

Original Research

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Assessing the Public Health Implications of Aviation Terrorism: A Retrospective Analysis of Global Trends and Response Strategies

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Abstract

Objectives: Terrorist attacks on the aviation sector represent a significant security challenge due to the high-profile status of airports and aircraft. These attacks not only jeopardize global security but also have severe public health repercussions, leading to widespread casualties and psychological distress.

Methods: This study conducted a comprehensive retrospective analysis using data from the Global Terrorism Database to explore the patterns, frequencies, and impacts of terrorist attacks on the aviation sector worldwide. The analysis spanned incidents from 1970 to 2020, focusing on attack types, affected regions, and the direct and indirect health consequences arising from these incidents.

Results: Over the 50-year period, the study identified 1183 terrorist attacks targeting the aviation sector. Bombings and explosions emerged as the most common and deadliest forms of attack, responsible for the majority of fatalities and injuries. The data also highlighted significant regional disparities, with certain areas experiencing higher frequencies of attacks and more severe outcomes. Notably, North America bore a disproportionately high number of fatalities, primarily due to the events of September 11, 2001.

Conclusions: The findings emphasize the ongoing and evolving threat of terrorism in the aviation industry, underscoring the critical need for a proactive and comprehensive approach to security and public health preparedness. Future strategies should prioritize the integration of advanced technological solutions, enhanced international cooperation, and thorough public health planning to mitigate the impact of terrorist attacks on aviation effectively.

Terrorist attacks targeting the aviation sector present significant security challenges in today's interconnected world. Airports and aircraft, as symbols of global connectivity, are often selected targets due to their potential for high-impact devastation. These attacks not only disrupt international travel but also trigger immediate public health crises, including traumatic injuries and long-term psychological effects, as noted by Price & Forrest and Stewart & Mueller.^{1–2} The unique position of airports as hubs of international movement amplifies their vulnerability, turning them into epicenters for mass casualties and widespread panic that strain health care and emergency services.^{3–4}

Despite advancements in airport security, the evolving tactics of terrorists continue to outpace preventive measures, emphasizing the need for a comprehensive understanding of the broader health implications of such events.⁶ Beyond the immediate chaos, these attacks have lasting repercussions, including a pervasive anxiety about air travel safety, which complicates international perceptions of security.⁵ This anxiety is compounded by the symbolic significance of aviation, which makes these targets particularly appealing to those aiming to instill fear and disruption on a global scale.^{7–9}

The direct physical injuries caused by these attacks are often accompanied by significant psychological fallout, necessitating a coordinated, multidisciplinary response. This includes trauma care, mental health support, and policy development aimed at enhancing emergency health care delivery and long-term recovery.^{10–11} The study aims to explore these public health ramifications in detail to inform the development of more resilient health care frameworks that can effectively respond to and recover from such incidents.¹²

Given the international nature of terrorism, no country can afford to tackle these challenges in isolation. There is an urgent need for intensified global cooperation, not only among security agencies but also across public health organizations, to create a robust, cross-border strategy for managing crises that stem from aviation-related terrorism.¹³ Such collaboration is crucial for sharing intelligence, best practices, and advancements in technology to strengthen the resilience of the global aviation network.^{14–19}

While security measures are vital, the public health impact of terrorist attacks on aviation requires equal attention. This study seeks to illuminate the health implications of past incidents, thereby contributing to the development of comprehensive response plans that enhance global public health preparedness.

Materials and Methods

Conceptual Framework

This study adopts a comprehensive retrospective approach to examine the impact of terrorist attacks on the aviation sector, focusing on public health implications and the effectiveness of response strategies. Specifically, we analyze historical patterns, attack severity, and the public health repercussions, aiming to provide actionable insights for improving emergency response and health system preparedness in the context of aviation terrorism.

