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Résumé de l'article

Les récentes avancées en matière d'enquêtes criminelles, en particulier dans les affaires non résolues très médiatisées, ont contribué à consolider le rôle de l'analyse d'ADN dans les contextes d'enquête. Par conséquent, certaines juridictions cherchent à étendre les méthodes de collecte et d'analyse de l'ADN. Au Canada, une loi a été proposée pour élargir la Banque nationale de données génétiques (BNDG) et autoriser les recherches familiales dans les enquêtes criminelles et médico-légales. Cet article présente les implications éthiques de la législation proposée et, plus largement, des méthodes généalogiques déjà utilisées qui fonctionnent en dehors de la BNDG et reposent largement sur des services d'ADN à but lucratif et grand public. Les analyses d'ADN effectuées actuellement dans le cadre du système de justice pénale sont fortement réglementées et offrent d'importantes protections non seulement aux individus, mais aussi à leurs parents génétiques, dont les données biométriques sont indirectement impliquées. En revanche, les recherches familiales présentent des risques pour la vie privée des délinquants et de leurs proches. En outre, la pratique de plus en plus répandue de la recherche généalogique repose sur des produits commerciaux non réglementés qui utilisent une technologie différente pour exposer des informations génétiques très détaillées. Cette technologie ne répond pas à des normes d'investigation rigoureuses et pose des problèmes importants en matière de consentement éclairé. Nous concluons que l'élargissement de la collecte d'ADN dans la BNDG pour y inclure la recherche familiale risque d'exacerber les préjugés systémiques existants et que la recherche généalogique génétique à l'extérieur de la BNDG est incompatible avec la législation canadienne actuelle qui protège la vie privée, la non-discrimination génétique et les droits et libertés fondamentaux.

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ARTICLE (ÉVALUÉ PAR LES PAIRS / PEER-REVIEWED)

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Résumé
Les récentes avancées en matière d'enquêtes criminelles, en particulier dans les affaires non résolues très médiatisées, ont contribué à consolider le rôle de l'analyse d'ADN dans les contextes d'enquête. Par conséquent, certaines juridictions cherchent à étendre les méthodes de collecte et d'analyse de l'ADN. Au Canada, une loi a été proposée pour élargir la Banque nationale de données génétiques (BNDG) et autoriser les recherches familiales dans les enquêtes criminelles et médico-légales. Cet article présente les implications éthiques de la législation proposée et, plus largement, des méthodes généalogiques déjà utilisées qui fonctionnent en dehors de la BNDG et reposent largement sur des services d'ADN à but lucratif et grand public. Les analyses d'ADN effectuées actuellement dans le cadre du système de justice pénale sont fortement réglementées et offrent d'importantes protections non seulement aux individus, mais aussi à leurs parents génétiques, dont les données biométriques sont indirectement impliquées. En revanche, les recherches familiales présentent des risques pour la vie privée des délinquants et de leurs proches. En outre, la pratique de plus en plus répandue de la recherche généalogique repose sur des produits commerciaux non réglementés qui utilisent une technologie différente pour exposer des informations génétiques très détaillées. Cette technologie ne répond pas à des normes d'investigation rigoureuses et pose des problèmes importants en matière de consentement éclairé. Nous concluons que l'élargissement de la collecte d'ADN dans la BNDG pour y inclure la recherche familiale risque d'exacerber les préjugés systémiques existants et que la recherche généalogique génétique à l'extérieur de la BNDG est incompatible avec la législation canadienne actuelle qui protège la vie privée, la non-discrimination génétique et les droits et libertés fondamentaux.

Mots-clés
généalogie génétique, recherche familiale, enquêtes criminelles, projet de loi S-231, confidentialité génétique, discrimination, technologie des tests ADN, biométrie

Abstract
Recent breakthroughs in criminal investigations, especially of high-profile cold cases, have helped to consolidate the role of DNA analysis in investigative contexts. Consequently, some jurisdictions are looking to expand DNA collection and analysis methods. In Canada, legislation has been proposed to expand the National DNA Databank (NDDB) and to allow familial searching in criminal and forensic investigations. This article outlines the ethical implications of the proposed legislation and, more broadly, of genealogical methods already in use that operate outside the NDDB and rely heavily on for-profit and consumer DNA services. Current DNA analysis within the criminal justice system is heavily regulated and provides important protections not only for individuals but also for genetic relatives whose biometric data is indirectly implicated. In contrast, familial searching poses risks for offender privacy as well as for their relatives. Additionally, the expanding practice of genetic genealogical searching relies on unregulated commercial products that use different technology to expose highly detailed genetic information. This technology falls short of rigorous investigational standards and poses significant problems for informed consent. We conclude that expanding DNA collection within the NDDB to include familial searching risks exacerbating existing systemic bias and that genetic genealogical searching outside of the NDDB is incompatible with existing Canadian legislation that safeguards privacy, genetic non-discrimination, and fundamental rights and freedoms.

Keywords
genetic genealogy, familial searching, criminal investigations, Bill S-231, genetic privacy, discrimination, DNA testing technology, biometrics

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INTRODUCTION

DNA analysis in criminal investigations is constantly changing as technology evolves. New techniques and approaches have recently been deployed to solve several cold cases in both Canada and the USA, and these investigative breakthroughs have propelled calls to expand DNA sampling and analysis beyond what is currently mandated by Canadian legislation. Eager to capitalize on new technological advances, legislators have proposed modifications to Canada's legislation around genetic testing in investigational contexts. At the same time, investigators are already working outside existing legislation to make use of the skyrocketing popularity and availability of commercial DNA testing services.

Bill S-231 *Increasing the Identification of Criminals Through the Use of DNA Act* was first proposed in December 2021 and is currently being studied by the Standing Senate Committee on Legal and Constitutional Affairs (1). Bill S-231 is not the first

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legislation proposed along these lines; an earlier piece of legislation, Bill S-236, died with the close of Parliamentary session 43 in 2021. Given these repeated attempts, it is clear that lawmakers are determined to propose legislation around the expansion of DNA sampling and the implementation of different technologies and tools. Whether or not the current Bill S-231 eventually receives royal assent, the bioethical and legal impacts of legislation around DNA analysis are sure to remain pressing issues in coming years.

The current sponsors of Bill S-231 have outlined three main objectives:

1. First, they propose to expand the number of DNA samples collected by police because the power of DNA profiling in investigations increases with the size of the profile databank. As of 2022, in Canada the RCMP's National DNA Data Bank (NDDB) contained roughly 670,000 profiles (2).[1] Canada's NDDB currently holds DNA samples taken from crime scenes and from individuals who are convicted of designated "Primary Offenses" (typically characterized by murder, sexual assault, or serious physical assault). Under current legislation, some serious "Secondary Offences" such as uttering threats and serious drug crimes are also subject to DNA testing. In addition, separate databanks contain profiles derived from forensic samples (crime scenes, human remains) and from relatives of missing persons. Proponents of the Bill outline a plan to capture DNA samples from people convicted of lesser crimes (like theft, minor drug offenses, fraud, and even the unlawful harvesting of logs that have escaped log-booms) in order to increase the size of the NDDB and thereby increase the probability of future investigative breakthroughs.

