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Familial searching: A specialist forensic DNA profiling service utilising the National DNA Database® to identify unknown offenders via their relatives—The UK experience

C.N. Maguire [a,*], L.A. McCallum [b], C. Storey [c], J.P. Whitaker [d]

[a] *Consolidated Forensic Laboratory, DC Department of Forensic Sciences, 401 E Street SW, Washington, DC 20024, United States*
[b] *SPSA Forensic Services, Nelson Street, Aberdeen, AB24 5EQ, UK*
[c] *Warwickshire Police HQ, Leek Wootton, Warwickshire, CV35 7QB, UK*
[d] *Principal Forensic Services Ltd., 18 York Road, Wetherby, LS22 6SL, UK*

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ABSTRACT

The National DNA Database (NDNAD) of England and Wales was established on April 10th 1995. The NDNAD is governed by a variety of legislative instruments that mean that DNA samples can be taken if an individual is arrested and detained in a police station. The biological samples and the DNA profiles derived from them can be used for purposes related to the prevention and detection of crime, the investigation of an offence and for the conduct of a prosecution. Following the South East Asian Tsunami of December 2004, the legislation was amended to allow the use of the NDNAD to assist in the identification of a deceased person or of a body part where death has occurred from natural causes or from a natural disaster [1].

The UK NDNAD now contains the DNA profiles of approximately 6 million individuals [2] representing 9.6% of the UK population [3]. As the science of DNA profiling advanced, the National DNA Database provided a potential resource for increased intelligence beyond the direct matching for which it was originally created [4].

The familial searching service offered to the police by several UK forensic science providers exploits the size and geographic coverage of the NDNAD and the fact that close relatives of an offender may share a significant proportion of that offender's DNA profile and will often reside in close geographic proximity to him or her. Between 2002 and 2011 Forensic Science Service Ltd. (FSS) provided familial search services to support 188 police investigations, 70 of which are still active cases. This technique, which may be used in serious crime cases or in 'cold case' reviews when there are few or no investigative leads, has led to the identification of 41 perpetrators or suspects.

In this paper we discuss the processes, utility, and governance of the familial search service in which the NDNAD is searched for close genetic relatives of an offender who has left DNA evidence at a crime scene, but whose DNA profile is not represented within the NDNAD. We discuss the scientific basis of the familial search approach, other DNA-based methods for eliminating individuals from the candidate lists generated by these NDNAD searches, the value of filtering these lists by age, ethnic appearance and geography and the governance required by the NDNAD Strategy Board when a police force commissions a familial search. We present the FSS data in relation to the utility of the familial searching service and demonstrate the power of the technique by reference to casework examples.

We comment on the uptake of familial searching of DNA databases in the USA, the Netherlands, Australia, and New Zealand.

Finally, following the adverse ruling by the European Court of Human Rights against the UK in regard to the S & Marper cases [5] and the consequent introduction of the Protection of Freedoms Act (2012) [6], we discuss the impact that changes to regulations concerning the storage of DNA samples will have on the continuing provision of familial searching of the National DNA Database in England and Wales.

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1. Introduction

In 2002 Forensic Science Service Ltd. (FSS) introduced familial searching of the UK National DNA Database (NDNAD) to support

* Corresponding author. Tel.: +1 202 442 8058; mobile: +1 202 263 9574.
E-mail addresses: christopher.maguire@dc.gov, maguirecn@gmail.com (C.N. Maguire).

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and progress criminal investigations in which a full DNA profile was available, originating from some biological trace evidence believed to have been left at a crime scene by the true offender, but where no match was recorded with the profiles of any individuals retained on the NDNAD. The introduction of this technique led to the identification of the man responsible for the killing of three 16-year-old girls in South Wales in 1973 [7], a series of offences that became known as the Llandarcy murders: the first success for the embryonic familial search process.

The first successful prosecution of an individual identified through familial search techniques occurred in 2004 when Craig Harman admitted to the manslaughter of Michael Little [8]. Harman threw a brick from a motorway bridge that crashed through the windscreen of Mr Little's lorry, striking him in the chest and causing him to have a fatal heart attack.

In this paper, the DNA profile recovered from the crime scene is designated the 'target DNA profile' and the subsets of the NDNAD profile data generated by the familial search process are designated as the 'candidate lists'. The power of the familial search approach relies on a full target DNA profile being available for searching and hence partial DNA profiles, whether generated from limited or degraded DNA samples or as a result of the de-convolution of mixtures, are excluded from this application.

Under the assumption that the target DNA profile is that of the true offender and is relevant to the offence, there may be a number of explanations as to why that offender's DNA profile is not present in the National DNA Database. For example, this might be the offender's first offence; this individual's other offence's may have gone undetected or unreported; the offender might have left the jurisdiction of UK police forces or he might have died subsequent to the offence being committed.

The FSS designed two types of search algorithms to (a) identify any DNA profile within the NDNAD that could be related to the target DNA profile as a parent or child, and (b) to identify those individuals more likely to be related as siblings to the true perpetrator by ranking the DNA profiles held in the NDNAD by the number of alleles shared with the target DNA profile. In effect, using these algorithms to search the NDNAD generates two candidate lists; a parent/child list and a sibling list (Figs. 1 and 3).

If the DNA profile of the true offender is not present in the NDNAD, the familial search algorithms aim to locate first order relatives (parent/child or siblings) of the offender by exploiting the fact that the DNA profiles of close genetic relatives are expected to exhibit a high degree of similarity to that of the offender [9]. This technique has the potential to generate adventitious matches as demonstrated by simulation experiments carried out by Reid et al. [10] and O'Connor [11] but the search processes have been designed to minimise these issues and to provide focussed investigative leads for the police team. The search processes are discussed below.

The technique of familial searching of DNA database has raised some fundamental legal and ethical issues [12,13] and, though there is great interest in the utility of this technique, its use is relatively limited outside the UK.

