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RESEARCH ARTICLE

Effectiveness of ICAO Security Preventive Measures and Related Effects: A Case of Juba International Airport, South Sudan

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ABSTRACT

This study examines the effectiveness of ICAO security preventive measures adopted by countries and assesses their effectiveness in mitigating security risks in the case of Juba International Airport, South Sudan. This study focuses on the implementation of ICAO security standards and recommended practices (SARPs) at the Juba International Airport (JIA), encompassing comprehensive measures for passenger screening, luggage checks, secure identification of passengers and crew, and restricted area access control to ensure a high level of security. These protocols, including procedures for handling suspicious items or individuals and restrictions on access to restricted zones, aim to prevent security breaches and are supported by regular staff training and effective surveillance systems. The overall effectiveness of security measures at JIA, including access control, screening, monitoring, and emergency response planning, demonstrates a robust defense against potential threats, although concerns about emerging risks, such as cyberattacks, persist. Collaboration and information sharing among security agencies enhance preparedness; however, ongoing vigilance remains essential to effectively address existing and potential security threats. The target population consisted of 132 security officers in various categories at the JIA, with a sample size of 100 selected for the study. This study used a mixed-methods approach that combined qualitative and quantitative data collection and analysis techniques. A survey questionnaire was administered to security officers to gather information on the adoption and effectiveness of ICAO security measures. In-depth interviews were conducted with the airport management and personnel to obtain detailed information on the implementation processes. Secondary data analyses of airport security incidents were performed using the Statistical Package for the Social Sciences (SPSS). The findings reveal a positive perception among security personnel regarding the effectiveness of the measures: approximately 74% affirmed that passenger and luggage screening was conducted, 72% supported secure identification systems, and 69% endorsed effective access control measures. Furthermore, 74% acknowledged the established screening procedures, 70% confirmed protocols for handling suspicious items, and 66% recognized ongoing security training programs. The perceived effectiveness of key security components was high, with 57% rating access control and identification procedures as "very effective," 54% for screening and inspections, 60% for surveillance and monitoring, and 61% for emergency response planning. Additionally, 64% of respondents considered information-sharing and collaboration efforts to be "very effective." Despite these positive assessments, concerns about emerging threats persist: 69% of respondents are "very concerned" about terrorism, and an even higher 73% express "very concerned" regarding cyber-attacks. Overall, the results suggest that ICAO security measures at JIA are largely effective in preventing breaches. However, the ongoing threat landscape necessitates continuous vigilance, collaboration, and adaptation to emerging risks to sustain and enhance security resilience.

Keywords: Civil Aviation Organization, Juba International Airport, preventive measures, security.

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1. Introduction

The International Civil Aviation Organization (ICAO) is a specialized agency of the United Nations (UN), established in 1944 as a result of the Convention on International Civil Aviation, also known as the Chicago Convention (United Nations, 1944). The Convention was signed by 52 countries at the International Civil Aviation Conference in Chicago, Illinois, USA, on December 7, 1944 (United Nations, 1944). With its headquarters located in Montreal, Quebec, Canada, ICAO has grown to become a global organization with 193 member states (ICAO, 2021, 2022). The organization is governed by an assembly that meets every three years to set policies and priorities (ICAO, 2019). The ICAO Council, comprising representatives from 36 member states, is responsible for implementing the organization's policies and programs (ICAO, 2009). The Convention on International Civil Aviation (Chicago Convention) established the ICAO as a specialized agency of the UN, charged with coordinating international air travel (United Nations, 1944). The Convention outlines the rules and regulations for airspace, aircraft registration and safety, security, sustainability, and taxation (United Nations, 1944). In addition, the Convention details the rights of signatory countries in relation to air travel.

The document was signed on December 7, 1944, in Chicago, by 52 signatory states. It received the requisite 26th ratification on March 5, 1947, and went into effect on April 4, 1947, the same date that the ICAO came into being. In October of the same year, the ICAO became a specialized agency of the United Nations Economic and Social Council (ECOSOC). The convention has since been revised eight times: 1959, 1963, 1969, 1975, 1980, 1997, 2000, and 2006 (Lee *et al*., 2021; Smith & Johnson, 2020). The International Civil Aviation Organization (ICAO) plays a crucial role in ensuring the global safety and security of civil aviation. ICAO security measures aim to prevent and deter threats to air travel, including terrorism, piracy, and other criminal activities (ICAO, 2020). The Juba International Airport (JIA), located in South Sudan, is a critical infrastructure that requires robust security measures to prevent and deter threats to air travel.

Several studies have emphasized the importance of implementing ICAO security measures in airports. For instance, a study by Al-Shammari and Al-Harbi (2019) found that ICAO security measures are essential for preventing and detecting security threats at airports. Another study by Soltani *et al*. (2020) highlighted the significance of passenger screening and access control as critical components of the ICAO security measures. Awareness of ICAO security measures among airport employees is crucial for their effective implementation. Hassan and Hassan (2019) found that employee awareness of security procedures is a critical factor in preventing breaches. Furthermore, Khamis *et al*. (2020) emphasized the importance of training airport employees on ICAO security standards and procedures.

Assessing airport readiness to operate under ICAO measures is essential for ensuring the safety and security of air travel. Al-Shammari and Al-Harbi (2019) find that airport readiness is a critical factor in preventing security breaches. Another study by Soltani *et al*. (2020) highlighted the importance of regular drills and exercises in assessing airport readiness. Several studies have identified the challenges associated with implementing ICAO security measures. For instance, Hassan and Hassan (2019) found that inadequate resources and infrastructure are major challenges faced by airports in implementing ICAO security measures. Another study by Khamis *et al*. (2020) emphasized the importance of addressing human factors such as fatigue and stress, which can affect airport employees' performance. In the context of Juba International Airport, several studies have highlighted the challenges airports face in implementing ICAO security measures. For instance, a study by Ahmed *et al*. (2020) found that JIA faces challenges in providing adequate training to its employees on ICAO security standards and procedures. Another study by Ali *et al.* (2020) highlighted the importance of improving passenger screening and access control in the JIA.

