Science & Justice 59 (2019) 20–28

Contents lists available at ScienceDirect

Science & Justice

journal homepage: www.elsevier.com/locate/scijus

Familial DNA searching- an emerging forensic investigative tool☆

Sara Debus-Sherrill*, Michael B. Field

ICF, 9300 Lee Highway, Fairfax, VA 22031, United States

ARTICLE INFO

Keywords:
Familial DNA searching
Partial matching
Partial matches
CODIS
DNA

ABSTRACT

In recent years, jurisdictions across the United States have expressed a growing interest in aiding criminal investigations through the use of familial DNA searching (FDS)- a forensic technique to identify family members through DNA databases. The National Survey of CODIS Laboratories surveyed U.S. CODIS laboratories about their perceptions, policies, and practices related to FDS. In total, 103 crime labs completed the survey (77% response rate). Labs in 11 states reported using FDS, while labs in 24 states reported using a similar-but distinct-practice of partial matching. Although the majority of labs had positive perceptions about the ability of FDS to assist investigations, labs also reported a number of concerns and challenges with implementing FDS. Respondents reported using either practice a limited amount with modest numbers of convictions resulting from both FDS and partial matching. The article reports on varying practices related to official policies, training, eligibility, the software search, lineage testing, requirements for releasing information, and subsequent investigative work. Finally, the article discusses what can be learned from this survey, accompanying limitations, and implications for decision-makers considering using FDS.

1. Introduction

In recent years, jurisdictions across the United States have expressed a growing interest in the use of familial DNA searching (FDS) to aid criminal investigations. FDS is an extension of the traditional matching of DNA profiles whereby, instead of searching for exact matches between unique, non-coding STR (short tandem repeat) patterns at the specified CODIS loci, specialized software identifies similar- but not exact- matches at the same loci that may be indicative of a family relationship.

FDS has two primary components: (1) the software comparison of a DNA profile from an unknown contributor with known profiles from a DNA database (e.g., CODIS convicted offender profiles) and (2) lineage testing to further support relatedness. The software uses genetic algorithms[1] to identify patterns in similarity that are likely to occur within close family relationships (e.g., parent/child, siblings).[2] An important subsequent step is lineage testing, which further supports or refutes biological relatedness between the unknown evidence sample and candidate samples identified through the database. These lineage tests reduce the presence of false-positives from a list of partial matches. Lineage testing primarily involves Y-STR testing, which examines STR patterns specific to the Y-Chromosome in order to assess paternally derived relatedness. Due to the nature of this test, it is only helpful for confirming relatedness between two males. Other lineage tests exist for supporting the relatedness of a female family member, such as mitochondrial DNA testing which can help determine maternally derived relatedness. However, few labs currently have the capability to perform this test.

A similar, but distinct, approach to identifying a perpetrator's potential family members in a DNA database is called “partial matching” (PM). In contrast to FDS which uses software specifically designed to identify familial relationships, this technique relies on CODIS' inherent functionality to search for profiles which are similar. CODIS software can be set to search at three different stringency levels: high, moderate, and low. High-stringency searches require all alleles to match exactly at all loci, while moderate and low stringency levels allow for the identification of partial matches (also referred to as near or close matches) [1]. Although lower stringency searches of CODIS can uncover partial

☆ Area 1. Professional Articles: on matters of a professional nature including casework reports, non-technical reviews and essays, legal comment, the investigative sciences, and any items concerned with the professional standing of expert witnesses.

* Corresponding author.
E-mail addresses: Sara.Debus-Sherrill@icf.com (S. Debus-Sherrill), Michael.Field@icf.com (M.B. Field).

[1] Currently, most FDS software employs Identify by State, Likelihood Ratio, or some combination of these two statistical techniques to determine the strength of potential familial associations found during familial searching. Labs must decide a specific threshold to use for the statistics produced in order to narrow down possible matches to those most likely to be a true biological relation.

[2] More distant family relationships are also possible to identify, but, due to less genetic similarity, the search results are not as accurate in identifying these.

https://doi.org/10.1016/j.scijus.2018.07.006
Received 22 September 2017; Received in revised form 16 March 2018; Accepted 31 July 2018

matches fortuitously during a routine CODIS search, it is not ideal for deliberately identifying familial matches. This is because the measures of similarity in the CODIS search are not designed to capture the types of similarities specifically found in familial relationships, as opposed to other types of genetic similarity found randomly in the population. The Scientific Working Group on DNA Analysis Methods (SWGDAM) Ad Hoc Committee on Partial Matches states that "there is little useful probative value in the majority of partial matches using the current CODIS searching rules and algorithms" [2]. The Committee recommends a number of additional requirements (e.g., use of single source samples, additional lineage testing, calculation of additional kinship statistics) to increase the utility of partial matching.

Studies examining the efficacy of FDS with statistical simulations of data generally find that the technique (when it includes lineage testing) reliably removes non-familial matches for certain family relationship types [3–8]. Some studies have also identified a potential for false positives despite the advanced abilities of the statistical FDS software [9–11].

Critics have also raised a number of ethical, legal, and logistical considerations regarding FDS. For instance, one expressed concern is whether family members of individuals in CODIS should be subject to this type of law enforcement monitoring when they have not given up their privacy rights by virtue of being under state control like those individuals in CODIS [12–18]. Another concern shared is that familial searching has a disproportionate impact on minority communities since there is already an overrepresentation of racial and ethnic minorities in CODIS [16, 18–24]. Other noted considerations in the literature include: general discomfort with the widening scope of DNA collection; the investigation of innocent family members due solely to questions of relatedness (e.g., in a case where multiple brothers may need to be investigated but only one is guilty); whether an investigation may interfere with an individual's social understanding of his or her family (e.g., if unknown paternity/adoption is uncovered or if it was not known that a family member was convicted of a crime); and practical challenges related to resources and costs, training needs, and the development/approval of policies [12–14, 16–18, 23, 25, 26]. Ultimately, proponents of FDS argue that the practice has indeed been legally vetted and does not violate constitutional protections, but no judicial rulings have occurred to date.

