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The transnational exchange of DNA data: Global standards and local practices

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Abstract:
The creation of systems for the transnational exchange of information raises multiple issues related to the establishment of common infrastructures, protocols and regulation. The development and adaptation of standards is paramount in reaching operational levels of harmonization. This paper focuses on the case of a system for the improvement of cross-border cooperation in the European Union through the exchange information among databases of Member States. The Prüm Treaty and the subsequent Prüm Decisions have established a framework for the exchange of DNA profiles, dactyloscopic data, and vehicle registration data, for the purpose of combating cross-border crime and terrorism.

The historical specificity of DNA profiling data in terms of the development of international standards and the sensitivity it represents for data protection regulation constitutes it as a relevant object in order to analyze the challenges raised in the context of transnational cooperation.

First, this paper provides an overview of the trajectory and characteristics of DNA as an object of standardization. Second, through interviews with local actors involved in the implementation and operationalization of the network for the exchange of DNA data, the global standards are compared with practices at the local level.

The adoption of minimal standards allows flexibility and autonomy at a local level, thus allowing interoperability to exist in a scenario of national differentiation. However, a relatively wide margin of discretion in terms of the routine local operation of the system can create frictions and lead to isolated solutions that can be seen as sub-optimal.

Introduction

The history of forensic DNA profiling and databasing is built upon the necessity, design, validation and dissemination of standards (Jordan & Lynch, 1998; Lynch, 2002). DNA profiling technologies have, since the inception of its use for individual identification, encompassed multiple laboratorial techniques that have slowly converged into feasible and standardized methodologies (Derksen, 2003).

Culturally perceived as the “ultimate” identification evidence in forensic contexts (Lazer, 2004), DNA technologies have been metaphorically described as “gold standard”, the “signature of god”, or “truth machine” (Lynch, 2003; Lynch, Cole, McNally, & Jordan, 2008). However, the trajectory of DNA profiling has had its periods of contention and uncertainty. In fact, at the time of its earlier uses in the 1980s, the absence of norms and standards for the production and interpretation of early profiling techniques led to judicial conflicts about their admissibility as evidence in the so-called “DNA wars” (Derksen, 2003, 2010). These involved, for instance, the judicial challenging of DNA evidence by questioning the techniques and protocols for the production of DNA profiles. Another strategy was to challenge the calculations used by laboratories to declare matches between samples from suspects and crime scenes, namely the probability that the sample could randomly match someone else (Lynch et al., 2008).

The validity and reliability issues associated with the early judicial uses of DNA technologies, particularly in the context of the United States of America (USA), prompted efforts toward the development of procedural standards and materials that would be used in forensic DNA laboratories around the world (Aronson, 2008). In 1992, the National Research Council produced a report containing recommendations on DNA typing methods. Since then, several national and international advisory bodies have been constituted for the discussion and development of forensic science and DNA technologies (Butler, 2014).

In the 1990s', the evolution of DNA profiling methods and in computer technology have enabled the construction of forensic DNA databases, which support criminal investigation purposes through the systematic comparison of reference profiles from known individuals and unknown profiles obtained from crime scene samples (Santos, Machado, & Silva, 2013). Attentive of these developments, the Council of Europe issued a set of guidelines on the use of DNA technologies within the context of criminal justice systems (Council of Europe, 1992). Besides the recommendations about the collection and uses of biological samples, this document already referenced the importance of establishing the accreditation of laboratories and institutions working with DNA analysis, standards of conformity with data protection conventions and technical standards. Remarkably, the last recommendation already concerned the "transborder exchange of information", stating that DNA analysis can be obtained from laboratories and institutions in other countries as long as these satisfy the requirements prescribed in the document (Council of Europe, 1992).

From a technical-scientific perspective of the forensic uses of DNA technologies, European scientists and forensic experts have a trajectory of agency in the creation and implementation of common parameters, protocols and laboratorial practices for DNA analyses. Following a meeting between representatives of eleven state forensic laboratories from Western Europe countries, the European Network of Forensic Science Institutes (ENFSI) was created in 1995, with the purpose of discussing matters of common interest. Since then, ENFSI congregated several expert groups in diverse areas of forensic science. One of those groups is the DNA Working Group, dedicated to the development and standardization of analytical methods, and also to the establishment of standardized markers to be adopted in the EU. In fact, the European Commission has recognized, in 2009, ENFSI's monopoly status for forensic sciences in Europe. In the scope of its competences, ENFSI has developed actions for the accreditation of forensic laboratories through the implementation of ISO/IEC 17025 standards, training, validation of analytical methodologies, and proficiency testing.