Data Definition of Aviation Terrorism and Related Terms

Aviation terrorism in this study is defined as any act of terrorism that directly targets aviation-related facilities, including airports, aircraft, and associated infrastructure. This encompasses incidents such as bombings, hijackings, armed assaults, and sabotage aimed at disrupting aviation operations or endangering the safety of passengers, crew, and personnel. Specifically, hijacking refers to the unlawful seizure of an aircraft during flight, with the intent to use it as a bargaining tool, weapon, or to create mass casualties. Bombing or explosion incidents involve the detonation of explosive devices intended to damage aircraft or airport facilities, causing fatalities and injuries. Armed assault includes any attack using firearms or other weapons aimed at causing harm within airport premises or on board an aircraft.

Source of Data

Data for this analysis were sourced from the Global Terrorism Database (GTD)²⁰, which provides a comprehensive record of terrorist incidents globally. The study specifically focuses on incidents targeting aviation facilities from 1970 to 2020. While the GTD offers extensive coverage, it is important to note that there is partial missing data for the year 1993, which may affect trend analysis for that period.

Data Collection and Verification

The data collection process involved extracting all records from the GTD that explicitly mentioned aviation-related targets. This included filtering for keywords such as “airport,” “aircraft,” “hijacking,” “bombing,” “explosion,” and “armed assault.” Each relevant entry was meticulously reviewed for completeness and accuracy. Discrepancies or missing details were addressed by cross-referencing with additional sources such as news archives, government reports, and scholarly articles to ensure data robustness. Cross-referencing was conducted for all events where essential details were missing or inconsistent.

Statistical Methodology

Descriptive statistical analysis

Descriptive statistics were employed to analyze the characteristics of terrorist attacks on aviation, including the frequency of attacks,

types of methods used, geographical distribution, and casualty demographics. This analysis aimed to identify prevailing patterns and anomalies within the dataset.

Health impact evaluation

The evaluation of health impacts focused on both immediate and long-term effects. Immediate impacts were assessed based on reported fatalities and injuries, while long-term psychological effects were inferred from existing literature and the broader context of similar attacks. Although the GTD provides limited direct data on psychological outcomes, the study utilized related public health research to contextualize potential disruptions to health care services and the psychological toll on affected populations. The evaluation also considered the strain on health care facilities and emergency services during and after these incidents, assessing their capacity and effectiveness in response to the attacks.

Search Strategy

The search strategy for identifying relevant GTD records involved the use of specific terms related to aviation and terrorism. The primary search terms included “airport,” “aircraft,” “hijacking,” “explosion,” “bombing,” “armed assault,” and “aviation terrorism.” These terms were used to filter the database for incidents that fit the study’s criteria, ensuring a comprehensive capture of relevant data.

Results

Our analysis underscores the extensive public health repercussions of terrorist attacks targeting aviation facilities globally. These events have varied in nature and magnitude, impacting a diverse array of targets, which has led to complex challenges for public health and emergency response frameworks.

Detailed Analysis of Attack Targets

Table 1 presents the distribution of target types in terrorist attacks on aviation facilities. Most incidents (1055 of 1183; approximately 89.2%) directly targeted airports and aircraft. A smaller portion of incidents involved combined targets, such as airports with private

Table 1. Breakdown of target types in aviation terrorism

Target type	Count of target type	
Airports and aircraft	1055	89.2%
Airports and aircraft, private citizens and property	31	2.6%
Military, airports and aircraft	25	2.1%
Airports and aircraft	13	1.1%
Business, airports and aircraft	10	0.8%
Police, airports and aircraft	7	0.6%
Airports and aircraft, government (diplomatic)	6	0.5%
Government (general), airports and aircraft	5	0.4%
Business, airports and aircraft, Private citizens and property	5	0.4%
Other (categories with 4 incidents or fewer)	26	2.2%
Grand total	1183	100%

properties (31 incidents, 2.6%) or military installations (25 incidents, 2.1%). Less common targets included educational institutions and food supplies, each involved in only 1 incident (0.08%).

