Executive Summary

Utilizing genetic genealogy technology in forensic investigation is a recent approach to resolving cold cases. However, apprehensions regarding the protection of privacy have emerged concerning its use in the forensic process. Stored deoxyribonucleic acid (DNA) data from past investigations could impact inquiry efficacy, potentially leading to unequal incarceration rates for underrepresented groups. This policy brief examines legal and policy issues tied to this technology and proposes policy alternatives for communities, including implementing suitable safeguards at the state level if the technology is employed.

The Golden State Killer Case, a notorious serial rape and murder investigation, was solved after more than four decades by matching data in external genetic genealogy databases. The utilization of private genetic genealogy databases for forensic purposes marked a significant achievement, uncovering more than 150 additional crime suspects through privately maintained databases after DeAngelo, the Golden State Killer, was captured.

Background

Genetic Genealogy is an emergent technology combining genetic analysis with traditional research that helps build family trees and study family history.[1] It is of commercial interest because it helps trace back one's family history to up to five generations, analyze ethnic estimates, and provide non-professional medical suggestions regarding hereditary diseases at high risk. Sample data collection can be as easy and fast as gathering saliva. The forensic system is advancing technologies for enhanced investigation efficiency; DNA evidence further aids in identifying missing and unidentified individuals in cold-case violent crimes.[2]

Introduction to the Genetic Genealogy Technology

Genes are made up of DNA, which is hereditary material important for the development and functioning of an organism. In constructing a DNA, each single nucleotide polymorphism (SNP) has four alleles, acting as biological markers to help scientists locate specific genes. Short tandem repeats (STRs) measure the number of times a sequence of SNPs is repeated at a specific location, helpful in identifying individuals' relationships.[3] In biotechnology and medicine, DNA serves as a fundamental guide to understanding bodily functions, disease processes, pathogen identification, disease pathways, genetic disorder diagnosis, and drug development. Nowadays, individual DNA distinctiveness plays a pivotal role in forensics, aiding criminal identification and establishing parentage.

[1] Steen, T. Y., Buchanan, C., & Budge, S. (2021, June 11). Genetic Genealogy: DNA and Family History. (W. Whitney, Ed.). Retrieved May 5, 2023, from https://guides.loc.gov/genetic-genealogy#:~:text=Genetic%20genealogy%20creates%20family%20history,combination%20with%20traditional%20genealogical%20methods.

[2] U.S. Department of Justice | Office of Justice Programs | National Institute of Justice. (2023, July 2). *Using DNA to Solve Cold Case*. National Commission on the Future of DNA Evidence. https://www.ojp.gov/pdffiles1/nij/194197.pdf.

[3] What is STR and SNP DNA? (2023, May 1). *Who do you think you are?* Retrieved August 15, 2023, from https://www.whodoyouthinkyouaremagazine.com/tutorials/dna/what-is-str-and-snp-dna/.

There are three sources of information in a DNA sample that are generally extracted for genealogical testing.[4]

- Autosomal DNA testing (atDNA): higher matches of atDNA indicate closer generations of relatives, benefiting identifying exact relationships of up to five to seven generations due to recombination in each generation that creates a high variance.[5]
- Mitochondrial DNA testing (mtDNA): pairs of DNA owned by the mitochondria and passed from mother to child with rare mutations, allowing tracing of direct maternal ancestry and indicating shared ancestry of up to 50 generations ago if perfectly matched.
- Y-chromosome DNA testing: a male-specific, nearly unchanged through inheritance sex chromosome used to trace direct paternal, male-line ancestry and conduct surname projects to determine relatedness between individuals sharing the same surname.