2. Familial searching approach in the UK

Familial Searching of the UK National DNA Database is based on five general principles. These are:

1. The DNA profiles of close genetic relatives will exhibit a greater degree of genetic similarity to that of a true offender than unrelated individuals. This is because DNA is inherited such that children receive half of their DNA alleles from each parent. The extent to which siblings share their DNA is variable, but on average two siblings might be expected to share about 65% of their DNA alleles [9],
2. Research indicates that family members of an offender might also be involved in offending behaviour due to the social environment in which they live and therefore have an increased likelihood of their DNA profile being included in the NDNAD [14–16]. In the USA, data from the National Bureau of Statistics indicates that a significant number of incarcerated prisoners indicated that they had minor children (under 17 years) living at home [17]. The same study showed that 50% of these incarcerated parents also had close relatives who had been imprisoned (34% brothers and 19% fathers) [18],
3. Family members tend to reside within a restricted geographic area [19],
4. Family dispersion is positively correlated with higher income and higher education [20]. It may be asserted that those with a propensity to offend are often from lower income families and consequently the opportunities for family dispersion may be more limited,
5. Some studies indicate that offenders tend to commit crimes in close geographic proximity to where they live [21–23].

Whilst some of these claims are supported by results of the DNA Familial Search programme in England and Wales there are other researchers who have raised significant concerns about the governance and ethics of this approach to crime investigation. Haimes [12] summarises these concerns succinctly as:

i. Violating the privacy of the person already on the NDNAD,
ii. Violating the privacy of the (potentially large) pool of possible relatives revealed by these procedures who would otherwise not be involved in police investigations,
iii. Reinforcing views about the alleged prevalence of criminality within certain families,

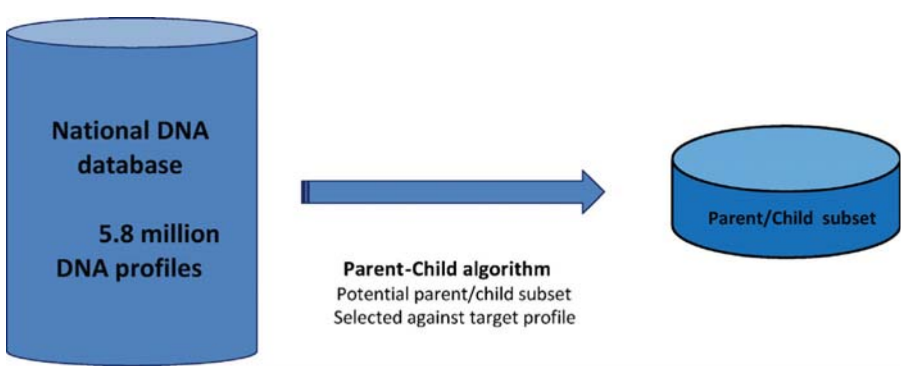

Fig. 1. The Parent/Child algorithm creates a subset of DNA profiles by selecting only those DNA profiles which share a single allele at each locus with the target DNA profile.

iv. Revealing to relatives the presence of a family member on the NDNAD,
v. Revealing a previously unknown genetic link between individuals, Revealing an absence of a genetic link, which individuals had thought, existed.

All of the agencies concerned with the definition and delivery of familial searching of the UK National DNA Database, including the forensic science providers, acknowledge the relevance of these issues and have taken steps to ensure there is a sufficient level of policy and procedural governance of them, even though there is no specific legislative instrument through which familial searching is authorised in England & Wales. All of the forensic science suppliers in the UK are subject to the Governance and Ethics regimes described below, though each of the forensic science suppliers have developed their own familial search algorithms and Likelihood Ratio ranking applications.

3. Familial searching process – governance and ethics

Familial searching makes use of the fact that related individuals are more likely to share alleles at a locus than those who are unrelated and parents and children share alleles in a particular and specific way. These techniques are used to:

- Investigate the most intractable cases,
- Re-start or re-invigorate stalled investigations,
- Support victim-led cold case reviews, and
- Provide an added value intelligence service to the Criminal Justice System.

These techniques exploit the retention and storage of DNA profiles in a searchable form in a local, state or nationally maintained DNA database; supporting the Police and Criminal Justice System by providing an intelligence tool to aid criminal investigations and assisting in the exoneration of the innocent and prosecution of true offenders.

There is no legislation in the UK that specifically allows or mandates the police or the forensic community to use the technique of familial searching of the National DNA database. The technique was developed because of a technical 'push' rather than from a societal 'pull' and, perhaps for this reason, the governance processes which are now in place were developed as the practical technique evolved rather than being established or legislated prior to its inception (c.f. the situation in the Netherlands as outlined below).

Familial searching is a process which is often initiated during a 'cold case' investigation of undetected sexual offences or homicide cases. The police investigative team will consult their forensic science supplier to identify the availability of evidential materials from which a DNA profile may be derived. These might include microscope slides made for the identification of spermatozoa, tapings from semen or blood stained clothing or DNA extracts prepared during earlier examinations. The police may also consult with the victim of an unsolved sexual offence and may choose whether or not to undertake the investigation without his/her express permission.

Before any familial search programme is initiated, the police investigation team must seek and receive approval from the National DNA Database Strategy Board. These letters of approval become part of the investigation policy documentation. The police investigation team will then receive advice from the forensic supplier about the familial search methodology and the limitations of the technique. The police are required to complete a form for the forensic science provider indicating their understanding of the process. This form becomes part of the investigative policy documentation and is, in effect, the 'contract' between the forensic science provider and police investigative team [24].

The NDNAD Strategy Board is made up of members representing the Association of Chief Police Officers and ACPO (Scotland), the Home Office, the UK Forensic Science Regulator, the NDNAD Ethics Group, the Information Commissioner, the NPIA, the Scottish Police Services Authority, and the Criminal Justice Service and Scientific Support Services of Northern Ireland [25].

The NDNAD Ethics Board monitors and reviews the use of the familial search technique in the UK [26].

4. Familial searching process – practical considerations

The UK National DNA Database grew rapidly from its inception on 10th April 1995 largely due to government support of £235 million for sample collection between 2000 and 2005 [27] and a series of legislative instruments [1], which created the world's first arrestee database. It is the size of the NDNAD that makes familial searching a particularly effective investigative technique.

The utility of familial searching of a DNA database is predicated on the fact that close genetic relatives are likely to have more similarities in their DNA profiles than unrelated individuals. The familial search technique is a two-step approach:

- To establish candidate lists based on a specific allele sharing pattern (parent/child) and the degree of allele sharing (siblings)
- To refine and rank the candidate lists by taking into account the genetic information using a likelihood ratio (LR) and parameters of geography, age and ethnic appearance, which will be unique to each case.

