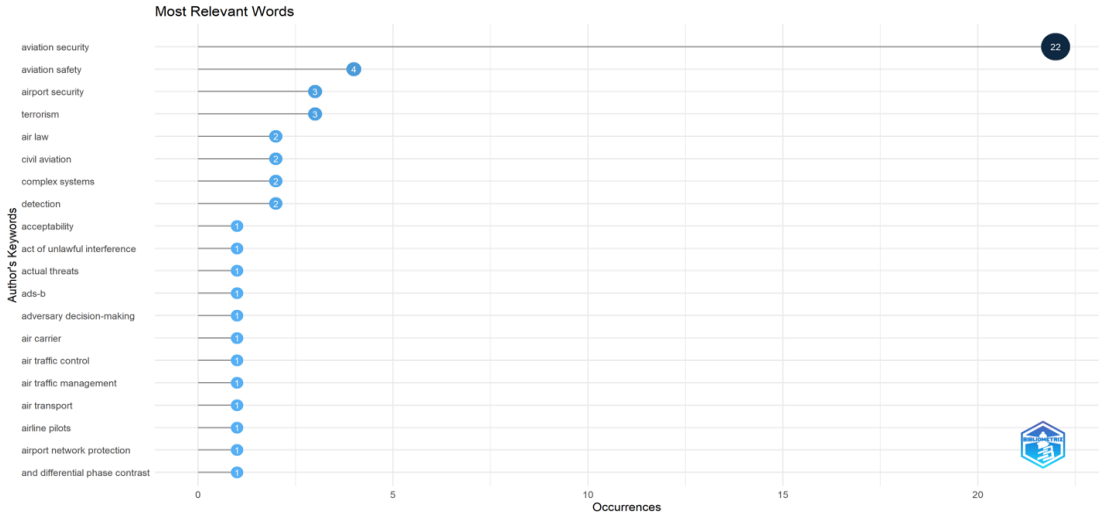
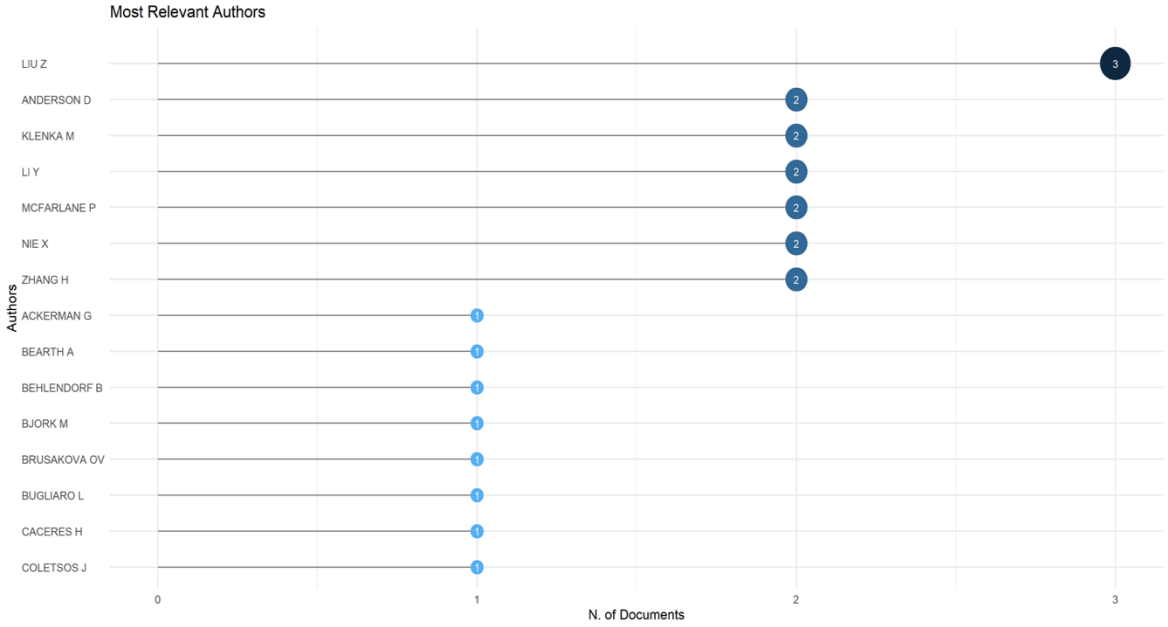


