







Review

Missing persons response: national programs and global cooperation in Brazil's migration context

Aline Minervino^{a,b,c,*} , António Amorim^{d,e,f} , Francisco Corte Real^{d,g} , Laura Cainé^{b,d,f} 

^a Brazilian National DNA Database, Brasília, Brazil

^b Faculty of Medicine of the University of Porto, Porto, Portugal

^c National Police Academy, Federal Police, Brasília, Brazil

^d National Institute of Legal Medicine and Forensic Sciences, Coimbra, Portugal

^e Faculties of Medicine and Sciences of the University of Lisbon, Lisbon, Portugal

^f REQUIMTE – Associated Laboratory for Green Chemistry and Technology, University of Porto, Porto, Portugal

^g Faculty of Medicine of the University of Coimbra, Coimbra, Portugal

ARTICLE INFO

Keywords:

Forensic genetics
International cooperation
DNA database
Transnational disappearance
Unidentified human remains
I-Familia

ABSTRACT

The search and identification of missing persons represent a pressing global issue with profound humanitarian, legal, and institutional implications. This study presents an illustrative documentary review of MP/UHR identification initiatives in countries selected for their migration-related links to Brazil and their relevance to transnational DNA cooperation (Brazil, Portugal, Spain, France, the United Kingdom, the United States, Canada, Mexico, and Belgium). Grounded in the United Nations guidelines and using peer-reviewed literature, official reports, and documentation from international organizations, the analysis examines how forensic genetics is integrated into MP/UHR workflows, the legal and governance frameworks that enable or constrain the processing of relatives' reference profiles, and the operational arrangements that support cross-border exchange. The synthesis indicates that identification outcomes depend not only on laboratory capacity, but also on institutional coordination and the linkage of *ante-mortem* and *post-mortem* data. The study also describes international mechanisms such as INTERPOL's I-Familia database, and humanitarian identification platforms. Although these tools show great potential, their effectiveness is limited due to inconsistent adoption across countries and variations in national protocols. The identification of missing persons must be approached as a shared international responsibility, requiring cooperation in science, law, and policy to ensure dignity, truth, and justice for families of the missing.

1. Introduction and theoretical context

The phenomenon of missing persons is a global problem of alarming scale, and the international community has acknowledged the urgency of this issue. The search for and identification of missing persons is not simply a matter of public security, but an ethical and juridical imperative, essential for safeguarding the rights to life, dignity, truth, and justice for the affected families [1].

The United Nations (UN) has established 16 Guiding Principles for the Search for Disappeared Persons to ensure that such process is effective and transparent. The search should be initiated immediately and be governed by comprehensive public policy. Such a policy should ensure respect for the human dignity of both the disappeared and their families at every stage, adopting a differential approach that recognizes

and addresses specific vulnerabilities (such as children, women, elderly, and migrants). The process should also respect the right of participation of victims and family members, require a coordinated and effective search, and utilize robust forensic methods and specialized technical personnel [1].

The International Convention for the Protection of All Persons from Enforced Disappearance, Article 24, emphasizes that countries should take all appropriate measures to search for, locate and release missing persons, and, in cases of death, to recovery, respect and return their remains. Article 15 demands cooperation between countries to assist victims of enforced disappearance and in the search, location, and release of missing persons [2]. The International Committee of the Red Cross (ICRC) reinforces this position, arguing that all efforts must be made to recover bodies and personal effects of missing persons, once

* Corresponding author at: Instituto Nacional de Criminalística - SAIS Quadra 07, Lote 23, Setor Policial Sul, Brasília, DF, Brazil, 70610-902
E-mail address: aline.acm@pf.gov.br (A. Minervino).

their status has been determined as fatal [3]. Furthermore, the jurisprudence of the European Court of Human Rights establishes that the failure of public authorities to conduct adequate investigations into the fate of a missing person constitutes a violation of Article 3 of the European Convention on Human Rights, highlighting the country's obligation to ensure an exhaustive investigation [4].

The UN advises that institutions should explore creative ways to increase their visibility among particularly vulnerable groups and gain trust. The most effective education and information campaigns are generally designed and implemented at national and local levels, considering cultural contexts and traditions. Like any public or private service provider, the institution should take particular care to be known by all its potential beneficiaries. A national institution cannot be accessible to a public that is unaware of its existence [5].

This study aims to conduct a review of institutional models and national programs dedicated to the identification of missing persons in countries selected for their migration-related links to Brazil. It focuses on the integration of forensic genetics into missing-persons work, the legal and governance frameworks that enable or constrain this integration, and the public-policy and operational arrangements that support international cooperation. Particular attention is given to transnational disappearance and identification challenges in humanitarian contexts, including migration and human trafficking.

Although the technical effectiveness of forensic genetic databases is well established, this review uses the selected countries to draw structural and policy lessons on how humanitarian objectives can be strengthened or constrained by institutional design, operational capacity, and legal/governance arrangements. The analysis emphasizes that the primary barriers to realizing the humanitarian potential of international mechanisms such as INTERPOL's I-Familia are often not technical, but relate to governance and legal alignment for data sharing in transnational cases.

2. Review methodology

This study presents an illustrative review of selected national and transnational initiatives for identification of missing persons, with a particular focus on the integration of forensic genetics in missing persons cases, the legal and governance frameworks that enable or constrain such integration, and the policy and operational arrangements that support international cooperation.

Country selection followed a strategy anchored to Brazil's transnational context, emphasizing: a) countries with strong migratory links to Brazil; b) countries connected to those migration corridors; and c) countries illustrating international DNA cooperation mechanisms. First, Portugal and the United States were used as primary reference points due to their relevance as migration destinations to Brazilian citizens [6]. Subsequently, Spain, France, and the United Kingdom were included because they presented the highest number of DNA matches with Portugal in the Prüm system in 2023 [7]. Within the U.S.-centered corridor, Mexico was considered due to its centrality in the context of migration to the United States [8], as was Canada, given the potential for transnational disappearances to occur at both land borders. Finally, Belgium was considered a relevant case study due to a recent legislative change which, by expanding the international sharing of DNA profiles, directly affected transnational cooperation [9].