5. Parent/Child relationships – theoretical considerations

Since a child inherits half of his alleles from his father and half from his mother a parent/child algorithm has been designed which searches the DNA database for any profile that has one matching allele in common with the target profile at each locus. This algorithm generates a subset of the DNA database of all those profiles that could represent that of a parent or child of the individual from whom the target profile originated. This is shown graphically in Fig. 1 below:

This 'at least one allele per locus' matching approach was the first method used by FSS Ltd. Subsequent refinements in 2007/8 led to the consideration of the allele frequencies to rank the candidate lists by likelihood of relationship (Likelihood Ratio approach).

Depending on the rarity of the alleles in the target profile, the parent/child subset may contain hundreds or thousands of DNA profiles. If the alleles in the target profile are particularly common then this file might contain three to five thousand profiles. In our experience these files are of a manageable size.

6. Sibling relationships – theoretical considerations

Defining the genetics of a sibling relationship is far more difficult, and designing an algorithm to select potential siblings is also more challenging. The FSS approach was to rank the profiles in the National DNA database according to the number of alleles that the individuals' DNA profiles share with the target profile. Again this uses the principle that closely related individuals are expected to have more alleles in common than unrelated individuals.

STR DNA Profiling test chemistry in use in the UK is SGMplus^{TM}. This system has ten informative loci and a sex test (Amelogenin). Using the SGMplus^{TM} chemistry, any non-identical sibling pair may share as many as nineteen alleles in their DNA profiles or may share no alleles at all. Similarly, unrelated individuals can share alleles by chance and, again, this is described by a normal

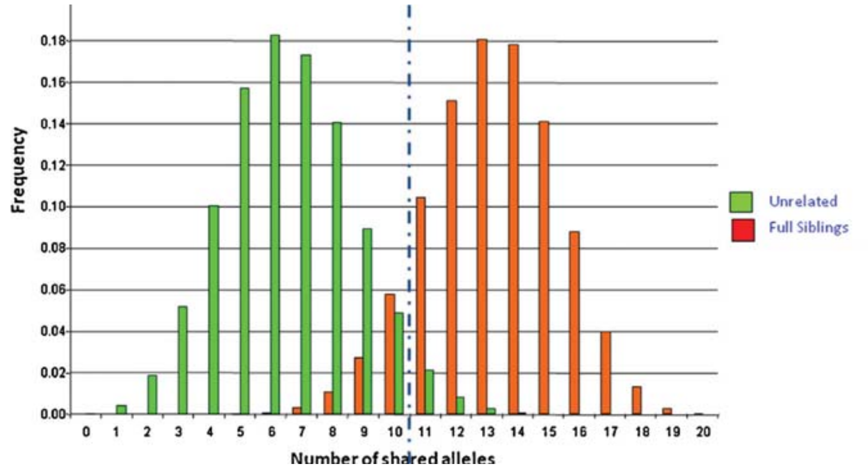

Fig. 2. Results of simulation experiments looking at the degree of allele sharing amongst siblings and unrelated individuals.

distribution. The results of such a simulation experiment are shown in Fig. 2 below. This work is unpublished FSS data of Lindsey Foreman.

The issue with using this approach is that there is an overlap between the number of shared alleles between the DNA profiles of potential siblings and unrelated individuals. The operator has to choose an appropriate 'cut off value' for the number of shared alleles knowing that:

- if the level chosen is high (13 shared alleles) there is a possibility of false exclusion of true siblings
- if the level chosen is low (7 shared alleles) there is a possibility of false inclusion of unrelated individuals

In practice this issue is discussed with the police investigation team and a joint decision made. Often the FSS will recommend a sibling cut off value of about 11 shared alleles.

Several researchers including Buckleton et al. [28], Bieber et al. [9], Jianye Ge [29] and Curran & Buckleton [30] have reported the results of simulation experiments, generating 'sibling' profiles within large databases and counting the number of shared alleles (or calculating Likelihood Ratios) between each sibling pair. These researchers have shown that the technique is very successful at locating parent/child or sibling pairs in large databases.

The sibling search algorithm in use by FSS Ltd. ranks the DNA profiles in the National DNA Database by the number of alleles shared with the target profile and by Likelihood Ratio (LR). The operator then selects those DNA profiles that meet the selected criteria of 'at least 11 alleles in common' and generates the output file accordingly. The sibling 'candidate lists' may contain many thousands of DNA profiles which are ranked by likelihood of relationship (Likelihood Ratio approach). This is shown diagrammatically below in Fig. 3.

It is important to note that the individuals identified by the Parent/Child or Sibling searches of the NDNAD cannot be responsible for the deposition of any of the DNA material under from which the target DNA profile has been derived; they are excluded from being the true perpetrator. The purpose of the test is to use the genetic similarities of DNA profiles of close relatives to identify a potential offender.

The UK NDNAD is linked to the Police National Computer, a system that contains data pertaining to the individual and their arrest records. This data includes:

- Subject (name, date of birth),
- Ethnic appearance (as determined by the arresting officer),
- Geographic factors (the police force and division where the sample was taken).

In the UK these non-genetic data can be used to filter the familial search results and to refine the information available to the police investigation team. By combining the results of the genetic testing (LR ranked candidate lists) and non-genetic (case specific) filters the scientist can present the police investigation with the most pertinent intelligence information. The ranked and filtered candidate lists can also be used as a starting point for additional genetic testing; Y-STR analysis (or mitochondrial DNA sequencing) can be utilised to further prioritise the candidate lists.

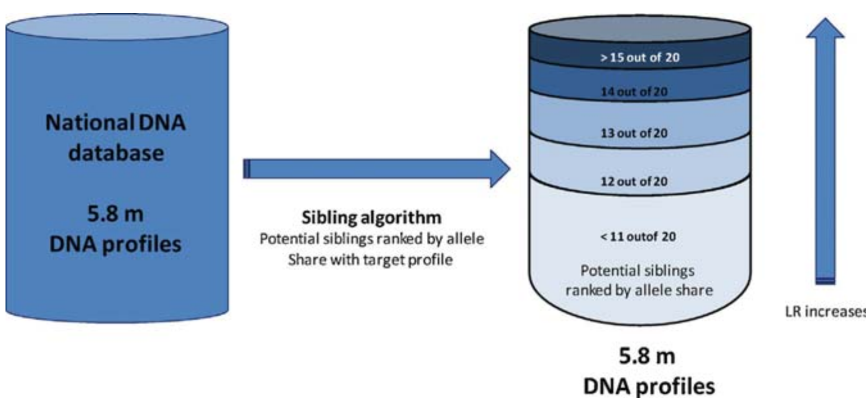

Fig. 3. Sibling Algorithm ranks the DNA profiles in the NDNAD according to the number of alleles shared with the target DNA profile.