Currently, FBI policy prohibits searches at the national level of CODIS (i.e., NDIS) with the intent of uncovering a familial match; therefore, FDS is currently limited to searches of state (i.e., SDIS) and local (i.e., LDIS) CODIS databases [27].[3] The landscape of FDS is quickly evolving among states, and there is a need for more updated information about current practices related to FDS across the United States to understand the extent of expansion and how the technique is being implemented. One policy study of FDS occurred in 2011, but it consisted primarily of informal conversations with a selection of crime labs. In this study, Ram (2011) provided preliminary information about the use of FDS and PM. At the time of her study, Ram found that 4 states permitted both FDS and PM (California, Colorado, Texas and Virginia), while 19 states permitted PM, either through explicit permission or lack of explicit prohibition [18].

Another source of information about practices around FDS is the Forensic Technology Center of Excellence four-part webinar series [28]. This 2014 webinar series hosted virtual discussions about FDS with panels of legal and forensic presenters. This series served as an important forum for sharing practical experiences and information from a variety of individuals across the country. However, presenters were more heavily weighted towards proponents of FDS, and information was presented as more of a free-form discussion.

These two efforts offer a helpful foundation for understanding the use of FDS in the United States, but both use more informal techniques to collect data, and the Ram study has become outdated as more states have begun to adopt the practice. Moreover, the Ram study does not explore the specific practices and policies for *how* the technology is implemented, while the webinar series delves into many of these issues but may not provide as representative a viewpoint across all states. Beyond these two sources, much of the information available regarding FDS practices stems from anecdotal accounts, media articles, and scholarly arguments about the various constitutional, ethical, and practical implications of its use. Little empirical research exists to document the policies and practices, explore how the justice system operates in practice with FDS cases, or understand case-level outcomes of FDS. To begin to fill these knowledge gaps and provide more information on this emerging practice, this article describes the results of the National Survey of CODIS Laboratories which collected systematic data on lab practices related to FDS and PM.

2. Methods

The Study of Familial DNA Searching was a mixed-methods study conducted by ICF and funded by the National Institute of Justice. The study examined the scope and practices of FDS in the United States through multiple components: (1) two expert roundtables with diverse stakeholders, (2) a legislative and policy review, (3) a national survey, (4) intensive case studies of four states, and (5) an econometric analysis of the cost implications of using FDS. This article shares findings from the National Survey of CODIS Laboratories, a survey of state and local CODIS laboratories to learn about key considerations and varied practices related to FDS and PM.

2.1. Instrument

The survey instrument was developed in consultation with the project's expert roundtable members after an in-depth review of scholarly literature, existing surveys, and legislation and agency policies. The survey mode was primarily on-line with hard-copy versions of the survey available upon request. The instrument used branching questions and had 28–54 questions (the exact number was dependent on the branching structure in response to the respondent's earlier answers). It included the following topics: lab/respondent background, legislation and policies, scope of using FDS and/or PM, perceptions and opinions of FDS and PM (including benefits and concerns), and specific practices related to FDS and PM (e.g., eligibility criteria, lineage testing protocols). We chose to include questions about PM because these two techniques can be used for similar purposes, and practitioners and others in the field sometimes experience confusion about the distinction between these two practices. The survey provided the following definitions to help ensure the use of common terminology when completing the survey:

2.1.1. Familial DNA searching

A *deliberate* search of a DNA database using specialized software (separate from CODIS) to detect and statistically rank a list of potential candidates in the DNA database who may be close biological relatives (e.g., parent, child, sibling) to the unknown individual contributing the evidence DNA profile, combined with lineage testing to confirm or refute biological relatedness.

2.1.2. Partial matching

A moderate stringency search of a DNA database using the routine search parameters within CODIS that results in one or more partial matches between single-source and non-degraded DNA profiles that share at least one allele at each locus, indicating a potential familial relationship between the known individual in the DNA database and the unknown individual contributing the evidence DNA profile. *Disclosing or proceeding with* a partial match would be to use information

[3] FDS is also used internationally, including in the United Kingdom, New Zealand, and the Netherlands.

learned through partial matching in an investigation.

2.1.3. Lineage testing

Additional genetic testing, such as Y-STR and mtDNA analysis, used to confirm or refute biological relatedness between the known individual in the DNA database and the unknown individual contributing the evidence DNA. Y-STR analysis is the examination of STR patterns specific to the Y-Chromosome that is used to determine paternally derived relatedness among DNA profiles, whereas mtDNA is found in the mitochondria of cells and is used to determine maternally derived relatedness.

2.2. Sample

With help from the National Forensic Science Technology Center, ICF developed a list of 133 CODIS laboratories operating in all 50 states, the District of Columbia, one U.S. territory, and at the federal level. The survey was emailed to lab directors with instructions to complete the survey in coordination with their CODIS administrator, as needed. In cases of multi-laboratory systems, only the overarching laboratory director was asked to complete the survey, as policies are typically consistent across labs within a system.

2.3. Administration

The survey remained in the field from December 2014 to May 2015 and was publicized through national professional organizations, industry contacts, and communications outlets.[4] ICF offered a dedicated helpline and email account to offer assistance and conducted follow-up outreach by phone and email to labs which had not responded or only partially completed the survey to try to obtain a more comprehensive response. A $200 raffled gift card was offered to help encourage responses.[5]

2.4. Analysis

The survey was aggregated to the state level to ensure confidentiality and improve honest reporting. Two scales were created to assess the degree of perceived institutional support for FDS and for PM practices. Four items[6] comprised each scale, with each item using a 5-point Likert agreement from 1 = *Strongly Disagree* to 5 = *Strongly Agree*. The internal reliability for both scales was adequate (Cronbach's $\alpha = 0.84$ for FDS and $\alpha = 0.77$ for PM). All other items were analyzed on an individual basis. Survey results were analyzed using descriptive statistics and statistical comparison tests (e.g., chi-square, ANOVA tests).

3. Results

3.1. Respondents

In total, 103 crime labs completed the survey (a 77% response rate including 50 LDIS and 53 SDIS).[7] Respondents represented 48 states, Washington D.C., one U.S. territory, and two federal labs. About half (52%) of respondents represented SDIS labs, and the state crime lab completed the survey in all 48 states which provided responses. Respondents were well distributed by size, with 22% of respondents serving between 1 and 5 police agencies, 19% serving 6–25 agencies, 23% serving 26–100 agencies, and 36% serving over 100 agencies. Almost one-third (30%) represented multi-laboratory systems which had a range of 2–13 associated labs.