Documents were selected from three main sources: a) scientific literature indexed in Scopus, ScienceDirect and Google Scholar; b) official reports from national police, forensic institutes, and government ministries; and c) documentation from international organizations including INTERPOL, International Commission on Missing Persons (ICMP), ICRC, and UN. The search strategy used key terms such as "Missing Persons", "Forensic Genetics", "DNA Database", "International Cooperation", "I-Familia", "Unidentified Human Remains", and "Transnational Disappearance". Materials were included based on their relevance to the search and identification of missing persons and/or

unidentified human remains, and for providing substantive information on forensic methods, databasing practices, governance safeguards and/or legal instruments enabling data processing and cooperation. In this manuscript, "missing persons" (MPs) refers to individuals whose locations are unknown, and "unidentified human remains" (UHRs) refers to bodies or fragments for which the identity is unknown.

It is acknowledged, however, that the analysis is constrained by its reliance on publicly available sources (such as official reports and institutional websites), differences in terminology, irregular degrees of public transparency, and incomplete publicly available technical detail. Therefore, absence of detailed description for a given country should not be interpreted as absence of initiatives; rather, it reflects the scope of this review and the variable availability of public documentation.

3. Institutional models and national identification programs

The management of missing persons search and identification differs significantly among countries, reflecting varied levels of investment in institutional integration and technology. Success demands a multidisciplinary approach combining the work of forensic specialists (pathologists, anthropologists, geneticists) with effective institutional coordination across multiple agencies.

Building on this need for multidisciplinary coordination, identification workflows commonly prioritize scientifically reliable methods, including fingerprints analysis, dental records, development of a biological profile through forensic anthropological examination, and forensic genetics analysis [10].

3.1. The potential of forensic genetics

Forensic genetics provides a robust tool for the identification of missing persons through the comparison of genetic profiles from unidentified human remains (UHR) with reference material from the missing person and/or from biological relatives. In practice, this methodology encompasses two primary analytical approaches: a) direct matching, established when the genetic profile of a UHR corresponds to a direct *ante-mortem* reference from a missing person (e.g., personal items or clinical biological samples); and b) indirect matching (kinship matching), obtained by comparing a UHR profile with reference samples collected from biological relatives [11]. Although direct matches can provide stronger statistical support, *ante-mortem* references obtained from personal items may present chain-of-custody limitations (e.g., potential item substitution) or pre-examination contamination [3]. In some cases, a direct-match result may require confirmation through independent evidence, including kinship-based comparison using relatives' reference samples.

In accordance with humanitarian principles, genetic profiles obtained from relatives for inclusion in missing-persons databases should not be compared with criminal or crime scene profiles, thereby ensuring a clear and ethical separation between humanitarian identification efforts and criminal investigations. The establishment and maintenance of dedicated DNA databases substantially enhance the capacity to perform these comparisons, thereby strengthening the reliability and effectiveness of human identification efforts.

Because missing-person cases and unidentified remains frequently involve cross-border movement, effective use of these genetic comparisons often depends on international cooperation. Transnational DNA data exchange is commonly described through four principal models: a) creation of a centralized international database; b) establishment of linked or networked national databases; c) request-based data exchange; and d) strategic combination of these methods to increase investigative reach [1213]. For any model to be effective, it is essential to populate databases with genetic profiles from UHRs and appropriate reference profiles (from missing persons and/or their relatives). Kinship searches require accurate reconstruction of pedigree structures that model biological relationships. Increasing the number of relatives represented,

with the analysis of a broader set of genetic data, can increase the likelihood of generating informative matches and improves identification outcomes. This expansion of genetic data may include increasing the number of STR (Short Tandem Repeat) markers, incorporating SNPs (Single Nucleotide Polymorphisms) for higher resolution in complex cases, and utilizing lineage markers (mitochondrial DNA and Y-STR) to provide additional evidentiary support for kinship inference.

The inclusion of relatives' profiles depends on informed consent and voluntary sample donation. Biological samples must be preserved, documented, expertly analyzed, and reported, maintaining a clear chain of custody for identification purposes and potential accountability processes [10]. To enhance the tool's potential, transparency regarding database governance should be prioritized, and awareness of the DNA database should be promoted within society regarding its use in missing person search and identification.

Building on these kinship-based database comparisons, Forensic Genetic Genealogy (FGG) is an emerging approach to human identification in missing-persons cases, with potential to generate investigative leads through more distant kinship inference when searches in national DNA databases do not produce matches. FGG combines distant kinship inference with linkage to publicly accessible records, using data voluntarily uploaded for genetic genealogy databases [13]. Despite its potential, FGG is not yet routine in most official forensic genetics laboratories and is generally applied on a case-by-case basis under specific legal and operational conditions.

3.2. Countries models: Brazil-centered transnational context

Effective identification systems are supported by multidisciplinary collaboration, institutional integration, and evidence-based public policy. In this manuscript, "public policy" refers to the legal, administrative, and operational measures structuring MP/UHR identification, including institutional responsibilities, standardized procedures, governance safeguards for sensitive data, and the formal cooperation mechanisms used for cross-border exchange. While these principles are universal, their practical implementation varies across countries, reflecting differences in legal frameworks, operational capacity and inter-institutional coordination.

Publicly available documentation on MP/UHR programs is heterogeneous across countries and frequently insufficient to extract the same operational and governance variables consistently. Therefore, the synthesis below relies on features explicitly described in the sources reviewed, and absence of description should be interpreted as a documentation limitation rather than evidence of absence in practice.

Brazil's National Policy on the Search for Missing Persons (PNBPDes), instituted in 2019, structures a state effort to centralize and prioritize missing persons' searches. PNBPDdes innovates by requiring that, in cases of UHRs, the collection of physical and genetic information is promoted for insertion into national databases, a strategy reinforced by campaigns from the Ministry of Justice and Public Security (MJSP) for collecting biological samples from relatives of missing persons [14,15]. The Integrated Network of DNA Databases (RIBPG) actively engages in these campaigns, promoting the obtained profiles into databases and processing samples from UHRs and living persons without known identity [14,15]. As of May 2025, RIBPG held 12,485 UHRs profiles and 11,990 relative profiles. Collectively, the RIBPG databases have enabled the identification of 577 individuals, the majority through genetic kinship matches between relatives and UHRs profiles [16].