7. The Familial search process

The individual process steps in the UK familial search protocol are as follows:

1. Police identify a case for which Familial Searching might generate an investigative lead and for which appropriate DNA-rich material, believed to be that of the true offender, is available
2. The appropriate permissions are obtained from the Chairman of the National DNA Database Strategy Board and in some instances (often cases of sexual assault) also from the victim
3. The NDNAD Custodian provides the forensic science provider with an extract of the NDNAD which is loaded onto an server containing software capable of running the Parent/Child and Sibling algorithms and generating the appropriate likelihood ratios. Note: This server is housed in the office of the NDNAD Custodian and no data contained within it or pertaining to the parent/child and sibling data subsets generated by the familial search process is allowed to be removed from the office of the NDNAD Custodian
4. In the FSS protocol Forensic intelligence Bureau staff undertake the familial search process; running the parent/child and sibling algorithms and generating four data files; two unfiltered data sets ranked by Likelihood Ratio only and two filtered data sets ranked by Likelihood Ratio and other non-genetic filters agreed with the police investigations team (Geography, Age, Ethnic Appearance)
5. The NDNAD Custodian takes these four data sets and further populates them with the case specific demographic data such as name and gender by reference to the sample unique identifiers (sample barcodes). These files are then encrypted and stored pending a meeting between the concerned agencies
6. A final meeting is arranged between the police investigation team, the FSS Forensic Intelligence Bureau team and the NDNAD Custodian at which the familial search results are revealed and discussed. It is at this meeting that investigative priorities are determined and further forensic support (e.g. Y-STR analyses) discussed

An outline of the complete familial search process is shown below in Fig. 4.

8. Familial searching process – FSS outcomes

DNA profiling has been used as an investigative tool in approximately 210 cases in the UK since its introduction as a forensic technique in 2002. The FSS Forensic Intelligence Bureau has undertaken familial searches relating to 188 of these cases. The familial search technique has proved to be an effective intelligence tool leading to the identification of the true perpetrator. The outcomes and utility of the FSS familial search process are shown in Table 2 below:

The utility of the familial search process as undertaken by the FSS Forensic Intelligence Bureau (FIB) is clear to see; 32 of the 188 completed familial search investigations (i.e. 17%) undertaken by FSS Ltd. resulted in the identification of a relative of the true offender. In addition, in a further 9 cases (4.8%) the relative(s) of the offender were present in the candidate list derived from the familial search though the police had identified the suspect by other investigative means.

9. Familial searching – LGC forensics and orchid forensics outcomes

The authors have been informed that LGC Forensics completed eleven familial search cases by December 2010; five of which have resulted in the identification of the true offender. Three of these cases resulted in a court disposal. The other six cases remain active.

Since 2003 Orchid Forensics has completed twelve familial search cases; five of which were undertaken in 2010. The authors have no details of the outcomes of these cases.

10. Effectiveness of non-genetic filters

As the UK National DNA Database is linked to the Police National Computer each DNA profile is associated with a unique identifier (barcode) and a comprehensive file of non-genetic demographic data which includes the arrestees name and date of birth, an ethnic appearance code, an arrest summons number and offence code and details of the police force and division where the sample was taken. The fact that this data exists allows the forensic science provider and the police investigation team to filter the raw

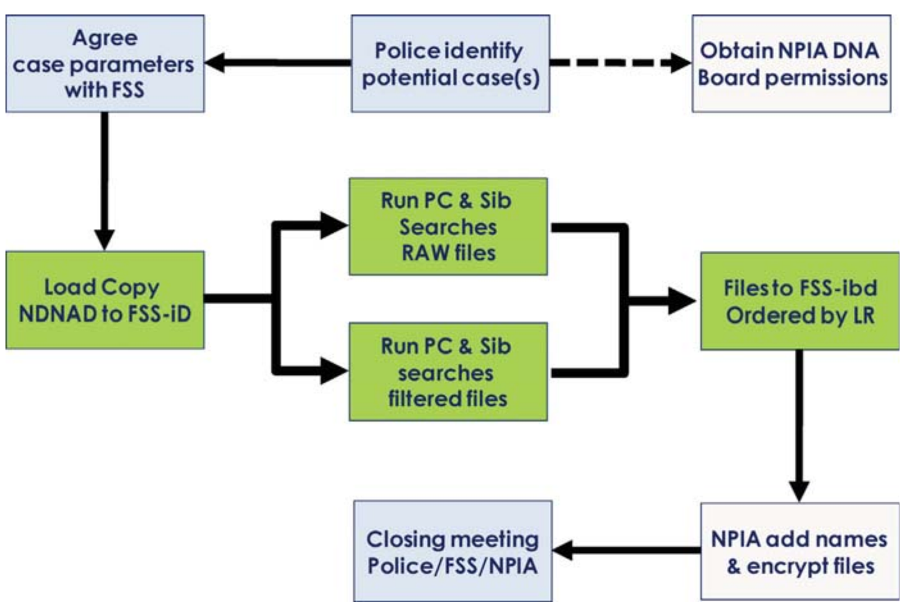

Fig. 4. The FSS Familial Search Process.

Table 1
Impact of additional filters on the position of the relative of the true offender in the candidate lists.

Operation	Offence	Parent/child (P/C) Sibling (allele count)	LR Only	+Ethnicity	+DOB	+Geography
Sparrow	Rape	Sib (16/20)	23/6806	1/918	1/912	1/27
Mallard	Sexual Assault (series)	Sib (15/20)	2/4694	13/4507	10/4440	2/541
Turf	Rape	Sib (14/20)	21/3351	62/3145	61/3113	4/122
Remark	Rape	Sib (12/20)	1261/1913	1265/1784		35/45
Dakota	Sexual Assault (series)	P/C	330/3391	320/3119	235/2476	6/60
Holly & Angel	Abandoned babies	Sib (17/20)	2/9131	2/8461		1/250
Alaskan	Attempted rapes	P/C	33/1204		31/1115	1/18
Orchid	Rape	P/C	21/2691	17/2312	17/1976	1/85
Addendum	Burglary & Rape	P/C	849/17329	675/15326	436/9741	13/199
Alverston	Linked sexual assaults	P/C	9/545	9/486	7/330	1/13
Lapwing	Rape	Sib (17/20)	1/2946	1/2785	1/2761	1/30
Nightingale	Linked rapes	Sib (13/20)	19/1425	53/1352	24/1114	2/25
Greystone	Rape	P/C	89/1442	78/1373		3/35
Comet	Attempted rape	P/C	54/1888	39/1496	27/941	1/35
Node	Rape & Murder	Sib (13/20)	36/1294	56/1280		2/28
Fireblade	Rape	Sib (14/20)		2/275	2/257	2/50
Stord	Murder	Sib (13/20)	29/2530	451/2418		5/133
Dagali	Indecent Assault	P/C	8/6892	6/6111		1/785
Kanab	Rape/abduction	P/C	34/5949	29/5570	25/4634	2/193

data from the parent/child and sibling candidate lists to enhance the impact of the familial search process on a case by case basis.