This paper focuses on a relatively recent development in the forensic uses of DNA profiling and databases which is the construction of a decentralized network for the transnational exchange of DNA data. This phenomenon congregates multiple intersections between science, law, culture, history, but it is also a space where we can interrogate how standards operate in multiple contexts (Timmermans & Epstein, 2010). A first part briefly describes the evolution of DNA profiling and databasing in order to understand the choices and priorities shaping the regulation and standardization of the network for the exchange of DNA data. A second part draws from interviews with privileged informants, providing some insights into the local challenges and complexities involved in the implementation and operation of the system.

Standardizing DNA profiles

In 1995, the National DNA Database of England, Wales and Northern Ireland (NDNAD) pioneered the establishment of centralized DNA profiles databases. Other countries also started their own national DNA databases, like the Netherlands and Austria in 1997, Germany in 1998, or Finland in 1999. These databases store digital or numerical representations of DNA profiles based on *Short Tandem Repeats* (STR). What is important about these STRs is that they enable the construction of a "DNA profile" that can be associated with a particular individual. This technique operates by targeting certain areas of the DNA and measuring the length of the repeating sequences therein. It is the length of these sequences that varies between individuals. Another feature of STRs is that there are two alleles at each genetic locus (or genetic site on a chromosome), which are inherited from each parent, making them useful for establishing familial relationships. Then, for a given genetic marker (for example, D18S51) a visual or numerical representation of the profile displays the number/length of tandem repeats found in each allele, e.g., 12|15.

The criteria that preside to the selection of these genetic areas of forensic interest are mainly based on the notion that they are not know to codify human genetic traits or diseases, their low mutation rate, or high level of independence, among others (Hares, 2015). Considering the application in forensic case work and databasing, further criteria have to be considered in view of database growth and the inherent risk of adventitious matches, or extended applications of databases for the identification of missing persons or "familial searching" (Ge, Eisenberg, & Budowle, 2012).

While it would not be unlikely that two unrelated individuals have the same number of repetitions in a given locus of a STR marker, it is the particular combination and independence of a set of markers that will statistically enable the identification of an individual through the product rule – as the probability of several events can be multiplied. Commercially developed kits of STR markers have been expanding the number of DNA markers, so that their discriminating power is also raised (Butler, 2006). In fact, because DNA profiling is rooted within solid scientific disciplines and it offers a probability based assessment of the evidence, it represents a step further from traditional forensic identification disciplines, or as Saks and Koehler (2005) have dubbed it, a paradigm shift.

Therefore, STR kits of genetic markers soon became the standard technology used to produce DNA profiles for forensic DNA databases all around the world. For example, the "Second Generation Multiplex Plus" (SGM+) has been used in the NDNAD since 1998. It includes ten genetic markers, or known loci of *Short Tandem Repeats* plus the sex marker Amelogenin. However, database systems like CODIS (Combined DNA Index System) in the USA, share only some of the SGM+ markers. Over the years, many different STR kits have been developed for different markets. The European Network of Forensic Science Institutes (ENFSI) lists in its yearly reports on "DNA-database management review and recommendations" the most common used loci and kits used in DNA databases, amounting to 58 different kits (ENFSI, 2016, p. 9). The compatibility between STR systems has long been a concern among the forensic genetics community, and several standards have been developed over the years, like the ISSOL (Interpol Standard Set Of Loci), ESS (European Standard Set - recommended by ENFSI) and CODIS (Combined DNA Index System) loci (Ge et al., 2012; Gill, Fereday, Morling, & Schneider, 2005). Therefore, comparisons between STR systems used in different databases are conditioned by the existence of a minimum of common markers.

From forensic DNA databases to Prüm

The development of the forensic DNA profiling and databasing was conjugated with the redefinition of risks and security concerns to bring about a new panorama in transnational policing (Sheptycki, 2007). The scenario of transnational criminal threats would bring about the creation of systems for the exchange of information. The historical experiences of some European countries with terrorism would be reflected in systemic developments of several legal and technical-scientific instruments created in the EU framework (Monar, 2008). One of the instruments to increase and facilitate transnational cooperation and exchange of information would become known as the Prüm Treaty.