Given Brazil's transnational context, Portugal constitutes a primary reference point due to its strong migratory links with Brazilian citizens [6]. In Portugal, criminal investigation and disappearance-reporting procedures have been analyzed to identify challenges and align with international guidelines. The Judiciary Police (PJ) and the National Institute of Legal Medicine and Forensic Sciences (INMLCF) share the objective of searching for missing persons and identifying UHRs. The PJ registers disappearance cases and conducts investigations [17]. The

INMLCF is responsible for processing UHRs. Coelho (2024) observes that while the PJ compiles missing persons' records and the INMLCF processes *post-mortem* data, the absence of effective coordination limits the overall efficiency of case correlations [18]. The formalization of inter-institutional cooperation protocols is seen as essential to develop an effective communication system and to improve data interlinking. Almeida (2024) argues that, with respect to specific legislation governing fingerprint and forensic genetics data, there are legal mechanisms to design a response model and establish a unified database for missing persons, which can act as an international interlocutor when required [19].

Within the Portuguese corridor, Spain, France, and the UK show high Prüm-related exchange activity, providing additional comparative value for examining cross-border interoperability [7]. Spain's National Centre for Missing Persons (CNDES) proposes a multidisciplinary approach. In a key effort to optimize identification, in 2023 the CNDES integrated its two DNA databases for relatives: the national PDYRH (Persons Missing and Human Remains) and the international INT-FENIX. This coordination sought to synchronize the central repository of *ante-mortem* and *post-mortem* information, facilitating data cross referencing. Following integration, law enforcement agencies were instructed to revisit cases to include DNA profiles from relatives not yet present in PDYRH, thereby maximizing the chances of resolving disappearances, especially in long-term cases [20].

France's National Automated Genetic Fingerprint File (FNAEG) is an instrument of scientific policing that supports missing persons investigations. The system permits collection of biological samples from relatives of a missing person, always subject to their consent. Moreover, data is automatically erased from the database once the person is discovered or definitively identified, ensuring the temporary nature of its storage [21]. In addition, there are databases such as CADDIS and FENIX, which compile UHR *post-mortem* data. However, a challenge lies in the lack of interoperability between CADDIS (managed by the Gendarmerie) and FENIX (operated by the Police), which makes data integration and interagency investigations more difficult [4].

The policing system in the UK establishes official conduct guidelines aiming to standardize service levels and ensure a consistent investigative response in missing persons cases. The UK Missing Persons Unit (UKMPU) was established in April 2008 and is responsible for the search for missing persons and UHRs at both national and international levels. The system adopts a multi-agency approach and places safeguarding of vulnerable individuals with its operational strategy. In this context, the collection of DNA, fingerprint and dental records is required to facilitate the identification of the missing person. Within the domain of forensic genetics, collection of samples from the missing person or close relatives are requisitioned to obtain comparative reference profiles. Submission and search of these profiles within the DNA database can produce identity information [22,23]. The UK has established a specialized Missing Persons DNA Database (MPDD), which as of 31 March 2024 held 2335 records and reported 28 matches for the 2023/2024 period [24].

The U.S.-centered migration corridor was considered due to its direct relevance to Brazilian citizens and its cross-border dynamics [6]. In 2005, the US National Institute of Justice led a collaborative initiative involving federal, state, and local stakeholders to draft a model state legislation addressing the collection, analysis, and dissemination of evidence in missing persons cases. It proposed, for example, prohibiting cremation of UHRs, mandating that law enforcement agencies accept all missing persons reports, that DNA samples be collected within 30 days of the disappearance, and that DNA analysis be performed on all UHRs [25]. The National Missing and Unidentified Persons System (NamUs), administered by NIJ, is the centralized national repository that automatically crosses data and consolidates records for missing persons (NamUs MP), unidentified persons (NamUs UP), and unclaimed UHRs. The platform provides free forensic services, including fingerprint, odontology, and anthropology examination, and facilitates DNA sample

collection. As of January 2025, NamUs recorded 54,110 resolved missing persons cases and maintained 25,566 active cases [26]. DNA profile storage and searching are performed within the FBI's National Missing Persons DNA Database in CODIS/NDIS, which supports the comparison of DNA profiles for missing and unidentified individuals [27].

Within the same U.S.-centered corridor, Canada's National Missing Persons DNA Program, established in 2018 through cooperation between the Royal Canadian Mounted Police and the National DNA Data Bank, was created to support humanitarian investigations. Relatives' profiles are compared solely to the Missing Persons and UHRs indexes, maintaining the system's humanitarian and non-criminal orientation. By March 2024, the program had assisted in identifying human remains in 84 cases [28].

Mexican nationals constitute the largest immigrant-origin group in the US[8], and Mexico provides an additional perspective on how procedural frameworks can affect identification outcomes. Quinto-Sánchez and Huerta-Pacheco (2023) characterize the Mexican situation as a human-rights emergency and report recurring delays in the formal initiation of prosecutorial case files [29]. Although searches are expected to begin promptly, the authors describe that, in practice, many cases are subject to a 72-hour waiting period before an investigation folder is formally opened. Using disappearance reports recorded in CENAPI (2006–2018), they found that within this 72-hour window only 34.53 % of individuals were located (alive or deceased), which the authors interpret as supporting the need for earlier investigative activation. Accordingly, they argue for evidence-informed time thresholds, early investigative response, and the use of forensic intelligence to guide operational practice and public policy in this context [29].

Finally, Belgium was included as a policy-relevant case study because recent legislative updates [30], and the related implications for international cooperation and cross-border DNA profile sharing are discussed later in the manuscript [9]. Belgium's National DNA Database for Missing Persons (BD_MP), operational since 2018, stores genetic profiles from missing persons, their relatives, and UHRs. The comparisons within the BD_MP are conducted indirectly through pedigree-based kinship analyses [31].