3.2. Perceptions and use of FDS

Respondents were provided with definitions for FDS and PM (see *2.1 Instruments* above) and asked whether their lab performs FDS and/or discloses/proceeds with partial matches. Twelve labs in 11 states (12% of respondents) reported conducting FDS, with the earliest adopting the practice in 2007. Forty labs in 24 states (and one territory) (39% of respondents) reported disclosing/proceeding with partial matches, and seven labs reported using both FDS and PM (the 12 FDS and 40 PM labs reported above include these 7). Figs. 1 and 2 show which states had at least one lab reporting that they performed these techniques, and Fig. 3 shows the chronological adoption of FDS.

Of labs that do not currently conduct FDS, the vast majority (75%) said they have discussed using it in the past, and nearly half (42%) are considering using it in future investigations. Fig. 4 displays the resources labs used in helping decide whether or not to use FDS, as well as reasons why labs have chosen not to use FDS (for the latter item, responses were qualitatively coded into the listed categories).

The survey asked about laboratories' perceptions of FDS and PM. Employing a 5-point Likert scale, respondents were asked to indicate the degree to which they agreed or disagreed with specific statements related to FDS and PM (1 = *Strongly Disagree* to 5 = *Strongly Agree*). Two items asked about the potential of FDS or PM to help identify suspects, and four questions apiece were combined into scales measuring perceived institutional support for FDS and perceived institutional support for PM (see *2.4 Analysis* above for more information about these scales and comprising items). Fig. 5 shows the average score for both institutional support scales and the two items about potential for identifying suspects across three groups: (1) labs which use neither FDS nor PM, (2) labs which disclose/proceed with partial matches but do not perform FDS, and (3) labs which use FDS (this includes lab that may or may not disclose/proceed with partial matches in addition to performing FDS).

ANOVA tests measured significant differences between groups for both institutional support scales (for FDS support: $F[2,89] = 19.52$, $p < .001$ and for PM support: $F[2,89] = 11.78$, $p < .001$) and the item about disclosing/proceeding with partial matches having the potential to increase labs' ability to identify suspects ($F[2,90] = 4.51$, $p = .014$). Specifically, perceived institutional support for FDS was significantly higher for labs using FDS compared to the other two groups, while perceived institutional support for PM was significantly higher for labs that either use FDS or only perform PM compared to labs that use neither tool. Laboratories which performed PM- but not FDS-had a significantly higher opinion of PM's potential than other labs. Moreover, laboratories conducting FDS gave higher ratings for its investigative potential compared to PM, whereas labs that do not conduct FDS (either only perform PM or use neither practice) gave similar ratings for the investigative potential of both FDS and PM.

The survey also asked if labs had various concerns related to FDS, including resources (e.g., staff and funding), civil liberties (e.g., privacy), legal (e.g., case being overturned), accuracy (e.g., false

[4] Organizations included American Society of Crime Laboratory Directors (ASCLD), National Forensic Science Technology Center (NFTSC), Scientific Working Group or DNA Analysis Methods (SWGDAM), and American Academy of Forensic Sciences (AAFS).

[5] This study was proposed and approved prior to NIJ's new guidelines on incentives which prohibit raffles.

[6] Individual items included: "There is adequate collaboration among agencies in my jurisdiction to [perform FDS / disclose/proceed with a partial match]," "My laboratory is supportive of [using FDS / disclosing/proceeding with partial matches] during criminal investigations," "[Laboratory staff / Criminal justice officials (e.g., police, prosecutors)] in my jurisdiction receive adequate training related to [FDS / disclosing/proceeding with partial matches]."

[7] The number for SDIS labs includes: two regional labs within one state which both serve as SDIS labs, two federal labs, Washington D.C., and a U.S. territory. Therefore, there are 53 SDIS labs serving 48 states.

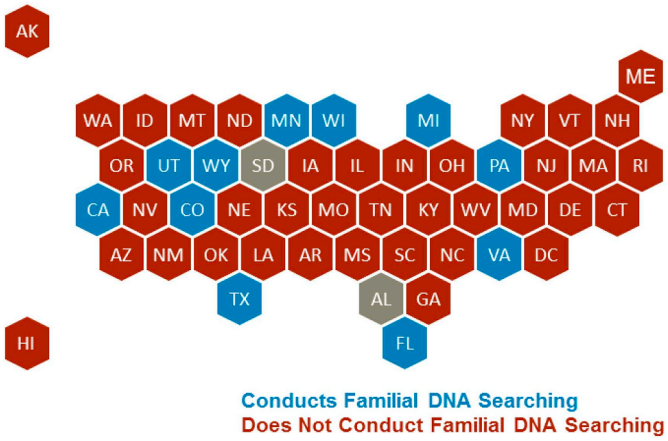

Fig. 1. States with labs performing familial DNA Searching in 2014.

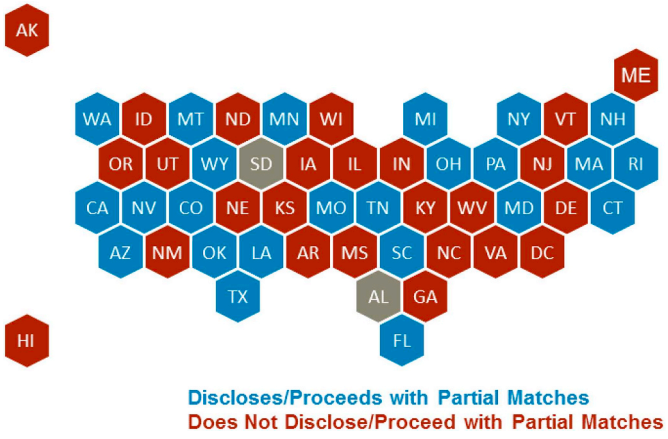

Fig. 2. States with labs disclosing/proceeding with partial matches in 2014.