History of Genetic Genealogy

Genetic Genealogy, utilized in biotechnology, history, and anthropology, emerged in 1989 when the Dallas Morning News discussed applying gene-reading technology to trace human ancestry. Although the development of genetic genealogy technology had been taking place in academia for over a century, it wasn't until 2000 when FamilyTreeDNA in Houston, TX offered genetic genealogy tests to the public for the first time.[6]

For-Profit Companies and the Intersection of Commercial DNA Databases and Forensic Usage

Founded in 2000, FamilyTreeDNA pioneered public genetic genealogy testing, offering comprehensive analysis, including the unique Cohanim DNA test.[7] With over 2 million contributors, it boasts the industry's largest DNA-matching database.[8] Other key players are 23andMe, AncestryDNA, MyHeritage, and GEDmatch; they compete based on reference samples and population coverage.[9] 23andMe, established in 2006, provides FDA-approved reports, collaborates on disease treatment studies, and has over 1 million users.[10] [11] AncestryDNA, since 2012, excels in detailed ethnicity estimation stories such as

[4] McDermott, M. (2022, December 23). *Genetic Genealogy.* Genealogy Explained. https://www.genealogyexplained.com/genetic-genealogy/#:~:text=How%20does%20genetic%20genealogy%20work,them%20to%20other%20people's%20chromosomes.

[5] Genealogical DNA test. (2023, August 10). In *Wikipedia*. Retrieved May 5, 2023, from https://en.wikipedia.org/wiki/Genealogical_DNA_test#Procedure.

[6] Timeling: History of genetic genealogy. (n.d.). In *ISOGG Wiki*. Retrieved May 10, 2023, from https://isogg.org/wiki/Timeling:History_of_genetic_genealogy.

[7] McDermott, M. (2022, December 23). *Family Tree DNA Test Review (FTDNA).* Genealogy Explained. https://www.genealogyexplained.com/family-tree-dna-review/.

[8] FamilyTreeDNA, Inc. (2001). https://www.familytreedna.com/.

[9] *Best DNA test for Asian ancestry and ethnicity in 2023.* Your DNA Guide. (2023, March 14). https://www.yourdnaguide.com/best-dna-test-for-asian-ancestry#:~:text=For%20those%20who%20want%20to,84%20regions%20around%20the%20world.

[10] 23andMe, Inc. (2023). https://www.23andme.com/.

[11] Maggie. (2015, December 3). *23andMe: Evolution of a genomics company*. Technology and Operations Management - MBA Student Perspectives. https://d3.harvard.edu/platform-rctom/submission/23andme-evolution-of-a-genomics-company/#:~:text=23andMe's%20competitive%20advantage%20depends%20on,such%20as%20the%20Michael%20J.

paths and geographical details of regions their ancestries had moved to.[12] [13] MyHeritage focuses on 2,114 geographic regions, particularly Europe, while AncestryDNA concentrates in North America.[14] [15] GEDmatch, founded in 2010, accepts raw DNA uploads from its competitors.[16]

Since the involvement of commercial genetic genealogy databases with the forensic investigation process, the public has become more aware of the privacy policies each company possesses and the options provided to opt in or opt out of authorities' access. 23andMe and AncestryDNA have constantly rejected requests from law enforcement agencies to access their databases for forensic purposes. FamilyTreeDNA and GEDmatch, on the contrary, had either voluntarily provided the Federal Bureau of Investigation (FBI) with access to its services or been a publicly accessible genealogy database. They have subsequently modified their policies to limit authority accessibility by providing consumers with a choice after public backlash.[17] However, The lack of clear regulations fuels the genetic privacy and law enforcement debate, amplified by undisclosed investigation actions.[18]

Assessing the Use of Genetic Genealogy

The expanded genetic genealogy use in commercial and forensic realms enhances public awareness, boosts investigation efficiency, and contributes to community safety. However, this advancement can perpetuate bias and worsen inequalities for vulnerable groups. Before delving into controversies, a brief overview of crime case investigation and existing federal and state regulations will be presented.

Investigative Genetic Genealogy (IGG) and Authority Use Regulations

What is IGG?

Forensic genealogy describes the U.S. nationwide application of genealogical methods in cases that have legal implications, such as heir hunting and establishing citizenship. Investigative genetic genealogy

[12] McDermott, M. (2023, July 28). *Who Owns Ancestry.com?* Genealogy Explained. https://www.genealogyexplained.com/who-owns-ancestry/#:~:text=in%20its%20database.-,When%20was%20Ancestry%20DNA%20founded%3F,million%20have%20utilized%20this%20product.