The history of Prüm dates back to 2003. The German Ministry of the Interior Otto Schily made a proposal towards closer cooperation in Justice and Home Affairs to the governments of France, Belgium and Luxembourg (Luif, 2007, p. 6). Besides the concerns with the increase in cross-border criminal activities brought about by the end of the Cold War and the elimination of border controls in the Schengen area (Luif, 2007), the motivation to increase transnational cooperation also reflected apprehensions for EU border security in the aftermath of the 11 September 2001 attacks in the USA (M'charek, Schramm, & Skinner, 2014). The information that these attacks were perpetrated by individuals originating from the so-called Al-Qaeda Hamburg Cell in Germany may have contributed to unleash the transnational realization that there is a great potential for domestic radicalization and recruitment (Monar, 2008, p. 214).

Following debates on what model of cooperation should be adopted, in 27 May 2005, the so-called Prüm Convention or Prüm Treaty was signed in the German town of Prüm between seven EU Members States (Austria, Belgium, France, Germany, Luxembourg, the Netherlands, and Spain), in a process where Austria and Germany were the leading actors, and where France and Spain were last minute signatories (Balzacq, Bigo, Carrera, & Guild, 2006). According to Walsch (2008), Germany's initial proposal was to create centralized databases in Luxembourg, but the other partners disagreed and decided to create a system connecting national DNA databases using national contact points (NCP) for the exchanges. This allowed national institutional autonomy in the setting-up and governing of national DNA databases, while avoiding the transference and storage of data in other databases. At the time, there was already a sort of centralized DNA database which belonged to INTERPOL, where the authorities can upload DNA profiles. In 2013, INTERPOL's DNA Gateway held approximately 140.000 DNA profiles from 68 countries (Noble, 2013). However, the main purpose for the creation of Prüm was to design a system that would enable a very fast and secure access to criminal intelligence in other countries.

The Prüm Convention (2005), also known as Prüm Treaty, constituted a step in line with the Hague Program (EU Council, 2004) and the so-called Swedish Decision 2006/960/JHA (EU Council, 2006a) towards the establishment and implementation of a framework to simplify, coordinate and improve the circulation of information between law enforcement agencies of EU Member States. The provisions of the Treaty intended for the creation of a system to intensify cross-border cooperation to face the abovementioned threats through the automated exchange of information between Member States, namely of DNA profile data, fingerprints, and vehicle registration data. These were the types of digital data regarded as more suitable for transnational exchange at the time, but cooperation is expected to expand into other types of forensic information (McCartney, 2014). The text also envisioned the adoption of the Treaty's dispositions into the EU's legal framework (Prum Convention, 2005, p. 4). The main aspects were formally adopted into the EU's legal framework in 23 June 2008 through Decisions 2008/615/JHA and 2008/616/JHA (EU Council, 2008a, 2008b).

The incorporation into EU law meant that all Member States became obligated to build and maintain the necessary infrastructures, as well as to enact adequate legislation, in order to implement the operational requirements to establish connections to other Member States and exchange data. The Decisions marked a deadline of one year for the operational exchange of Fingerprints (FP) and Vehicle Registration Data (VRD) and, exceptionally, three years for the implementation of DNA data exchange. An extended deadline for DNA exchange was motivated by the fact that several Member States did not have an operational national DNA database.

In the European Union, DNA databases are mostly dedicated to the storage of DNA profiles of convicted offenders and DNA profiles of unidentified stains collected for criminal investigation purposes, although most can also serve purposes of civil identification, for example, in cases of missing persons or mass disasters (Williams & Wienroth, 2014). In spite of their common set of designed purposes, in the EU, national DNA databases can vary significantly in terms of their governing legislation and overall criminal justice system and police practices, which affects aspects like the proportion of the population included, size and rate of growth of the database, rules of access to DNA data, or the type of searches that are admitted (Reed & Syndercombe-Court, 2016; Santos et al., 2013).

In order to be able to exchange DNA data, Member States were required to comply with a number of formal requirements, as well as technical implementation and operational tests. The evaluation procedure and conditions that must be met before a Member State can start exchanging DNA data with others consists of a questionnaire regarding the status and conformity of data protection, a “pilot run” (i.e., a simulated exchange to be carried out with the database in another country), and an evaluation visit, which will assess the laboratorial and technical infrastructures of the evaluated country.