Taken together, these national programs illustrate that multidisciplinary and inter-institutional collaboration can be operationalized through different institutional designs, including centralized repositories and integrated *ante-mortem/post-mortem* data management. In addition to State-led arrangements, some contexts also involve contributions from civil society actors, which are noted here briefly given their relevance to humanitarian identification pathways.

Non-Governmental Organizations (NGOs) and international humanitarian bodies, such as ICRC and ICMP, may support MP/UHR identification by facilitating family engagement and reference-sample collection, documenting cases, preserving relevant records, and conducting human-rights monitoring. However, these inputs are often fragmented, and integration raises data protection, privacy, ethics, security, and information-integrity considerations that depend on willingness to collaborate and trust between stakeholders. In contexts such as migrant fatalities, armed conflict, or high levels of violence, NGOs have reported operational activities including recovery and burial of UHR, collection of DNA samples, and compilation of photographs and family testimonies to support cross-border identification. In some locations, they may also function as alternative channels for case documentation when reporting to official authorities is constrained, including along the US–Mexico border where the Colibrí Center for Human Rights maintains an independent database on missing migrants, with additional examples reported in North Africa and Iraq [32].

4. Transnational challenges and international cooperation

Transnational disappearance arises when a missing-person case involves two or more countries, which can limit access to records and

reduce the effectiveness of purely national identification systems, as illustrated by migrant deaths along border routes. In the context of human trafficking, victims are often selected based on vulnerability and may face intimidation or lethal violence. These individuals may be moved across countries, identification remain unreported or be recorded under incomplete identities [33]. When there are indications that a missing person may be in a foreign country (e.g., as a migrant, refugee, or potential trafficking victim), competent authorities should activate available national and international cooperation mechanisms and establish formal coordination procedures where such mechanisms are not in place [1].

4.1. Mechanisms of international cooperation

Several global organizations operate in this sphere, collecting and managing data on disappearances. The ICMP plays a central role in the global effort to address the issue of missing persons by providing technical, legal, and institutional support to countries. The organization assists in the development of national capacities, facilitating international cooperation, and securing the rights of families to truth, justice, and reparations. Through its advanced DNA identification programs, the ICMP has contributed to the resolution of some of the world's most complex post-conflict and disaster-related missing persons cases [32].

The ICRC is an essential part in the identification of missing persons, particularly in contexts of armed conflicts, natural disasters, and widespread violence. The committee supports efforts to identify human remains and clarify the fate of the missing, providing assistance to both countries and the relatives of victims. The organization collaborates closely with national authorities, humanitarian organizations, and forensic institutions, establishing humanitarian protocols for the collection and protection of data, ensuring that these processes respect the rights of families, including the right to privacy and dignity. Its work is based on the principles of impartiality, neutrality, and independence, in accordance with international humanitarian law [3].

The Schengen Information System (SIS) supports Europe in maintaining internal security in the absence of border checks since 1995. In March 2023, the system's capacity was upgraded to verify identities by incorporating biometric data (such as photographs and fingerprints) into various alerts, including those related to missing persons. To facilitate cross-border data exchange and coordinate SIS alerts, each participating country maintains a dedicated SIRENE (Supplementary Information Request at the National Entries) Office [34].

In the U.S., efforts to identify human remains of foreign nationals discovered on American soil have led to specific humanitarian initiatives. The Humanitarian DNA Identification Database (HDID), established by the University of North Texas Center for Human Identification, was created to address the difficulties faced by relatives in approaching U.S. authorities. As an independent humanitarian database, HDID offers a more accessible avenue for non-U.S. families to voluntarily donate DNA samples for comparison with UHRs found in the U.S. [33]. Another initiative, Operation Identification (OpID), coordinated by the Forensic Anthropology Center at Texas State University, aids local authorities in Texas' border regions with identifying probable migrant decedents[35]. Both initiatives aim to increase access to humanitarian identification and bring closure to families.

In its role as an international police cooperation organization, INTERPOL is an important part in the identification of missing persons by facilitating global cooperation between law enforcement agencies and forensic institutions across member countries [32]. One of its key tools is the system of Notices and Databases to manage missing persons and UHRs cases. The Yellow Notice is the primary tool for locating missing persons or assisting identity confirmation of those unable to self-identify. The Black Notice is issued specifically to share information about UHR aiding in their identification. Through its global network, INTERPOL also manages international databases that store genetic profiles, promoting interoperability among national identification

systems. Additionally, the organization provides technical support and training to local authorities, ensuring that DNA collection and other forensic procedures comply with international standards while safeguarding human rights [36,37].

4.2. Global database dedicated to missing persons identification

In July 2021, INTERPOL enhanced its capacity by launching I-Familia, a global database designed for identifying missing persons via DNA kinship matching. I-Familia gives investigators an additional tool for forming international connections between missing persons cases and UHRs by using the DNA data of the missing person's relatives when samples from the missing person are unavailable. When I-Familia identifies an international DNA kinship match, a notification is sent to the contributing countries, which then decide whether to pursue the forensic intelligence link [37].

Laurent *et al.* (2022) describe the scientific foundation and technical design of INTERPOL's I-Familia, focused on optimizing transnational identification of missing persons. The main challenge of this approach is the complexity of forensic statistics across borders, especially when the individual's ancestry is uncertain and diverse marker sets are used. To streamline decision-making, I-Familia uses calculations performed by the BONAPARTE software, which applies worldwide allele frequencies and specific \log_{10} LR cutoff thresholds [38].

In March 2024, Belgium's legislature expanded the country's DNA data exchange capabilities. The new law allows exchange with databases managed by European or international organizations, such as INTERPOL's databases, specifically for direct or indirect identification of UHRs and missing persons [30]. The legislative change enabled a discovery in a longstanding missing person's case: the identification of Dutch national Angelique Hendrix's remains, who had disappeared in 1990. The case remained unresolved for 34 years until Belgian DNA profiles were shared with the I-Familia, demonstrating the critical role of international cooperation and legal alignment in solving cold cases and providing answers to families [39].

Brazil's RIBPG significantly expanded its international data sharing from 2018. By May 2025, 11,174 UHR profiles were submitted to the I-Familia to support missing persons identification. Additionally, Brazil submitted genetic profiles corresponding to 61 INTERPOL Yellow Notices for missing persons suspected to have crossed national borders [16].