Simulation experiments conducted by Curran and Buckleton [30] show that there is approximately 78% chance that a sibling of a true offender will be in the top 100 profiles using a LR methodology. Similar DNA experiments described by O'Connor[1] [11] indicated that to reach a probability of 0.95 of finding the true parent/child pair the top 0.1% of the LR values would have to be investigated, and for the true full sibling pair, the top 3% of the LR values would have to be scrutinised.

The empirical data obtained from familial search casework undertaken by the FSS shows that if a relative of the true offender is in the NDNAD then, utilising a likelihood ratio or allele counting methodology together with additional age, ethnic appearance and geographic filters, the relative would be expected to occur in the top thirty returns in either the parent/child or sibling candidate lists in the majority of cases.

The impact of the geographic filters (police force and division) is particularly marked as can be seen in the cases designated Dakota, Alaskan and Addendum in Table 1. The use of these additional prioritisation factors is dependent on case specific information and will be agreed between the forensic science supplier and the police investigation team. These decisions will also be a matter of record in the police policy documentation.

The FSS developed a strategy of identifying the top 30 individuals in the prioritised, familial search lists and, if it was appropriate and agreed with the investigating officer, targeted these individuals for further analysis usually using Y-STR chemistry. This process is possible because two DNA sample swabs are collected from each individual on arrest; one of which is used to generate the STR profile and the other is stored by the forensic science supplier. In this way the Y-STR analysis of samples representing those involved in the candidate lists can be conducted without the necessity of interviewing and sampling these individuals again. The Y-STR analysis corroborates the familial link with the true offender, eliminated many false inclusions, and prevented an unnecessary invasion of privacy of most of the individuals in the candidate lists.

Table 2
Outcomes of FSS Familial Search cases 2003–2011.

Cases submitted	188
Cases subsequently closed or withdrawn	37
Cases detected by other means – no relative identified	35
Cases detected by Intelligence-led Screen (FSS FIB process)	5
Familial Search Successes – Suspect Identified	32
Conviction of suspect in judicial process	22
Cases currently sub-judice – suspect identified	3
Offender identified – 6 deceased, 1 acquittal	7
Case detected by other means – relative in familial lists	9
Active cases	70

Amongst the last of the cases undertaken by the FSS familial search team before its closure in December 2011 was the identification of the perpetrator of a series of linked kidnappings and sexual assaults of female children. In 1995 two 5-year-old girls were abducted and sexually assaulted in Newcastle in the northeast of England. These offences were linked to the abduction and sexual assaults of two other young female children; offences committed in Hampshire in the south of England in 1982 and 1983.

An initial familial search was conducted in 2011. Using a geographic filter of Northumbria Police returned no significant matches. However, the wider, unfiltered familial search led to a familial link to an individual from Hampshire. A Y-STR analysis indicated the correct familial link had been established to the perpetrator and the investigation was directed to a man who lived and worked in Ulverston in the northwest of England. Police enquiries determined that this man, David Bryant, had been in Newcastle in 1995 and in Hampshire in the early 1980s. Between 1984 and 1995 he had lived and worked in Saudi Arabia. In January 2012 David Bryant pleaded guilty to two offences and two further offences committed in Northumbria in 1995 [31] and was sentenced to a term of 16 years imprisonment.

11. Impact of recent legislative and policy changes in the UK

The National DNA Database (NDNAD) of England and Wales was established on the 10th April 1995 and, since that date, has grown to be the largest, per capita DNA database in the world. The growth in the collection and retention of DNA profiles has been driven by legislative changes [1] and the Home Office DNA Expansion Programme (2000–2005), which provided £240 million to support the use of DNA profiling in crime investigation [32]. By March 2012 there were approximately 5.95 million individuals' DNA profiles and 405,000 crime scene sample profiles retained in the National DNA Database [2].

The size of the National DNA Database and the fact that related genetic material is retained has led to claims of the National DNA

Database being a vital tool in the investigation and detection of crime and counter-claims that the consequent invasion of privacy and personal genetic identity outweighs its utility in crime detection.

These issues were brought to a head by the cases of S and Marper vs The Chief Constable of South Yorkshire Police [33]. In each of these cases the contention of the appellant was that the retention of DNA profiles and DNA samples breached the individuals' rights to privacy as neither was convicted of an offence. The South Yorkshire Police contested this view and the appeals were subsequently dismissed in a 2002 judgement in the Court of Appeal. S and Marper were given leave to appeal to the Grand Chamber of the European Court of Human Rights (ECtHR) and, in December 2008, the ECtHR ruled that the 'blanket and indiscriminate' nature of the UK Government's policy on the retention of DNA profiles and samples in England and Wales, regardless of the age of the offender, the seriousness of the offence, or whether the individual had been charged or convicted; was a breach of the right to privacy (Article 8) of the European Charter of Human Rights [34]. Following this decision the Government conducted a review and a comparison of DNA retention policy with those of other jurisdictions, notably that of Scotland.

The Government has, quite properly in the view of the authors, amended the rules on the retention of DNA profiles and DNA samples for those not convicted of an offence or those against whom investigative or judicial proceedings are discontinued. However, the Government has gone much further; the Protection of Freedom Act (2012) allows DNA samples to be retained for a maximum period of six months to ensure a full DNA profile is created for inclusion in the National DNA Database and to allow for re-examination and re-analysis if necessary [35]. Thereafter, under this legislative instrument the DNA samples must be destroyed. The Government has also indicated that the 'legacy' samples, i.e. the 6 million swabs currently held by forensic science suppliers will be destroyed within 12 months of the regulations being enacted. This latter decision is likely to severely impact upon the ability of the police to deliver an effective familial search service.

