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RELEVANCE OF DNA IDENTIFICATION WORKS IN MATTERS LIKE AIR CRASH INVESTIGATIONS AND LEGAL MATTERS OF AIR CRASH INVESTIGATIONS

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Abstract

In mass fatality events like plane crashes or natural disasters, physical features may be unrecognizable. DNA becomes the most reliable method of identification in such cases. It provides a reliable means of identifying victims, offering closure to families and facilitating legal and insurance processes. The most daunting task is the identification of bodies, which may have got charred or disfigured beyond recognition because of the impact of the crash and the ensuing explosion. The pressure is on forensic doctors to identify and hand over the bodies to the relatives on an urgent basis, but this kind of pressure may be counterproductive. In disasters, identification is established by taking a post mortem DNA sample, which is matched with their first-degree biological relative. Apart from the DNA Identification, Legal Matters as per Montreal Protocol and Carriage by Air Act 1972 are also looked into with regards to the responsibility of liability and other cases.

Keywords: Disaster victim identification; Forensic Anthropology; Aircraft crash; DNA profiling, Liability,

Introduction

The identification of dead bodies in mass casualties has been a Herculean task since time immemorial. Fatal crash of civil or military airliners generally leaves numerous unidentified bodies. As compared to other mass casualties viz. earthquakes, floods and collapse of building, the identification of bodies is more difficult post-aircraft accidents as the bodies are mutilated to a large extent and at times decomposed when the aircraft crashes in remote places and recovery is delayed. There have been numerous modalities in identifying the dead in mass

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casualties like sex, body stature, identification by next of kin, face (if not mutilated), medals (in case worn by the military pilots), identification discs worn by the pilots, personal metal belongings e.g. metal chain, rings and dentition. DNA profiling is the gold standard for human identification. This technique has been widely used successfully not only in forensic and crime investigations but also in identification of victims in mass disasters, including air crash.

A mass disaster is an unexpected event that causes serious injury and death to a number of people. Mass disaster events may be natural disasters (earthquakes, flooding, and tornadoes), accidental disasters (aircraft crashes, train crashes and derailments, and building fires), or intentioned terrorism acts (direct attacks on significant objectives, and bombing of populated areas, including suicide attacks and deployments of chemical and biological weapons). Forensic identification of victims is essential for humanitarian reasons, but also for civil or criminal investigative needs, and it is essentially based on forensic anthropology, fingerprints, forensic odontology, radiology, and DNA typing.

The main task of forensic DNA laboratories faced with mass disaster cases is to help name every anonymous victim, thus bringing closure to surviving family members and friends. This is done by matching DNA profiles of postmortem tissue samples with those of antemortem DNA samples (personal items or biological specimens) or by kinship analysis with living relatives. Generally, mass disaster cases require managing, analyzing, and comparing large numbers of biological samples and DNA profiles (mainly autosomal short tandem repeat [STR] profiles but also occasionally mtDNA sequence and Y-Chromosome STR [Y-STR] haplotype data) making necessary the use of electronic laboratory information management systems for large-scale sample logging and tracking, coupled with bioinformatic tools for DNA database searching according to different matching algorithms (ie, complete or partial allele sharing on each locus for autosomal STR markers), and software solutions to evaluate the significance of each match by likelihood ratio (LR) calculations.

There are many different interrelated factors and circumstances involved in each specific mass disaster scenario that may challenge the final DNA identification goal, such as: the number of victims, mechanisms of body destruction, the extent of body fragmentation, rate of DNA degradation, the body accessibility for sample collection, or type of DNA reference samples availability.

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Experiences gained from previous mass fatality incidents reinforce the need to make all necessary steps to guarantee sample preservation for DNA analysis and to use suitable protocols for documenting the chain of custody of DNA sampling and body tracking. To help with this purpose, specialized and trained disaster victim identification (DVI) multidisciplinary teams composed of medical examiners, forensic pathologists, anthropologists, forensic odontologists, fingerprint specialists, radiologists, and experts in search and recovery of physical evidence have been developed worldwide. Some examples of federal resources providing aid to local communities in mass disaster response in the USA are the Disaster Mortuary Operational Response Teams (DMORT), the Federal Bureau of Investigation's Evidence Response Team (ERT), and the Office of the Armed Forces Medical Examiner (OAFME). Different Interpol DVI teams have also been developed worldwide and a standing committee on DVI is responsible for recommending measures for improving identification procedures, by encouraging international co-operation and standardization.

Additionally, recent guidelines were published to assist the medical examiner with the whole process of victim identification in mass fatalities, including detailed procedures for DNA sample collection and data management.

How are DNA samples examined?

The initial 24 to 72 hours are crucial for triage and potential life-saving interventions. However, when fatalities are extensive, the focus shifts to forensic recovery, identification, and the dignified management of remains.

Charred bodies present unique challenges. High temperatures from aviation fuel fires often obliterate facial features, fingerprints, and even dental records, making traditional identification methods ineffective. In such cases, DNA profiling becomes the only reliable means of identification.