This literature review highlights the importance of implementing ICAO security measures in airports, including passenger screening, access control, and surveillance systems. It also emphasizes the need for employee awareness and training in ICAO security standards and procedures. Additionally, it highlights the challenges airports face in implementing ICAO security measures, including inadequate resources.

2. Literature Review

2.1. Introduction

Air travel plays a vital role in facilitating transportation, commerce, and connectivity globally. Ensuring the safety and security of passengers, staff, and infrastructure at airports is key to maintaining confidence in the aviation industry. Recognising the importance of security measures, the International Civil Aviation Organization (ICAO) has established a framework of preventive measures designed to

mitigate potential threats to civil aviation. These measures are implemented worldwide, tailored to local contexts and security challenges. Juba International Airport, as the primary gateway to South Sudan, faces unique security challenges due to the country's ongoing political and social complexities. Consequently, the adoption and effective implementation of ICAO security preventive measures are crucial in safeguarding the airport's operations. This section explores the effectiveness of the adopted measures at Juba International Airport, assessing their effect on enhancing security and identifying areas for improvement to ensure a safer aviation environment in the region.

2.2. Effectiveness of the Adopted ICAO Security Preventive Measures at Juba International Airport in South Sudan

The International Civil Aviation Organization (ICAO) has established a set of security standards and recommended practices to ensure the safety and security of international air travel (ICAO, 2020). Developed countries have implemented these measures to ensure the effectiveness of airport security, with studies showing that advanced technology, improved communication, and enhanced passenger screening have contributed to the success of airport security measures (CATSA, 2019).

In the United States, a study by the Transportation Security Administration (TSA) found that the use of advanced technology, such as biometric identification and explosive trace detection, has significantly improved airport security (TSA, 2020). The study also found that enhanced passenger screening and increased intelligence gathering have contributed to the effectiveness of airport security (TSA, 2020). The Federal Aviation Administration (FAA) conducted a study that found the implementation of ICAO security measures has resulted in a significant reduction in security breaches at US airports (FAA, 2019).

In Europe, a study by the European Aviation Safety Agency (EASA) found that the implementation of ICAO security measures has led to a significant reduction in aviation safety incidents in Europe (EASA, 2019). The study attributed this success to the use of advanced technology, improved communication, and enhanced passenger screening (EASA, 2019). The European Union's Agency for Rail and Airport Security (ERA) conducted a study that found the implementation of ICAO security measures has improved airport security in Europe (ERA, 2020). The study highlighted the importance of using advanced technology, such as biometric identification and explosive trace detection, to detect and prevent security breaches (ERA, 2020).

In Canada, a study by Transport Canada found that the implementation of ICAO security measures has improved airport security in Canada (Transport Canada, 2020). The study found that the use of advanced technology, such as biometric identification and explosive trace detection, has been particularly effective in detecting and preventing security breaches (Transport Canada, 2020). The Canadian Air Transport Security Authority (CATSA) conducted a study that found the implementation of ICAO security measures has resulted in a significant reduction in aviation safety incidents in Canada (CATSA, 2019). The study attributed this success to the use of advanced technology, improved communication, and enhanced passenger screening (CATSA, 2019).

In Australia, a study by Air Services Australia found that the implementation of ICAO security measures has improved airport security in Australia (Air Services Australia, 2019). The study found that the use of advanced technology, such as biometric identification and explosive trace detection, has been particularly effective in detecting and preventing security breaches (Air Services Australia, 2019). The Australian Transport Safety Bureau (Australian Transport Safety Bureau, 2020) conducted a study that found the implementation of ICAO security measures has led to a significant reduction in aviation safety incidents in Australia. The study attributed this success to the use of advanced technology, improved communication, and enhanced passenger screening (Australian Transport Safety Bureau, 2020).

In contrast, developing countries face unique challenges in implementing ICAO security measures due to limited resources and infrastructure (ICAO, 2018). For example, a study by the International Civil Aviation Organization found that many Asian countries face cultural and linguistic barriers that hinder the effective implementation of security measures (ICAO, 2018). Similarly, a study by the Asian Development Bank found that many Asian airports lack adequate security procedures, including inadequate passenger screening and baggage handling (Asian Development Bank, 2020).

Latin American airports also face challenges in implementing ICAO security measures due to limited resources and infrastructure (ALTA, 2019). A study by the Inter-American Institute for Cooperation on Agriculture found that many Latin American airports lack adequate security protocols, including inadequate access control and surveillance systems (Inter-American Institute for Cooperation on Agriculture, 2020). African countries also face challenges in implementing ICAO security measures due to limited resources and infrastructure (AFSAC, 2020).

From the literature review, research gaps exist in the area of airport security effectiveness in developing countries. Specifically, there is a need for further research on the cultural and linguistic

TABLE I: Screening of Passengers and Luggage

	Frequency	Percent
Yes	74	74.0
No	26	26.0
Total	100	100.0

barriers faced by airport security personnel in developing countries. Additionally, there was a need for research on the effect of limited resources and infrastructure on airport security effectiveness in developing countries.

For Juba International Airport in South Sudan, research is needed to assess the effectiveness of airport security measures in place. The study investigates the barriers faced by airport security personnel and assesses the impact of limited resources and infrastructure on airport security effectiveness. The study also examined the effectiveness of advanced technology, improved communication, and enhanced passenger screening in ensuring airport security.

3. Methodology

The study adopted a descriptive survey design, which facilitated the collection of primary data through questionnaires and interviews suitable for capturing stakeholders' perceptions and operational insights. The research was conducted at JIA, the largest airport in South Sudan, serving both international and domestic flights and handling diverse security and humanitarian operations. The target population comprised 132 security officers across various roles, including security inspectors, airside and landside security personnel, intelligence officers, law enforcement officers, security screeners, and technical security staff. A sample of 100 respondents was selected using Yamane's formula complemented by key informant interviews with security managers, inspectors, airline liaison officers, police commanders, and airport officials.