Methods of Terrorist Attacks

Table 2 outlines the methods employed in terrorist attacks on aviation facilities. Bombings and explosions were the most frequent, with 695 of 1183 incidents (58.7%). Hijackings followed, accounting for 207 incidents (17.5%). Armed assaults and facility/infrastructure attacks were recorded in 98 (8.3%) and 83 (7.0%) incidents, respectively. Less common methods, including hostage-taking and assassination, were documented in fewer than 15 cases.

Regional distribution of attack methods

Table 3 provides a regional breakdown of terrorist attacks on aviation facilities. Western Europe experienced 297 incidents, with bombings accounting for 187 (63.0%) of them. Sub-Saharan Africa recorded 125 incidents, primarily bombings (56.0%) and armed assaults (17.6%). Southeast Asia reported 45 incidents, dominated by bombings (51.1%) and hijackings (20.0%). South Asia saw 151 incidents, with bombings making up 69.5%. South America recorded 120 incidents, featuring a varied attack profile. North America had 47 incidents, mostly bombings (57.4%).

The Middle East and North Africa had the highest number of incidents (256), with bombings comprising 64.5%. Other regions, including Eastern Europe, East Asia, and Central Asia, reported fewer incidents but displayed diverse methods. Table 3 summarizes these regional patterns, highlighting the need for tailored security strategies.

Temporal distribution of incidents

Figure 1 shows the frequency of terrorist attacks on the aviation sector from 1970 to 2020. The early 1970s saw 21 incidents, with a peak of 67 attacks in 1979. The 1980s maintained high levels, with over 50 incidents per year. In the 1990s, attack frequency declined, though 2001 saw 20 incidents, including the September 11 attacks. Post-2001, attacks generally stayed below 30 per year, with a peak of 49 in 2014. The lowest number of incidents occurred in 2017, with only 4 attacks. A total of 1183 incidents occurred over the 50-year period, highlighting the persistent threat to aviation security.

Table 2. Prevalent attack Methods on aviation targets

Attack type	Count of attack type	
Bombing/explosion	695	58.7%
Hijacking	207	17.5%
Armed Assault	98	8.3%
Facility/infrastructure attack	83	7.0%
Unknown	33	2.8%
Hostage taking (kidnapping)	13	1.1%
Hostage taking (barricade incident)	12	1.0%
Assassination	11	0.9%
Other combined methods (less than 5 occurrences each)	31	2.7%
Total	1183	100%

Table 3. Regional distribution of aviation terrorism methods

Region	Attack Type	Count of Attack Type	Percentage (%)
Middle East and North Africa	Bombing/explosion	165	64.5%
Western Europe	Bombing/explosion	187	63.0%
Sub-Saharan Africa	Bombing/explosion	70	56.0%
South Asia	Bombing/explosion	105	69.5%
Southeast Asia	Bombing/explosion	23	51.1%
South America	Bombing/explosion	54	45.0%
North America	Bombing/explosion	27	57.4%
Middle East and North Africa	Hijacking	51	19.9%
South America	Hijacking	30	25.0%
Sub-Saharan Africa	Hijacking	24	19.2%
South Asia	Hijacking	15	9.9%
North America	Hijacking	9	19.1%
Sub-Saharan Africa	Armed assault	22	17.6%
Middle East & North Africa	Armed assault	17	6.6%
South Asia	Armed assault	10	6.6%
Southeast Asia	Armed assault	7	15.6%
Western Europe	Armed assault	9	3.0%

Global patterns and spatial trends

A breakdown of the frequency of terrorist attacks targeting aviation assets by country reveals notable variations in the number of attacks across different nations. This data highlights regional security challenges and the global spread of aviation-related terrorism.

Table 4 lists the top 20 countries with the highest number of aviation-related terrorist attacks between 1970 and 2020. These countries account for a significant portion of the total incidents, providing insight into the regions most affected by such activities.