Under these new regulations the familial search process can still be used to generate the appropriate filtered or unfiltered candidate lists. It is the ability to utilise rapidly further genetic analysis that will be compromised by this decision. At present, the stored biological material (buccal swabs) from those individuals in the candidate lists can be used for Y-STR analysis without further contacting those individuals and it could be argued that their personal freedoms suffer minimal intrusion because of this. In future, the police will have to decide whether to trace and interview some, or all, of those individuals identified by the familial search process and seek a second, volunteered DNA sample for Y-STR analysis.

The outcomes of such a policy change are unknown. Individuals might refuse to supply samples and true perpetrators could be warned by their relatives when alerted by the request to supply a sample and it might simply be prohibitively expensive for the police to trace, interview and sample potentially many hundreds of individuals. It will be interesting to see how this develops.

12. Familial searching in the USA

In the USA, familial searching has been championed by the Colorado State Forensic Science Laboratory and the Denver District Attorney [36] and the California Department of Justice Laboratory. The publication of a 'DNA Partial Match (Crime Scene DNA Profile to Offender) Policy by the State Attorney General's Office in 2008 [37] allowed Californian law enforcement agencies and the state forensic science laboratories to use a modified CODIS (Combined DNA Index System) search [38] to provide investigative information by indicating whether the source of a crime scene DNA profile might be genetically related to another offender retained within the California DNA Data Bank.

California has had two significant investigative successes using a familial search of the state DNA database; identifying **Lonnie David Franklin Jr. as** the 'Grim Sleeper', the alleged perpetrator of a series of homicides that took place in Los Angeles [39], and **Elvis Lorenzo Garcia** as the perpetrator of a rape in Santa Cruz in 2008.

By contrast, the State of Maryland passed legislation [40] that allowed the collection of DNA samples when a suspect was charged with an offence and increased the number of offences for which the collection of a DNA sample was mandated, but in the same legislative instrument, banned the use familial searching.

Since March 2011 the Commonwealth of Virginia [41] allows the use of DNA Familial Searching and the Virginia Department of Forensic Science will consider requests from law enforcement agencies to "conduct familial DNA searches in cases involving unsolved violent crimes against persons where other investigative leads have been exhausted and critical public safety concerns exist" [42].

Most US states follow the FBI interim policy on partial DNA matches in CODIS databases [43]. The FBI define a partial match as "... the spontaneous product of a regular database search where a candidate offender profile is identified as not being identical to the forensic profile but because of a similarity in the number of alleles shared between the two profiles, the offender may be a close biological relative of the source of the forensic profile". By contrast, a familial search is "... an intentional or deliberate search of the database conducted after a routine search for the purpose of potentially identifying close biological relatives of the unknown forensic sample associated with the crime scene profile" [44].

California, Colorado, Virginia, and Texas perform limited familiar searching against their State DNA databases, yet all 50 States face the possibility of being involved in a partial match [38,45]. The FBI restrictions on the reporting of partial matches include:

(1) The profile must be a single-source DNA profile;
(2) Additional confirmatory testing may be requested;
(3) The partial match must contain data at all 13 CODIS core loci;
(4) Expected Match Ratios (EMR) and Expected Kinship Ratios (EKR) must be calculated;
(5) Police and Prosecution Authorities must commit to investigate and pursue prosecution of any individual identified by a partial match;
(6) The State holding a possible relative's information is solely responsible for a legal review to determine if releasing the information is permissible under State law or policies

The FBI does not regulate familial searching at a State level.

13. Familial searching in the Netherlands

In the Netherlands, a legislative, rather than a regulatory, approach has been taken to the introduction of DNA profiling in the criminal justice system. The 1994 Forensic DNA Profiling Act set the legislative framework for the creation of a National DNA database and determined the rules for the collection, use and destruction of DNA samples and the conditions under which DNA profiles can be generated, compared and stored [46,47]

In April 2012 the Dutch Ministry of Security and Justice introduced legislation to allow the use of DNA familial searching in support of police investigations of serious, unsolved criminal cases. Within days of this legislation being enacted, the police and the Netherlands Forensic Institute used the technique to support the investigation of an unsolved rape and homicide of Marianne

Vaastra, a 16 year old female, which occurred in 1999. It was believed that as the offence took place in a rural area of northern Holland the perpetrator was a man with local knowledge. A full DNA profile believed to be that of the perpetrator was obtained from evidential materials left at the scene. Three lines of enquiry were followed initially; an autosomal STR familial search of the National DNA database, Y-STR analysis and comparison of males selected from the Dutch DNA database based on residency or place of birth and Y-STR analysis based on rare surnames from the area in which this offence had been committed. In each case all of the potential candidates were eliminated from the enquiry. In October 2012 the Minister of Security and Justice announced that DNA samples would be requested from approximately 8000 men who, in 1999, had been living within a 5 km radius of where Marianne Vaastra's body was found. In effect these 8000 samples formed a case-specific DNA database. Initially these samples were compared with the target DNA sample using Y-STR profiling techniques to eliminate all but paternally related individuals. Not only did this technique rapidly locate potential relatives of the perpetrator, an autosomal DNA match was obtained with one individual. A 45-year-old local man has now been arrested and charged with Marianne Vaastra's rape and murder [48,49].

14. Familial searching in Australia and New Zealand

The six States and two Territories of Australia have independent DNA databases which support criminal investigations and the individual state/territory Criminal Justice Systems. At a Commonwealth level the state/territory DNA databases support the National Criminal Investigative DNA Database (NCIDD). None of the current Australian DNA database legislation expressly permits, nor prohibits, the use of familial searching. However, there is a concern that familial searching represents a 'function creep' in the use of DNA databases beyond that of direct matching of suspects and crime scenes for which they were created [50].

In New Zealand the Criminal Investigations (Bodily Samples) Act 1995 provides the framework for the collection of DNA samples from individuals for inclusion in the DNA Profile Databank (DPD). This legislation does not cover extended forensic uses of the DPD but the NZ Police and the forensic supplier ESR have agreed operational procedures [51] for the use of familial searching which are very similar to those derived in the UK as described below. Familial searching has been used as 'a last resort' in 38 cases in New Zealand. In their 2010 report 'A brief history of Forensic DNA 1990–2010' ESR cites two cases as examples of the successful prosecution of a familial search [52]. However, there appear to be calls for a parliamentary debate about the technique with suggestions that "The effect of it (*familial searching*) is to increase the footprint of the database without Parliament having legislated for that increased footprint" even though the NZ Justice Minister appears content with the use and management of this technique [53].