Source: Data Processed (2024)

Based on the figure above, it can be seen that several key terms emerge as most relevant, namely: Aviation Safety, Airport Security, Terrorism, Air Law, Air Traffic Control, Air Traffic Management, Airline Pilots, and Airport Network Protection. This study also shows the most relevant authors to see what topic emerge from the trusted authors. This following figure will show the intended information:

Figure 5. Most Relevant Authors in Aviation Security



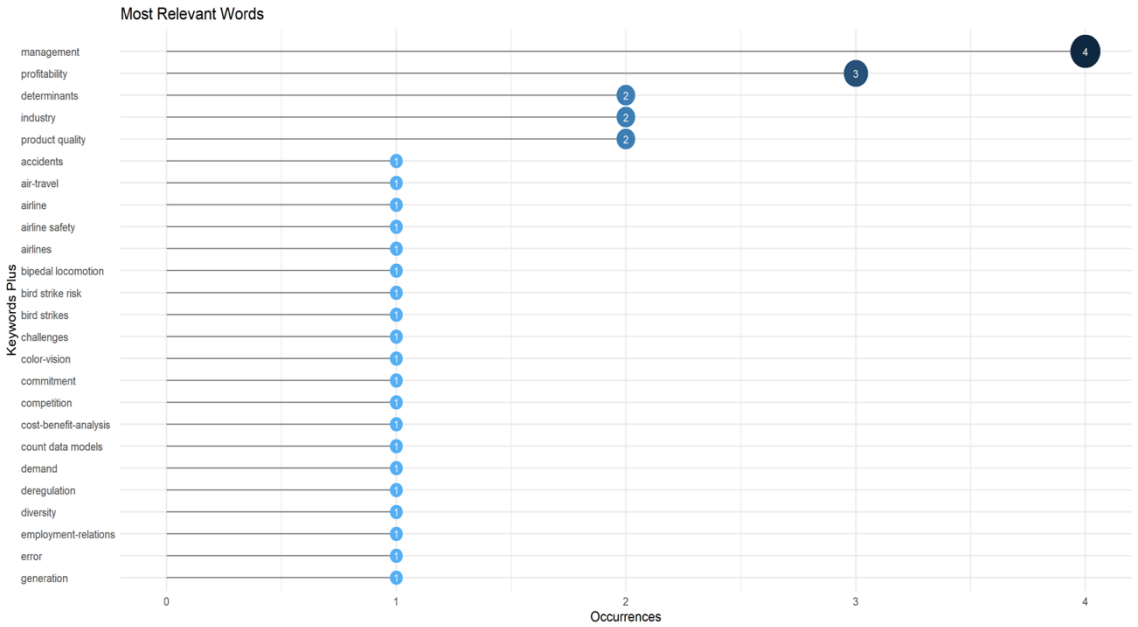
Sourced: Data Processed (2024)

In the context of aviation security, Li et al. (2021) in their study linked institutional trust factors to Safety Operation Behavior (SOB) and found a significant correlation between the two among airline pilot samples. Vukadinovic et al. (2023), as the second most relevant author, related this to airport security aspects (luggage screening x-ray) which is as a part of screening processes. Additionally, other technologies were also discussed in the study by Wu et al. (2023), which related to game simulation in emergency situations during flights (in-flight cabin). This indicates that security can also be viewed from a technological perspective. Cordova (2022) in his study stated that the focus of aviation security has shifted from