These 20 countries account for 736 incidents, or approximately 62.2% of the total 1183 aviation-related terrorist attacks recorded globally between 1970 and 2020. The data reflect the concentration of aviation terrorism in regions with ongoing conflicts, political instability, or historical ties to international terrorism.

Fatalities from aviation terrorism by region

Figure 2 presents a regional breakdown of fatalities from aviation-related terrorist attacks between 1970 and 2020. North America recorded the highest number of fatalities (3351), largely due to the September 11 attacks. Sub-Saharan Africa followed with 1241 fatalities, while Western Europe reported 666 fatalities. The Middle East and North Africa recorded 641 deaths, reflecting ongoing security challenges. Eastern Europe and South Asia reported 493 and 318 fatalities, respectively. Other regions, such as Southeast Asia, South America, and Central America, had lower but still significant fatality counts.

In contrast, East Asia and Central Asia reported the fewest fatalities, likely due to fewer incidents or effective security measures. Overall, the total of 7264 fatalities underscores the global impact of aviation terrorism and highlights the need for targeted public health and security responses.

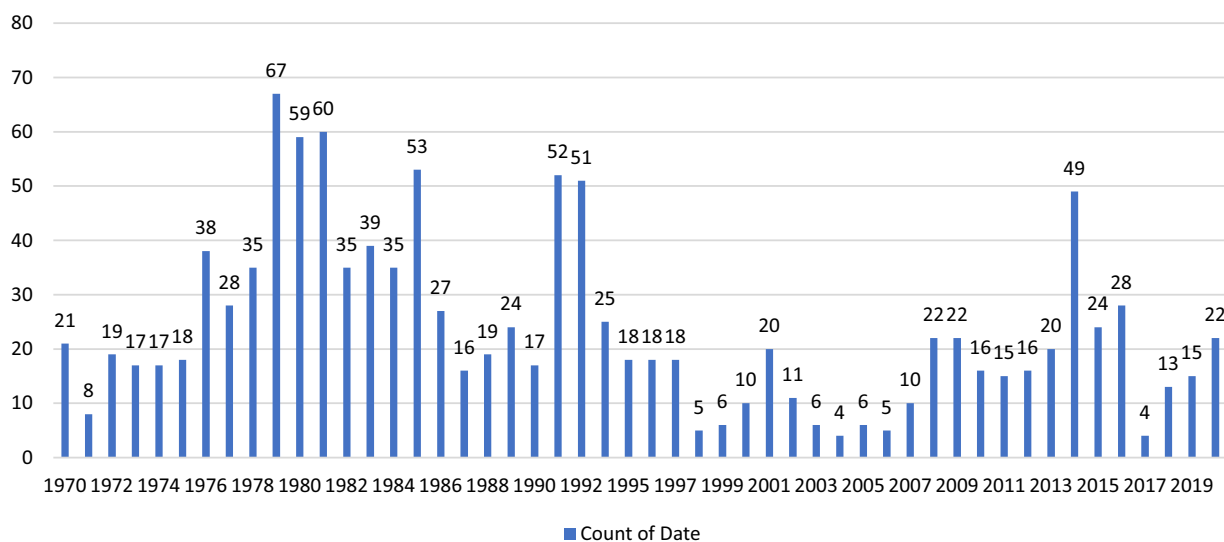


Figure 1. Temporal distribution of terrorist attacks on the aviation sector (1970–2020).

Table 4. Frequency of aviation-related terrorist attacks by country (1970–2020)

Country	Number of attacks
Colombia	59
Afghanistan	59
France	56
Italy	53
Pakistan	52
Lebanon	49
Somalia	48
Spain	47
Libya	45
United States	44
Iraq	42
Japan	37
Turkey	34
Peru	28
India	23
Philippines	22
Greece	21
West Germany (FRG)	19
United Kingdom	18
Guatemala	18

Analysis of fatalities and injuries by attack type

Table 5 reveals that the combination of “Hijacking and Armed Assault” was the most lethal and injurious, causing 3007 deaths and 21 871 injuries. “Bombing/Explosion” was the second deadliest method, responsible for 3343 deaths and 3266 injuries. Stand-alone hijackings caused 397 deaths and 292 injuries, while armed assaults led to 223 deaths and 233 injuries.