Canada's National DNA Data Bank maintains an active international cooperation framework via INTERPOL. In 2018, an agreement was updated to permit international comparisons of DNA profiles related to missing persons and UHRs. By March 2024, Canada has received 113 international requests to search missing persons' and remains' profiles and made 65 outgoing requests to other countries with INTERPOL agreements. These collaborative efforts have resulted in four putative identifications (two incoming and two outgoing) [28], which provides operational evidence that transnational searches can yield actionable leads in cases that would otherwise remain unresolved at the national level.

The UK Forensic Information Databases Strategy Board's 2024 report highlighted significant enhancements to missing persons services. These include retention of DNA profiles for individuals interred at sea and international sharing of missing persons' profiles via I-Familia database. These advancements are expected to aid future investigations into missing persons and UHRs [10].

Spain's handling of international missing persons cases is governed by existing cooperation protocols. Its procedure mandates liaison with the Ministry of Foreign Affairs, INTERPOL and the SIRENE Office. In long-term cases, Spain may request cross-referencing of DNA profiles and fingerprints across INTERPOL's global databases, including I-Familia [40].

The I-Familia represents a promising effort to facilitate international DNA kinship matching; however, its adoption is not yet systematic

across all countries. Full integration is hindered by the absence of unified national protocols in some countries, impeding alignment with international frameworks. In fact, Amankwaa *et al.* (2025), in a study on stakeholder perspectives on the use of I-Familia, noted that a lack of transparency and trust in the management of such humanitarian records were critical challenges that limit broader adoption and data sharing [41]. Thus, coordination must extend beyond technical aspects to include regulatory, legal, and operational dimensions.

In this manuscript, "effectiveness" in the transnational context is used in a functional sense: given that cross-border exchanges are typically episodic, case-specific, and often focused on long-term investigations or cold cases, any confirmed or putative identification generated through I-Familia/INTERPOL database constitutes evidence that the mechanism can produce results that might not be achievable through isolated national systems. Accordingly, outcomes are interpreted primarily as proof-of-function and added investigative reach, rather than as a rate-based performance metric. Future initiatives should explore incorporating national systems into this global architecture, adapting the platform to routine forensic identification workflows [4]. However, it is noted that the scope of this study is limited by the selection of a few countries for analysis, as well as by its reliance on public available information.

4.3. Ethical aspects of international cooperation

The humanitarian potential of DNA databases extends beyond investigative purposes, offering a tool to restore family connections disrupted by wars, migration, human trafficking or humanitarian crises. When governed under explicit safeguards, internationally coordinated mechanisms can facilitate identification and family reunification while ensuring voluntary participation, privacy protection, and transparent governance [42].

Because program effectiveness depends on the collection, processing, and exchange of sensitive information, international cooperation raises core ethical and legal questions, particularly the balance between humanitarian identification and public-security goals, and the protection of privacy and genetic data. In many countries, MP/UHR identification is framed as a humanitarian task and is expected to be governed by purpose limitation and informed consent, especially when collecting reference samples from relatives. The principal challenge is therefore not the absence of these principles, but the inconsistent legal articulation, operational implementation, and public documentation of how they are applied, particularly where humanitarian processes share infrastructure with criminal/public-security systems.

In this context, the ethical objective is to ensure that humanitarian DNA Databases are processed within a dedicated and explicitly separated framework for MP/UHR identification supported by clear limits that prevent crossover into criminal databases whether at the national level or through international mechanisms such as INTERPOL's I-Familia. Machado *et al.* (2022) highlight concern about the increasing exchange of civil identification data coupled with the security-oriented forensic approach of the Prüm system, arguing that such practices may pose risks to civil liberties. To mitigate these risks and avoid data duplication, they contend that the exchange of civil identification data within the Prüm framework should be reconsidered. These authors emphasize that the ethical and most suitable alternative is the use of the I-Familia database, which is specifically designed for identifying missing persons via DNA kinship matches [43]. However, other authors note that international tools such as I-Familia may require clearer, standardized regulation to meet the criteria of transparency and trustworthiness demanded by forensic policy[41].

Ethical cooperation also requires operational safeguards that are consistently defined and implemented. Protocols should specify the scope of use, access control, retention rules, auditability, and secure data transfer, with deletion or anonymization when the identification purpose has been fulfilled. In many countries, MP/UHR identification is

framed as a humanitarian task governed by consent and purpose limitation, but the main challenge lies in the inconsistent legal articulation and operational implementation of this humanitarian pathway. Such safeguards are intended to prevent misuse, including: a) transfer of relatives' genetic profiles into criminal databases or searching against criminal/crime-stain indexes without specific legal authority; b) secondary use for surveillance or unrelated investigative purposes beyond humanitarian identification; and c) retention or reuse of profiles beyond authorized time limits, including continued processing after identification or resolution of the case. These scenarios are central to maintaining legitimacy and sustaining family participation.

The ICRC provides guidance on ethical and legal safeguards for genetic data in humanitarian identification. While informed consent is generally expected in established MP/UHR systems, the ICRC emphasizes that consent should be specific, voluntary, and transparent, and that samples and profiles should be used exclusively for humanitarian identification purposes and not transferred to criminal databases without clear and specific legal authorization [3]. In addition, the ICRC underscores that identification practice must be grounded in respect for families and the right to know the fate of the missing. Although human remains are generally not treated as legal rights-holders per se, their recovery and management engage the rights and interests of families and intersect with societal duties of dignity and respect. The ICRC therefore highlights an ethical obligation to recover, document, and handle remains with dignity and in accordance with the cultural and religious traditions of families, irrespective of the circumstances of death [3]. This ethical framing supports minimum standards for recovery, documentation, chain-of-custody, respectful storage, and communication with families as integral components of humanitarian identification practice.