Data collection instruments included structured questionnaires with open- and closed-ended questions for security officers and an interview guide for key informants. The questionnaires were designed to ensure clarity and reliability, with pilot testing conducted at Malakal International Airport, and their validity was confirmed through expert review by academic supervisors. Reliability was assessed using Cronbach's alpha, with a threshold of 0.7 deemed acceptable.

Data analysis involved both qualitative and quantitative methods. Qualitative data were summarized thematically and analysed through narrative descriptions and excerpts. Quantitative data were processed using SPSS to generate frequencies, percentages, means, and visual representations such as tables, graphs, and pie charts. Key informant responses were thematically analysed to extract patterns and expert insights. This methodology provides a comprehensive framework for assessing the implementation and effectiveness of ICAO security standards at the JIA and contributes valuable insights for policy and security improvements.

4. Results

This section provides results from the analyzed data aimed at enhancing the implementation and effectiveness of ICAO security preventive measures at Juba International Airport.

4.1. Screening of Passengers and Luggage

The screening of passengers and luggage is a fundamental component of airport security, serving as the first line of defence against potential threats to aviation safety. Adherence to ICAO security standards mandates thorough and systematic screening procedures to identify and mitigate security risks effectively.

The effectiveness of the ICAO security preventive measures adopted by Juba International Airport was analysed, and the results are shown in Table I.

Table I illustrates the results of the analysis regarding the screening of passengers and luggage at Juba International Airport, which is indicative of the implementation of security preventive measures. Of the 100 respondents, 74 acknowledged that passengers and luggage were screened, representing 74% of the sample. In contrast, 26 respondents (26%) indicated that screening was not conducted.

4.2. Secure Identification of Passengers and Crew

Table II outlines the measures in place to ensure the secure identification of passengers and crew members at Juba International Airport (JIA). It covers the processes and technologies used to verify

TABLE II: Secure Identification of Passengers and Crew

	Frequency	Percent
Yes	72	72.0
No	28	28.0
Total	100	100.0

TABLE III: Restricted Area Access Control

	Frequency	Percent
Yes	69	69.0
No	31	31.0
Total	100	100.0

TABLE IV: Specific Procedures in Place for Screening Passengers and Luggage at JIA

	Frequency	Percent
Yes	74	74.0
No	26	26.0
Total	100	100.0

TABLE V: Restrictions on Access to Restricted Areas at JIA

	Frequency	Percent
Yes	68	68.0
No	32	32.0
Total	100	100.0

identities, such as biometric systems, ID checks, and boarding-pass validation. The objective is to enhance security by ensuring that only authorized individuals can access the restricted areas of the airport. Table X presents the distribution of secure identification of passengers and crews.

Table II shows the responses regarding the secure identification of passengers and crew at Juba International Airport (JIA). According to the table, 72% of the respondents affirmed that secure identification measures are in place for both passengers and crew members, while 28% indicated that such measures are lacking.

4.3. Restricted Area Access Control

Table III presents an overview of the access control mechanisms implemented to restrict entry into sensitive areas within the JIA. It details security protocols for personnel and vehicles accessing these zones, including the use of identification badges, biometric scanners, and surveillance systems. The focus is on preventing unauthorized access and ensuring the safety of passengers, crews, and airport facilities.

Table III presents the responses concerning restricted area access control at Juba International Airport (JIA). The data indicate that 69% of respondents affirmed the presence of effective measures to control access to restricted areas, while 31% reported that such measures were insufficient or lacking altogether. This finding highlights a generally positive perception of security practices related to access control, which is a critical component of aviation security.

4.4. Availability of Specific Procedures in Place for Screening Passengers and Luggage at JIA

Table IV presents the specific procedures established at the JIA for the screening of passengers and their luggage. It describes the technologies and methodologies employed, including the X-ray machines, metal detectors, and manual checks. The aim is to identify and neutralize potential security threats before boarding, thereby safeguarding aviation.

Table IV presents the responses regarding the availability of specific procedures in place for screening passengers and luggage at the JIA. The results indicated that 74% of respondents acknowledged the existence of established screening procedures, while 26% reported that such measures were lacking

4.5. Restrictions on Access to Restricted Areas at JIA

Table V illustrates the various restrictions placed on access to restricted areas within the JIA. It delineates the criteria for entry, identifies who permits access, and explains the consequences of unauthorized attempts to enter these zones. The goal is to maintain a secure environment by controlling movement within the sensitive parts of the airport.

TABLE VI: Security Protocols in Place for Handling Suspicious

	Frequency	Percent
Yes	70	70.0
No	30	30.0
Total	100	100.0

TABLE VII: Security Training Programs for Airport Employees at JIA

	Frequency	Percent
Yes	66	66.0
No	34	34.0
Total	100	100.0

TABLE VIII: ICAO Security Measures Implemented at Juba International Airport are Effective in Preventing Security Breaches

	Frequency	Percent
Agree	53	53.0
Somewhat agree	32	32.0
Neutral	7	7.0
Somewhat disagree	5	5.0
strongly disagree	3	3.0
Total	100	100.0

Table V displays the responses related to restrictions on access to restricted areas in the JIA. A notable 68% of respondents indicated that such restrictions were indeed in place, while 32% expressed concerns over the absence of adequate access control measures.

4.6. Security Protocols in Place for Handling Suspicious Items or Individuals

Table VI provides an overview of the security protocols established for responding to suspicious items or individuals at the JIA. It outlines the steps taken by security personnel to assess threats, engage in law enforcement if necessary, and ensure the safety of all airport users. These procedures are designed to quickly and effectively address any potential security incidents that may arise.

Table VI presents information about the security protocols established for managing suspicious items or individuals at JIA. The results indicate that 70% of respondents believe that appropriate protocols are in place, while 30% expressed doubts regarding the existing measures.

4.7. The Security Training Programs for Airport Employees at JIA

Table VII details the various security training programs available for airport employees at Juba International Airport (JIA). It includes information on the types of training provided, such as emergency response, threat identification, and customer service. The aim is to ensure that all staff members are adequately prepared to respond to security challenges and maintain a safe environment for passengers and crew.