Lesser-known methods like “Facility/Infrastructure Attack” resulted in 5 fatalities and 83 injuries. Hostage-taking incidents and assassinations also contributed to the death toll. Some attack methods, such as combined “Bombing/Explosion and Armed Assault,” led to immediate fatalities with few injuries.

Overall, the data shows a total of 7264 fatalities and 25 898 injuries, highlighting the significant dangers posed by terrorism in the aviation sector and the critical need for robust security and emergency preparedness.

Impact of aviation terrorism: fatalities and injuries by country

Table 6 provides a breakdown of fatalities and injuries by country from aviation-related terrorist attacks between 1970 and 2020. The United States recorded the highest impact, with 3022 fatalities and 21 978 injuries, primarily due to the September 11 attacks. Somalia followed with 675 fatalities and 414 injuries, while Ukraine and Canada reported significant fatalities with no injuries.

Countries like Italy, the Philippines, and Turkey experienced both high fatalities and injuries, reflecting the severity of attacks in these regions. Overall, the data show 7264 fatalities and 25 898 injuries across the top 20 countries, emphasizing the global nature of aviation terrorism and the need for targeted medical and psychological support in heavily impacted regions.

Discussion

The findings from this study offer a sobering perspective on the persistent threat of terrorism within the aviation industry, a sector that remains a high-profile target due to its global significance. This analysis confirms that certain attack types, particularly bombings and explosions, have been the most frequent and deadliest. This trend parallels findings in other research on transportation terrorism, emphasizing the high impact of such attacks in terms of both casualties and psychological effects on the public.^{21–22} However, it is critical to note that while bombings and explosions are prevalent, the combined tactics of hijacking and armed assault have resulted in the highest number of fatalities and injuries. This highlights the catastrophic potential of synchronized terrorist methods.

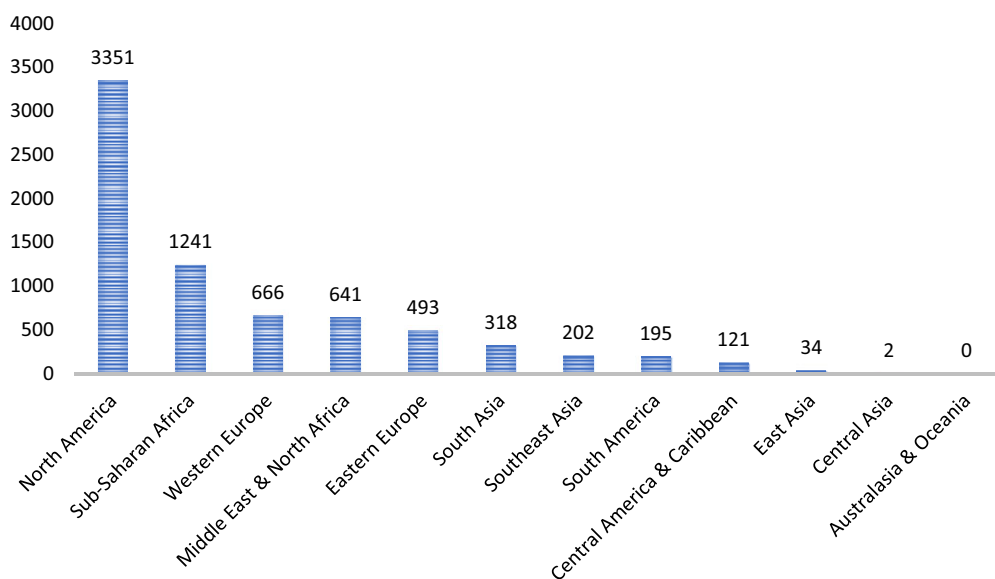


Figure 2. Regional fatalities due to aviation terrorism (1970-2020).