2. A second objective, also addressed by enlarging the NDDB, is that a larger national DNA databank might provide exclusionary evidence to exonerate suspects from suspicion if their DNA profile does not match samples taken from crime scenes. This would reduce the incidence of false suspicion/conviction and make investigations more efficient by narrowing the list of possible suspects.

3. A third objective is to use DNA profile databanks to identify potential suspects, via their genetic relationships, to profiles already on file. Existing laws, specifically the *Canadian Criminal Code*, the *Criminal Records Act*, the *National Defence Act*, and the *DNA Identification Act* (3), currently prohibit using the NDDB to conduct familial searches. These restrictions are not unique to Canada. Internationally, other jurisdictions also impose restrictions to protect genetic privacy and ensure that innocent individuals are not directly or indirectly implicated in criminal investigations. Bill S-231's authors aim to allow familial searching in the context of serious crimes where an offender may be sentenced to 14 years or more.

Bill S-231's two operational goals are therefore to: 1) Expand the size of the NDDB by capturing a greater number of DNA profiles; and 2) Allow, for the first time, familial searching in investigations. These two explicit aims raise ethical and legal dilemmas, but they also highlight an obvious gap between what the Bill explicitly addresses and the ongoing investigational practices it ignores.

In this paper, we develop two arguments. First, we show that the provision to allow familial searching in Bill S-231 is both ethically and practically problematic. Familial searching is, as Amy Conroy puts it, a "technique that allows criminal investigators to identify potential suspects based on the familial links that can be observed between the separate profiles of genetically related individuals" (4, p.172). In the context of the NDDB, investigators performing a familial search would submit a DNA profile to the NDDB in the hopes of identifying an immediate relative (parents, siblings, offspring) whose DNA profile is already on file. Unfortunately, the NDDB and its underlying DNA profile technology are ill-suited to familial searching and unlikely to produce the investigational breakthroughs that the proponents of the Bill hope to facilitate. In our view, the possible benefits of permitting familial searching do not justify the privacy and ethical risks involved.

Second, we argue that the Bill does not address another, even more urgent practice: the unregulated use of genetic genealogical investigations. Genetic genealogical searching is a distinct process; investigators submit a DNA profile to a non-NDDB databank, attempt to trace the individual through their extended genealogy, and then draw on additional sources such as records of births, marriages, census records, etc. By comparing crime scene DNA samples to profiles and genealogical records contained in popular consumer products, investigators can often trace the perpetrator through their distant genetic relatives. Unlike familial searching, which is limited in its biometric detail and in its scope, genealogical searching yields extremely detailed biometrics of a much wider group of individuals.[2] Bill S-231 does not address the use of genetic genealogical searches outside the purview of the NDDB and that use unregulated commercial and consumer-oriented services. While offering significant investigational advantages, these genetic genealogical searches pose far more serious privacy and ethical risks that urgently need to be addressed by new legislation.

The Bill's failures to address the current use of commercial technologies and services leaves Canadians at risk of privacy violations, arbitrary search, loss of presumption of innocence, and non-consensual use of their biometric information. To examine the bioethical implications of Bill S-231's move to expand the national databank, to legalise familial searches, and to leave genetic genealogy unregulated, we first outline the technological differences and propensity for error in DNA analysis generally. We demonstrate that the NDDB presently offers important protections against discrimination and privacy violations,

[1] Contrary to assertions by the Bill's sponsors, on a per capita basis, Canada's NDDB is not small but average in size relative to other G7, G20, and EU countries. See APPENDIX.
[2] Rafaela Granja emphasizes the broad scope of these searches with her phrase "long-range familial searches" (5).

both for offenders *as well as for their genetic relatives*. We then show that familial searching compromises these protections, and that genetic genealogy is even more intrusive and prone to error, ethical problems, and human rights violations. Finally, we conclude with some broader ethical considerations that should inform policy makers going forward.

DNA TECHNOLOGY AND ANALYSIS: ERROR AND RISK

Televisions dramas like the CSI series and high-profile cases like the apprehension of the "Golden State Killer" have entrenched DNA analysis as a definitive gold standard for proof in the minds of the public, investigators, and jurists alike. However, the underlying technology and analysis is open to error and misinterpretation: like any other science, DNA profiling involves a degree of subjective interpretation, and its reliability depends on myriad factors. Moreover, DNA profiling and analysis are by no means the unique purview of law enforcement. DNA profiling is increasingly common in medical tests, direct-to-consumer DNA tests and their publicly accessible databanks, and profiles from missing persons/human remains. DNA technology is changing rapidly and is becoming increasingly available and affordable. The biometric detail offered by these technologies is astonishing, revealing a uniquely intimate and comprehensive picture of our racial origins, familial relationships, disease predispositions, physical and physiological traits, and even of our lifestyles and environment.

Whereas DNA analysis by law enforcement is usually regulated by legislation and relies on specific technology, DNA profiles can be derived from various other technologies, each of which comes with different propensities for error and each of which also reveals different degrees of biometric detail. The risks and propensity for error of DNA testing and analysis depends on what *type* of technology is being deployed, the *purity and quality* of the DNA sample obtained, *who* is conducting the analysis, *what kind* of comparison is being done, and *where* the biometric data is stored.

The reliability of genetic testing depends on the way that DNA is sampled and processed, and on the way that the results of the analysis are subsequently interpreted and then stored. At the sampling and preservation stage, sample contamination is a major risk. DNA profiles sampled directly from convicts generally preserve high quality DNA samples suitable for purification and laboratory analysis. Samples are derived from cheek swabs, sputum, or blood specimens and immediately preserved for analysis, thereby lowering the risk of sample contamination.

By contrast, DNA samples from crime scenes have often been subjected to environmental exposures (light, temperature, humidity, chemicals, etc.) and far from being fresh are often hours, days, or even years old. This kind of contamination and sample degradation can lead to spurious results. As legal expert Erin E. Murphy puts it: "A doctor would never just say, 'bring in an old bloody Band-Aid and we will run some tests!' Crime scene testing, however, is like seeking results from that dirty Band-Aid – after it has been in the trash for two weeks" (6, p.19). Another complicating factor is that people shed DNA continuously (some much more than others) and can leave traces behind that are detectable for many years. This type of contamination, called DNA transfer, can be surprisingly indirect: our DNA lands on people, objects, and places with which we have never had direct contact. Again, this has profound consequences for criminal DNA investigations. For example, DNA found on the underwear of a rape/murder victim at Yale University was linked to a convicted felon. However, this suspect had died two years *prior* to the murder under investigation. In his capacity as a construction contractor, the felon had left DNA behind on pipes, and these traces transferred to the victim's body when it was hidden by the real perpetrator (6).

Sampling materials and lab conditions can also lead to investigational error. German police spent 16 years investigating a serial killer, dubbed the "Phantom of Heilbronn," based on DNA samples found at 40 crime scenes in Germany and Austria from 1993-2009. It was finally discovered that the genetic matches were the result of contaminated cotton swabs that were licensed as sterile for medical but not forensic use. The individual whose DNA was supposedly found at the crime scenes was in fact a worker in the factory producing the swabs (7).

