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National DNA databases—practice and practicability. A forum for discussion

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Abstract. The success of the established National DNA databases (NDNAD) in linking crimes and nominating possible suspects has prompted many countries to enact legislation for the introduction of their own databases. While the technology used in the production of the DNA profiles remains consistent (there is a core set of STR loci common to all laboratories), there is considerable variation in the regulations which cover the entry of personal profiles. Five invited speakers presented the current situation with NDNADs in Europe and North America. The presentations included: (1) the various categories of crime for which a profile can be entered onto a database; (2) the numbers of profiles held on the databases; (3) whether the DNA samples can be retained for future analysis; (4) the successes of the various databases; (5) the interaction between the operators of the databases and other elements of the criminal justice systems. There were also discussions of the possible future technological developments that may affect the databases and a cautionary note on the quality measures necessary to ensure accuracy of analysis and database management and the potential for the misuse of the data retained.

Keywords: National DNA database; DNA profile; STR multiplexes

1. Introduction

DNA databases for criminal offenders and unsolved crimes have now become established in many countries as an everyday tool for use in the investigation of crime. Also, there is now very little challenge to their use in courts of law. However, the collection and storage of personal data has always been an emotive issue as there is a public perception that either the scientists or the authorities might use the information for something other than the stated purpose.

While it is universally accepted that DNA profiles obtained from all crime scene samples should be automatically entered and retained on a database, the subject of the entry of personal profiles from suspects or convicted persons continues to be debated. Given the robustness and reliability of DNA profiling, it has been suggested that everyone

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should be placed on a DNA database. While there is no argument with this logic, there are practical concerns for its implementation not least of which is the cost.

It is taken for granted that all DNA profiles which are obtained from scenes of crime should automatically be added as data for future comparison. This cannot infringe any civil rights issues as initially these results are not assigned to any individual.

In general terms, there is now almost no objection to the existence of national DNA databases as they have had considerable success in crime investigation and in the identification of possible perpetrators of very serious offences. There remains, however, considerable discussion about which individuals should have DNA profiles entered onto the databases and which samples should be retained for future analysis.

2. The current situation in the UK

The UK DNA database was first established in 1995 and is now used as a routine step in the investigation of crime. In the initial stages, the need for a National DNA Database (NDNAD) was identified to aid in crime reduction. As past records have shown in the UK, the majority of those who commit serious crime have previous convictions for minor offences. Consequently, in the UK, there was a decision to allow for the retention of personal DNA profiles from offenders convicted of minor as well as serious crime, the objective being to identify the perpetrator of a serious crime before the commission of a series of offences such as sexual assault or murder.

By April 2003 the UK NDNAD held approximately 2.3 million profiles and had achieved more than 280,000 person to crime matches and about 30,000 crime to crime matches. Typically, there are 1250 matches reported per week which include on average 14 murders, 20 sex offences and 137 violent crimes. The current aim is to process the samples within 14 days to allow for rapid elimination or inclusion. As well as providing the names of possible suspects in crime cases, the NDNAD is also able to provide links between different offence types (see Table 1).

Recently, there was a successful initiative to form a partnership with the police to provide a fast-track service designed to identify the perpetrators of burglary before they could commit multiple offences. During this initiative, which lasted for 11 months, nearly four times the previous number of samples were received and the analysis time was reduced from 29 days to 10 days. The analysis of 425 cases was undertaken and 74% resulted in the production of a profile suitable for a database search. Scene of crime to person matches were found in 221 cases (52%) and 48 individuals were convicted. Subsequently, the UK government gave financial assistance for additional scene of crime officers and funding to

Table 1
Matches obtained by the UK NDNAD with crimes other than the arrestable offence

Arrest offence	Autocrime	Burglary	Damage	Drugs	Robbery	Theft	Violence	Homicide	Other sex	Rape
Total matched	1193	1593	1105	1209	307	3687	1521	32	103	39
Percentage matched different offence type	51%	26%	80%	98%	75%	42%	96%	69%	84%	49%
Percentage matched serious offence	4%	2%	4%	8%	17%	5%	10%	50%	24%	69%

the laboratories to continue the initiative to reduce crime. The rapid production of DNA profiles has played a key role in this intelligence-led approach to crime investigation.