[13] Mendoza, B., & Diallo, A. (2022, December 1). *The best DNA testing kit.* The New York Times|Wirecutter. https://www.nytimes.com/wirecutter/reviews/best-dna-test/.

[14] MyHeritage, Ltd. (2023). https://www.myheritage.com/?utm_source=ppc_google&utm_medium=cpc&utm_campaign=mh_search_us_en_des_mul_exact_myheritage&utm_content=635237003027&utm_term=myheritage&tr_camp_id=344023924&tr_ad_group=myheritage&tr_ag_id=24241928044&tr_placement=&tr_device=c&tr_account=904-055-9108&keyword=&tr_size=&recordtype=&recordlocation=&gclid=CjwKCAjwp6CkBhB_EiwAlQVyxUIjDmMfw8TYs2lSZfP_LCDbT6MU6WY91PYbX_YlfZpeTrh-Y7j1pRoC77AQAvD_BwE.

[15] Takano, T. (2023, February 9). *AncestryDNA vs. MyHeritage: Expert review.* Genomelink. https://blog.genomelink.io/posts/ancestrydna-vs-myheritage-a-simple-comparison-for-the-dna-newbie#:~:text=%E2%80%8DDifferences%20Between%20Ancestry%20And%20MyHeritage%E2%80%8D&text=While%20both%20of%20their%20databases,may%20want%20to%20use%20Ancestry.

[16] Smith, D. (2020, December 17). *GEDmatch Reviews.* Genomes Unzipped. https://www.genomesunzipped.org/gedmatch-reviews/.

[17] Hazel, J. W., & Clayton, E. W. (2021, January 20). *Law Enforcement and Genetic Data.* The Hastings Center. https://www.thehastingscenter.org/briefingbook/law-enforcement-and-genetic-data/.

[18] St. John, P. (2020, December 8). *The untold story of how the Golden State Killer was found: A covert operation and private DNA.* Los Angeles Times. https://www.latimes.com/california/story/2020-12-08/man-in-the-window.

(IGG) is a subset of forensic genealogy that uses information about genetic similarities and known family relationships to generate criminal investigative leads.[19]

Sample collection at a crime scene initiates a criminal investigation. An accredited forensic laboratory generates an STR profile as a forensic sample, applies traditional methods such as one-to-one matching with existing STRs in local, state databases, or the Combined DNA Index System (CODIS), interviews, and evidence analysis, and confirms manually before releasing the matched name. Confirmed matches become investigation leads, while no match indicates the potential of turning to IGG, where a private lab on behalf of the investigative agency creates SNP profiles from the forensic sample, and uploads them to one or more privately-housed genetic genealogy databases. The databases help generate relative lists and shared DNA data, aiding family tree development through targeted testing, which may involve family members. The IGG identifies individuals who are high-likelihood suspects based on known offender demographics and activities.

Post-IGG, normal investigation resumes using one-to-one forensic STR matching and further investigation of the suspects. This last stage may unearth new information about family relationships and result in expanding or modifying the IGG-created family tree.[20]

Combined DNA Index System (CODIS)

The CODIS is the U.S. national DNA database created in October 1998 and managed by the Federal Bureau of Investigation (FBI).[21] It comprises indexes of convicted offenders, arrestees, forensic samples collected from crime scenes, missing persons, and staff at three hierarchical geographical levels: local, state, and nation.[22] Participating laboratories can upload and compare DNA profiles to link crimes to other previously unrelated cases, to persons already convicted of specific crimes, and potentially to suspects based on this evidence.[23] For privacy reasons, the CODIS does not include any personally identifiable information, such as the name associated with the DNA profile. The uploading agency will be notified of any hits to their samples and is tasked with the dissemination of personal information pursuant to their laws.[24] Some digital facts about CODIS are outlined below.

- CODIS saves massive data from all 50 states, the District of Columbia (DC), Puerto Rico, the FBI Lab in Washington, D.C., and the U.S. Army Laboratory in Forest Park, Georgia.
- In the 3 years since DeAngelo was identified through IGG, likely several hundred cases, many of them decades old, have been solved with genetic genealogy.