DNA analysis is a highly sensitive and fundamentally interpretive task that is often incorrectly thought of as an objective assessment. Tellingly, the authors of a 2011 study evaluating the reliability of DNA analysis submitted a DNA profile and case notes to 17 different analysts working in a single accredited lab in the USA. There was no consensus but rather widely differing opinions from the analysts regarding the probability that the individual profiled was guilty of the crime (8). These divergent conclusions emerged in spite of the fact that the analysts worked to a standardized protocol, used standardized tools and reagents, and shared the same workspace. As technology develops to detect progressively fainter traces of DNA, the regulation of analysts and analysis protocols and an acknowledgement of technical limitations will become increasingly crucial in mitigating the risk of misinterpretation and error. This risk of error is always present, but regulating protocols and the degree to which the technology can be pushed goes some way to ensuring the integrity of results and guarantees that investigators can document each stage of the analysis and subsequently retrace the chain of custody of samples if needed.

In view of the risk of error and ensuing privacy concerns, jurisdictions worldwide have tried to regulate and standardize DNA analysis in criminal investigations. Canadian law enforcement currently employs a Combined DNA Index System (CODIS), the same system used by the EU, UK, and the USA (the FBI). The Canadian database of CODIS profiles is housed in the National DNA Data Bank (NDDB), a division of the national police force, the RCMP. CODIS technology provides a simple genetic

"barcode" that is unique to each person. This technology derives the "barcode" from only a few dozen short DNA sequence markers (Short Tandem Repeats or STRs). Like fingerprints, these markers are unique to individuals.[3]

In terms of its risk of error and its privacy implications, CODIS is relatively safe compared to other technologies. Already at the time of its inception, international authorities identified one crucial advantage of CODIS technology: as a critical review conducted in 2013 confirmed, authorities were reassured that CODIS barcodes provide enough information to link a profile with one individual without revealing genetic traits, health predispositions, or racial data (10). As the US Department of Justice's regulations confirm, CODIS profiles are "sanitized 'genetic fingerprints' that can be used to identify an individual uniquely, but do not disclose an individual's traits, disorders, or dispositions" (11, p.74937). In Canada, the CODIS profiles stored in the NDDB are anonymized using reference numbers that can only be linked to a name if a crime scene sample registers a match to a specific profile. The privacy risk to individuals whose DNA is sampled using this technology is therefore low, as is the potential for discrimination on the basis of race or health predispositions. CODIS only requires a small amount of DNA for analysis and its reliance on short "barcodes" can be useful even when sample degradation is a factor, as the technology only requires a short segment of legible DNA to generate a profile. CODIS technology is not immune to procedural error, but the federal regulations around the NDDB and the processing of samples by accredited experts at least standardizes each stage of the process, ensures that chains of custody are traceable, and attenuates the risk of error as much as possible.

CODIS's reliance on short "barcodes" provides an important degree of privacy, but its protections come at a cost: CODIS has limited reliability in the context of familial searching. The limitations of CODIS technology in familial searching were highlighted in a study conducted by the FBI in 2022. This study concluded that for familial searches, CODIS profile comparisons "have very low efficiency in locating true relatives in offender databases" (12, s31). Similarities between genetic profiles are sometimes flagged as "related" even where there is no genetic relationship between the individuals. Because of this, the probability of a false result actually *increases* with the size of the databank (12). For this reason, CODIS is much less useful as a technology for familial searching.

The use of DNA technology in forensic and criminal investigations is currently regulated in Canada by the *DNA Identification Act* (3). The *Act* permits investigators to match individuals to a specific crime/forensic scene: the Commissioner can report perfect or likely profile matches (*DNA Identification Act* 5.5-6.1). Since the NDDB was established in 2000, legislation has specifically precluded database curators from disclosing partial matches that could implicate relatives of individuals whose profiles were on file (Section 6 of the *DNA Identification Act* and Statutory Review [3,13]). The limitations on familial searching reflect international legislative practices. In the USA, the FBI does not permit familial searching of its DNA databank (14). Various State jurisdictions impose additional limits. The states of Maryland and Montana, for example, have recognized the implications for relatives of criminals and consequently require specific conditions to be met before a familial search can be conducted: the crime must be deemed extremely violent, investigators must demonstrate that additional evidence is unlikely to be found, and a judge's permission must be obtained (12). The UK likewise only permits familial searches when the crimes under investigation are serious (15). One way to establish investigative necessity is by imposing a requirement for a warrant; this is the case in Montana (16).

In Canada, the *DNA Identification Act* does not allow the reporting of overlapping profiles, e.g., profiles that have some markers in common but where others are discernibly different. In other words, the Commissioner cannot reveal partial matches that might suggest a genetic relationship between two samples: a previously unknown profile obtained at a crime scene, and one from a related person already registered in the databank. In essence, this prohibition on familial searching guards against the implication, investigation, and exposure of genetic information of the *relatives* of offenders. This prohibition simultaneously protects their personal information, privacy, and legal rights as outlined in the *Charter of Rights and Freedoms*. There is one notable exception to this prohibition: in Canadian forensic investigations of missing persons and unidentified human remains, familial comparisons can be carried out if immediate relatives explicitly consent to provide samples for this purpose. A circumstance where this might occur is when a family hopes to identify missing or murdered relatives.[4] In such cases, family members' privacy is protected because the DNA of victims, volunteers, and human remains are not stored in the NDDB's Convicted Offenders Index or the Crime Scene Index, but rather in the Voluntary Donors Index, the Victims Index, the Missing Persons Index, the Human Remains Index, and the Relatives of Missing Persons Index.

In the push to expand the size of the NDDB in Canada and to permit familial searches, legislators have repeatedly downplayed the privacy implications of these changes. At the second reading of Bill S-231, Senator Claude Carignan even emphatically asserted that "Bill S-231 does not change these important privacy protections" (1). This view is hard to justify given that the legislation will not only increase the number of individuals sampled but also subject their genetic relatives' profiles to scrutiny and potential privacy violations. Moreover, the Bill proposes to expand the familial search to include indices outside of the NDDB's Convicted Offenders Index by including the indices containing profiles from missing persons, victims, and volunteers. This combined resource would also be used to aid foreign governments, organizations, and institutions.[5]

[3] Indeed, The Supreme Court of Canada (in R. vs Rodgers) explicitly recognized that CODIS "barcoding" was analogous to a fingerprint with regard to specificity to a single individual (9).
[4] This specific category of investigation can also involve more revealing and intimate biometrical tests such Y-chromosome analysis, mitochondrial DNA, and whole genome sequencing.
[5] Section 18 of Bill S-231 proposes to add 6.41 to section 6.4 of the *DNA Identification Act*.

ETHICAL AND PRIVACY IMPLICATIONS OF FAMILIAL SEARCHING

Familial searching in the context of criminal investigations is widely acknowledged to pose significant risks in terms of ethics, privacy, and consent, and there have been numerous calls for a detailed study of these risks (17,18). In its own Statutory Review of the *DNA Identification Act* published in 2010, the Standing Senate Committee on Legal and Constitutional Affairs emphasized that familial searching was "one of the most controversial subjects" (13, p.61) that it had reviewed and recommended that "before kinship analysis or familial searching be permitted, the Department of Justice further study the matter…to analyze the impact that allowing kinship analysis or familial searching might have on the protection of society, the administration of justice, the privacy of individuals and the presumption of innocence" (p.64). To our knowledge, the Department of Justice has yet to undertake such a study.