Year Started	State(s)
2007	Colorado
2008	California
2010	Texas
2011	Virginia, Wyoming
2012	Florida, Michigan, Pennsylvania
2013	Minnesota
2014	Utah, Wisconsin

Fig. 3. Year states adopted familial DNA searching.

positives), or other concerns. Fig. 6 shows that labs that conduct FDS expressed significantly more concerns about the practice than labs that do not conduct FDS, specifically related to resources (X^2 [1, N = 94] = 11.56, p = .001), civil liberties (X^2 [1, N = 94] = 10.35, p = .001), legal concerns (X^2 [1, N = 94] = 4.879, p = .027), and accuracy (X^2 [1, N = 94] = 5.92, p = .015).[8] This may be due to FDS labs having undergone extensive discussions, vetting, and review processes to address concerns prior to approval.

3.3. Policies and practices of familial DNA searching and partial matching

Laboratories that reported conducting FDS or disclosing/proceeding with partial matches provided additional information about the extent they've used these tools and specific practices related to their use. However, since FDS is still an emerging practice, limited data is available, and readers should interpret the following results with caution due to small sample sizes (n = 12 FDS labs [10 state and 2 local labs] and n = 40 labs that disclose/proceed with partial matches [22 state and 18 local labs]). It is possible that as the practice expands to a larger number of labs, the representativeness of these results may change.

3.3.1. Guides to practice- policies and training

Forty percent of surveyed labs reported having official policies in place that addressed whether disclosing/proceeding with partial matches was allowed, while 30% of labs reported official policies addressing the permissibility of FDS. Many of these policies - 48% of FDS policies and 62% of PM policies- are publicly available according to respondent report. Labs performing FDS also reported that justice professionals often received at least some type of training about FDS, including crime lab staff (100%), police (100%), prosecutors (100%), defense (50%), and judges/court staff (50%). Other than lab staff who some respondents reported received annual training, most professionals were trained one time or training was not formalized or set by a schedule (e.g., information may have been shared at statewide conferences that some professionals may have happened to hear). Labs allowing PM were less likely to report training for PM across these same categories (21–38%), with lab staff still having the highest reported rates of training (69%).

3.3.2. Case frequency and outcomes

Respondents shared the number of FDS/PM cases which the lab had performed since the beginning of using either technique, how many of those cases resulted in a confirmed familial association (i.e., was verified to be a true biological relationship), and how many of these cases have resulted in a conviction. Fig. 7 shows that, while the number of familial searches varies greatly by lab, the number of convictions from FDS cases is low across all labs. Only five labs reported having any FDS cases that resulted in a conviction.

Data on labs that disclose/proceed with partial matches reflect similar trends, even though PM is more widespread and identification of partial matches can occur automatically as part of routine CODIS searches. One-fifth (20%) of labs that allow PM say they have not had any cases in which they chose to disclose/proceed with a partial match, and a majority (63%) of labs reported using it in only 1–5 cases.[9] Smaller portions of respondents indicated disclosing/proceeding with partial matches in 11–25 cases (3 labs), 26–50 cases (1 lab), 51–75 cases (1 lab), and over 100 cases (2 labs). Similar to FDS, convictions resulting from partial matches were very rare. Only 20% of labs (7 labs) that disclosed/proceeded with partial matches reported any convictions resulting from those cases.

3.3.3. Case eligibility and processing

The survey asked labs to select from a list of eligibility criteria for performing familial searches or disclosing/proceeding with partial matches (see Fig. 8). If respondents selected “case status,” “DNA sample specifications,” or “crime type” they were presented with additional options in those sub-categories to further specify eligibility criteria. Labs reported more eligibility requirements for FDS than PM. Labs also tend to have very consistent practices for FDS while no single eligibility criteria was indicated by a majority of labs for PM. Eligibility criteria

[8] The Chi-square analyses used the continuity correction since these were 2 × 2 categorical comparisons. Some analyses had less than 5 counts per cell; in these instances, the Fisher's Exact Probability Test was checked, which confirmed results in all cases.

[9] Eight lab respondents reported no cases, and 25 labs reported 1–5 cases.

Resources Labs Used for Guidance on Decision to Use FDS or Not (n=94)		Reasons Labs Are Not Using FDS (n=50)	
FBI/NDIS guidance	44%	Lack of clear guidelines	34%
Our state's legislation or court rulings	37%	Expected usefulness	26%
Practices within other jurisdictions	34%	Training	24%
Other states' legislation or court rulings	18%	Technological considerations	22%
My lab has not considered whether or not to use FDS	17%	Cost/resources	12%
Membership organizations (e.g., ASCLD)	12%	Prohibited by state	12%
My lab has not used any resources to guide its decision	9%	Prohibited by another entity	8%
Other	31%	Civil liberty concerns	8%
		Other	6%

Fig. 4. Resources and reasons in deciding whether or not to use FDS.
Note. Additional resources written in by labs for resources used to help with decision-making included resources related to the Attorney General's office; Department of Justice; local District Attorney's office; department legal counsel; state CODIS administrator or state lab; journal articles; trainings; and other forensic commissions, working groups, or oversight committees. "Other" reasons why the lab is not using FDS all related to the respondent not being an SDIS lab.

	Neither (n=51)	Only PM (n=30)	FDS (n=12)
Familial DNA searching has the potential to increase the ability of crime labs to identify suspects.✦	3.9	4.2	4.3
Disclosing/proceeding with partial matches has the potential to increase the ability of crime labs to identify suspects.*	3.6_a	4.1_b	3.4_a
Support for familial DNA searching scale*	2.5_a	2.8_a	4.1_b
Support for partial matching scale*	2.5_a	3.1_b	3.4_b

* Asterisked items have statistically significant differences in ratings between lab types, according to ANOVA tests (p<.05). For these items, ratings that do not share lettered subscripts (e.g., a, b, c) are significantly different from each other according to Bonferroni post-hoc tests.

✦The ANOVA test was significant for this item (F[2,91]=3.68, p=.029), but post-hoc tests were not (p=.100 and p=.101), indicating that overall there were statistically observed differences between groups, but these differences could not be detected when comparing each group to each other while controlling for type I error. This may be due to a lack of power for specific comparisons due to the small sample size for FDS labs.

Fig. 5. Average Perceived Potential and Institutional Support for FDS and PM by Lab Type.