3. The current situation in Europe

The majority of European countries now have either operational NDNADs or are in the process of implementation (see Table 2).

In the UK, the law is comparatively liberal and comprehensive by allowing profiles to be obtained and retained from a wide range of individuals who are either suspected or convicted of crimes. There is also the legal right to keep all samples for further analysis if required. This situation does not pertain to all European countries and Table 3 illustrates the wide diversity of criteria which legislate for the operation of the various NDNADs.

The situation is further complicated with reference to the samples which are used for profiling. These can be retained for future testing in England, Austria, Finland, Denmark, Hungary, Slovenia and Croatia but, in the other countries, samples must either be destroyed after the profile is obtained or after the court has reached a decision.

While the 10 SGM Plus loci are most commonly used within Europe, not all 10 loci are always used for databasing. Some countries have opted for different systems but seven agreed loci are always part of all European databases.

At the present time, the European NDNADs have reached different stages of maturity with some showing remarkable success rates in the identification of suspects and also in identifying crime to crime links (see Table 4). The UK National DNA Database is the most effective in Europe in terms of the individuals nominated as suspects in crime investigation and also as a means of determining links between different crime scenes. The major reason for this success comes from the law which allows for the retention of such a large number of personal DNA profiles. The databases that generate most matches are those which contain a very large percentage of personal profiles. Anyone suspected or convicted of an extremely wide variety of crimes could have their DNA profile entered onto the NDNAD and the results could remain on the database indefinitely regardless of whether or not a conviction is obtained.

4. The current situation in France

Although the necessary legislation for the French NDNAD was enacted in 1998, the database is still in its infancy. Originally, it was implemented to hold profiles only from

Table 2
National DNA databases in Europe

1995	England
1996	Northern Ireland, Scotland
1997	The Netherlands, Austria
1998	Germany, Slovenia
1999	Finland, Norway
2000	Denmark, Switzerland, Sweden, Croatia, Bulgaria
2001	France, The Czech Republic
2002	Belgium, Estonia, Lithuania, Slovakia
2003	Hungary, Latvia
In preparation	Poland, Portugal, Spain, Greece, Ireland, Yugoslavia

Table 3
Criteria for retaining DNA profiles in various European countries

Country	Entry criteria for suspects	Entry criteria for convicted offenders	Removal criteria
England	Any recordable offence		Never removed, including suspects
Austria	Any recordable offence		After acquittal
Croatia	Any recordable offence		Never removed
Slovenia	Any recordable offence		Dependent on severity of crime
Switzerland	Any recordable offence		After acquittal or 5–40 years after conviction
Germany	>1 year in prison	After court decision	After acquittal or 5–40 years after conviction
Finland	>1 year in prison		After acquittal but never if convicted
Denmark	>1.5 years in prison		10 years after acquittal or 5–40 years after conviction
Norway	Many serious offences	After court decision	Never removed
Hungary	5 years in prison		After acquittal or 5–40 years after conviction
Sweden	No suspects entered	>2 years in prison	5–40 years after conviction
Belgium	No suspects entered	After court decision	5–40 years after conviction
Netherlands	No suspects entered (except when the suspect's DNA is tested for the case)	>4 years in prison	5–40 years after conviction
France	No suspects entered	Serious offences, voluntary samples only	5–40 years after conviction

Table 4
The composition of National DNA databases for some European countries

	UK	Netherlands	Austria	Germany	Finland	Sweden	Denmark	Switzerland	Slovenia	Belgium	France
Last update	April 03	August 03	March 03	July 03	April 03	July 03	July 03	July 03	September 03	June 03	August 03
Entries	2.31 million	13,100	68,800	285,700	9700	11,200	5300	38,640	6450	3470	6400
Persons	92%	25%	80%	86%	64%	34%	36%	85%	68%	16%	90%
Suspects included	+	–	+	+	+	–	+	+	+	–	–
Stain samples	8%	75%	20%	14%	36%	66%	64%	15%	32%	84%	10%
Hits	313,600	6450	1900	13,200	1480	2620	1040	800	380	210	150

Most other European countries either have or are in the process of developing databases.

those found guilty of sexual assaults and offences against minors. In 2001, the law was changed to include serious offences against persons and property and in 2003 another law was enacted to include almost all categories of serious offences. This new law also allows for a police officer to take a buccal sample, for DNA profiling and database search, without reference to an investigating magistrate or a public prosecutor.