preventing aircraft hijackings to thwarting the smuggling of explosives and their precursors onto aircraft. There have been attacks and attempted attacks on commercial planes involving explosives concealed in checked luggage, carry-on baggage, and air cargo. Furthermore, Cordova (2022) in his study also implicitly stated that technology and aviation safety are closely linked. Flashback in the event of Pan Am Flight 103 (Boeing 747) that was exploded over the town of Lockerbie (Scotland) by plastic explosive materials hidden in cassette player and stored in suitcase led to the rapid aircraft destruction and it becomes the subject of Britain's largest criminal (CIA, 2023 and Britanica, 2024). The hidden explosive material should be concerned and closely related to the baggage screening at the airport. Cordova (2022) argue that several emerging technologies are promising for improving primary screening such as X-Ray Diffraction (XRD), Phase Contrast (PC) and Differential PC (DPC), Nuclear Quadrupole Resonance (NQR), and Neutron Scanning. Furthermore, Klenka (2019) in their study associated several criminal acts in the aviation world, such as aircraft hijacking and terrorism. Based on this study, it can be concluded that, in general, the topic of aviation safety and security is related to the behavior of implementing safety operation standards, airport security, the assistance of technological devices, and threats like hijacking and terrorism.

We also attempted to examine the relationship between aviation security and economic perspectives. Hence, the keywords "Aviation Safety" + "Economic" are used in the analysis. Surprising results were observed in the specified keywords, where there was a significant decline in the number of studies during the sample years. This indicates that the topic about aviation safety in the economic perspectives has experienced a drastic decrease (-41,52%). Moreover, there are several words associated in the context of Aviation Safety and Economics. It can be seen from the figure below:

Figure 6. Most Relevant Words in Aviation Safety and Economic Context



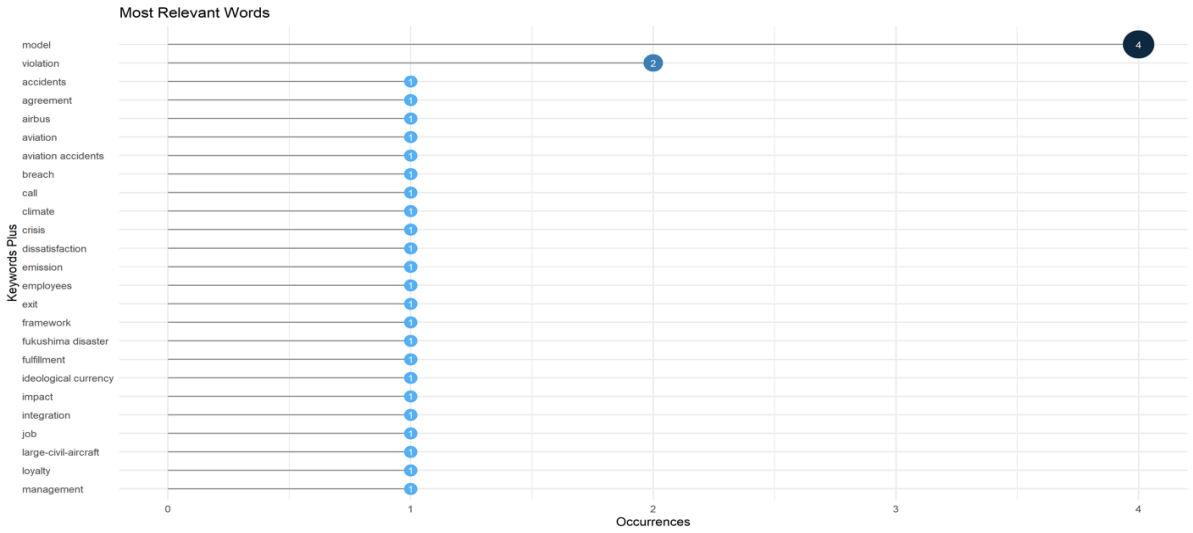
Source: Data Processed (2024)