Table 5. Impact of terrorist attacks on the aviation sector: fatalities and injuries by attack type (1970–2020)

Attack type	Sum of injured	Sum of fatalities
Hijacking, armed assault	21 871	3007
Bombing/explosion	3266	3343
Hijacking	292	397
Armed assault	233	223
Facility/infrastructure attack	83	5
Hostage taking (barricade incident)	80	153
Assassination	61	40
Bombing/explosion, armed assault	5	18
Unarmed assault	2	0
Hostage taking (barricade incident), bombing/explosion, armed assault	2	1
Hostage taking (kidnapping), armed assault	1	11
Armed assault, hostage taking (kidnapping)	1	5
Unknown	1	44
Other (categories with 0 fatalities/injuries)	0	0
Total	25 898	7264

In addition to the predominant focus on airports and aircraft, it is important to consider the broader range of targets in aviation terrorism. While attacks on military installations, private property, and educational institutions were less common, they reflect the evolving and unpredictable nature of terrorist strategies. These less frequent targets, though representing a small percentage of incidents, contribute to the complexity of the threat landscape. Their inclusion in the dataset highlights the need for comprehensive security measures that account for diverse potential targets, extending beyond the traditional focus on airports and aircraft. This underscores the necessity for flexible and adaptive emergency response frameworks to address various attack scenarios.

Table 6. Frequency of aviation-related Terrorist attacks by country (1970–2020)

Country	Sum of fatalities	Sum of injured
United States	3022	21 978
Somalia	675	414
Ukraine	338	0
Canada	329	0
United Kingdom	271	29
Egypt	227	11
Colombia	186	59
Greece	178	111
Niger	171	0
Russia	129	168
Ethiopia	126	0
United Arab Emirates	117	2
Afghanistan	109	73
Rhodesia	102	0
Malaysia	100	1
Italy	90	222
Philippines	84	340
Turkey	76	379
Angola	75	26
Barbados	73	0

The temporal trends revealed by this dataset illustrate significant shifts in the types and targets of attacks over the decades. Before the September 11, 2001, attacks, a decline in aviation-related terrorism was observed, likely due to increased security measures. However, post-9/11, there has been a diversification in terrorist tactics, with a noticeable shift from hijackings to attacks on airport facilities. Despite the implementation of enhanced security protocols, the

aviation sector remains vulnerable, as evidenced by the continued occurrence of such attacks. This adaptability of terrorist groups in response to evolving security measures highlights the need for continuous innovation in aviation security.²³

It is important to contextualize this study within the broader literature on transportation terrorism. For instance, the study by Tin et al. on terrorism targeting transport, including aviation, based on the Global Terrorism Database (GTD), emphasizes the importance of specialized studies focused solely on aviation to understand the unique vulnerabilities and implications of attacks on this sector.²⁴ While transportation terrorism as a whole is a critical area of study, the distinct characteristics of aviation—such as its international scope, symbolic significance, and potential for mass casualties—warrant separate, detailed examination.

Another key aspect of the discussion should focus on the implications of these findings for current aviation security measures. The data suggest that, although there have been significant advancements in security since 9/11, the aviation sector is still not entirely secure. This ongoing vulnerability may be partly due to the shift in terrorist tactics and target types over the decades. The data indicate that more recent attacks have increasingly targeted airports rather than aircraft, reflecting changes in both terrorist strategies and security vulnerabilities.