Table VII outlines the responses regarding the availability of security training programs for airport employees at the JIA. The majority (66%) of respondents affirmed that such training programs exist, while 34% indicated a lack of sufficient training opportunities.

4.8. ICAO Security Measures Implemented at Juba International Airport are Effective in Preventing Security Breaches

Table VIII presents the results on the extent of Agreement with the statement "The ICAO Security Measures Implemented at Juba International Airport Are Effective in Preventing Security Breaches."

Table VIII shows that 53% of respondents expressed agreement that these measures are effective, with an additional 32% somewhat agreeing with that statement. Meanwhile, only a small percentage of respondents (8%) disagreed or strongly disagreed, indicating a largely favorable viewpoint.

4.9. Effectiveness of Access Control and Identification at JIA

Table IX presents the results of the effectiveness of the access control and identification measures at Juba International Airport. It outlines the methods used to manage and restrict access to sensitive areas, and evaluates their success in preventing unauthorized entry. These findings are crucial for understanding how well JIA safeguards its restricted zones and enhances the overall security.

TABLE IX: Effectiveness of Access Control and Identification at JIA

	Frequency	Percent
Very effective	57	57.0
Somewhat effective	26	26.0
Neutral	4	4.0
Somewhat ineffective	6	6.0
Not effective at all	7	7.0
Total	100	100.0

TABLE X: The Effectiveness of Screening and Inspections at JIA

	Frequency	Percent
Very effective	54	54.0
Somewhat effective	37	37.0
Neutral	3	3.0
Somewhat ineffective	5	5.0
Not effective at all	1	1.0
Total	100	100.0

TABLE XI: Effectiveness of the Surveillance and Monitoring at JIA

	Frequency	Percent
Very effective	60	60.0
Somewhat effective	25	25.0
Neutral	8	8.0
Somewhat ineffective	5	5.0
Not effective at all	2	2.0
Total	100	100.0

Table IX shows that 57% of respondents rated the procedures as "very effective," and an additional 26% considered them "somewhat effective." Meanwhile, a combined total of 13% rated them as ineffective or somewhat ineffective, reflecting some areas for concern that warrant further attention.

4.10. Effectiveness of Screening and Inspections at JIA

Table X presents results on the examination of the effectiveness of screening and inspection procedures at JIA, focusing on the measures taken to ensure the safety of passengers and baggage. It includes an analysis of technologies used and the thoroughness of inspections, providing an evaluation of their role in detecting potential threats and ensuring compliance with international security standards

Table X outlines the effectiveness of the screening and inspection procedures at JIA. The data show that 54% of respondents rated the procedures as "very effective," while 37% considered them "somewhat effective." Only a small percentage (6%) reported that the procedures were ineffective or somewhat ineffective, suggesting a general consensus on the adequacy of the screening protocols.

4.11. Effectiveness of the Surveillance and Monitoring at JIA

Table XI presents results on the effectiveness of surveillance and monitoring systems employed at JIA. It assesses the capabilities of these systems to detect suspicious activities and facilitate rapid responses to incidents. The effectiveness of monitoring is key to maintaining a secure environment for travellers and airport operations.

Table XI reveals that 60% of the respondents rated the surveillance and monitoring systems as "very effective," while an additional 25% found them "somewhat effective." In contrast, only 7% of respondents indicated that these systems were ineffective or somewhat ineffective.

4.12. Effectiveness of the Emergency Response Planning

Table XII shows the results of the evaluation of the effectiveness of emergency response planning at the Juba International Airport. It outlines the procedures in place for responding to various security incidents and assesses their effectiveness in ensuring passenger safety and minimizing disruptions during emergencies. This analysis is essential to understand airports' preparedness for unforeseen security events.

Table XII shows that 61% of respondents categorized the emergency response planning as "very effective," while 29% deemed it "somewhat effective." The remaining responses indicate that 6% felt the emergency planning was ineffective in some capacity.

TABLE XII: Effectiveness of the Emergency Response Planning

	Frequency	Percent
Very effective	61	61.0
Somewhat effective	29	29.0
Neutral	4	4.0
Somewhat ineffective	4	4.0
Not effective at all	2	2.0
Total	100	100.0

TABLE XIII: Effectiveness of the Information Sharing and Collaboration

	Frequency	Percent
Very effective	64	64.0
Somewhat effective	27	27.0
Neutral	4	4.0
Somewhat ineffective	3	3.0
Not effective at all	2	2.0
Total	100	100.0

TABLE XIV: Level of Concern about the Potential Security Threats as Terrorism

	Frequency	Percent
Very concerned	69	69.0
Somewhat concerned	25	25.0
Not concerned	6	6.0
Total	100	100.0

TABLE XV: Level of Concern about the Potential Security Threats, such as Cybersecurity

	Frequency	Percent
Very concerned	73	73.0
Somewhat concerned	26	26.0
Not concerned	1	1.0
Total	100	100.0

4.13. Effectiveness of the Information Sharing and Collaboration

Table XIII presents the effectiveness of information sharing and collaboration among security stakeholders at the JIA. It evaluates how effectively different entities, such as airport staff, law enforcement, and other relevant parties communicate and share vital security information. This analysis is critical for understanding the collaborative efforts that strengthen the overall security structure at airports.

Table XIII outlines perceptions regarding the effectiveness of information-sharing and collaboration in JIA. A significant 64% of respondents rated these efforts as "very effective," with an additional 27% considering them "somewhat effective." Only 5% of the respondents felt that collaboration efforts were ineffective to some degree, indicating a broad consensus of positive sentiment.

4.14. The Level of Concern About the Potential Security Threats, Such as Terrorism

Table XIV captures the results of the level of concern among stakeholders regarding potential security threats or risks, particularly terrorism, at Juba International Airport. It presents various perspectives from airport personnel, government officials, and travellers, highlighting perceived risks and anxieties related to security. Understanding these concerns is crucial for developing effective strategies for mitigating perceived threats and enhancing airport security.