15. Concluding remarks

In this paper we have outlined the development and use of familial searching of DNA databases in the UK, Europe, Australasia, and the USA with reference to legislative concerns and illustrated by casework successes. We have also outlined the concerns raised by ethicists [12] about the use of the familial search technique. These are succinctly summarised as,

> How can you justify the use the genetic information from totally innocent individuals to find your true perpetrator?

We would argue that, when used with safeguards of the kind described earlier, familial searching of forensic DNA databases accords with widely accepted ethical principles of beneficence and non-maleficence [54]. It can provide intelligence information to support the Criminal Justice System by excluding innocent individuals from police investigations and identifying and supporting the prosecution of true offenders. It also supports the rights to justice for the victims of crime.

The use of additional genetic testing (Y-STR profiling) may help to eliminate false inclusions and reduce intrusion and unnecessary direct contact with nominated, putative relatives. However, this is not to deny the ethical complexity of the application of this forensic technique or the necessity of policy and practice attentiveness to such complexity.

We have outlined the processes, utility, and governance of the familial search service in which the UK NDNAD is searched for close genetic relatives of an offender who has left DNA evidence at a crime scene but whose DNA profile is not represented within the NDNAD. We have outlined the scientific basis of the familial search approach and the use other genetic methods for eliminating individuals from the 'candidate lists' generated by these NDNAD searches. We have demonstrated the value of using additional factors to prioritise the individuals in the candidate lists; filtering by age, ethnic appearance and geography. We present the FSS data in relation to the utility of the familial searching and demonstrate the power of the technique by reference to casework examples. Finally we have commented on the likely impact on the current familial search processes in England and Wales given the destruction of the stored DNA swabs as required by Protection of Freedoms Act (2012).

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References

[1] Criminal Justice and Public Order Act (1994); Criminal Evidence Act (1997); Criminal Justice and Police Act (2001); Criminal Justice Act (2003); Serious Organised Crime and Police Act (2005), 2013 www.legislation.gov.uk.
[2] National Policing Improvement Agency, NDNAD Statistics (September 2012), 2012 http://www.npia.police.uk/en/13338.htm.
[3] Office for National Statistics, Statistical Bulletin (June 2011), 2011 http://www.ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk–england-and-wales–scotland-and-northern-ireland/mid-2010-population-estimates/index.html.
[4] M.A. Rothstein, M.K. Talbott, The expanding use of DNA in law enforcement: what role for privacy? Journal of law, Med. Ethics 34 (2) (2006) 153–164.
[5] Case of S. & Marper vs The United Kingdom, 2013 http://hudoc.echr.coe.int/sites/eng/pages/search.aspx?i=001-90051#{itemid:[001-90051]}.
[6] Protection of Freedoms Act, 2012 http://www.legislation.gov.uk/ukpga/2012/9/pdfs/ukpga_20120009_en.pdf.
[7] Operation Magnum, the reinvestigation of the Llandarcy murders – see: The Hunt for the Saturday Night Strangler, 2013 http://www.guardian.co.uk/uk/2003/jan/18/wales.kevintoolis.
[8] R. v Craig Harman, 2013 http://news.bbc.co.uk/1/hi/england/3640199.stm.
[9] F.R. Bieber, C.H. Brenner, D. Lazer, Finding criminals through the DNA of their relatives, Science 312 (2006) 1315–1316, http://www.sciencemag.org/content/suppl/2006/05/11/1122655.DC1/Bieber.SOM.Rev.pdf.
[10] T.M. Reid, M.L. Baird, J.P. Reid, S.C. Lee, R.F. Lee, l Use of sibling pairs to determine the familial searching efficiency of forensic databases, FSI: Genetic 2 (2008) 340–342.
[11] K.L. O'Connor, Familial Searching of DNA Databases, in: International Conference On Forensic Inference and Statistics, Seattle, WA, (July 2011), 2013, http://www.biostat.washington.edu/sites/www/content/files/8th_International_Conference_on_Forensic_Inference_and_Statistics:_Online_Presentations/is8_koconnor_pdf_4e5fd3c744.pdf.
[12] E. Haimes, Social and ethical issues in the use of familial searching in forensic investigations: insights from family and kinship studies, J. Law Med. Ethics 34 (2006) 263.
[13] J.D. Gabel, Probable cause from probable bonds: a genetic tattle tale based on Familial DNA, Hastings Womens Law J. 21 (2010) 3, Georgia State University College of Law, Legal Studies Research Paper No. 2009-23. Available at SSRN: http://ssrn.com/abstract=1495128.
[14] M. Gal, R.D. Hoge, A profile of the adolescent sex offender, Forum Correct. Res. 11 (1999) 7–11, http://www.csc-scc.gc.ca/text/pblct/forum/e112/e112b-eng.shtml.
[15] Youth Justice Board for England and Wales, YJB., Research Note 5, Risk and protective factors associated with youth crime and effective interventions to prevent it (2001).

[16] J. Graham, B. Bowling, Young People and Crime, Home Office Research Study, 145, HMSO, London, 1995.

[17] L.E. Glaze, L.M. Maruschak, Aug 2008 (Revised 30 March 2010) Parents in Prison and their Minor Children US DOJ, Office of Justice Programmes, in: Bureau of Statistics Special Report NCJ 222984, 2008.

[18] L.E. Glaze, L.M. Maruschak, Parents in Prison and their Minor Children US DOJ, Office of Justice Programmes, in: Bureau of Statistics Special Report NCJ 222984 Aug 2008, 2008 (Revised 2010) Table 11..

[19] N. Shelton, E. Grundy, Looking beyond the household: intergenerational perspectives on living kin and contact with kin in Great Britain, Popul. Trends 97 (1999) 19–27.

[20] N. Shelton, E. Grundy, Proximity of adult children to their parents in Great Britain International, J. Popul. Geogr. 6 (2000) 181–195.

[21] W. Bernasco, P. Nieuwbeerta, How do residential burglars select target areas? Brit. J. Criminol. 44 (2005) 296–315.

[22] N. Tilley, K. Pease, M. Hough, R. Brown, Burglary Prevention Early Lessons from the Crime Reduction Programme, Crime Reduction Research Series, Paper 1, Home Office, London, 1999.