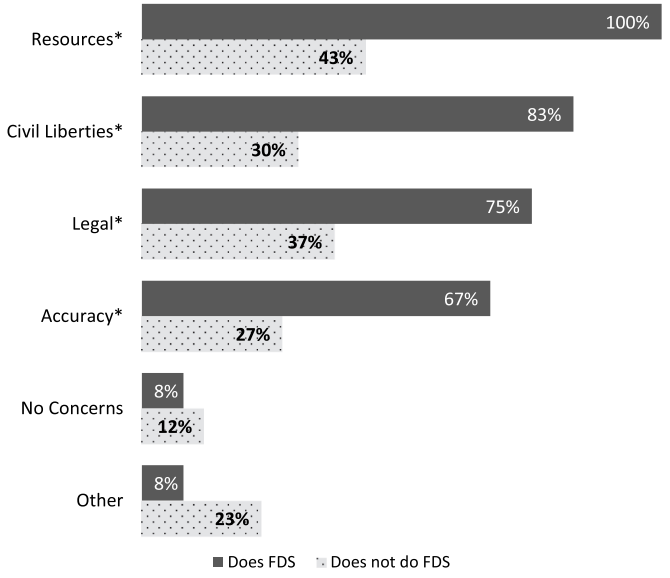

Fig. 6. Percentage of labs endorsing concerns related to familial DNA searching by whether or not lab conducts familial DNA searching.
Note. Asterisks denote statistical significance at the $p < .05$ level. "Other" responses included issues related to prohibition by state or agency law/policy, lack of guidance on whether it is allowed, and usefulness (e.g., whether it produces meaningful results).

for FDS included exhausting all other investigative leads (100% of labs using FDS), DNA sample specifications such as number of profiled alleles or being single-source (92%), commitment from police (92%) or prosecution (83%) to pursue the case, exigent circumstances/high public safety risk (83%), and particular crime types (75%). While labs tended to focus more on violent crimes, one lab reported that property crimes would also be eligible for FDS. The majority of FDS labs accepted both active/open cases (83%) and cold cases (83%).

Since FDS does not occur as part of a routine CODIS search (as with PM), labs that conduct FDS were asked what entity(s) in their jurisdictions typically request or approve familial searches. Nearly three-quarters (73%) of labs reported requests coming from police agencies, while labs also noted requests from the crime laboratory itself (46%), prosecution (27%), or a multi-stakeholder committee (18%). All labs said that the crime laboratory must approve the request for the familial search; additionally, some labs also required approval from a multi-stakeholder committee (33%), police (17%), and prosecution (8%).

Once FDS is approved, the lab performs the actual search. Specialized software is a key component of FDS, and the survey asked labs to specify what software they use. Four states reported using software developed by the Denver Police Crime Lab, four use MPKin FS Edition developed by the University of North Texas, and one apiece use GeneMarker and software developed internally by California's state laboratory. All of the labs indicated that they performed their own validation checks on the programs before beginning to use them for familial searches.

FDS labs reported using the tool with convicted offender (83%), arrestee (50%), and forensic unknown (42%) profiles, and more rarely with other types of profiles such as suspects, victims, missing persons, or lab staff (8–17%). Labs performing FDS were also asked whether they had used FDS in more unique circumstances. Four labs reported using FDS with female offenders,[10] but none indicated using FDS on

[10] Whether labs interpreted this to mean conducting FDS to identify a female

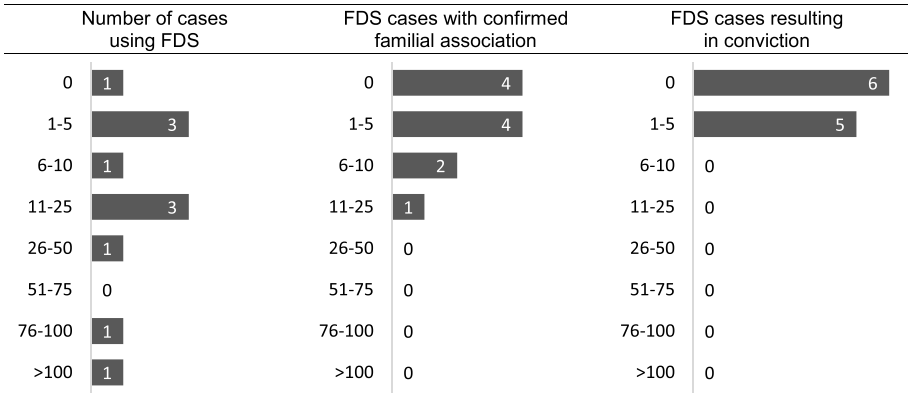

Fig. 7. number of labs reporting FDS cases and outcomes.

	FDS (n=12)	PM (n=40)
Exhausted all other investigative leads	100%	25%
Case status	92%	28%
Active/open cases	*83%*	*25%*
Cold cases	*83%*	*23%*
Serial/related crimes	*83%*	*20%*
Other	*8%*	*0%*
DNA sample specifications	92%	53%
Minimum number of alleles profiled	*67%*	*38%*
Single-source sample	*67%*	*43%*
Non-degraded sample	*50%*	*20%*
Other	*33%*	*13%*
Commitment from police	92%	43%
Commitment from prosecution	83%	40%
Exigent circumstances	83%	25%
Crime type	75%	25%
Homicide	*67%*	*30%*
Other violent/person crimes	*67%*	*18%*
Sexual	*50%*	*30%*
Property	*8%*	*8%*
Weapon	*8%*	*5%*
Drug	*0%*	*5%*
Other	*0%*	*8%*
No eligibility criteria	0%	38%
Other	17%	13%

Fig. 8. Percentage of Labs Reporting Eligibility Requirements for FDS and PM.
Note. "Other" eligibility responses included eligibility criteria related to NDIS guidelines, statistical thresholds, and lineage testing ability or results. "Other" case status responses included one response related to a mixtures of case status and crime type. "Other" DNA sample specifications included responses related to allowing mixed samples if a single source could be deduced, specific loci requirements, statistical thresholds, and ability to type Ys. "Other" crime types included other crimes with significant safety concerns, all violent crimes, and all crime types.

mixed DNA samples or for exoneration purposes.[11] Only one lab reported using FDS in inter-state searches, compared to 35% of labs using PM.

Although PM occurs as part of routine CODIS searches, we were curious if labs ever manually change the default search settings, which could make identifying a partial match more or less likely. A small number of surveyed labs reported restricting searches to high-stringency searches (that would not result in finding partial matches) for all (8%) or some (5%) searches. No labs reported changing the settings to low-stringency searching for all searches, but one lab reported changing the setting to a lower-stringency search for some searches, as needed.