One of the harmonizing effects of the Prüm Decisions was the standardization of laboratorial practices. In order to ensure the integrity of the data circulating across borders and different laboratories Decision 2008/616/JHA (EU Council, 2008b) established the norm ISO/IEC 17025 as the common reference. This norm defines the general requirements for the competence of testing and calibration laboratories. Later, the EU Council enacted the Framework Decision 2009/905/JHA on the “Accreditation of forensic service providers carrying out laboratory activities” (European Council, 2009). The stated purpose of this Decision is to address “the absence of an agreement to apply a common accreditation standard for the analysis of scientific evidence”, in order to establish “mutual trust” (European Council, 2009, p. 15). This means that national DNA databases should not include DNA profiles that were produced in unaccredited laboratories in their data exchanges with other countries.

Regarding the legal regulation of forensic DNA databases in the EU, there is considerable heterogeneity. Although most EU Member States had operational DNA databases and comprehensive legislation, a few countries like Portugal, Spain or Italy did not have a specific law. Others were required to amend existing regulations in order to meet data protection standards and, particularly, the S. and Marper Decision of the ECHR[1]. In the EU there was, and there is still, significant heterogeneity in terms of the criteria for the inclusion and exclusion criteria of DNA profiles in forensic DNA databases. Santos, Machado, and Silva (2013) conceptualize two main tendencies: an “expansive” group where there few restrictions for the inclusion of profiles combined with long periods of retention; and a “restrictive” group where the prescribed criteria involve the suspicion or conviction for a certain type of crime, the length of a potential prison sentence, or a decision by a magistrate, and where retention periods tend to be smaller than in the first group (Santos et al., 2013). Considering a prospective exchange of DNA data, the different criteria for inclusion and exclusion in the EU Member States create a context where it is possible that a DNA profile from an individual legally included in the database of one country is compared against the database of another where the legal regime would not have determine their inclusion. The next section will provide more detail on the

[1] The S. and Marper Decision became a landmark case whereby the ECHR ruled that the fingerprints and DNA profiles of individuals that were detained at one point, but not convicted or formally accused, should be removed (McCartney, 2012).

regulation and functioning of the system for the transnational exchange of data by focusing on the particular case of DNA profiles.

Decisions and implementation

Mindful of the diversity of national regulations and contexts in terms of DNA profiling and databasing, as well as the need to create coordinating structures, in 2006 the Presidency of the Council of the European Union (CEU), asked COREPER (Committee of Permanent Representatives in the European Union) to set up an Ad Hoc Group on Information Exchange with a mandate to "propose solutions for the exchange of DNA data on a hit/no-hit basis by a direct automated access from an NCP of a Member State to the DNA database of other Member States" (EU Council, 2006b). On 30 October 2007, by initiative of the Federal Republic of Germany, a Decision draft was composed with a view to implement what would become the Decisions 2008/615/JHA and 2008/616/JHA.

On 28 June 2010, the "Ad Hoc Group on Information Exchange" was created to implement the exchange of information under the principle of availability[2] (EU Council, 2006a). This Ad Hoc group would later become the "Working Party on Data Protection and Information Exchange – DAPIX". This working party was mandated to overview and support the tasks and procedures related to the implementation of the so-called Prüm Decisions (2008/615/JHA and 2008/616/JHA). Member States that had already become operational in data exchange under the Prüm Treaty were expected to provide assistance in the implementation of the Prüm Decisions in other countries.

The three-year deadline to implement DNA exchanges ran until 26 August 2011. On this date, only 12 Member States met the operational requirements, although not all of them were exchanging DNA data. The Member States that were exchanging data in August 2011 were: Austria, Bulgaria, Finland, France, Germany, Luxemburg, the Netherlands, Romania, Slovakia, Slovenia, and Spain. From the group of 12, Portugal was the only authorized country not to have started DNA data exchange.

The latest report on the progress of the implementation of Prüm, in January 2017, indicated that there were still six Member States not exchanging DNA profiles with other countries: Denmark, Croatia, Greece, Ireland, Italy, and the United Kingdom. Nevertheless, the levels of readiness are differentiated, since, for example, Denmark and Greece are ready to start, while Croatia, Ireland, Italy still lack some required steps. The case of the United Kingdom appears to be moving forward, having had a pilot run with the Netherlands (EU Council, 2017).