The NDNAD is controlled by a committee under the direction of a high ranking prosecutor and is operated, using the CODIS software, by the technical and scientific police who are responsible to the Minister of the Interior. The scene of crime samples are stored at the National Criminal Research Institute of the Gendarmerie. At the moment there are 28 scientists in 14 different laboratories who are authorised to perform the DNA analyses within the guidelines of well established methodologies. The aim is to gain accreditation for all laboratories given the authority to do work for the NDNAD.

Although the French law does not compel a person to provide a sample for analysis anyone who refuses could face the prospect of a jail sentence or a considerable fine. Following an administrative order, the DNA profile can remain on the database for up to 40 years but there is a system whereby a person can request its removal.

5. The current situation in the USA

The NDNAD in the USA came into existence following the enactment of the DNA Identification Act of 1994. In its initial stages, the database was designed to cope with entries from a number of DNA technologies but its mainstream activity has now settled on a system of entry and search against profiles obtained from 13 STR loci that can be typed for with commercially available kits.

The FBI designed and implemented the system and now has overall responsibility for an operation which includes input from 173 state and local laboratories as well as the US Army Crime Laboratory and Puerto Rico. The CODIS software for running the database has been extremely successful and has been adopted by 18 other countries worldwide.

While the database has expanded rapidly and contains files from a number of activities (see Table 5), there are plans for further expansion.

Under current legislation only personal DNA profiles are entered onto the database from those individuals convicted of certain specified crimes (the categories of crime will vary according to the specific laws of the individual states). However, due to the success in nominating crime suspects and linking crimes, there are now plans to widen the scope of the database to include a variety of further crime categories and to incorporate personal profiles from arrested and indicted individuals. At present, some past cases may come under the Statute of Limitations (a time limit after which no prosecution can take place) and, following so many DNA identifications in old cases, it is considered that there would be advantage in either extending the time or eliminating this statute. Other files including Missing Persons and Relatives of Missing Persons will also accept mtDNA, SNP and Y chromosome STR data to allow for the examination of skeletal remains and also other degraded material.

To address concerns that DNA data and samples will be used inappropriately, access to the data is limited to criminal agencies for law enforcement identification purposes, to

Table 5
File entries in the US National DNA database

Convicted offenders	1,519,584
Forensic samples	67,191
Missing persons	72
Relatives of missing persons	248
Human remains	116
Population statistics	August 2003

judicial proceedings and for criminal defence purposes where a defendant might require information pertinent to analyses performed in his or her case. There are both federal and state laws which protect against the unauthorised disclosure of database information.

6. National DNA databases issues

In the early stages of development of NDNADs, there was considerable challenge to the accuracy and statistical relevance of matches, especially in the adversarial forms of criminal justice practiced in such countries as the UK and USA. Nowadays, there is relatively little challenge to the evidence and this has allowed the scientists more time to concentrate on the quality issues associated with the detailed maintenance of the databases. While all countries have legislation to prevent the unauthorised disclosure of database information, it would be foolhardy to believe that all the databases are error-free. However, NDNADs do allow for vast pairwise comparison experiments and provide a unique opportunity to test the impact of the phenomenon of errors into the process of genetic matching. With the knowledge that these large collections of genetic data will invariably contain errors, it is important to introduce systems which will first of all recognize potential sources of errors and then steps may be taken to assist the process. To this end, expert systems are being developed to recognize the source of errors. However, there is an onus, not only on the operators of the database but also on the laboratories submitting data to the NDNAD for searching, to have quality systems in place to ensure that the profiles being stored and searched have been correctly prepared.