The survey also asked labs to select listed requirements they must meet before releasing the identity of a DNA profile found through FDS or PM to law enforcement (see Fig. 9). All labs performing FDS noted that they must conduct Y-STR testing on potential male relatives, confirming lineage testing's key role in FDS. Interestingly, about half of labs that disclose/proceed with partial matches also reported that Y-STR testing was required prior to releasing information from a partial match. Commitments by other justice professionals to pursue the case and additional levels of approvals were the next most common requirements. Training and additional investigation (e.g., through records research) were also required for one-quarter of the labs using FDS (but slightly fewer labs using PM). While all FDS labs reported some extra requirements before releasing information found through FDS, nearly one-fifth (18%) of labs disclosing/proceeding with partial matches said they had no additional requirements that must be met before they could release the results of partial matches to law enforcement.

Labs were asked about differences in collecting DNA confirmation samples from suspects in FDS and PM cases compared to cases that do not use these techniques. One-quarter (25%) of FDS labs noted differences, such as a preference for a surreptitious sample, longer discussions between the lab and law enforcement, and more training or

(*footnote continued*)
perpetrator of a crime or to identify a potential female family member in the CODIS database is unclear. To date, we are unaware of any instances of FDS being used when the perpetrator of the crime being investigated was female.

[11] However, a partial match was used to help exonerate Darryl Hunt in 2003, after serving 19 years in prison for a murder he did not commit, demonstrating the potential for FDS to similarly be used for this purpose in the future.

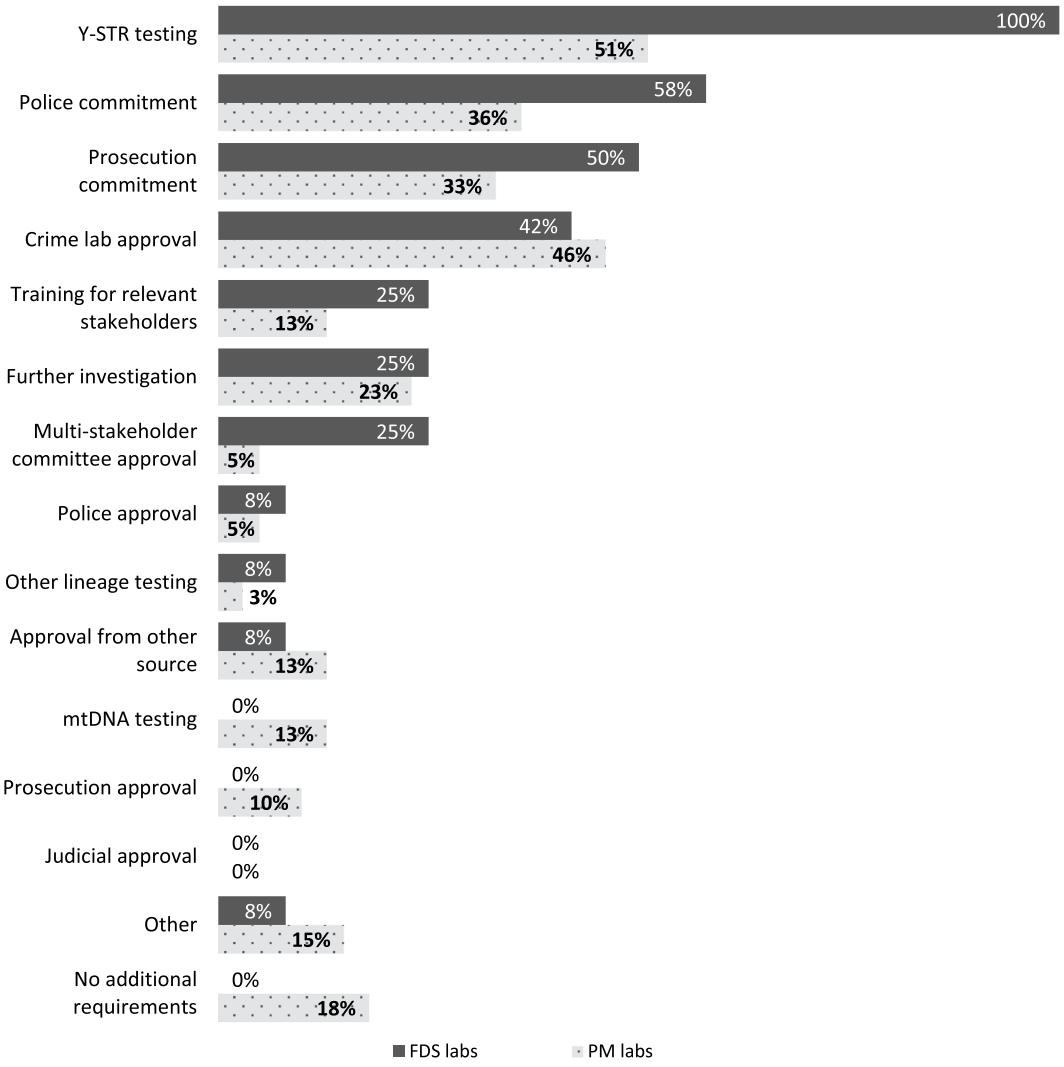

Fig. 9. Percentage of Labs Reporting Requirements for Releasing Investigative Lead Information.
Note. "Other" requirements included responses related to additional statistical evaluations and joint approvals. "Other sources of approval" responses included approval from additional labs, committees, the Attorney General, or Office of Chief Counsel.

education for law enforcement. Only 8% of PM labs reported differences in confirmation DNA sample collection between the types of cases. Similarly, labs were asked about differences in investigative practices between FDS or PM cases and normal DNA match cases. Three-quarters of FDS labs and a little over half (53%) of PM labs reported differences. Similar types of differences were noted by both sets of labs, including extra consideration for the privacy of potential relatives of the offender, education provided by the crime lab to law enforcement on the search results, the construction of a family tree through geographical and biological information, and assigning FDS cases to detectives with special training.