However, collecting viable DNA from heat-damaged tissue or bones requires advanced forensic capability and time. It's a logistically and emotionally intense exercise.

According to forensic experts, given the present scenario, the teams rely on DNA profiling, considered the most reliable method when visual identification or fingerprinting is impossible. The identification process begins at the crash site, where forensic teams meticulously recover

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human remains. Every bone fragment, tissue sample, or personal item is collected and preserved for laboratory examination.

Handling over 250 bodies also involves coordination between multiple agencies – disaster response teams, forensic laboratories, local hospitals, law enforcement, and the airline. Bodies are first numbered, photographed, and mapped at the site before being transported to a mortuary or hospital.

The autopsy of a dead body or remains of the pilot is only one, yet highly important step in the investigation process. This procedure provides information about the injuries observed on pilot's body and possible history of underlying diseases, which along with the results of toxicological screen (alcohol, medication, drugs) contributes to elucidating the cause of the accident. Checking of pilot's medical records prior to accident might indicate potential causes of sudden health episode that might have been associated with the loss of capacity. The examination of pilot's hands and feet can reveal soft tissue laceration and bone fractures, which result from striking the fixed structures of the aircraft controls (control surface injuries). In that respect, radiological examination can prove useful. Such injuries are not specific for the pilot only and may have high incidences in passengers, thus requiring highly cautious interpretation and drawing of conclusions. Tissue remains on the parts of aircraft controls mechanism could be of importance in the DNA identification of the pilot.

Fatal aircraft accidents involving large number of casualties reveal uniform injury pattern in all victims, commonly massive mechanical injuries induced by decelerate forces. A decline from such injury pattern in any of passengers might suggest the action of some specifically different force such as explosive device. Suspected fire in a cabin can be confirmed or excluded in a toxicological analysis and determination of the blood level of carboxyhemoglobin in the victims. The cause of death in plane crash victims found in water can include submersion or hypothermia due to prolonged period in cold water. High speed and extreme decelerate forces at the moment when plane hits the ground often cause decomposition and fragmentation of the body, which makes the examination of mortal remains particularly difficult. In such instances, identification of the bodies is crucial, followed by collecting relevant samples for toxicological analysis. The degree of body decomposition often does not allow visual identification of the victims. Dental and fingerprint identification are much more effective and reliable provided that medical records on victims' dental status are available and that hands are preserved (non-

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charred bodies). Tattoos, scars or other body marks could also be of help in the process of identification. Finally, DNA identification is the most superior method in conditions of heavily injured and mostly decomposed tissues.

A forensic anthropologist may create facial reconstructions to help identify skeletal remains [4]. Facial reconstruction clay is placed and shaped over the victim's actual cranium, and it takes into account the decedent's estimated age, ancestry, and sex. With the help of this technique, a composite of the victim can be drawn and advertised in an attempt to identify the victim. Forensic anthropologists are also helpful in identifying victims of a mass disaster such as a plane crash. When such a tragedy occurs, forensic anthropologists can help identify victims using the collection of bone fragments. Usually, the identification of the remains will depend on medical records, especially dental records of the individuals. However, definite identification of remains can be made only by analyzing the decedent's DNA profile, fingerprints, or medical records. Recovered remains may still contain some soft tissue material, such as the tissue of the hand, which may yield a DNA profile for identification purposes. If the tissue is dried out, it may be possible to rehydrate it to recover fingerprints also.

Boeing 787-8 Dreamliner Had a History of Technical Issues

The Boeing 787-8 Dreamliner model has faced recurring technical scrutiny in recent years. A previous Economic Times report documented repeated diversions of a Dreamliner with registration code N819AN due to hydraulic leaks and flap malfunctions, leading to multiple flight cancellations in a span of just 25 days earlier this year.

In addition, Boeing engineer and whistleblower Sam Salehpour had earlier raised alarms in major U.S. outlets like The New York Times and CNN, alleging that the company took manufacturing shortcuts on both the 777 and 787 Dreamliner models. Salehpour warned that such compromises could pose catastrophic risks as these aircraft age.

History Of India's Deadliest Airline Crashes & What It Means for Aviation Safety

India has witnessed over 50 major air disasters since independence, from fatal commercial crashes to hijackings, raising urgent concerns over aviation safety protocols and regulatory enforcement. With the latest Air India crash in Gujarat on 12 June 2025, aviation experts call

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for systemic reform in one of the world's fastest-growing air travel markets.

Over the decades, India has seen numerous fatal crashes and hijackings involving commercial airliners, with pilot error, technical failures and security lapses among the leading causes. As India continues to expand its aviation infrastructure, experts warn that lapses in enforcement, maintenance, and training could hinder progress and endanger passengers.

India has recorded some of the world's deadliest aviation incidents. Among them is the catastrophic Charkhi Dadri mid-air collision in 1996, which claimed 349 lives and remains the deadliest mid-air crash in aviation history. The disaster was attributed to pilot miscommunication and air traffic control lapses.