The specific risks associated with familial searching have been described at length, including in the Senate Committee's Report on the *DNA Identification Act*, which noted numerous concerns from witnesses that familial searching could:

- Compel family members to become unwilling "genetic informants;"
- Lead police to match an individual to a crime *other* than the one being investigated;
- Link the genetic profiles of innocent individuals to a crime;
- Lead to "genetic surveillance of certain groups of people," including groups overrepresented in the justice system;[6]
- Expose biometric information unrelated to the criminal investigation, such as instances of false paternity and adoption (13, p.63-4).

In many respects, familial searching of the NDDB would subject not only convicted offenders but their genetic relatives to privacy invasion, arbitrary search, and violations of their right to be presumed innocent. Given that certain racialized populations are overrepresented in the NDDB, familial searching will disproportionately affect these populations. The most recent incarceration demographics in Canada clearly show that racialized people are overrepresented in the criminal justice system: in 2020-21, individuals self-reporting as Indigenous and Black made up 27% and 8% of offenders (19), although they represent only 5% (20) and 3.5% (21) of the national population, respectively. An expanded NDDB will perpetuate these demographic inequalities and compromise the privacy rights of racialized populations. Subjecting these populations to routine searches constitutes a serious violation of key tenets of the legal system. As Murphy explains, familial searches "embody the very presumptions… [that] evidentiary rules have long endeavored to counteract: guilt by association, racial discrimination, propensity, and even biological determinism" (15, p.304).

Canada's laws around DNA abandonment further compound this risk of systemic discrimination. As Amy Conroy has convincingly argued, the Supreme Court of Canada has shown reluctance to categorize DNA sampling from abandoned articles (discarded ginger ale cans, cigarette butts, facial tissues) as examples of arbitrary search. She points out that DNA "can be obtained from bodily tissues that are routinely and unconsciously shed by individuals in the course of their daily activities," (4, p.176) and the Supreme Court's position currently leaves "individuals with no meaningful right to refuse police the use of genetic materials that are shed and discarded daily" (p.188). This is problematic in and of itself, but when combined with familial searching, investigators would potentially be able to obtain "abandoned" DNA not only from suspects but from innocent individuals and submit these profiles to the NDDB for comparison. This, Conroy concludes, "present[s] a serious risk for genetic privacy" (p.184) but it also circumvents the key tenet of the *DNA Identification Act*, which is to ensure that the NDDB "only contain the profile information of convicted offenders" (p.174).

Legal scholar Colton Fehr likewise argues that familial searches would likely contravene Section 8 of the *Canadian Charter of Rights and Freedoms* (23). This section explicitly protects "the right to be secure against unreasonable search or seizure" (24). Fehr likens familial searching to communication intercepts to make a compelling point: most people would find it unacceptable to have their telephone traffic routinely monitored because a distant relation is an offender. As Fehr points out, just as innocent parties are likely to get unfairly caught up in an investigation if their private exchanges are surveyed, analysing DNA databanks for familial connections will indiscriminately capture a larger number of innocent parties. In the interest of privacy and security, Fehr argues, there should be a constitutional obligation to limit such investigations to cases of violent and immanent injury or threat (23).

Fehr's analysis echoes the findings of a 1995 Report by the former Privacy Commissioner of Canada, which considered genetic testing in relation to *The Privacy Act* (1985). In it, the Commissioner stipulated that DNA should be regarded as a form of personal information and should be subject to the "fair information practices" set out in the *Privacy Act*, notably that government agencies can:

- collect only the personal information they need to operate programs;
- collect the information directly from the person concerned, if possible;
- tell the person how it will be used;
- use personal information only for the purpose for which it was collected or for a 'consistent' purpose;
- disclose the information only as the Act permits;
- take all reasonable steps to ensure the accuracy and completeness of the information;
- allow the person access to his or her personal information;

[6] Amy Conroy has subsequently shown that familial searching of the NDDB would perpetuate racial stereotyping and systemic bias of Indigenous communities, who are disproportionately represented in the criminal justice system (22).

- and allow the person to make objections to the correctness of personal information kept by government, have the objections stated on file, request changes to the file, and notify users of the information of the objections. (25, p.55)

Furthermore, the Commissioner highlighted the fact that genetic information must, under the *Privacy Act*, be collected "directly" from an individual (except under very specific circumstances):

> personal genetic information must be collected directly from the individual to whom it relates. Even if it is possible to identify a genetic characteristic of one person from a test of a relative, the genetic information should, if possible, be collected directly from that person, not the relative (25, p.60).

The Commissioner concluded that forensic use of genetic information should only be implemented after it has been subject to a "study of the privacy and other human rights implications" and, "if the study finds the data bank to be acceptable," subsequently be subject to "specific authorizing legislation" (25, p.50). Advances in DNA analysis have made this study all the more urgent, especially given the potential for "abandoned" DNA to play a role in investigations and in familial searches.

In direct contrast to these recommendations, Bill S-231 does not grant any consideration to how the use of genetic profiling in criminal investigations will affect the privacy of persons *indirectly* linked to the investigation through familial relationships, nor does it provide any guidance around consent. As we will demonstrate, addressing these issues is important not only in the context of Bill S-231's proposal to allow familial searching given that current investigational practices already operate outside the NDDB and the purview of the *DNA Identification Act* to use genetic genealogy in criminal investigations.

ETHICAL AND PRIVACY IMPLICATIONS OF GENETIC GENEALOGY AND COMMERCIAL/ CONSUMER SERVICES

Given CODIS's limited efficacy in familial searching and the stringent regulations surrounding use of the NDDB, it is small wonder that investigators are eagerly making use of genetic genealogy techniques, often in collaboration with commercial services and open-source databanks. Where familial searching of the NDDB raises significant ethical and privacy issues, these are magnified in the context of genetic genealogy and its completely unregulated use. Until recently, this use was largely limited to municipal police units (whose activities are not governed by the *DNA Identification Act* unless they are using the NDDB), but the RCMP has now also adopted genetic genealogy as an investigational method.

The impetus for this transition to genetic genealogy occurred in 2018 when, after an investigation spanning decades, the Californian "Golden State Killer" was arrested. Instead of relying on police-run DNA databanks, investigators submitted anonymous crime scene DNA samples to a commercial lab, FamilyTreeDNA. The resulting genetic profile was then uploaded to and compared with family trees on consumer-oriented genealogy websites such as MyHeritage and GEDmatch (26-28). Family tree data, as well as the gender, age, race, and height of the offender, allowed police to identify the perpetrator. Encouraged by this and similar breakthroughs, Canadian investigators have eagerly adopted genetic genealogy techniques to crack cold cases: the Toronto, Calgary, and Edmonton Police Departments have been early adopters. In November 2023, the RCMP announced that they had solved the 47-year-old murder of Pauline Brazeau by submitting a crime scene DNA sample to Othram, a Texas-based commercial company specializing in forensic genetic genealogy (29). The technical approach was to conduct whole genome sequencing of a crime scene sample and then reverse-engineer the data to permit comparison to the profiles one might find on GEDmatch, for example.[7] Genealogical investigators then built family trees to narrow the search. The RCMP were able to solve this investigation without recourse to the NDDB and were therefore not bound by regulations prohibiting familial or genealogical searching.