3.3.4. Challenges

Lastly, both sets of labs were asked if they had experienced any challenges when conducting FDS or PM. Only 33% of FDS labs and 23% of PM labs reported challenges, including issues related to interagency collaboration, resources/budget, technical challenges, and the fact that they have not found any successful associations to date (see Fig. 10). Additionally, no labs reported any legal challenges against FDS in courts in their jurisdictions/states.

4. Discussion

Findings from the National Survey of CODIS Laboratories offer a comprehensive portrait of CODIS crime labs' perceptions, policies, and procedures regarding FDS and PM. These two practices, similar but distinct (and sometimes confused with each other), have been understudied forensic areas with limited information and guidelines beyond anecdotal accounts. This survey of 103 CODIS crime labs (77% response rate) offers systematic data to help understand current practices regarding the two forensic tools.

Twelve labs across 11 states reporting performing FDS, with adoption of the practice ranging from 2007 to 2014 (the year the survey was administered). A substantially higher number (40 labs) reported being able to disclose or proceed with partial matches found through routine searches of CODIS. Labs reported modest numbers for using either of these tools and for conviction outcomes resulting from them, indicating that they are not being used as routine practice, and in the case of FDS, tend to be reserved for specifically selected cases.

Survey results demonstrated that perceptions of these practices were generally positive, with most respondents (87%) believing that FDS has potential to assist investigations and the majority (69%) of respondents feeling that PM has such potential. However, perceived institutional support was more variable, and labs shared a number of concerns or

	FDS (n=12)	PM (n=35)
Our jurisdiction has not experienced any challenges	67%	77%
Interagency collaboration (e.g., lack of coordination or training)	8%	6%
Prosecution (e.g., prosecution did not pursue case)	8%	6%
Resources (e.g., insufficient staff, budget)	0%	6%
Technical (e.g., lack of sophisticated software/equipment)	0%	6%
Investigation (e.g., police did not pursue lead)	0%	3%
Legal (e.g., case being overturned)	0%	0%
Other	25%	11%

Fig. 10. Percentage of labs reporting challenges when conducting FDS and PM.
Note. "Other" challenges included responses related to not having any found associations to date, a critique of training, and lack of victim cooperation.

challenges related to FDS. Despite this, interest in FDS remains high as evidenced by the majority of labs reporting past or current consideration of the tool. Analysis of those labs not performing FDS suggests that the primary reason may be a lack of guidelines or other logistical concerns, as opposed to ethical or legal concerns.

Most labs using these tools reported having publicly available policies and/or provided training to help guide criminal justice staff with the use of these tools, although both were more common for FDS compared to PM. Similarly, eligibility restrictions were more common for FDS than for PM. All FDS labs had specific processes for approving a request to perform FDS, which always included approval from the crime lab but also could include other entities such as multi-stakeholder committees, police, or prosecution. Respondents reported a small number of software programs (four) being used for FDS, and validation was an important initial implementation step for all FDS labs. Labs often had additional layers of approval or requirements that needed to be met prior to releasing information about potential family associations, again with more requirements for FDS cases than for PM. For the most part, labs reported that after releasing a lead to law enforcement, the investigation was fairly similar to other types of DNA cases. However, some labs did share that there were differences in collecting the confirmation DNA sample, providing additional education or training to investigators, building family trees through records data, and taking special precautions for the privacy of family members.

While most labs reported using FDS with convicted offender profiles in CODIS, survey respondents also reported searching for family associations within arrestee, suspect, and other types of profiles (e.g., victims, missing persons), which may draw concern from privacy advocates or others fearful about expanded "genetic surveillance" or DNA databasing. Although the existing literature discusses using FDS to solve crimes committed by both genders and for exoneration purposes, this appears to be mostly theoretical at this point since labs shared challenges related to using FDS to identify female family relationships and no labs reported using FDS for exoneration purposes. Inter-state FDS searches were also not common practice among surveyed labs, although it was more likely to occur with PM cases.

Overall, although only 12 labs reported using FDS, their practices were remarkably consistent. Disclosing or proceeding with partial matches, on the other hand, was more commonly allowed, but had wider variation in requirements and practices. Across the board, policies and practices around FDS tended to be more stringent with greater requirements and restrictions at various stages of the process. These differences in requirements and protections are notable since the two practices involve many of the same concerns and challenges from opponents. Therefore, it may be advisable to have similar protections in place for disclosing/proceeding with partial matches (especially given the fact that PM is not specifically designed to detect family relationships and may result in lower accuracy of investigative leads).

Though these survey findings offer some of the first systematic data on variations in policies, practices, and procedures related to familial DNA searching (and the closely aligned practice of PM), there are some important limitations to note. The most significant is that FDS is still an emerging practice and, given this, it is difficult to draw representative data from the limited available experiences of FDS. As the practice evolves, researchers should continue studying its impacts and revisit the conclusions drawn through this study.

The survey had a high response rate (77%), but it is possible that those labs that did not respond could change the results of the study, especially if any of them perform FDS. However, from ICF's other background research, it is unlikely that these non-responding labs perform FDS at this time. There was also some evidence of confusion among a small number of survey respondents regarding definitions of FDS and PM. To resolve this, ICF held follow-up discussions with survey respondents where potential confusion was detected, correcting responses as necessary if definitions or questions had been misunderstood.

Ultimately, FDS in the U.S. is still in its relative infancy, and potential impacts will be better understood in the future as more cases undergo this technique. We hope that, in the meantime, the information gathered through this study will help guide other jurisdictions in their decision-making by offering an initial foundation of knowledge. This knowledge can inform discussions around FDS through sharing the existing practices, leading concerns, and perceived benefits from those who have already begun to navigate these complex decisions.

Acknowledgments

The Study of Familial DNA Searching was sponsored by the National Institute of Justice (NIJ), U.S. Department of Justice. The authors wish to thank the current and former NIJ staff who assisted with this project, including Eric Martin, Katharine Browning, and Laurie Bright. We also thank the other team members who contributed to this study, including Avi Bhati, Simone Boyce, Christina Nguyen, and Saniya Seera, as well as former ICF staff who worked on this project including Seri Irazola, Emily Niedzwiecki, Sarah Calhoun, and Alex Barton. We have also benefited from the insight and expertise of individuals outside the ICF and NIJ teams, for which we are extremely grateful in helping to guide the study. Our partners and roundtable members have been indispensible in the success of this project: William Blackburn, Douglas Hares, Jay Henry, Greggory LaBerge, Gerald LaPorte, Julia Leighton, Kevin Lothridge, Mitchell Morrissey, Ron Reinstein, Michael Risher, Steven Siegel, Jason Tulley, Jennifer Wendel, and Richard Wilson. And finally, this survey could not be completed without the generous time given by our confidential respondents - thank you all for sharing your time and experiences with us; we are immensely grateful.