5. Structural analysis and comparative lessons

The ICRC establishes a series of guidelines for the integration of investigation processes, data collection, forensic analysis, and humanitarian engagement. This includes the need for inter-institutional coordination, involving the development of standard policies and procedures by the relevant authorities (police, forensic institutes, prosecutorial and judicial authorities), to ensure that all entities involved work together and share information in an efficient and standardized manner [3]. The integrated process comprises two complementary lines of action requiring coordinated implementation. The first focuses on the comprehensive collection of *ante-mortem* data, including the circumstances of disappearance, personal and medical information, personal effects or other biological sources related to the missing person, and biological reference samples from relatives. The second is *post-mortem* data processing, which includes proper recovery, handling, and analysis of UHRs, including DNA analysis. Successful identification depends on the quality and integration of both *ante-mortem* and *post-mortem* data.

A model framework should prioritize a set of transferable policy, governance, and operational components that can be adapted by different countries to structure MP/UHR search and identification and to support international cooperation. Implementation should delineate responsibilities across relevant entities such as law enforcement, prosecutorial authorities, forensic institutes, database custodians, and international cooperation organizations. At a minimum, the framework should define institutional responsibilities and coordinated workflows including reporting and early investigative activation, *post-mortem* data collection, laboratory analysis, and comparative searching. It should also establish governance safeguards for sensitive information such as purpose limitation, consent where applicable, access controls, auditability, data security, retention/deletion rules, and specify procedures for interoperability and international data exchange.

Within the scope of this illustrative review, identification performance is best understood as a function of institutional coordination, data integration, and governance clarity, rather than technology alone.

Models with a clear mandate for multi-agency coordination and data centralization are more likely to support timely linkage of *ante-mortem* and *post-mortem* information and to enable transnational cooperation when required. This perspective reinforces the need for international cooperation mechanisms that place humanitarian objectives at the core of forensic science and transnational collaboration.

6. Conclusion and recommendations

The identification of missing persons is not only a humanitarian issue, but also a complex cultural, legal, scientific, and institutional challenge. In this illustrative review of countries selected for their migration-related links to Brazil, diverse approaches have been adopted to managing disappearances, with differences in institutional coordination, governance arrangements, and operational capacity determining how identification pathways are implemented, including the extent of international cooperation.

Among the forensic sciences, genetics has emerged as one of the most powerful tools for the identification of missing persons. However, its potential can only be realized when DNA databases are appropriately populated, supported by quality-assured workflows, and embedded in clear legal and ethical frameworks. A crucial factor is the establishment of public policies ensuring the systematic processing of UHRs, as well as guaranteeing accessible mechanisms for relatives to provide biological samples for humanitarian identification purposes.

A key consideration is that limiting the use of relatives' genetic profiles exclusively to humanitarian purposes is essential to build public trust and increase participation in DNA databases. Equally essential is the establishment of clear, rights-based guidelines for the voluntary collection of DNA samples, ensuring full respect for privacy and data protection. The development of robust legal frameworks and ethical guidelines for use and exchange of genetic data ensures that technological advancements do not compromise privacy rights or humanitarian principles.

Transnational disappearances present additional challenges, including those involving migrants, human trafficking or humanitarian crises. In this context, both national and international coordination are indispensable, as the increasing number of disappearances across borders requires coordinated legal frameworks and shared data mechanisms to enable effective and cooperative investigations. The limitations of national systems to address transnational cases have contributed to international mechanisms, such as INTERPOL's I-Familia, and cooperative protocols designed to facilitate the exchange of forensic genetic data. While these instruments represent progress, their functional effectiveness is primarily demonstrated by their ability to generate actionable links in otherwise unresolved transnational cases, and their broader impact depends on the standardization and adaptation of national procedures, legal alignment, and operational capacity to engage with international partners.

The disparity in transnational cooperation is not just a technical challenge but reflects substantial political and legal barriers. The primary issues include not only the lack of legislative alignment among countries, particularly regarding data protection laws and restrictions on the international transfer of data, but also a significant lack of sustained resource commitment to support the operational and technical infrastructure required for identification efforts. While systems such as Prüm and the SIS facilitate data exchange in security contexts due to their own regulatory frameworks, bilateral cooperation or participation in international humanitarian tools frequently requires legal adjustments and the establishment of internal protocols.

This study is limited in scope, as it examined a restricted number of countries based on publicly available data. Consequently, the findings provide only a partial view of the global scenery of missing persons search and identification systems. Further research is needed to analyze a broader range of national protocols, evaluate operational and legal frameworks, and assess participation in international cooperation

initiatives. Expanding this line of inquiry would contribute to identifying best practices and strengthening global mechanisms for the search and identification of missing persons.

Although limited in scope, the analysis presented here offers a practical foundation for advancing policy and operational alignment in humanitarian MP/UHR identification, particularly in transnational contexts linked to migration and human trafficking. Based on the evidence synthesized in this manuscript, three recommendations emerge. First, countries should prioritize legislative alignment to permit the safe and ethical exchange of humanitarian DNA data through international mechanisms such as INTERPOL's I-Familia. Second, countries should strengthen integrated policy and institutional arrangements that support data centralization and effective linkage of *ante-mortem* and *post-mortem* records, coupled with mandatory inter-institutional coordination to improve timeliness and case resolution. Third, legal guarantees should explicitly protect humanitarian exclusivity by ensuring that relatives' reference profiles are used only for MP/UHR identification and are not transferred to criminal databases or searched against criminal indexes without specific legal authorization and safeguards, which is essential for sustaining public confidence and participation.

The identification of transnational missing persons constitutes a collective global responsibility that requires international cooperation. The ultimate goal is to ensure that data collected from UHRs can be effectively compared with the information provided by relatives and integrated with other scientifically reliable identification methods. From a policy perspective, collaboration in science, technology, and innovation must be matched by governance and legal alignment to support secure, accountable, and humanitarian data exchange, thereby enabling broader integration into international identification platforms.

7. Funding source

There was none funding source.

8. Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

During the preparation of this work the corresponding author used Gemini IA (by Google) in order to assist in reviewing translations and generating images for the graphical abstract. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

CRedit authorship contribution statement

Aline Minervino: Writing – original draft, Investigation, Conceptualization. **António Amorim:** Writing – review & editing, Supervision. **Francisco Corte Real:** Writing – review & editing, Supervision. **Laura Cainé:** Writing – review & editing, Supervision, Methodology.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

- U. N. UN, "Guiding Principles for the Search for Disappeared Persons," 2019. Available: <https://www.ohchr.org/en/documents/legal-standards-and-guidelines/guiding-principles-search-disappeared-persons>. [Accessed: Oct. 02, 2025].
- U. N. UN, "International Convention for the Protection of All Persons from Enforced Disappearance," 1992. Available: <https://www.ohchr.org/sites/default/files/disappearance-convention.pdf>. [Accessed: Dec. 01, 2025].
- I. C. R. C. ICRC, "Pessoas Desaparecidas, Análise de DNA e Identificação de Restos Mortais," 2009. Available: https://www.icrc.org/sites/default/files/2024-08/4010_007-ebook%20%282%29.pdf. [Accessed: Oct. 03, 2025].
- L. Franceschetti, et al., Medico-legal identification of unidentified bodies and missing persons in Milan and Paris: a comparative institutional study, *Sci. Rep.* 15 (1) (2025) Dec, <https://doi.org/10.1038/s41598-025-14095-9>.
- U. N. UN, *National human rights institutions : a handbook on the establishment and strengthening of national institutions for the promotion and protection of human rights*. United Nations, 1995. Available: https://dcjri.ministeriopublico.pt/sites/default/files/documentos/pdf/formacao_profissional_4.pdf. [Accessed: Oct. 03, 2025].
- M. das R. E. MRE, "Comunidades Brasileiras no Exterior - 2023," 2024. Available: <https://www.gov.br/mre/pt-br/assuntos/porta-conular/brasileiros-no-exterior-estimativas-ano-a-ano>. [Accessed: Oct. 29, 2025].
- A. Minervino, V. Bogas, P. Cardoso, F. Corte Real, and P. Brito, "O Desempenho da Base de Dados de Perfis de ADN Portuguesa sob o Tratado de Prüm," vol. 34, Dec. 2024, Available: <https://gestlegal.pt/colecao/revista-portuguesa-de-ciencia-criminal/>.
- Pew Research Center, "What the data says about immigrants in the U.S.," Aug. 2025. Available: <https://www.pewresearch.org/short-reads/2025/08/21/key-findings-about-us-immigrants/>. [Accessed: Dec. 02, 2025].
- INTERPOL, "INTERPOL welcomes new DNA legislation in Belgium," Apr. 2024. Available: <https://www.interpol.int/en/News-and-Events/News/2024/INTERPOL-welcomes-new-DNA-legislation-in-Belgium>. [Accessed: Dec. 02, 2025].
- M. KLINKNER, *The Bournemouth Protocol on Mass Grave Protection and Investigation*. 2020. Available: <https://www.bournemouth.ac.uk/research/projects/mass-grave-protection-truth-justice>. [Accessed: Oct. 03, 2025].
- E. N. F. S. I. D. W. G. ENFSI, "Guideline for DNA Database Management Review and Recommendations," Oct. 2023. Available: <https://enfsi.eu/wp-content/uploads/2024/07/DNA-GDL-004-GUIDELINE-FOR-DNA-DATABASE-MANAGEMENT-REVIEW-AND-RECOMMENDATIONS.pdf>. [Accessed: Oct. 03, 2025].
- A. O. Amankwaa, "Trends in forensic DNA database: international exchange of DNA data," *Forensic Sciences Research*, vol. 5, no. 1. Taylor and Francis Ltd., pp. 8–14, Jan. 2020. doi: 10.1080/20961790.2019.1565651.
- J.M. Butler, Recent advances in forensic biology and forensic DNA typing: INTERPOL review 2019–2022, *Forensic Sci. Int.* 6 (Jan. 2023), <https://doi.org/10.1016/j.fsisyn.2022.100311>.
- M. J. S. P. MJSP, "Relatório Estatístico Anual de Pessoas Desaparecidas e Localizadas Anos-base 2022 e 2023," 2024. Available: <https://www.gov.br/mj-pt-br/acesso-a-informacao/acoes-e-programas/desaparecidos/politica-nacional>. [Accessed: Oct. 03, 2025].
- R. C. Silva Junior et al., "DNA databases as a tool to improve the search for missing persons in Brazil," *Forensic Sci Int Genet Suppl Ser*, vol. 8, pp. 167–169, Dec. 2022, doi: 10.1016/j.fsigss.2022.10.023.
- R. I. B. P. G. RIBPG, "XXII Relatório da Rede Integrada de Bancos de Perfis Genéticos," May 2025. Available: <https://www.gov.br/mj-pt-br/assuntos/sua-seguranca/seguranca-publica/ribpg/relatorio>. [Accessed: Oct. 03, 2025].
- A.R. Machado, *A investigação criminal no desaparecimento de pessoas em Portugal, Universidade Autónoma De Lisboa* (2013).
- J. B. COELHO, "Comunicação de Desaparecimento em Portugal: Procedimentos, Desafios e Diretrizes Internacionais," master, Universidade de Coimbra, 2024. Available: <https://estudogeral.uc.pt/handle/10316/117444>. [Accessed: Oct. 10, 2025] <https://estudogeral.uc.pt/handle/10316/117444>.
- D. V. C. ALMEIDA, "Proposta de Base Única de Pessoas Desaparecidas em Portugal," Universidade do Porto, 2024. Available: <https://repositorio-aberto.up.pt/bitstream/10216/164515/2/702244.pdf>. [Accessed: Oct. 03, 2025] <https://repositorio-aberto.up.pt/bitstream/10216/164515/2/702244.pdf>.
- C. N. D. CNDES, "Informe Anual Personas Desaparecidas 2025," 2025. Available: https://www.interior.gob.es/opencms/export/sites/default/galleries/galeria-de-prensa-documentos-y-multimedia/balances-e-informes/2025/06_Informe_anual_personas_desaparecidas_2025.pdf. [Accessed: Oct. 02, 2025].
- C. Byk, Le Fichier National Automatisé des Empreintes Génétiques, *J Int Bioethique Ethique Sci* 32 (2) (Jun. 2021) 45–58, <https://doi.org/10.3917/jibes.322.0045>.
- A. C. P. O. ACPO, "Guidance on The Management, Recording and Investigation of Missing Persons," Hampshire, 2005. Available: <https://mpih.org.uk/2023/12/05/guidance-on-the-management-recording-and-investigation-of-missing-persons-2005/>. [Accessed: Oct. 02, 2025].
- N. P. I. A. NPIA, "Collection of Missing Persons Data," 2009. Available: <https://assets.publishing.service.gov.uk/media/5a74c30340f0b61df477849d/9787771146872.pdf>. [Accessed: Oct. 02, 2025].
- F. I. D. S. B. FIND, "Forensic Information Databases annual report 2023 to 2024," 2024. Available: <https://www.gov.uk/government/publications/forensic-information-databases-annual-report-2023-to-2024/forensic-information-databases-annual-report-2023-to>.
- N. RITTER, "Missing Persons and Unidentified Remains: The Nation's Silent Mass Disaster," *NIJ Journal*, no. 256, 2007. Available: <https://nij.ojp.gov/library/publications/nij-journal-issue-no-256>. [Accessed: Oct. 03, 2025].
- N. I. J. NIJ, "NamUs," 2025. Available: <https://namus.nij.ojp.gov/library/reports-and-statistics>. [Accessed: Oct. 03, 2025].
- F. B. I. FBI, "NDIS Missing Person Comparison Request." Available: <https://le.fbi.gov/science-and-lab/biometrics-and-fingerprints/codis/ndis-missing-person-comparison-request>. [Accessed: Dec. 02, 2025].
- R. C. M. P. RCMP, "The National DNA Data Bank of Canada - Annual Report 2023-2024," 2024. Available: https://publications.gc.ca/collections/collection_2024/grc-rcmp/PS61-4-2024-eng.pdf. [Accessed: Oct. 03, 2025].
- M. Quinto-Sanchez, N.S. Huerta-Pacheco, Missing persons patterns from Mexico: evidence of a forensic emergency crisis, *Forensic Sci. Res.* 8 (4) (Dec. 2023) 288–294, <https://doi.org/10.1093/fsr/owad026>.
- M. B. MB, "Loi modifiant le code d'instruction criminelle, la loi du 22 mars 1999 relative à la procédure d'identification par analyse ADN en matière pénale et la loi