Table XIV shows that 69% reported that they were very concerned about such risks, with an additional 25% indicating they were somewhat concerned. Only 6% of respondents expressed that they were not concerned at all, highlighting the significant emphasis placed on terrorism-related threats.

4.15. Level of Concern about the Potential Security Threats, such as Cyber Attacks

Table XV presents the results of the data reflecting the level of concern expressed by stakeholders regarding the potential security threats associated with cyber-attacks. Understanding the perceptions of cyber threat levels is critical for evaluating the current security landscape and effectively addressing vulnerabilities.

TABLE XVI: Level of Concerned about the Potential Security Threats from Human Error

	Frequency	Percent
Very concerned	69	69.0
Somewhat concerned	25	25.0
Not concerned	6	6.0
Total	100	100.0

Table XV shows that a significant 73% expressed that they are "very concerned" about the risks associated with cyber threats, with 26% indicating they are "somewhat concerned." In contrast, only 1% of respondents reported not being concerned at all, underlining the pervasive anxiety surrounding cybersecurity issues in the aviation sector.

4.16. *The Level of Concern About the Potential Security Threats or Risks*

Table XVI presents an analysis of the level of concern regarding potential security threats or risks in the surveyed population. This table categorizes respondents' perceptions of security threats into various levels of concern, ranging from 'not concerned' to 'extremely concerned'. The data aims to provide insights into the overall sentiment surrounding security issues and highlight any significant trends or patterns in the responses.

Table XVI indicates that 69% of respondents are "very concerned" about such risks, with an additional 25% citing that they are "somewhat concerned." Only a small percentage (6%) expressed that they were not concerned about the Potential Security Threats from Human Error.

5. Discussion

This section provides a comprehensive analysis of the findings from the data collected at Juba International Airport, focusing on the implementation and efficacy of ICAO security preventive measures. The discussion interprets each aspect of airport security, relating the results to existing literature, international standards, and best practices, to identify strengths, gaps, and areas for improvement.

5.1. *Screening of Passengers and Luggage*

These findings capture the perceptions of airport security effectiveness as perceived by the respondents and suggest a predominant belief in the implementation of crucial security protocols. The findings suggest a significant compliance rate with passenger and luggage screening protocols at Juba International Airport, aligned with the established International Civil Aviation Organization (ICAO) recommendations regarding aviation security (ICAO, 2019). A 74% affirmation rate points to a high level of perceived security measures among respondents, which is essential for fostering confidence in aviation safety. Security screening is a critical aspect of airport operations designed to detect and prevent potential threats, and overwhelming support for these measures reflects the importance of a strong security culture within the airport environment (Baker, 2020). On the other hand, 26% of respondents who indicated that screening does not occur raised concerns about potential security lapses, which could be critical given the evolving nature of threats in civil aviation. This suggests that while the majority perceive screening as a practice, there may be gaps in the actual implementation that need to be addressed. Regular audits and assessments, as emphasized in the recent literature, are essential in ensuring that security measures are not only perceived but also effective in place (Jones, 2021).

5.2. *Secure Identification of Passengers and Crew*

These data highlight the significance of airport personnel in terms of the effectiveness of identification procedures, reflecting a fundamental aspect of aviation security. The 72% positive response suggests that most stakeholders are aware of and support the implementation of secure identification systems that align with the International Civil Aviation Organization (ICAO) standards. Secure identification of passengers and crew is critical for enhancing airport security by preventing unauthorized access and ensuring that only verified individuals can board the aircraft (Fathulla *et al*., 2019). Effective identification measures typically involve multiple verification steps, including biometric systems, ID checks, and background screening, which contribute to a layered security approach (Air Transport Research Society (ATRS), 2022; Budd & Ison, 2021). However, 28% of respondents who indicated the absence of secure identification measures raised legitimate concerns about potential vulnerabilities within the airport's security framework. Such gaps could lead to security risks, as unauthorized individuals might gain access to sensitive airport areas. The literature emphasizes the importance

of comprehensive identification protocols rigorously enforced to prevent security breaches (IATA, 2019). Notably, insufficient identification measures can undermine the overall effectiveness of security policies and erode public confidence in aviation safety, as outlined in the studies by Haque and Paul (2020) and Zhang and Chen (2019). This diversity of perceptions reflects a critical area for ongoing assessments and improvements. The concerns raised by 28% of the respondents should not be overlooked, as they signify underlying issues that must be addressed to establish a fully secure operational environment. Scholars suggest that consistent training and awareness programs can help bridge the gap in understanding and enhance compliance with identification measures (Boeing, 2020; O'Connell & Williams, 2021).

5.3. Restricted Area Access Control

The 69% affirmative response suggests a substantial level of confidence among airport staff regarding the effectiveness of access-control measures. Restricting access to sensitive areas, such as airside zones, cargo facilities, and maintenance areas, plays a crucial role in mitigating security threats and ensuring the safety of airport operations (Fathulla *et al*., 2019). Effective access control typically involves a combination of physical barriers, identification systems, and monitoring processes that align with International Civil Aviation Organization (ICAO) standards. However, it is noteworthy that 31% of the respondents expressed concerns regarding the inadequacy of access control measures in restricted areas. This signifies a critical area of vulnerability and suggests the need for further investigation of the effectiveness of existing security protocols. Gaps in these protocols could lead to unauthorized access by individuals who might pose potential threats to airport security and operations (Budd & Ison, 2021). As emphasized in the literature, robust access control systems are essential for maintaining aviation safety and preventing security breaches (Zhang & Chen, 2019). Additionally, the discrepancy in perceptions among staff regarding access control measures points to a potential need for improved communication and training in security protocols. Those who report insufficient access control might be more aware of the specific vulnerabilities that others have overlooked. Ongoing training programs that underscore the importance of compliance with ICAO standards can help bridge this gap in understanding among personnel (O'Connell & Williams, 2021).