Funding

This work was supported by the National Institute of Justice, Office of Justice Programs, U.S. Department of Justice [Award No. 2013-R2-CX-0013]. The opinions, findings, and conclusions or recommendations expressed in this publication are those of the authors and do not necessarily reflect those of the U.S. Department of Justice or ICF.

Conflicts of interest

None known.

References

[1] E. Steinberger, G. Sims, Finding criminals through the DNA of their relatives – familial searching of the California offender DNA database, Prosecutor's Brief. 31 (1–2) (2008) 28–32.
[2] Federal Bureau of Investigation, SWGDAM Recommendations to the FBI Director on the Interim Plan for the Release of Information in the Event of a Partial Match at NDIS, Forensic Science Communications 11 (4) (2009).
[3] F.R. Bieber, C.H. Brenner, D. Lazer, Finding criminals through DNA of their relatives, Science 312 (5778) (2006) 1315–1316.
[4] J. Ge, R. Chakraborty, A. Eisenberg, B. Budowle, Comparison of familial DNA database searching strategies, J. Forensic Sci. 56 (6) (2011) 1448–1456.
[5] T. Hicks, F. Taroni, J. Curran, J. Buckleton, V. Castella, O. Ribaux, Use of DNA profiles for investigation using a simulated national DNA database: Part II. Statistical and ethical consideration on familial searching, Forensic Science International: Genetics. 4(5) (2010) 316–322.
[6] S.P. Myers, M.D. Timken, M.L. Piucci, G.A. Sims, M.A. Greenwald, J.J. Weigand, K.C. Konzak, M.R. Buoncristiani, Searching for first-degree familial relationships in California's offender DNA database: validation of a likelihood ratio-based approach, Forensic Science International: Genetics. 5 (5) (2011) 493–500.
[7] R.V. Rohlfs, S.M. Fullerton, B.S. Weir, Familial identification: Population structure and relationship distinguishability, PyLOS Genetics 8 (2) (2012).
[8] K. Slooten, R. Meester, Probabilistic strategies for familial DNA searching, Journal of the Royal Statistical Society Series C. 63 (3) (2014) 361–384.
[9] C.E. Pu, A. Linacre, Systematic evaluation of sensitivity and specificity of sibship determination by using 15 STR loci, J. Forensic Legal Med. 15 (5) (2008) 329–334.
[10] D. Mueller, Can simple population genetic models reconcile partial match frequencies observed in large forensic databases? J. Genet. 87 (2) (2008) 101–108.
[11] T.M. Reid, M.L. Baird, J.P. Reid, S.C. Lee, R.F. Lee, Use of sibling pairs to determine the familial searching efficiency of forensic databases, Forensic Science International: Genetics. 2 (4) (2008) 340–342.
[12] J. Epstein, "Genetic surveillance" - the bogeyman response to familial DNA investigations, journal of law, technology, and, Policy 2009 (1) (2008) 141–173.
[13] J.D. Gabel, Probable cause from probable bonds: a genetic tattle tale based on familial DNA, Hastings Women's Law Journal. 21 (1) (2010) 3–58.
[14] Innocence Project, Innocence Project position on familial searching of DNA databases. http://www.innocenceproject.org/free-innocent/improvethe-law/FamilialSearchPolicyFinal.pdf/view, n.d.
[15] D. Kaye, S. Mercer, B. Jenkins, Family feud: The familial DNA search controversy continues, Forensic Magazine, 2011, http://www.forensicmag.com/article/2011/09/family-feud-familial-dna-search-controversy-continues.
[16] E. Murphy, Relative doubt: familial searches of DNA databases, Michigan Law Review. 109 (3) (2010) 291–348.
[17] A. Pattock, It's all relative: Familial DNA testing and the fourth amendment, Minnesota Journal of Law, Science, & Technology 12 (2) (2011) 851–876.
[18] N. Ram, Fortuity and forensic familial identification, Stanford Law Review. 63 (4) (2011) 751–812.
[19] Bureau of Justice Assistance (BJA), An introduction to familial DNA searching for state, local, and tribal justice agencies: Issues for consideration (NCJ 238603), U.S. Department of Justice, Office of Justice Programs, Bureau of Justice Assistance, Washington, DC, 2012.
[20] H.T. Greely, D.P. Roirdan, N.A. Garrison, J.L. Mountain, Family ties: the use of DNA offender databases to catch offenders' kin, journal of law, Medicine & Ethics. 34 (2) (2006) 248–262.
[21] D.J. Grimm, The demographics of genetic surveillance: familial DNA testing and the Hispanic community, Columbia Law Review. 107 (5) (2007) 1164–1194.
[22] B. Mares, A chip off the old block: familial DNA searches and the African American community, Law & Inequality. 29 (2) (2011) 395–424.
[23] E. Haimes, Social and ethical issues in the use of familial searching in forensic investigations: insights from family and kinship studies, the journal of law, Medicine & Ethics. 32 (2) (2006) 263–276.
[24] M. McCarthy, Am I my brother's keeper?: familial DNA searches in the twenty-first century, Notre Dame Law Review. 86 (1) (2011) 381–412.
[25] D.H. Kaye, The genealogy detectives: a constitutional analysis of "familial searching", American Criminal Law Review. 51 (1) (2013) 109–163.
[26] J. Kim, D. Mammo, M.B. Siegel, S.H. Katsanis, Policy implications for familial searching, Investigative Genetics 2 (22) (2011).
[27] DNA-Sample Collection and Biological Evidence Preservation in the Federal Jurisdiction, 73 Federal Register 238, 10 December 2008, pp. 74932–74943.
[28] Forensic Technology Center of Excellence, Familial DNA searching: Current approaches – Final report, https://rti.connectsolutions.com/p49iz1rzbpi/, (2015).