Another dark chapter was the 2010 Air India Express Flight 812 crash in Mangalore, where a Boeing 737-800 overshot the runway and burst into flames, killing 158 passengers. More recently, in 2020, Air India Express Flight 1344 skidded off the runway in Kozhikode, killing 18 and injuring dozens. Investigations cited poor runway conditions and adverse weather as contributing factors.

India's skies have also seen a disturbing number of hijacking attempts — more than 15 recorded between 1971 and 2000 alone. One such incident involved Indian Airlines Flight 814 in 1999, which was hijacked to Kandahar by armed militants. Though most passengers survived, the government was forced to negotiate the release of terrorists in exchange for hostages.

A 2019 audit by the International Civil Aviation Organisation (ICAO) had raised red flags about India's air traffic services and regulatory oversight. While improvements have since been made, such as modernising air traffic systems and setting up a civil aviation safety oversight board, experts still see room for major reform, particularly in pilot training, crisis management, and runway infrastructure.

The sheer volume of air traffic in Indian skies—driven by a rapidly growing middle class and regional connectivity programmes like UDAN (Ude Desh ka Aam Naagrik)—means that safety cannot be compromised. India is now the world's third-largest domestic aviation market, but its record of mishaps raises the question of whether safety standards have kept pace.

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Moreover, weather conditions, challenging airport topographies, and infrastructural constraints contribute to operational difficulties. The Mangalore and Kozhikode airports, both located on table-top runways, have repeatedly come under scrutiny for their hazardous layouts.

As the Directorate General of Civil Aviation (DGCA) initiates another probe into the latest crash, the aviation sector faces increased pressure from passengers, stakeholders, and international watchdogs to enhance safety protocols across the board.

Airline Liability: Compensation Under International Law

In International Flights like this one, airlines are legally responsible for compensating victims and their families. India is a signatory to the Montreal Convention, 1999, which governs compensation for injury or death during air travel. The Montreal Convention of 1999 applies to all international air travel between countries that are signatories—including the United States, and the United Kingdom.

As per the convention, passengers are entitled to a compensation of up to 128,821 Special Drawing Rights (SDRs) — which is approximately Rs 1.4 crore per person, irrespective of who was at fault. This amount may go even higher if negligence or fault on the part of the airline is proven. While this law is specifically for international flights, Indian carriers also tend to offer similar compensation for domestic flights as per **DGCA guidelines**. Article 33 of the Convention provides families of crash victims with multiple options for legal jurisdiction. They can file claims in the country where the airline is based, where the flight was headed, where the ticket was purchased, or where the passenger resided—if the airline operates in that country.

The Carriage by Air Act, 1972, as amended in 2009, incorporated the relevant provisions under Schedule III in conformity with the Montreal Convention. The Act empowers the Central government to extend the Convention's provisions to domestic carriage, which it has done. Thus, passengers are covered by the same compensation rules whether they are on a domestic or an international flight.

In the case of *S Abdul Salam v. Union of India*, the victim had died in an Air India Express plane owned by the erstwhile Air India Corporation. The company offered a sum of ₹35,00,000 as a one-time settlement against which the heirs of the victim went to the Kerala High Court

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for mandatory compensation under the Montreal Convention. The carrier company had argued that the compensation of 1,00,000 SDR does not mean that the company has to pay exactly that much. It argued that the compensation was dependent on factors like age, job and salary of the victim. Rejecting the contention, the Court held: "*The Carriage by Air Act is a special statute by itself, taking care of the situation, particularly in the light of the steps being taken by India to join hands with other countries, to give effect to various international conventions such as Warsaw, Hague and Montreal. This is with intent to have "uniformity and certainty" in the related spheres, particularly when the international flights operated by various Carriers across different countries in the world, carrying passengers from different countries and in the event of casualties, all such victims have necessarily to be treated on an equal platform, providing atleast the minimum extent of compensation, both in the case of persons and property. When the statute does not refer to payment of compensation with reference to age/income/loss of dependency etc., it can never be connected to any such considerations upto the level of 'One lakh SDR', beyond which, it will be for the claimants to substantiate the position as to have higher amounts and it will, of course, be open to the Carrier as well, to put forth their defence as to the absence of negligence and the lack of liability to pay any amount over and above 'One lakh SDR'.*"

Looking Ahead

The new technological revolution in the field of forensic genetics is allowing the implementation in laboratories (both public and private) of the methodology of massive parallel sequencing (MPS), for example, to determine some phenotypic characteristics (skin, eye and hair color). The use of this new technology constitutes a tool of undoubted utility in criminal investigation, as well as in the identification of victims from disasters and catastrophes. Several studies have already evaluated the existence of polymorphisms associated with skin color, hair color, eye color, male pattern baldness, type/shape of head hair, age, facial morphology, height, earlobe folding and hair graying, among others.

Despite the different difficulties encountered in identifying victims resulting from a catastrophe, genetics is the only modern tool with universal character, which can be used in essentially all biological samples, giving an identification of more or less accurate statistical character, depending on whether nuclear or lineage markers are used.

India's aviation future hinges not only on fleet expansion and new airports but also on stringent

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safety reforms. The tragedies of the past should not repeat due to bureaucratic inertia or corporate negligence.

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