From the figure, it can be seen that several key terms emerge as the most relevant regarding aviation safety from an economic perspective, such as: Profitability, Industry, Product Quality, Competition, Cost-Benefit Analysis, and Demand. The figure also shows that the keyword Profitability has the highest occurrence rate, appearing approximately three times. Furthermore Fardnia et al. (2021) used the Ordinary Least Square (OLS) approach with a sample of 110 airline companies across 26 countries from 1990 to 2009. The results of the study indicated that the

profitability level of airlines has a negative and significant impact on airline safety. Additionally, macroeconomic variables were also found to affect safety levels. Furthermore, safety aspects are also considered to have an impact on the competitive advantage of airlines, as mentioned in the study by Rutkowski (2020). Stamolampros (2022) in his study identified macro variables such as fuel prices, stock market volatility, industrial sector growth, and Treasury Bills interest rates. The results indicated that these macro variables impact aviation safety through airline managerial decisions, aligning with the concepts of financial distress and budget constraints that influence managerial policies. Collaboration between regulator and operator will enhance the quality of aviation security. In economic perspectives, the better financial performance of airlines will push them to create innovation and adding additional investment for safety reason. Meeting the regulation might be costly for airlines. Good economic performance enables compliance without compromising operational efficiency.

To answer the research question about safety violation, authors also used "Aviation + Violation" keywords to compile several issues emerge from the result. There are several words that are associated with those keywords, such as: Violation, Accidents, Airbus, Aviation Accidents, Climate, Emission, dan Fukushima Disaster.

Figure 7. Most Relevant Words (Aviation + Violation)



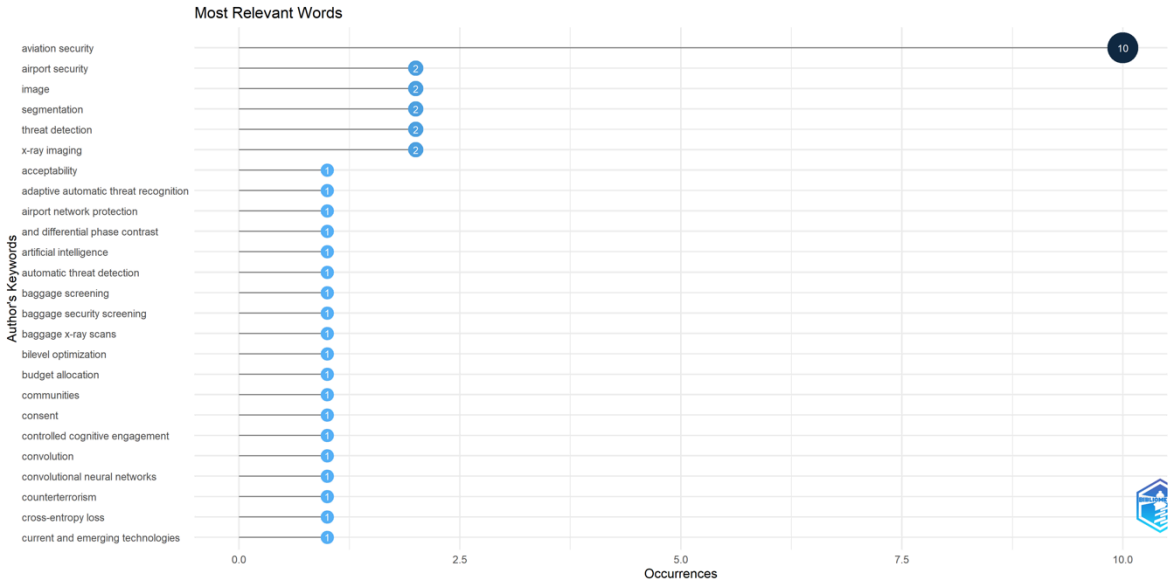
Sourced: Data Processed (2024)

Zhu & Chen (2023) in their study argue that human factors are the primary contributors to aviation accidents, particularly through Air Traffic Control (ATC). Furthermore, Abd Halim et al. (2024) mapped 107 accidents that occurred between 2017 and 2020. The results revealed that 59% of accidents were due to human error, 36% due to violations, and 5% due to skill-based errors. Based on these two studies, it can be concluded that human resource issues are crucial in violations affecting aviation safety. In this context, human resources can be viewed from the perspectives of: Violation, Human Error, and Skill-Based Error. Furthermore, for safety screening context, the knowledge of officers might be directing their behavior that over-relying on technology where officers might assume that technology will catch all threats and it potentially neglecting their own responsibilities for procedures in the screening process. Moreover, the more advance screening technology should be followed with the skills. When screening technology is highly advanced, it still relies on human interpretation. Errors in reading X-ray images, misidentifying objects, or failing to notice subtle anomalies can allow dangerous items to pass through. Therefore, screening processes it's not all about advanced technology, but also human skill to handle it precisely. In the case of Lockerbie Bombing (Pan Am Flight 103), the explosive material hidden and stored in cassette player and suitcase was not properly detected during screening processes and the officers failed to detect the bomb and indicating lapses in the procedure of screening. This true tragic event,