- du 5 août 1992 sur la fonction de police,” Mar. 2024. Available: https://www.ejustice.fgov.be/mopdf/2024/03/14_1.pdf#Page7. [Accessed: Oct. 02, 2025].
- [31] I. N. C. C. INCC, “Banques Nationales de Données ADN - Rapport Annuel 2022,” 2023. Available: https://nicc.fgov.be/upload/images/2022_fr_0.pdf. [Accessed: Oct. 02, 2025].
- [32] I. C. M. P. ICMP, “Global Report on Missing Persons,” 2021. Available: https://icmp.int/wp-content/uploads/2021/08/ICMP_Global-Report_April_Digital.pdf. [Accessed: Oct. 02, 2025].
- [33] B. Budowle, M.M. Bus, M.A. Josserand, D.L. Peters, A standalone humanitarian DNA identification database system to increase identification of human remains of foreign nationals, *Int. J. Legal Med.* 134 (6) (Nov. 2020) 2039–2044, <https://doi.org/10.1007/s00414-020-02396-9>.
- [34] E. C. EU, “Schengen Information System,” 2025. Available: https://home-affairs.ec.europa.eu/policies/schengen/schengen-information-system_en.
- [35] M.A. Kaplan, et al., Alternative workflows for identifying transnational missing persons, *Forensic Sci. Int.* 7 (Jan. 2023), <https://doi.org/10.1016/j.fsisyn.2023.100445>.
- [36] D. NAZAT, “Une approche en matière d’enfants disparus : le dispositif « Alerte enlèvement »,” *Cahiers de la sécurité et de la justice*, vol. 55, pp. 166–173, 2022. Available: <https://www.cairn.info/revue-cahiers-de-la-securite-et-de-la-justice-2022-2-page-166.htm>.
- [37] INTERPOL, “I-FAMILIA Newsletter 1st edition,” 2023. Available: Restricted access. [Accessed: Oct. 15, 2025].
- [38] F.X. Laurent, A. Fisher, R.F. Oldt, S. Kanthaswamy, J.S. Bucketon, S. Hitchin, Streamlining the decision-making process for international DNA kinship matching using Worldwide allele frequencies and tailored cutoff log10LR thresholds, *Forensic Sci. Int. Genet.* 57 (Mar. 2022), <https://doi.org/10.1016/j.fsigen.2021.102634>.
- [39] INTERPOL, “Angelique Hendrix identified through international DNA match,” Oct. 11, 2024. Available: <https://www.interpol.int/News-and-Events/News/2024/Breakthrough-in-longstanding-Dutch-missing-person-case>.
- [40] M. menéndez SIMARRO and N. BUENO-GUESSA, “Hacia un Protocolo Internacional de Actuación en Materia de Desaparecidos a través de un Análisis Comparativo de los Protocolos Español e Inglés,” *Revista Electrónica de Criminología*, vol. 08, 2024, doi: 10.30827/rec8.33144.
- [41] A.O. Amankwaa, B. Kupčuláková, K. Randall, Humanitarian Forensics: Stakeholder perspectives on the use of international kinship matching DNA databases, *J. Forensic Leg. Med.* 116 (Nov. 2025) 103018, <https://doi.org/10.1016/j.jflm.2025.103018>.
- [42] A. Stasi and K. Choavaratana, “Leveraging DNA Databases to Reconnect Families Separated by Conflicts and Humanitarian Crises,” *OBM Genetics*, vol. 9, no. 3. LIDSEN Publishing Inc, 2025. doi: 10.21926/obm.genet.2503304.
- [43] H. Machado, R. Granja, A. Amorim, Ethical challenges of merging criminal identification and civil identification within the Prüm system, *Forensic Sci. Int. Genet.* 57 (Mar. 2022), <https://doi.org/10.1016/j.fsigen.2022.102660>.