Both of these breakthroughs were achieved thanks to a technology that is fundamentally different from CODIS and is much better suited to genetic genealogy: SNP (Single Nucleotide Polymorphisms) Microarray analysis predominates due to its prevalence in the direct-to-consumer market, but other technological approaches, like mitochondrial sequencing, Y-chromosome analysis, and whole genome sequencing are also used by investigators. These newer technologies generate far more detailed genetic profiles and can reveal more distant genetic relationships than CODIS. Where CODIS records 13-20 short DNA markers, SNP technology maps approximately 680,000 DNA markers using a microarray platform.[8] As a result, SNP assays produce highly detailed genetic profiles revealing not only genetic relatedness but also information on gender, health predispositions, race/ethnicity, and physical traits. The granularity of detail revealed by SNP is so rich that distant family – extending far beyond immediate family to thousands of genetic relatives – can be identified. By way of comparison, where CODIS can sometimes confirm immediate relatives, SNP technology can show genetic links between seventh or eighth cousins, linking hundreds if not thousands of genetic relations. Yaniv Erlich et al. have estimated that if just 2% of Americans of European descent were to deposit SNP profiles, 99% of the total population of that ethnicity would be detectable via 3rd cousins (30).

[7] Whole-genome sequencing reveals not only the 680,000 markers mapped by SNPs but some 4 billion nucleotides. The increased granularity of detail exposes vastly more intimate information that heightens the privacy risks.

[8] Microarrays are small glass slides to which hundreds of thousands of distinct DNA sequences have been affixed. When a labelled DNA sample from a crime scene is added to the microarray, the complementary DNA sequences light up. In a test (or assay), each sample will light up subsets of those 680,000 sequences that are unique and characteristic of that sample.

These enriched profiles and capabilities come with specific propensities for error, serious privacy risks, and unresolved issues around consent. We briefly consider these disadvantages by comparing CODIS to newer technologies.

Propensities for Error

The level of informational detail provided by SNP analysis widens the scope for procedural error. SNP analysis requires 20-100 times the quantity of DNA sample compared to CODIS (31). Obtaining this quantity of DNA from a crime scene without introducing contaminated or degraded DNA is all the more difficult when compared to CODIS and increases the likelihood of false results. For example, contaminated samples of DNA would produce a distorted pattern in a SNP result and could lead investigators to falsely exclude a suspect (31). Studies also show that DNA sample degradation can lead to poor prediction of kinship (32).

In terms of reliability, CODIS and direct-to-consumer SNP microarray technology are both susceptible to error at each stage of the investigative process. However, SNP technology carries numerous additional risks. Open-source genealogy databases are compiled by amateurs and volunteers and may contain errors. Genealogical information input by users is supposed to be substantiated by documentary evidence (birth, death, and marriage certificates, census forms), but the rigour, training, and inclination of the hobbyists that populate the data is variable. Much more seriously, commercial genetic genealogy services rely on customers to collect their own cheek swab or sputum sample. Even when customers collect this DNA sample under ideal conditions, tests suggest that the assays can be so unreliable as to preclude their use for medical tests (33,34). Investigators using these commercial services access and compare profiles, but with no way of verifying the reliability of the samples submitted. They are also unable to determine whether samples submitted were obtained lawfully, consensually, and under the correct name. The analysis of samples is similarly unregulated, and the relative reliability of each company is impossible to ascertain.

Privacy Risks

Genetic genealogy carries some of the same privacy concerns as familial searching, including the risk of disclosing genetic relationships that are unknown to the families involved (e.g., illegitimate or adopted children), the risk of disclosure of medical information, and the subsequent bias that may affect individuals with genetic illness or predisposition towards disease. However, because genetic genealogy is almost always conducted through or in collaboration with commercial services and/or open-source databases, these risks are exponentially heightened.

A key consideration is the dynamic business landscape in which companies operate. One of the commercial companies that had previously catered to genealogy hobbyists, GEDmatch, was acquired by forensic analysis firm Verogen in 2019. Verogen itself was a 2017 spin off from Illumina Inc., the dominant provider of SNP microarrays and a major player and developer of DNA profiling and sequencing tools and services. Companies are constantly changing hands, reorganizing, and merging. Moreover, in view of the increased business from police investigators, several companies (e.g., Verogen, Parabon NanoLabs Inc., and Othram Inc.) now offer SNP analysis directly to police. Not only is it becoming difficult to separate police from commercially provided investigative services, but the businesses used over the course of investigations comprise specialty forensic, genealogy, direct-to-consumer, and hobbyist services. When individuals interested in genealogy or health predispositions deposit their DNA with a company and their profile is integrated into a database, all employees of these companies can potentially access extremely granular and intimate information.

Likewise, the commercial warehousing of a company's biometric data can be subcontracted or held in a third location, which means that customers' genetic information can be stored online or in remote jurisdictions where privacy is unprotected and potentially difficult to trace. Storing and transferring biometric data across city, state, provincial, and even national boundaries carry with it obvious risks. For example, a Canadian DNA profile submitted to 23andMe for analysis will be processed by a 23andMe subsidiary, Labcorp, in the USA. The DNA profile and resulting family tree will be housed wherever 23andMe dictates, and the information will be subject to American, not Canadian, legislation and protections. Consumers may then upload the 23andMe profile to GEDmatch for comparison to profiles and pedigrees obtained from other companies. While 23andMe might not have contributed directly to an investigation, the information derived from their assay becomes part of the larger GEDmatch resources that do. Companies are not always clear about what they do with the data, nor with whom it might be shared (35). Investigators relying on this data face myriad uncertainties. Is the chain of custody traceable? When data is stored by third parties in jurisdictions around the globe, who owns the samples and data? Have consumers consented to having their genetic data stored in other countries? What laws and regulations apply if the process crosses international borders? Do foreign powers have access to the data?

The collection, analysis, and storage methods deployed by commercial companies clearly violate several of the conclusions reached by the Privacy Commissioner in his 1995 report, namely that "personal information…must not be collected in a manner that risks inaccuracy…[and must be collected] in tightly controlled circumstances," and that "government institutions should ensure [that]...Only qualified persons should conduct genetic tests and interpret test results" (25, p.55). It is unclear if investigators using these commercial services are aware of the risks and potential violation of privacy protections.

Consent Issues

In the context of genealogical investigations, the issue of informed consent is fraught with problems. As we will explain, genetic information is often acquired under unregulated conditions and may have been obtained through coercive means or indirectly from relatives. Furthermore, samples can be used for purposes other than those explicitly consented to by the individual who provided the sample. In short, genetic genealogy has profound implications for the Privacy Commissioner's recommendation that information must be gathered "directly from the person concerned" and after informing each individual "how it will be used." (25, p.55)

The case of Michael Usry Jr. is revealing. In 2014, Usry was interrogated by Idaho Falls authorities as the prime suspect in the murder and rape of Angie Dodge in 1996. Investigators had submitted a DNA profile from the crime scene to a commercial DNA analysis service used by genealogy hobbyists. The investigators rapidly inferred Usry's guilt based on a DNA profile that his father had submitted to the commercial service several years earlier. Further DNA tests eventually cleared Usry of suspicion. The perpetrator was eventually revealed to be a 7th cousin, an individual unknown to Usry but with whom he shared a common ancestor born in 1741. Police had not understood the limitations of the testing technology, and investigational tunnel vision had ensued (36). Significantly, the genetic profile that implicated Usry in a criminal investigation was not retrieved from him directly; investigators relied on a profile that had been donated to a commercial DNA analysis service by his father, who had not explicitly consented to his DNA being used for investigational purposes (36).