the human error can significantly affect the aviation security and will let the terrorism more flourish.

In the screening context, we identify a several keywords emerges from "Aviation Security + Screening".

Figure 8. Most Relevant Words "Aviation Security + Screening"



Sources: Data Processed (2024)

Figure 8 proving that there are linkage between aviation security and screening processes. It can be seen that there are several keywords emerges from this result such as: Airport Security, Threat Detection, X-Ray Imaging, Adaptive Automatic Threat Recognition, Airport Network Protection, Artificial Intelligence, Baggage Screening, Baggage Security Screening, Baggage X-Ray Scans, and so on. Qian et al. (2020) making a innovation from screening technology based on new algorithm and machine learning to recognize the materials in screening processes. This technology is proven 90% accurate with rate of error below 20%. This study implies that research and development play a significant role for the aviation security and safety trough the calibration. This study is also supporting the Cordova (2022) who stated that technology is a crucial aspect for safety.

4. CONCLUSION

In general, the topic of aviation safety and security is related to the behavior of implementing operational safety standards, airport security, technological assistance (screening processes), and hijacking & terrorism threats. In conclusion, Standard Screening Requirement (SSR) affects the aviation security and safety through: (i). Synergy between advancement technology and human competencies to minimize the failure of meeting security and safety procedure. Updating and calibrating the technology periodically trough research and development will enhance the accuracy rate of screening processes towards threat objects. Moreover, advancing the technology should be followed by officer's competencies to prevent lapses safety procedures and over-relying on technology; and (ii). Intensive collaborating movement between Regulator (Airport, Station Support, Government) and Main Operator (Airlines) to meet the requirement. Airlines can contribute to enhance the quality of security and safety if they are financially are well performed. Furthermore, the higher security and safety created by SSR can generate a competitive advantage for Indonesia's Aviation, especially for Airlines. The improvement in the technology, competencies, stakeholder synergy should have an impact after implementing the SSR. It can be seen from the tragic event of aircraft bombing in 1988 that reforms the security regulations. Hence,

the SSR would contribute to the quality of security and safety in aviation Industry. Additionally, the financial performance of airlines (profitability) might become a factor for safety and security aspect. It might be impacting their financial burden that forced managerial decision which can affect the quality of service. Furthermore, violations in aviation safety are closely related to human resource aspects, whether from negligence or human error

The conclusion has an implication that technology, competencies, stakeholder synergy are directly affecting the aviation security and safety. On the other hand, Research & Development (R&D) is the most determinant factor influencing the security aspect indirectly. R&D will push the industry to yield a innovation of technology that affect security aspect. This study has two main limitations: (i). Only using single approach to analyze the phenomenon. This study should have conduct Focus Group Discussion (FGD) among stakeholders to give more precise answer of research question; and (ii). This study only using SSR to identify its impact on security and safety aspect. As we know, there have been several aspects can be touch in the context of security and aviation safety. For theoretical interest, we highly recommend the next authors to develop a Focus Group Discussion (FGD) to strengthen our own results. Furthermore, for practical interest, we recommend: (i). The government should give financial support through their budget policy to boost Research & Development in screening technology, enhance the human capital skills in screening procedures, and subsidize for airlines to make security technology investments; (ii). Government can develop a Public Private Partnership (PPP) in enhancing technology innovation to reduce their own burden on budget; (iii). Strengthening the monitoring in the airport screening processes to ensure the validity and reliability of current technology used.

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