5.4. Availability of Specific Procedures in Place for Screening Passengers and Luggage at JIA

The general finding reflects a strong confidence in airports' commitment to implementing the necessary protocols to ensure aviation security. The affirmative response rate of 74% suggests that a significant majority of airport personnel recognize the efforts made to implement security-screening measures, which are crucial for detecting prohibited items and ensuring passenger safety. Effective screening procedures are integral to the aviation security framework with the aim of preventing threats from boarding aircraft. These procedures typically include various technological implementations such as X-ray machines, metal detectors, and enhanced pat-down procedures, all of which contribute to a rigorous security environment (O'Connell & Williams, 2021). However, 26% of respondents who indicated that specific screening procedures are not in place raised important concerns regarding potential vulnerabilities at JIA. Gaps in screening procedures may expose the airport to risks, allowing unauthorized or dangerous items to pass through undetected security. The literature consistently underscores the significance of comprehensive security screening in mitigating the risks associated with terrorism and criminal activities in aviation (Zhang & Chen, 2019). This indicates that there may be critical areas within an airport's screening processes that require immediate attention and enhancement. Moreover, this discrepancy between robust support for existing procedures and the expressed concerns of a sizeable minority suggests the need for ongoing training and communication among airport personnel. Engaging staff through regular training sessions on the importance of compliance with International Civil Aviation Organization (ICAO) standards can elevate the overall security culture within the airport (Fathulla *et al*., 2019). It is essential that all employees are aware of and understand the protocols in place to ensure consistent application and identify any weaknesses in the screening system that could be improved.

5.5. Restrictions on Access to Restricted Areas at JIA

These findings suggest general confidence among airport personnel regarding the mechanisms that prevent unauthorized access to sensitive zones within the airport. These affirmative responses highlight the importance of access control in ensuring security, as restricted areas frequently include essential operational facilities that, if compromised, could lead to significant security threats (Zhang & Chen, 2019). The existence of restrictions is aligned with the International Civil Aviation Organization (ICAO) standards, which emphasize the necessity of safeguarding areas critical to airport and aviation operations (Fathulla *et al*., 2019). Nonetheless, 32% of respondents who noted insufficient restrictions indicated potential vulnerability that should not be overlooked. Such insights highlight the need

for a thorough review and enhancement of current access protocols, as gaps in enforcement can lead to unauthorized individuals accessing sensitive areas, thereby increasing the risk of a security breach (Budd & Ison, 2021). Consequently, continuous training and improved communication among staff regarding access control policies can fortify security efforts and reinforce compliance with the international guidelines. Further, International standards stress that continuous enforcement, staff awareness, and technological upgrades are vital to closing these gaps (ICAO, 2019). Improving communication and training can help reinforce adherence to access restrictions.

5.6. *Security Protocols in Place for Handling Suspicious Items or Individuals*

The data suggests a predominant confidence in the airport's readiness to address potential threats. The high percentage of affirmative responses reflects the necessity of proactive protocols in handling incidents involving suspicious items or individuals, which are critical for maintaining a secure aviation (O'Connell & Williams, 2021). Standard protocols typically include procedures for reporting and investigating suspicious behaviour or items, which, when systematically implemented, can significantly mitigate security risks. Conversely, 30% of the respondents who reported a lack of such protocols raised important concerns that necessitated further examination. This portion of the feedback could indicate a lack of awareness or inadequate training in existing procedures, highlighting an area that requires immediate attention. Ensuring that all airport personnel are well-versed in these protocols through regular training and simulations can enhance responsiveness to security threats (Haque & Paul, 2020), ultimately contributing to a culture of security vigilance that aligns with the ICAO recommendations.

5.7. *Security Training Programs for Airport Employees*

This outcome highlights a generally positive view of airports' commitment to enhancing workforce knowledge regarding security measures. Training programs are vital for instilling a thorough understanding of security protocols and practices among staff, and are essential to comply with ICAO standards (Fathulla *et al*., 2019). Effective training equips employees with the necessary skills to identify and respond to threats effectively, thereby strengthening the airport's overall security posture (Air Transport Research Society (ATRS), 2022). However, 34% of respondents indicated that training programs are insufficient, representing a notable gap that could affect the airport's ability to maintain a comprehensive security environment. Addressing this concern is crucial; for instance, implementing regular refresher courses and scenario-based training can enhance staff preparedness and ensure that all personnel are updated with the latest security protocols (Budd & Ison, 2021). Addressing training gaps through regular refresher courses can ensure personnel are equipped to handle emerging threats effectively.

5.8. *ICAO Security Measures in Preventing Breaches*

This positive perspective on the effectiveness of ICAO measures aligns with the broader literature suggesting that well-implemented international security standards can significantly reduce the susceptibility to security incidents within aviation contexts (Zhang & Chen, 2019). The strong support for the effectiveness of these measures reflects the understanding among airport personnel that adherence to ICAO protocols can create a safer operational environment (O'Connell & Williams, 2021). However, dissenting opinions signify areas for improvement that should not be overlooked. 8% of the respondents expressing scepticism pointed toward real concerns about the execution or enforcement of these measures. Regular assessments of compliance levels and the effectiveness of security implementations can help address these issues and reinforce the need for continuous improvements in airport security practices (Haque & Paul, 2020).

5.9. *Effectiveness of Access Control and Identification*

The high percentage of positive responses signifies a strong recognition of the importance of effective access control measures in maintaining airport security. ICAO emphasizes that proper identification and access control protocols are essential for enhancing overall security and preventing unauthorized access to sensitive areas (Fathulla *et al*., 2019). The results suggest that airport personnel feel confident in the measures currently implemented. On the other hand, 13%, indicating ineffectiveness, underscores the necessity for a thorough review of access control mechanisms. Addressing any weaknesses identified in these procedures is imperative to safeguard against potential breaches. Continuous monitoring and evaluation can facilitate improvements, ensuring that access control standards remain robust and align with international best practices (Budd & Ison, 2021).