Most direct-to-consumer DNA services do not obtain informed consent from customers for their information to be used in criminal investigations. When the database used for the "Golden State Killer" investigation, GEDmatch, was purchased by forensics lab Verogen Inc. in 2019, the company's new owners were forced to seek permission from past customers to use their genetic profiles for future investigations. As of 2019, only 14.2% had given consent (37). Even more troubling, some profiles contained in international research-oriented databanks may have been obtained through coercion. The Y-Chromosome Haplotype Reference Database (YHRD), for instance, is a research database that is also exploited by forensic labs and the manufacturers that provision direct-to-consumer kits – the YHRD contains both CODIS-like STRs as well as SNP markers. It also likely contains profiles taken forcibly from vulnerable populations such as the Uyghur (PRC) and Roma (eastern Europe). By accessing the YHRD, investigators and consumers alike are unwittingly participating in unethical practices (38).

Even where consent is requested, Gabrielle Samuel and Debbie Kennett point out that many consumers are ill-equipped to understand the subtle implications of consent for themselves or for their relatives (39). These authors and others have argued that there is a fundamental problem with a consent paradigm that centres upon individuals when extended families and collectives are put at risk (39-41). As Nina de Groot, Britta van Beers, and Gerben Meynen put it, "an individual consent model has significant limitations when it comes to IGG [investigative genetic genealogy] and needs to be complemented with a more collective approach" (40, p.793).

If consent is granted by an individual submitting a genetic sample, that consent cannot cover the individual's genetic relatives, whose biometric data is nevertheless exposed. As Michael Szego, Director of the Centre for Clinical Ethics at the University of Toronto explained in an interview with the authors:

> If I wanted to participate in a public genomics project that would involve sequencing my genome and making it publicly available, I could currently consent to such a project even though it would have implications for my family. Balancing individual autonomy with the privacy rights of 3rd party family members is a difficult question in genomics. Who ought to consent? Is that me? Or … by virtue of it affecting my family members, should they have a say in whether I participate or not?... What are the privacy rights of that fourth cousin [who] has never participated in any kind of genetic research, [who] wants to be… left alone and… by virtue of a family member that that individual probably has never met, has contributed a sample (2022/03/01)?[9]

David Goodis, former Assistant Commissioner of Ontario's Information and Privacy Commissioner, elaborates on this point in similar terms. When contributing DNA information, he argues,

> I'm also impacting my biological relatives, who themselves didn't consent… This is unusual in privacy law, because normally,… I can consent to the use and disclosure of my information. But [in this case]… I'm now also consenting to somebody else's information being disclosed or somebody else being identifiable by my information (2022/02/24).[9]

The repercussions of this disclosure of biometric data thus extend far beyond the parameters of criminal investigations. As DNA analysis becomes ever more detailed, the potential future impact of exposing biometric data remains unknown, and we have reason to protect the privacy of future generations, whose genetic privacy depends on how their immediate ancestors' genetic information is protected.

[9] Structured interviews were conducted of major stakeholders with expertise in genetic non-discrimination as part of the project entitled "Participatory Democracy and Canadian Genetic Non-Discrimination Act." The research was funded by Genome Canada and the Social Sciences and Humanities Research Council of Canada. Ethics protocols were approved by the Research Ethics Boards of the Universities of Windsor and Montréal. To date approximately 30 people have been interviewed. Consent was obtained from interviewees cited in this article prior to publication.

CONCLUSIONS: TRANSPARENCY, ACCOUNTABILITY, AND POLICY

It is clear that CODIS technology no longer satisfies investigational needs, but the use of familial searching, genetic genealogy, and commercial services are not currently compatible with the legal, ethical, jurisdictional, and procedural standards of criminal investigations. Bill S-231 does not address the reliability, privacy, and consent risks around the use of familial searching, nor does it seek to regulate the genetic genealogy and commercial databanks already in use by investigators.

In other jurisdictions, the use of commercial DNA analysis services is heavily regulated. For example, the 2019 guidelines from the US Department of Justice restrict federal investigators there from using commercial or direct-to-consumer resources unless specific conditions are fulfilled, namely that all other avenues of investigation have been exhausted (including CODIS); the crime under investigation is violent and/or presents a substantial threat to public security; the DNA sample obtained indicates a single offender, is available in sufficient quantity, and is of high quality; investigators use no deception in the submission and analysis of samples; and the data banks employed have explicit consent from data bank consumers that their DNA profiles can be used in this manner (14).

Although Bill S-231 tries to limit familial searching to serious offenses where traditional methods have failed to solve a case, it does not go far enough in addressing ethical and privacy concerns nor in addressing current and future DNA analysis technologies. Legislation is needed to protect investigators as well as those under investigation, and the interests of genetic relatives need to be front and centre in plans to expand genetic analysis in the criminal justice system. Such legislation, we conclude, needs to have longevity, advance equity, rethink privacy and consent as communal rather than individual, and proactively anticipate technological creep.

Longevity

DNA analysis and regulation is clearly a “transgenerational issue,” as de Groot, van Beers, and Meynen assert, both with regard to privacy and consent: “future generations might also be affected by today’s individual decision to make one’s genetic data accessible to law enforcement” (40, p.793). Regulatory legislation must take a long view of the potential impact on individuals and their descendants. This is particularly true of young people in the criminal justice system. At a presentation to the Standing Senate Committee on Legal and Constitutional Affairs, Stephanie DiGiuseppe, (Director, Criminal Lawyers Association) emphasized the risks that longevity of genetic profiles hold (42). With specific reference to juvenile offenders, DiGuiseppe pointed out that legislators must assess not only the immediate known risks to individuals, but also the future potential risks; over the 60-70 years remaining life expectancy of a young offender, for instance, it is not unthinkable that Canada’s democratic system undergo substantial changes. Longevity is a concern not only given the intergenerational dimension of DNA analysis but also with regard to the robustness of the legislation.

Advancement of Equity

The concerns around systematic bias and racial/ethnic inequity in the criminal justice system cannot be solved in the short term with genetic testing legislation. However, the discussion around DNA analysis can serve to highlight specific inequities and suggest possible ways to redress these. For instance, the disproportional representation of certain groups in the NDDB arises from its very selective profiling of individuals convicted of criminal offenses in Canada. In contrast, commercial databases are much less selective, contain many more profiles, and tend to represent racial/ethnic groups *other* than those represented in the NDDB. As Erin Murphy writes, “the racial composition of genealogical DNA sites – which heavily skew white – may end up balancing and complementing that of government databases, which disproportionately contain profiles from persons of colour” (43, p.7). To pursue this logic to its conclusion, a universal database containing profiles of an entire country’s population would be free from bias. The idea of a federally run universal database would also resolve the pressing issue of the commercialization of biometric data, which risks reproducing long-standing inequalities and power structures, as Rafaela Granja has discussed (5). However, when DNA and profiles are commodified, individual donors assume significant risks while the profits generated benefit commercial entities with little motivation to mitigate these risks. For these reasons, wide-scale genetic testing is, in de Groot, van Beers, and Meynen’s words, “generally not regarded as an acceptable option” (40, p.792).