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[19] Investigative genetic genealogy FAQs. (2023, August 10). In *ISOGG Wiki*. Retrieved June 12, 2023, from https://isogg.org/wiki/Investigative_genetic_genealogy_FAQs#cite_note-5.

[20] Guerrini, C. J., Wickenheiser, R. A., Bettinger, B., McGuire, A. L., & Fullerton, S. M. (2021). Four misconceptions about investigative genetic genealogy. *Journal of Law and the Biosciences*, *8*(1). https://doi.org/10.1093/jlb/lsab001.

[21] *United States Department of Justice Interim Policy: Forensic Genetic Genealogical DNA Analysis And Searching.* U.S. Department of Justice. (2019, September 2). https://www.justice.gov/olp/page/file/1204386/download.

[22] *Combined DNA index system (CODIS).* U.S. Department of Justice | Bureau of Justice Statistics. (n.d.). Retrieved June 18, 2023, from https://bjs.ojp.gov/taxonomy/term/combined-dna-index-system-codis#:~:text=CODIS%20is%20an%20acronym%20for,scene%20evidence%2C%20and%20missing%20persons.

[23] *Audit Report: The Combined DNA Index System.* U.S. Department of Justice | Office of the Inspector General. (2001, September).

[24] Combined DNA Index System. (2023, June 4). In *Wikipedia*. Retrieved June 18, 2023, from https://en.wikipedia.org/wiki/Combined_DNA_Index_System.

- As of November 2022, there are more than 15 million offender profiles as well as 4.8 million arrestees and 1.2 million forensic, producing over 637 thousand hits and assisting in more than 622 investigation leads.[25]
- It is also used to release the innocent; about 87 innocent people from prison were freed nationwide as of April 2001, including 10 people on death row.[26]
- The Defense Department may apply the technique to identify World War II soldiers, where CODIS is anticipated to contribute hugely.

Legal or Regulatory Oversights of IGG

Across the U.S., a growing number of regulations are under discussion. Below we outline the interim policy regulating specific agencies and states' newly launched laws or decisions.

I. Constitutional Principles

The Fourth Amendment safeguards against unreasonable searches, but exceptions like the third-party doctrine challenge privacy expectations.[27] The ongoing debate addresses whether "voluntarily" shared data with genetic genealogy firms is Fourth Amendment-protected. Some legal study scholars assert firms can share data with law enforcement under users' affirmative consent. Others cite *Carpenter v. United States*, questioning warrantless data seizure that easily provides an "all-encompassing record," prompting a deeper discussion on genetic data's status.[28]

In addition, DNA evidence collected at crime scenes might not be a Fourth Amendment "search." The "abandonment doctrine" permits testing abandoned DNA, and courts have followed this to allow testing on settings such as hair clippings and discarded cigarette butts.[29] IGG's legality centers on defining "abandoned DNA in public spaces."

Still another potential conflict arises with the Fifth Amendment takings clause. Genetic profiles, considered private property, should not be taken for public use without just compensations, which are not limited to money. Law enforcement accessing consumer genetics databases for public benefit without providing proper compensation raises concerns. These arguments underline the necessity for supplementary laws to strengthen protection, social justice, and human rights for individuals and their relatives.

II. U.S. Department of Justice (DOJ) Interim Policy on Forensic Genetic Genealogical DNA Analysis and Searching (FGGS)

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[25] *CODIS-NDIS Statistics.* FBI Law Enforcement Resources. (2022, July 1). https://le.fbi.gov/science-and-lab/biometrics-and-fingerprints/codis/codis-ndis-statistics#:~:text=Measuring%20Success,profiles%20as%20of%20November%202022.

[26] *The Combined DNA Index System.* U.S. Department of Justice | Office of the Inspector General. (2001). Retrieved June 18, 2023, from https://oig.justice.gov/reports/FBI/a0126/intro.htm.