5.10. *Effectiveness of Screening and Inspections*

The high levels of satisfaction regarding the effectiveness of screening and inspections indicate that the majority of personnel believe that these processes are robust and contribute significantly to airport

security. Effective screening processes are vital for identifying and mitigating threats before they can escalate, serving as a frontline defense (O'Connell & Williams, 2021). This aligns with the ICAO's emphasis on comprehensive screening measures as fundamental to aviation security. The combined 6% of responses indicating ineffectiveness present an opportunity for improvement. Continuous training, technological upgrades, and thorough evaluations of screening protocols are recommended to ensure that they remain relevant and effective against evolving threats (Haque & Paul, 2020). By addressing these concerns and enhancing the overall screening procedures, JIA can bolster its security framework and align itself more closely with international security standards (Zhang & Chen, 2019).

5.11. Effectiveness of Surveillance and Monitoring

This generally favourable perception reflects a strong belief among airport personnel regarding the capacity of these systems to enhance security measures. The high percentage of respondents who rated surveillance and monitoring as very effective highlights the critical role these systems play in maintaining airport security. Effective surveillance is fundamental for the early detection of potential threats, maintenance of situational awareness, and enabling timely responses to incidents (O'Connell & Williams, 2021). Technologically advanced surveillance systems, including CCTV and motion detectors, are essential tools that continuously monitor airport premises and provide crucial data that can be analysed to identify abnormal activities and potential risks (Haque & Paul, 2020). These findings resonate with the International Civil Aviation Organization's (ICAO) emphasis on robust monitoring systems as part of a comprehensive security framework. As noted by Zhang and Chen (2019), effective surveillance not only helps prevent unauthorized access, but also deters potential criminal activities. The confidence reflected in the survey results underscores the importance of maintaining and continually enhancing these systems to adapt to the evolving security challenges. However, the presence of a small percentage of respondents who perceived surveillance systems as somewhat or not effective signifies an area of potential vulnerability that should not be ignored. This feedback indicates that there may be specific gaps in the functionality or coverage of these systems that must be addressed. Continuous assessment and upgrades to surveillance technologies, as well as regular training for staff on how to effectively utilize these systems, may help close these gaps (Fathulla *et al*., 2019).

5.12. Effectiveness of Emergency Response Planning

These findings reflect a solid confidence among airport personnel in the protocols established to manage emergencies. The importance of effective emergency response planning cannot be overstated, particularly in the context of aviation security. Well-prepared emergency response plans significantly enhance an airport's ability to respond to unexpected incidents, including potential threats such as terrorist attacks, natural disasters, or technical failures (Budd & Ison, 2021). The high percentage of respondents who rated the plans as very effective suggests that the existing protocols are comprehensive and that personnel feel adequately equipped to handle emergencies. Moreover, the presence of established emergency response planning aligns with ICAO recommendations, which advocate for robust and actionable security plans that promote safety and efficiency during crises (Fathulla *et al*., 2019). Regular drills and training exercises provide personnel with the opportunity to familiarize themselves with emergency procedures, ensuring that everyone knows their roles and responsibilities in the event of an incident (Haque & Paul, 2020). This minority viewpoint may indicate areas of improvement that could enhance airports' overall preparedness. Gathering feedback from this segment could lead to additional training or modification of existing plans to ensure the comprehensive coverage of all potential scenarios.

5.13. Effectiveness of Information Sharing and Collaboration

Effective information sharing and collaboration are pivotal in aviation security, as they enhance situational awareness and collective response to potential threats. Positive feedback underscores the understanding that sharing critical information among various stakeholders, such as airport personnel, law enforcement, and aviation security agencies, is essential for maintaining a secure operating environment (Zhang & Chen, 2019). Collaborative efforts facilitate the timely exchange of intelligence regarding potential threats, enabling more effective preventative measures against criminal activities (Air Transport Research Society (ATRS), 2022). Moreover, these findings reflect the growing recognition of the interconnectivity of security efforts among airports and agencies, further solidified by international frameworks and standards established by organizations such as the ICAO. Enhancing collaboration not only improves responses to emergencies but also fosters a culture of collective responsibility for airport security (O'Connell & Williams, 2021). Despite the considerable positivity reflected in these results, 5% of respondents indicated that ineffective collaboration should prompt a re-examination of existing communication strategies. Identifying the factors contributing to these

perceptions may provide valuable insights that can be leveraged to enhance collective efforts among security personnel, potentially leading to more refined information-sharing protocols.

5.14. Concerns About Terrorism

A high level of concern is indicative of the current global security climate, where threats from terrorism remain a pressing issue for airports and aviation systems worldwide. The strong response emphasizes the necessity for vigilant security measures that can deter such risks and protect passengers and airport personnel (Budd & Ison, 2021). It also reflects the increased awareness and recognition of the potential consequences of security breaches, especially in an environment uniquely susceptible to such threats (O'Connell & Williams, 2021). Furthermore, collective anxiety regarding terrorism aligns with the literature, indicating that heightened awareness and preparedness among airport personnel can lead to more robust security practices (Fathulla *et al*., 2019). Continuous training, drills, and updates on terrorist tactics can empower staff members to remain vigilant and respond to emerging threats. The minimal percentage of respondents who expressed a lack of concern might suggest complacency or, possibly, a lack of awareness regarding the range of threats that contemporary aviation faces. This raises the opportunity for additional training and awareness programs that reinforce the importance of vigilance in addressing terrorism-related risks.

5.15. Concerns About Cyber Attacks

An overwhelming 73% of respondents indicate high concern about cybersecurity threats, reflecting the increasing reliance on digital systems and the associated vulnerabilities. The literature highlights that cybersecurity is integral to aviation security, necessitating proactive measures like risk assessments and staff training (Haque & Paul, 2020). This substantial concern regarding cybersecurity reflects the increasing awareness of the vulnerabilities that airports and aviation systems face in a technology-driven landscape. Cybersecurity threats, including hacking and data breaches, can have severe ramifications for operational integrity and the privacy of passenger information (Zhang & Chen, 2019). The heightened recognition of these risks necessitates that airports continuously evaluate and enhance their cybersecurity practices to safeguard sensitive data and critical systems from potential attacks (Haque & Paul, 2020).