[23] W. Bernasco, T. Kooistra, Effects of residential history on commercial robbers' crime location choices, Eur. J. Criminol. 7 (4) (2010) 251–265.

[24] Home Office Police Standards Unit, Tactical Advice – Using Familial Intelligence Products in Serious Crime, 2006.

[25] NDNAD Strategy Board, 2013 http://www.homeoffice.gov.uk/police/national-dna-database/ndnad-strategy-board/.

[26] NDNAD Ethics Group, 2013 http://www.homeoffice.gov.uk/agencies-public-bodies/fsr/ndnad-ethics-group/.

[27] Parliamentary Office of Science & Technology No. 258, Postnote: The National DNA Database, 2006 www.parliament.uk/documents/post/postpn258.pdf.

[28] J. Buckleton, C.M.S.J. Triggs, Walsh Forensic DNA Evidence Interpretation, CRC, Press, Boca Raton, London, New York, Washington, D.C, 2005p. 412.

[29] Jianye Ge, Comparisons of the Familial DNA Database Searching Principles, Familial Search Workshop, in: 21st International Symposium on Human Identification, 2010.

[30] J.M. Curran, J.S. Buckleton, Effectiveness of familial searches, Sci. Justice 84 (2008) 164–167.

[31] David Bryant jailed for 16 years, 2013 http://www.bbc.co.uk/news/uk-england-17520904 and http://www.bbc.co.uk/news/uk-england-tyne-17338490.

[32] DNA, Expansion Programme 2000–2005: Reporting achievement, Home Office, 2005.

[33] Cases of S and Marper vs The Chief Constable of South Yorkshire, 2013 http://www.publications.parliament.uk/pa/ld200304/ldjudgmt/jd040722/york-1.htm.

[34] Case of S and Marper vs United Kingdom, Grand Chamber, European Court of Human Rights, December 4, 2008 http://www.bailii.org/eu/cases/ECHR/2008/1581.html.

[35] Protection of Freedoms Act 2012 Chapter 1 §14 (5), 2013 http://www.legislation.gov.uk/ukpga/2012/9/part/1/chapter/1/crossheading/destruction-rules-for-samples-and-impressions-of-footwear-subject-to-pace/enacted..

[36] Mitchell R. Morrissey, District Attorney, Denver Colorado. Web page for familial DNA resources at: http://www.denverda.org/DNA/Familial_DNA_Database_Searches.htm (last accessed July 2013).

[37] Memorandum from Edmund G. Brown, Jr., Att'y Gen. of Cal. to All Cal. Law Enforcement Agencies and Dist. Att'ys Offices, DNA Partial Match (Crime Scene DNA Profile to Offender) Policy (April 25, 2008).

[38] FBI. Laboratory Frequently Asked Questions (FAQs) on the CODIS Program and the National DNA Index System – Partial Matches and Familial Searches, 2013 http://www.fbi.gov/about-us/lab/codis/codis-and-ndis-fact-sheet..

[39] G. Miller, Familial DNA testing scores a win in serial killer case, Science 239 (2010) 262.

[40] Maryland Senate Bill 211 §2-506 enacted 1st Jan 2009, 2013 http://www.goccp.maryland.gov/dna/documents/legislation.pdf..

[41] Virginia DFS Familial Search Acceptance Policy DFS Doc 107 D100 Revision 1 (9 March 2011), 2013 http://www.denverda.org/DNA_Documents/Policies/VA%20FS%20Policy.pdf.

[42] Governor McDonnell Announces Virginia Department of Forensic Science to Begin Using Familial DNA Searches in Virginia (March 21, 2011), 2013 http://www.publicsafety.virginia.gov/News/viewRelease.cfm?id=648.

[43] Federal Bureau of Investigation, Interim Plan for the Release of Information in the Event of a Partial Match at NDIS,, July 20, 2006 http://www.bioforensics.com/conference08/Familial_Searches/CODIS_Bulletin.pdf.

[44] Federal Bureau of Investigation, Familial Searching, 2013 http://www.fbi.gov/about-us/lab/codis/familial-searching.

[45] SWGDAM Recommendations to the FBI Director on the Interim Plan for the Release of Information in the Event of a 'Partial Match' at NDIS, 2013 http://www.fbi.gov/about-us/lab/forensic-science-communications/fsc/oct2009/index.htm/standard_guidlines/swgdam.html.

[46] A. Kloosterman, H. Janssen, Forensic DNA testing and its legislation in the Netherlands, Forensic Sci. Int. 88 (1997) 55–58.

[47] V. Toom, Forensic DNA databases in England and the Netherlands: governance, structure and performance compared, New Genet. Soc. 31 (2012) 311–322.

[48] Marianen Vaastra case news report, 2013 http://www.upi.com/Top_News/World-News/2012/09/06/8000-men-asked-to-give-DNA-in-murder-case/UPI-89831346942358/..

[49] A. Kal, C. van Kooten, R. Rintjema, J. Tjalsma, C. Reijenga, Familial Searching Combining autosomal and Y chromosomal STRs and surnames, in: Poster presented at the 23rd International Symposium on Human Genetics 2012, 15–18 October, Nashville, USA, 2012, http://dnadatabank.forensischinstituut.nl/Images/poster-arnoud-kal-2012-definitief_tcm127-456702.pdf.

[50] Australian Law Reform Commission Report 96 2003 (modified 2012) 'Essentially Yours' Sections 39 and 43, 2013 http://www.alrc.gov.au/sites/default/files/pdfs/publications/ALRC96_vol2.pdf.

[51] S. Rushton, Familial Searching and Predictive DNA testing for Forensic Purposes, A review of Laws and Practices, Victoria Law Foundation Legal Police Internship Program, 2010 http://www.dnaresource.com/documents/NZPolicy.pdf.

[52] A brief history of Forensic DNA 1990–2010: marking 20 years of DNA analysis for the New Zealand criminal justice system, (February 2010) Environmental Science and Research, 2013 http://www.esr.cri.nz/SiteCollectionDocuments/ESR/PDF/ForensicScience/Forensic20yearsDNA.pdf..

[53] Tony Wall, Privacy Fear for DNA dragnet (Jan 20), 2013 www.stuff.co.nz/national/8199938/Privacy-fear-for-DNA-dragnet.

[54] T.L. Beauchamp, J.F. Childress, Principles of Biomedical Ethics, 7th Ed., Oxford University Press, Oxford, 2013.