[27] *What does the Fourth Amendment Mean?* United States Courts. (n.d.). https://www.uscourts.gov/about-federal-courts/educational-resources/about-educational-outreach/activity-resources/what-does-0#:~:text=The%20Constitution%2C%20through%20the%20Fourth,deemed%20unreasonable%20under%20the%20law.

[28] Murphy, N. (2022, December 18). *What's next for forensic genetic genotyping in Maryland?* University of Baltimore Law Review. https://ubaltlawreview.com/2022/12/18/whats-next-for-forensic-genetic-genotyping-in-maryland/#_edn33.

[29] Berkman, B. E., Miller, W. K., & Grady, C. (2018). Is it ethical to use genealogy data to solve crimes? *Annals of Internal Medicine, 169*(5), 333–334. https://doi.org/10.7326/m18-1348.

In 2019, the DOJ introduced an interim policy applicable to DOJ-funded investigative agencies, specifying the parameters of Investigative Genetic Genealogy (IGG) involvement in publicly accessible genomics databases and direct-to-consumer genetic genealogy services. This policy limits IGG's role to assisting in cases involving potential perpetrators, unidentified homicide victims, or threats to public safety/national security, only after CODIS uploads yield no matches and not as the sole basis for legal decisions. The process mandates engagement with a designated laboratory official (DLO), obtaining prosecutor-approved search warrants, informed consent from non-suspects, and meticulous documentation. Confidentiality is maintained for IGG profiles and DTC data, with data deletion or return upon suspect arrest or IGG completion. Successful prosecutions' data is court-ordered for destruction, while unsuccessful cases' IGG information is also destroyed post-use. The policy addresses privacy, cautious IGG application, and system concerns, serving as a starting point for IGG regulation, yet remaining an internal guideline for DOJ agencies. Informed consent from third parties depends on genealogy companies, emphasizing the need for legislative actions by states and the federal government to balance privacy and law enforcement transparency.

III. The States

Maryland and Montana are the first states to pass the law regulating IGG's access and search in consumer DNA databases in 2021.[30] Over the past five years, Florida, Washington, and Utah also have intentions to pull relevant discussions to their Houses and are currently standing in different phases of the policy-making process.[31] [32] [33] [34]

Built upon the Froth Amendment, additional restrictive features to the DOJ interim policy in Maryland's newest law include:

a. allowing the use of IGG ONLY in cases of rape, murder, felony sexual offenses, kidnapping, human trafficking, and criminal acts that present "a substantial and ongoing threat to public safety or national security"
b. permitting law enforcement to use DTC genetic platforms ONLY when platforms obtain affirmative consent in writing from their users showing knowing and voluntary to participate in law enforcement efforts

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[30] Hughes, V.. (2021, May 31). *Two New Laws Restrict Police Use of DNA Search Method: Maryland and Montana have passed the nation's first laws limiting forensic genealogy, the method that found the Golden State Killer.* The New York Times. https://www.nytimes.com/2021/05/31/science/dna-police-laws.html.

[31] Wetsman, N. (2021, June 1). *States pass laws limiting use of DNA searches for criminal investigations: Maryland and Montana are restricting genetic genealogy.* The Verge. https://www.theverge.com/2021/6/1/22462859/dna-genetic-genealogy-criminal-laws-maryland-montana.

[32] Crume, R. (2022, May & June). *Investigative Genetic Genealogy: How DNA Testing Helps Solve Crimes.* Family Tree. https://familytreemagazine.com/dna/investigative-genetic-genealogy/#:~:text=How%20DNA%20Tests%20Solve%20Crimes&text=First%2C%20the%20assailant's%20DNA%20is,explicitly%20permit%20law%20enforcement%20use

[33] Taylor, M. (2022, March 9). *Utah's Commercial Genetic Genealogy Database Bill Fails.* Forensic® On the Scene and In the Lab. https://www.forensicmag.com/584095-Utah-s-Commercial-Genetic-Genealogy-Database-Bill-Fails/.