All those involved with the criminal justice systems should be aware that, when a random match is obtained from a database search, it is an aid to the investigation of a crime and not necessarily evidence of guilt. The ‘prosecutor’s fallacy’ (typically where the probability of a random match is transposed into the evidence of guilt) can unfairly bias the decision of a court, and there are instances where a database search has pointed at an individual who could not possibly have committed the crime.

As most of the NDNADs are operated within criminal justice organisations, successful partnerships are emerging in which cooperation between the NDNADs, law enforcement agencies and laboratories is encouraged to identify linked crimes. However, there has been some debate concerning the desirability of using other independent organisations as the guardians of the genetic information. While this might have some cosmetic appeal, it is important not to lose the understanding which has developed within this framework. In the Netherlands the defendant has the right to have the samples reanalysed by an independent, university-based laboratory and this is a simple but effective way of checking that the submitting laboratories and the NDNAD operators are competent.

The STR technology, currently used to form the databases, has no apparent value in giving genetic information other than for individuality. However, it is not only the results of the DNA analysis which are retained. The samples, which are provided for the analyses, can also be stored in case there is a need for re-analysis in a particular case or because there is a change in the technology whereby all accumulated samples can be re-examined. In some countries, the law allows for these samples to be held forever and here lies a potential problem. Molecular biology is advancing at a rapid pace and more and more personal information can be gleaned from genetic studies. In the event of the breakdown of stable sociopolitical systems, there would be the availability of some potentially harmful information from such a comprehensive set of DNA samples. Therefore, it is not surprising that many of the European legislators have insisted that DNA samples should be destroyed following analysis.

7. Future

Without doubt, the evolution of NDNADs has been a success story and the creation of large searchable databases will continue to be an invaluable asset in the investigation of crimes. The very success, however, is in some way, a potential bar to technological progress. The profiling of such large numbers of samples has involved a great deal of work and a substantial cost and embracing a change in the technology would require an overwhelming amount of work. It is generally agreed that, although SNP technology has the potential for a faster and cheaper way of performing the analyses, it is unlikely to supplant the current methodology in the foreseeable future. However, systems using SNPs in forensic science continue to be researched and, in the USA, they have been used in casework to provide indications of biogeographical origin. In The Netherlands, new legislation has already allowed for the future use of physical characteristics, determined from DNA analysis, in crime investigations. The determination and use of genetic disorders and disease associations is specifically prohibited and the methodology will only be used if it is pertinent to the particular investigation, the information obtained is shown to be reliable and the cost is within reason.

One of the most valuable assets of the current technology is that laboratories worldwide have settled on the use of comparable packages of STR loci. This offers the potential for any NDNAD to be interrogated for a match with a result from a crime scene sample. Although this is scientifically possible, the difficulties with the various legal systems remain. In the USA, there is a single database which receives input from all the state law enforcement agencies and entries and searches are carried out according to local state legislation. The advantage of this system is that a crime committed in one state could well be linked to a person living in another state. In Europe, the scientists initially involved with DNA profiling worked towards, and achieved, a harmonised system that would allow for the interchange of results. The introduction of the technology had coincided with a European Union initiative to have open borders and it was realised that there was the potential for an increase in cross-border crimes. The amount and seriousness of cross-border crime is difficult to evaluate, but there are many unsolved crimes within the member states which could well have been perpetrated by persons not domiciled in that particular country. In many cases, the interrogation of all the available databases could

prove valuable but, at the present time, there are many legal obstacles to the exchange of DNA information (particularly personal profiles) and, without some harmonisation of the legal systems, this problem will remain. A possible solution to this obstacle could be the creation of a European database which contains only DNA profiles from unsolved crime cases where there is evidence that the offender comes from another country. These DNA profiles could be downloaded individually and compared against the respective NDNAD. Thus, the personal DNA profiles could be used for international database searches but remain within the jurisdiction of the specific national DNA databases.

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In the process of setting up the forum, it was appreciated that many countries have well established, successful DNA databases, but time constraints allowed for only a limited number of presentations.