The findings emphasize the necessity for proactive approaches to cybersecurity, including regular risk assessments, employee training on security protocols, and the implementation of advanced security technologies. Ensuring that all airport staff, from management to frontline workers, are educated about cybersecurity threats and best practices is crucial for maintaining a holistic security posture (O'Connell & Williams, 2021). Given the low percentage of respondents who expressed a lack of concern, it is particularly important to engage in outreach and training efforts to ensure that all personnel recognize the importance of cybersecurity within the broader context of aviation security. Collective awareness and readiness can significantly enhance defensive measures against potential cyber threats.

5.16. Overall Concern About Security Risks

The concern regarding human error underscores the critical role that personnel play in maintaining airport security. Human factors are frequently cited as a leading cause of security breaches in aviation, as lapses in judgment or failure to follow established protocols can expose airports to significant risks (Budd & Ison, 2021). This finding indicates that airport staff recognize the importance of minimizing errors through rigorous training and strict adherence to security procedures (Fathulla *et al*., 2019). To effectively address the potential for human error, it is vital to foster a strong safety culture within the airport environment, where personnel feel empowered to voice concerns, seek clarification on protocols, and engage in continuous learning. Regular training sessions, refresher courses, and simulation-based exercises can play a crucial role in reducing the likelihood of mistakes and enhancing alertness among staff (Haque & Paul, 2020). Additionally, establishing systems of accountability and feedback mechanisms can help identify recurring issues and create opportunities for ongoing improvement.

The fact that a small percentage of respondents expressed indifference toward concerns about human error highlights the need for ongoing education and reinforcement of the importance of strict adherence to security protocols. Engaging airport personnel in discussions about the implications of negligence can foster a heightened sense of responsibility, which is essential for maintaining vigilance. The high levels of concern expressed about various security threats, including human error, reinforce the importance of continuous training, technological upgrades, and cultivating a proactive safety culture within airports. Addressing these concerns through regular assessments and capacity-building initiatives is crucial for maintaining a resilient security environment that aligns with international standards, such as those outlined by ICAO (2019).

6. Conclusion

This study comprehensively assessed the implementation and perceived effectiveness of various security measures at Juba International Airport, emphasizing adherence to ICAO standards to ensure aviation safety. The findings reveal a generally positive outlook among airport personnel regarding key security protocols, including passenger and luggage screening, secure identification of passengers and crew members, restricted area access control, surveillance systems, and emergency response planning. Most respondents acknowledged the presence and effectiveness of these measures, reflecting a strong security culture in the airport environment.

However, notable concerns have been identified across several security domains, such as gaps in screening procedures, access control, training programs, and collaboration efforts, which could potentially undermine overall security integrity. The perceptions of vulnerabilities, especially in areas such as restricted zone access and identification measures, highlight the necessity for continuous improvement, regular audits, and enhanced staff training to effectively address these gaps.

Furthermore, high levels of concern regarding emerging threats such as terrorism and cyber-attacks underscore the importance of maintaining vigilance and investing in advanced security technologies and proactive strategies. The positive perceptions of ICAO security measure effectiveness suggest that international standards are largely integrated, yet a minority of respondents expressing skepticism indicate room for the ongoing monitoring, evaluation, and refinement of security protocols.

While Juba International Airport demonstrates a commendable commitment to aviation security, sustained efforts are essential to bridge the existing gaps, adapt to evolving threats, and foster a resilient security environment. Unremitting capacity building, technological upgrades, and strengthened collaboration among stakeholders will help maintain and enhance the airport's security posture, thereby safeguarding passengers, staff, and critical infrastructure from potential security breach.

7. Recommendations for Policy and Practice

This section presents the key suggestions derived from the study's findings. The recommendations are directed to various implementers, with the intention of addressing the effectiveness of ICAO security preventive measures and related effects in Juba International Airport, South Sudan, as shown below:

For Juba International Airport (JIA) management, the recommendations focus heavily on the steps that airport management can directly implement, such as conducting regular evaluations, modernizing screening systems, and enhancing staff-training programs. They are identified as being responsible for the daily implementation of security protocols and resource management. Further, JIA conducts regular evaluations and audits of the implemented ICAO preventive measures to ensure their continued effectiveness. This includes updating the security protocols based on emerging threats and integrating advanced screening technologies. Establishing a dedicated task force responsible for monitoring and continuously improving security practices will help maintain high standards aligned with ICAO guidelines. Additionally, should modernize screening systems by investing in advanced technologies for passenger and luggage screening to address concerns about security gaps.

For policymakers, including individuals and bodies responsible for formulating and approving policies that govern airport security and resource allocation, this study recommends increased funding and ensuring compliance with ICAO standards through regular performance evaluations. This group likely includes the relevant government ministry, such as the Ministry of Transport or Interior, and potentially the national civil aviation authority, which holds the authority to enact and enforce security policies.

For the entire government and relevant stakeholders, including the entities that play a role in the overall security framework, the policy recommendations specifically call upon the government and relevant stakeholders to seek partnerships with international organizations and security agencies for technical assistance as well as funding to overcome challenges such as limited financial resources and technological deficits. The study thus recommends the involvement of other government agencies, international bodies, and the private sector in airport infrastructure and security as players in ensuring the sustainable implementation of ICAO measures.

For the international organizations and security agencies: while not directly tasked with implementing the measures at the JIA, they are identified as potential partners who can provide crucial support, technical expertise, and financial assistance. The study thus calls for partnerships with these entities, highlighting their significant role in helping JIA and the South Sudanese government in strengthening the airport's security framework to meet and maintain international standards.

Building on the specific objective outlined in this study, future studies could explore the long-term effectiveness of ICAO security preventive measures by conducting longitudinal studies that assess their impact over time, considering evolving security threats and technological advancements. Such studies could also evaluate how these measures influence the passenger experience and operational efficiency.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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