Collective Privacy and Consent

The collective and intergenerational dimensions of genetic testing will compel legislators to rethink privacy and consent. The notion of individual rights and freedoms does not capture the complexities involved in DNA analysis. Instead, legislators need to advocate for what Samuel and Kennett term a “societal approach” based on “solidarity” (39). Such an approach, they argue, would be grounded in “wide public engagement” and would “[aim] to foster public trust and legitimization by placing strong ethical emphasis on people’s willingness to engage in activities that may carry some risks for the benefit of others” (39, p.300). In order to foster this type of public good faith, Samuel and Kennett rightly argue, institutions – and not individuals – need to demonstrate transparency and accountability (39). The issue of consent should not rest uniquely on the individual; rather, the “responsibilization” of individuals needs to be shifted to institutions and governments. The “solidarity” model “places the responsibility on institutions to be transparent about their own stakes and interests, and about the types of harms that may not be foreseeable” (39, p.300). While it may be too much to hope that commercial companies undertake such a radical ethos of responsibility, legislators might feasibly insist that police and government institutions work to make processes and statistics fully transparent. As Murphy shows, such transparency is sorely lacking, and as a consequence, the public remains dangerously ill-informed about the practice of investigative DNA searches (43).

Anticipating Technological Creep

Given our environment of rapid technological change, policy needs to anticipate technological creep. Bill S-231's provision for familial searching is late to the game and does not address current practices, let alone imminent developments. Whereas previously whole genome sequencing was prohibitively expensive, costs have now dropped to be competitive with CODIS technology. Investigators will likely find it fiscally expedient to use this technology without understanding the potential consequences of scrutinizing vastly enhanced biometric detail. Not even investigators of the Human Genome Project were able to foresee that analytical methods would render void the anonymity of their genome donors (44). In spite of the promise of anonymity, privacy critics were able to use a combination of freely available genome sequence data, Y-chromosome data, and public genealogy websites to identify donors with high probability. Recently, Edmonton Police, in collaboration with the US firm Parabon NanoLabs Inc., published a mug shot based solely upon Parabon's extrapolation of phenotype from a DNA sample (45). The technology employed to create this mugshot remains opaque, and the mugshot was withdrawn after a public outcry. Journalist Taylor Lambert, quoting interviewee Brenda McPhail, Director of Privacy, Technology & Surveillance at the Canadian Civil Liberties Association, goes on to state that "what's needed are 'legal frameworks and guard rails' to limit how police and other public bodies can pursue DNA analysis… 'Although it doesn't mitigate the trauma that the community has surely felt…it does provide a really important and welcome opening for a public conversation about precisely what the risks of this technology are'" (45). Canada has been very slow to develop policy around genetic analysis, the Department of Justice has failed to undertake the recommended research into the impact of DNA analysis, and legislators repeatedly propose new policy that fails to address concerns expressed by numerous federal reports. For their part, investigators are likewise understandably frustrated by the failure to move forward with legislative action. The issues will not be solved with hasty debate or incomplete policy, but they will also rapidly grow more urgent with the passage of time. Murphy puts it succinctly: "Big genome data has arrived: it is time to do something more than gape in wonder at it." (43, p.8).

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REFERENCES

1. Parliament of Canada. S-231: An Act to amend the Criminal Code, the Criminal Records Act, the National Defence Act and the DNA Identification Act, 44th Parl, 1st Sess, Vol 153, No 7 (currently at Committee).
2. Royal Canadian Mounted Police. National DNA Data Bank statistics. Ottawa: Canada. 15 Jul 2023.
3. DNA Identification Act 1998 (Canada). S.C. 1998 c. 37.
4. Conroy A. Combining familial searching and abandoned dna: potential privacy outcomes and the future of Canada's National DNA Data Bank. Canadian Journal of Law and Technology. 2014;12(2):171-88.
5. Granja R. Long-range familial searches in recreational DNA databases: expansion of affected populations, the participatory turn, and the co-production of biovalue. New Genetics and Society. 2021;40(3):331-52.
6. Murphy EE. Inside the Cell: The Dark Side of Forensic DNA. New York, NY: Nation Books; 2015.
7. Himmelreich C. Germany's phantom serial killer: a DNA blunder. Time Magazine. 27 Mar 2009.
8. Dror IE, Hampikian G. Subjectivity and bias in forensic DNA mixture interpretation. Sci Justice. 2011;51(4):204-8.
9. R v. Rodgers. (2006 SCC 15,) 1 S.C.R. 554 (Supreme Court of Canada).
10. Katsanis SH, Wagner JK. Characterization of the standard and recommended CODIS markers. J Forensic Sci. 2013;58(suppl 1):S169-72.
11. Washington, DC: Federal Register, Department of Justice. DNA-Sample Collection and Biological Evidence Preservation in the Federal Jurisdiction. 2008;73(238):74932-42.