[34] Criminal Investigations and Technical Services Act, Utah Stat. § 403.7 (2023). https://le.utah.gov/xcode/Title53/Chapter10/53-10-S403.7.html?v=C53-10-S403.7_2023050320230503.

c. establishing robust protections for a nonsuspect third party in the investigations, such as presenting explicit refusion option, involving genetic counselors in the informed consent process, and prohibiting covert collection
d. ensuring equal accessibility of IGG to prove either guilt or innocence for criminal defendants and individuals with postconviction relief measures
e. imposing consequences of being sued and a minimum of $5000 if authorities wrongfully disclosed, collected, or maintained one's genetic information in violation of the law
f. publishing detailed annual public reports and reviews from expert panels and relevant stakeholders to ensure a transparent and accountable IGG process
g. prohibiting investigators from using any of the genetic information collected to learn about a person's psychological traits or disease predispositions[35]

Maryland's pioneering IGG regulations are deemed comprehensive, but experts believe it still allows some vulnerabilities. Further validation through experimental studies is required to substantiate the feasibility of all claims. Open questions also remain about Fourth Amendment protections against unreasonable government search and seizure, the Fifth Amendment Takings Clause, and fundamental concerns within forensic DNA science.

Concerns Regarding the Use of Genetic Genealogy

Public Interest vs Private Interest—Why is IGG controversial but still under usage?

Community safety is a prominent concern for community development and public management. IGG's involvement in cold and violent case investigations inspires confidence in a safer neighborhood. The notable example of the Golden State Killer case also revolutionized approaches to rape investigations and victim treatment, bringing a wave of relief.[36] [37] However, due to the nature of DNA, there are three things to note:

I. Genealogical accuracy hinges on relative relationships in data. As more contribute, outcomes for consumers and suspects improve, expediting IGG case resolution through increased data.
II. People often underestimate the accessible personal information in their DNA. A genetic genealogist highlights IGG genomic searches as akin to extensive medical and family record scrutiny for identification, revealing a lack of awareness about genetic data's depth.
III. Voluntary database contributions expose relatives to involuntary search, causing family tension due to potential revelations about others without each agreement. There's a risk of inadvertent inclusion in investigations and concerns about genetic discrimination in employment or insurance, though public health scholars note limited evidence but acknowledge potential.

One study suggests a database of around 1.3 million people could theoretically identify 60 percent of European ancestry individuals in the U.S. The use of personal biological and familial information without

[35] Lynch, J. (2021, June 7). *Maryland and Montana pass the nation's first laws restricting law enforcement access to genetic genealogy databases.* Electronic Frontier Foundation. https://www.eff.org/deeplinks/2021/06/maryland-and-montana-pass-nations-first-laws-restricting-law-enforcement-access.

[36] Fuller, T. & Hauser C. (2018, April 25). *Search for 'Golden State Killer' Leads to Arrest of Ex-Cop.* The New York Times. https://www.nytimes.com/2018/04/25/us/golden-state-killer-serial.html.

[37] Chavez N. (2019, February 13). *Arrest of alleged Golden State Killer brings 'wave of relief' to survivors and victims' families*. CNN. https://www.cnn.com/2018/04/26/us/reaction-golden-state-killer-survivors-victims/index.html.

consent triggers tensions and public trust issues in IGG debates. The justification of repurposing genealogy data for crime-solving and its implications also require interdisciplinary discussions.

Privacy Concern—What does "voluntarily participate" mean and how powerful is consent over authorities?

DTC genetic genealogy firms request consumer consent to allow the use of certain personal information, share a portion of consumer data with third parties, etc., as per constitutional and statutory requirements. Despite appearing aligned, the complex legal language often leads to unwitting inclusion rather than genuine consent. Only a small number of signatories grasp the consent's implications before selecting the "I agree..." option, and even fewer anticipate their commercially submitted data being utilized in forensic investigations, where they could be treated as suspects.

FamilyTreeDNA and GEDmatch, once offering law enforcement access, now allow customers to opt-in for forensic genealogical searches, although details remain unclear and default settings are on. In 2019, trial courts in the States of Florida and Pennsylvania issued warrants to search GEDmatch, despite opt-outs, and Ancestry.com databases, without the server's permission. These practices conflict with Maryland's laws demanding proactive customer choices and explicit informed consent for involvement. Furthermore, the limited search authorities' claim to conduct may not be true, but they usually refuse to provide more details regarding investigations.