The discussion must also consider the broader impacts of aviation terrorism, including its psychological effects. Beyond the immediate casualties, such attacks can lead to long-term psychological consequences, such as travel phobia and anxiety disorders. This is supported by studies that document the mental health consequences of terrorist attacks on passengers and the general public, which include increased instances of travel-related anxiety and the need for targeted mental health interventions.^{24–27} The phenomenon of travel phobia, in particular, has been highlighted in research as a significant issue following high-profile terrorist incidents, necessitating ongoing psychological support and treatment for affected individuals.

Furthermore, the economic impact of aviation terrorism extends beyond the immediate physical damage. Attacks on aviation also affect related sectors such as tourism and hospitality, leading to declines in international travel, empty hotel rooms, and disruptions in stock markets.²⁷ This is corroborated by studies that analyze the economic repercussions of terrorism, including its effect on tourism and financial markets.^{28–30} These broader economic impacts underscore the need for a holistic approach to counter-terrorism that includes economic resilience and recovery strategies in addition to traditional security measures.^{31–32}

The high fatality rate observed in North America, predominantly driven by the September 11 attacks, underscores the profound impact of singular high-casualty events on both statistical trends and public consciousness. This outlier effect is consistent with discussions in the literature about the disproportionate impact of such events, which can skew overall data and emphasize the need for contextual analysis.^{33–35} Additionally, the discussion should reflect on the importance of future-proofing aviation security measures against emerging threats. While artificial intelligence (AI) is mentioned as a potential solution, it is also crucial to consider the risks posed by new technologies, such as drones, which could be exploited by terrorists in the future.^{36–40} Integrating AI and other advanced technologies into security protocols must be done with careful consideration of ethical and privacy concerns, ensuring that these tools enhance safety without infringing on individual rights.^{41–42}

The findings of this study highlight the need for a comprehensive, multi-layered approach to aviation security that integrates technological advancements, psychological resilience, and international cooperation. The ongoing evolution of terrorist tactics requires a dynamic response strategy that not only anticipates potential threats but also mitigates the long-term impacts on public health and economic stability. By focusing on both immediate and long-term consequences, we can enhance our preparedness and response to the complex challenges posed by aviation terrorism, safeguarding both public safety and global connectivity.

Limitations

While this study provides a comprehensive examination of the impacts of terrorist attacks on the aviation sector, there are several limitations that should be considered. Firstly, the reliance on data from the Global Terrorism Database may introduce biases associated with the completeness and accuracy of reported incidents. Not all terrorist attacks may be equally reported or documented, potentially leading to underrepresentation of certain regions or types of attacks.

Secondly, the analysis is limited to the data available up to 2020, which excludes any evolving trends or new methods of terrorism that have emerged more recently. As terrorist tactics and global security landscapes are continuously evolving, the findings may not fully capture the current state or predict future trends accurately.

Another limitation is the study's focus on quantitative data, which provides valuable insights into the patterns and frequencies of attacks but may not fully encompass the qualitative aspects of terrorism's impact on individual and community psychology, or the effectiveness of post-attack recovery and response efforts.

Additionally, the study does not account for the possible variations in data quality across different countries. Reporting standards and capabilities vary globally, which might affect the consistency of the data analyzed.

Finally, while the study suggests various preventive and responsive measures, it does not empirically test their effectiveness. Future research could benefit from empirical evaluations of specific security and public health interventions to provide more definitive guidance on best practices in aviation security and terrorism response.

Conclusions

This study confirms that bombings and explosions are the most frequent and deadly forms of aviation terrorism, causing significant casualties and psychological harm. Regional differences highlight the varying impacts of these attacks, driven by geopolitical factors and differing national response capabilities.

The findings underscore the need for a multidisciplinary approach that combines advanced security measures, public health preparedness, and international cooperation to counter these evolving threats. Future research should focus on enhancing security technologies and resilience strategies to mitigate risks and safeguard global aviation.

As terrorist tactics evolve, our strategies must adapt to stay ahead, ensuring the ongoing protection of the aviation sector.

Data availability statement. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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