12. United States Federal Bureau of Investigation, Scientific Working Group on DNA Analysis Methods (SWGDAM) Ad Hoc Committee on Partial Matches. Frequently Asked Questions on CODIS and NDIS; 2022.
13. Fraser J, Wallace JD. Public Protection, Privacy and the Search for Balance: A Statutory Review of the DNA Identification Act. Final Report of the Standing Senate Committee on Legal and Constitutional Affairs, 40th Parliament, 3rd Session. Ottawa Canada: Senate of Canada. Jun 2010.
14. US Department of Justice. Interim policy, forensic genetic genealogical DNA analysis and searching. 9 Feb 2019.
15. Murphy E. Relative doubt: familial searches of DNA databases. Mich. L. Rev. 2010;109(3):291-348.
16. Hughes V. Two new laws restrict police use of DNA search method. New York Times. 31 May 2021.
17. Haimes, E. Social and ethical issues in the use of familial searching in forensic investigations: insights from family and kinship studies. J Law Med Ethics. 2006;34(2):263-76.
18. Gibbons SM, Kaye J. Governing genetic databases: collection, storage and use. Kings Law J. 2007;18(2):201-8.
19. Public Safety Canada. Corrections and Conditional Release Statistical Overview. Ottawa Canada: 2021.
20. Statistics Canada Plus. Canada's Indigenous population. 21 Jun 2023.
21. Statistics Canada. Black History Month... by the numbers. 31 Jan 2023.
22. Conroy, A. E-racing the genetic family tree: a critical race analysis of the impact of familial DNA searching on Canada's aboriginal peoples. PhD in Law, Faculty of Law. Ottawa: University of Ottawa; 2016.
23. Fehr C. Familial DNA searching and the Charter. In: Diab R, Hunt C, editors. Digital Privacy and the Charter of Rights and Freedoms. Toronto: Carswell Thompson Reuters; 2021. p. 261-81.
24. Canadian Constitution Act Part 1. Canadian Charter of Rights and Freedoms. Ottawa, Canada: 1867-1982.
25. Privacy Commissioner of Canada. Genetic Testing and Privacy. Ottawa; 1995.
26. St. John P. The untold story of how the Golden State Killer was found: a covert operation and private DNA. Los Angeles Times. 8 Dec 2020.
27. Zhang S. How a genealogy website led to the alleged Golden State Killer. The Atlantic. 27 Apr 2018.
28. Phillips C. The Golden State Killer investigation and the nascent field of forensic genealogy. Forensic Science International: Genetics. 2018;(36):186-8.
29. Mansukhani H. Police use DNA, genealogy to charge Alberta man in 1976 murder of teen girl. Calgary Herald. 8 Nov 2023.
30. Erlich Y, Shor T, Pe'er I, Carmi S. Identity inference of genomic data using long-range familial searches. Science. 2018;362(6415):690-4.
31. Kling D, Phillips C, Kennett D, Tillmar A. Investigative genetic genealogy: Current methods, knowledge and practice. Forensic Sci Int Genet. 2021;52:102474.
32. de Vries JH, Kling D, Vidaki A, et al. Impact of SNP microarray analysis of compromised DNA on kinship classification success in the context of investigative genetic genealogy. Forensic Sci Int Genet. 2022;56:102625.
33. Tandy-Connor S, Guiltinan J, Krempely K, et al. False-positive results released by direct-to-consumer genetic tests highlight the importance of clinical confirmation testing for appropriate patient care. Genet Med. 2018;20(12):1515-21.
34. Weedon MN, Wright CF, Patel KA, Frayling TM. Unreliability of genotyping arrays for detecting very rare variants in human genetic studies: Example from a recent study of MC4R. Cell, 2021;184(7):1651.
35. Baram, M, Pasternak A. The FTC is investigating DNA firms like 23andMe and Ancestry over privacy. Fast Company. 6 May 2018.
36. PBS Newshour. A father took an at-home DNA test. His son was then falsely accused of murder. Brangham W, Akpan N, Natour R, producers. Washington (DC): Public Broadcasting Service. 7 Nov 2019.
37. Bala N. We're entering a new phase in law enforcement's use of consumer genetic data. Slate: Future Tense. 19 Dec 2019.
38. Schiermeier Q. Forensic database challenged over ethics of DNA holdings. Nature. 2021;594(7863):320-22.
39. Samuel G, Kennett D. Problematizing consent: searching genetic genealogy databases for law enforcement purposes. New Genetics and Society. 2021;40(3):284-304.
40. de Groot NF, van Beers BC, Meynen G. Commercial DNA tests and police investigations: a broad bioethical perspective. J Med Ethics. 2021;47(12):788-95.
41. Widdows H. The Connected Self: The Ethics and Governance of the Genetic Individual. Cambridge: Cambridge University Press; 2013.
42. DiGiuseppe S. Witness Testimony Presented At: Hearing Before the Standing Senate Committee of Legal and Constitutional Affairs. Senate of Canada 80 Sess. Ottawa. 9 Nov 2023.
43. Murphy EE. Law and policy oversight of familial searches in recreational genealogy databases. Forensic science international. 2018;292:e5-9.
44. Gymrek M, McGuire AL, Golan D, Halperin E, Erlich Y. Identifying personal genomes by surname inference. Science. 2013. 339(6117): 321-4.
45. Lambert T. DNA-assisted mug shots in law enforcement are based on dubious science. So why would Edmonton police use them? CBC News: Analysis. 7 Oct 2022.

APPENDIX

Table 1. Comparison of Canadian DNA Sampling Versus G7

Per Capita Ratio Arranged Highest to Lowest[10]

G7	# DNA Samples (millions)	Population (millions)	Per Capita Sampled Ratio	Date Reported
UK	5.8	67.33	0.08614288	2021
France	5.22	67.55	0.07727609	2021
USA	12	328.3	0.03655193	2019
Canada	**0.67**	**38.93**	**0.01721038**	**2022**
Germany	0.827	83.13	0.00994827	2021
Japan	1.213	126.6	0.00958136	2019
Italy	0.007	59.01	0.00011862	2021

Table 2. Comparison of Canadian DNA Sampling Versus G20

Per Capita Ratio Arranged Highest to Lowest

G20	# DNA Samples (millions)	Population (millions)	Per Capita Sampled Ratio	Date Reported
UK	5.8	67.33	0.08614288	2021
France	5.22	67.55	0.07727609	2021
Australia	1.2	25.74	0.04662005	2021
USA	12	328.3	0.03655193	2019
Saudi Arabia	0.909	34.27	0.02652466	2021
EU	50.866	1294.04	0.0393079	2021
Canada	**0.67**	**38.93**	**0.01721038**	**2022**
South Africa	0.743	58.56	0.01268784	2021
Germany	0.827	83.13	0.00994827	2021
Japan	1.213	126.6	0.00958136	2019
Russia	0.7344	144.4	0.00508587	2021
Korea South	0.1798	51.76	0.00347372	2021
Italy	0.007	59.01	0.00011862	2021
China	N/A			
India	N/A			
Indonesia	N/A			
Mexico	N/A			
Argentina	N/A			
Brazil	N/A			
Turkey	N/A			

[10] DNA Sampling Rates per capita were calculated using statistics reported by the 2022 “Note: From EU General Secretariat of the Council to The Working Party on JHA Information Exchange (IXIM),” Brussels, 25 March, Interpol’s 2019 “Global DNA Profiling Survey Results,” and country-specific annual police and police lab sampling statistics. The number of unique DNA profiles held and reported was compared to the population for that particular country for the year reported.

Table 3. Comparison of Canadian DNA Sampling Versus EU

Per Capita Ratio Arranged Highest to Lowest

Canada vs EU Compared	# DNA Samples (millions)	Population (millions)	Per Capita Sampled Ratio	Date Reported
France	5.22	67.55	0.07727609	2021
Estonia	0.0651	1.329	0.0489842	2021
Lithuania	0.135	2.795	0.04830054	2021
Latvia	0.0701	1.883	0.03722783	2021
Finland	0.198	5.542	0.03572717	2021
Austria	0.256	8.96	0.02857143	2021
Denmark	0.15	5.875	0.02553191	2021
Czechia	0.2608	10.7	0.02437383	2021
Netherlands	0.356	17.53	0.02030804	2021
EU	8.801	446.727	0.01970107	2021
Canada	**0.67**	**38.93**	**0.01721038**	**2022**
Hungary	0.161	9.71	0.01658084	2021
Sweden	0.168	10.42	0.01612284	2021
Slovakia	0.085	5.45	0.01559633	2021
Slovania	0.0259	2.11	0.01227488	2021
Germany	0.827	83.13	0.00994827	2021
Ireland	0.04344	5.028	0.00863962	2021
Spain	0.403	47.33	0.00851468	2021
Bulgaria	0.0543	6.899	0.00787071	2021
Luxembourg	0.00436	0.639	0.00682316	2021
Belgium	0.0656	11.59	0.00566005	2021
Poland	0.143	37.53	0.00381029	2021
Romania	0.0657	19.12	0.00343619	2021
Greece	0.0195	10.66	0.00182927	2021
Cyprus	0.0017	1.22	0.00139344	2021
Croatia	0.0047	3.9	0.00120513	2021
Portugal	0.011	10.3	0.00106796	2021
Malta	0.000065	0.517	0.00012573	2021
Italy	0.007	59.01	0.00011862	2021