The National Institute of Health has a well-established genomic data management policy. In biomedical research, people often grant permission for initial use and are comfortable with subsequent wide-ranging applications. Yet, a contrast emerges between biomedical research and forensics. While broad consent is understood for medical knowledge, using genealogic data in criminal investigations surprises individuals due to its distant purpose. These perspectives underscore the necessity for clear, multi-phase, and proactive consent in IGG participation to ensure voluntariness.

Accuracy of Arrest—How is CODIS for IGG examined?

The FBI gauges CODIS success through the index "investigations aided," where DNA matches identify suspects or connect violent crimes through CODIS and lead criminal investigations. However, relying solely on quantitative analysis can lead to unjust arrests due to public management failure and raise procedure injustice concerns.

I. Overinterpretation of genetic evidence in the courts can contribute to wrong arrests.
II. Investigators might overstate IGG's necessity to swiftly secure judges' approvals or legal warrants
III. Speeding up DNA matching could increase false positives among arrestees, causing fear, eroding public trust, and burdening the incarceration system. [38]

Accuracy of Arrest—Are scientific interpretations of DNA testing results objective and consistent?

DNA evidence is upheld as a subjectivity-free gold standard in forensic science, notably in scientific, laboratory-based disciplines like DNA analysis. However, a 2011 empirical study highlighted subjectivity in DNA mixture interpretation. 17 North American DNA analysts provided varying conclusions despite following the same guidelines and working in the same lab and on exactly the same DNA profiles, raising

[38] *Incarceration statistics*. Vera Institute of Justice. (n.d.). https://www.vera.org/ending-mass-incarceration/causes-of-mass-incarceration/incarceration-statistics.

concerns about bias and context influence.[39] Despite incremental recommendations for incorporating quantitative statistical values to bolster DNA analysis conclusions, subjectiveness persists, risking injustice and inequality, disproportionately affecting vulnerable groups. Recognizing bias and cognitive differences is vital to enhance forensic science and promote fairness in the justice system. Recognizing the potential bias in statistical outcomes and the influence of human cognition on examiners' judgments is vital for accurately identifying avenues for improvements and minimizing injustices within the legal system.

Ethical Concern—Does ethnicity bias exist in data collection and linkage of IGG searches?

Biases in criminal justice and commercial DNA databases highlight disproportionate representation based on race, ethnicity, and geography. For instance, MyHeritage has more records from European countries and AncestryDNA's database focuses more on North American records; both primarily comprising White individuals. Government forensic databases also exhibit biased representation, mainly among young people of color with low socioeconomic status. This skewed usage could worsen existing inequalities. While concerns in genealogy databases differ, worries persist about potential discrimination if expansive forensic DNA analysis is used aggressively, particularly if certain groups are targeted based on racial or ethnic markers by the police department.

Recommendations for Improving the Use of Genetic Genealogy

Given the potential injustice associated with investigative genetic genealogy, we recommend that communities concerned about the use of IGG should consider the implementation of the safeguards listed below.

- Champion the adoption of policy at the state level, following Maryland and Montana.
- Establish regulations for utilizing IGG to guide criminal inquiries in particular types of cases.
- Restrict IGG to lead investigation only when other investigative methods have proven ineffective for cold cases, and as an investigative tool rather than a primary evidence source for criminal activities.
- Enforce clear choices for opting in and opting out of third party search within DTC genetic genealogy platforms, with the flexibility for users to modify their preferences at any time and with regular reminders sent to consumers.
- Require the authorization to secure proactive written consent from individuals for their voluntary participation and for search warrants, which should not supersede the company's refusal for external data linkage.
- Incorporate qualitative indicators into the CODIS performance evaluation.

[39] Dror, I. E., & Hampikian, G. (2011). Subjectivity and bias in forensic DNA mixture interpretation. *Science & Justice, 51*(4), 204–208. https://doi.org/10.1016/j.scijus.2011.08.004.