Decision 2008/615/JHA

Decision 2008/615/JHA sets up the rationale and main guidelines for the functioning of the "Prüm system" for cross-border cooperation. It is based on the main provisions of the Prüm Treaty, namely where Member States are to improve the exchange of information by granting mutual access rights to information stored in national databases. Besides the reciprocal exchange of DNA profiles, dactyloscopic data, and vehicle registration data, Decision 2008/615/JHA also contains dispositions that establish National Contact Points (NCP),

[2] The "principle of availability" was promoted in the Hague Programme (EU Council, 2004) and outlined in the Framework Decision 2006/960/JHA. It aimed to simplify the exchange of information and intelligence between law enforcement authorities of the MS of the EU, by ensuring that MS treat the exchange of information with other MS as if they concerned internal criminal cases and applying the equivalent restrictions to the request and provision of data (EU Council, 2006a).

measures for the prevention of terrorist offences, security of major events and mass events, and procedures for joint police operations.

In the cases of DNA profiles and fingerprints, the system is designed to operate on two-step system. In the so-called Step 1, Member States send and/or receive profiles that are automatically compared with the existing profiles that conform to the rules for exchange. This process can result in "matches" that can be pursued by the requesting Member State in Step 2. This second step involves asking for personal data related to the matching DNA profile to the authorities of the requested Member State and, if necessary, further information through established mutual assistance procedures.

The hit/no hit system, which will be explained in more detail in Decision 2008/616/JHA, is designed to guarantee minimal intrusions to personal privacy of individuals whose profile is included in national DNA databases. Step 1 is completely anonymous insofar as only profile data is exchanged (i.e., the "numbers" that compose a DNA profile). In terms of data protection, Decision 2998/615/JHA asserts that the standards for area of police and judicial cooperation in criminal matters apply. This means that they should not be lower than those prescribed in the Council of Europe Convention for the Protection of Individuals with regard to automatic Processing of Personal Data of 28 January 1981 and its later provisions (EU Council, 2008a).

Chapter 6 of Decision 2008/615/JHA states that the supply of personal data cannot take place if the abovementioned conventions and protocols for data protection are not incorporated into the national law of the countries involved in the exchange. Although Decision 2008/615/JHA defines the purpose and manner how information should be requested and supplied, as well as the limits of its use and storage, it does not provide clarification as to what categories of personal data can be supplied in Step 2 (e.g., biometric data, socio-demographic details, criminal records, etc.). Furthermore, since the original signatories of the Prüm Treaty were already engaged in the exchange of information prior to the Prüm Decisions, they were excused from the requirement of a Council Decision authorizing personal data exchange (EU Council, 2008a, Article 25, par 3). This type is authorization, as well as pilot tests and evaluation visits are required for all other MS before commencing the exchange of DNA data.

Decision 2008/616/JHA and matching rules for DNA profiles

Decision 2008/616/JHA also contains the framework for the necessary administrative and technical dispositions for the implementation of Decision 2008/615/JHA. Originally, the selected communication infrastructure was the TESTA II (Trans European Services for Telematics between Administrations), which was superseded by the upgraded sTESTA in 2008, offering stronger security features based on a dedicated private infrastructure completely separated from the Internet.

Most importantly, Decision 2008/616/JHA defines the standards that should govern the exchanges of data. Data are exchanged through an encrypted SMTP (Simple Mail Transfer Protocol) transporting an XML body structure on a closed VPN network. It also defines rules for requests and the respective replies, namely of the information and logging procedures that accompany transmissions. Focusing on the particular case of DNA data, integrity and interoperability of data are to be ensured by the use of common standards regarding the STR markers to be compared. These are the European Standard Set (ESS) and the Interpol Standard Set of Loci (ISSOL). This is a flexible solution since, as previously noted, different national DNA databases have used updated and more discriminative STR kits to include DNA profiles in databases. Therefore, Decision 2008/616/JHA includes a list of 23 STR markers plus the sex marker Amelogenin, where seven are common to the ISSOL and the ESS (i.e., VWA, TH01, D21S11, FGA, D8S1179, D3S1358, and D18S51).

The minimal standard of STR markers or loci to be compared has the advantage of enabling comparisons between the multiple EU DNA databases. However, as noted by the Netherlands DNA database custodian, Dr. Kees van der Beek, the high volume of profiles being exchanged and the relatively low number of loci increases the probability of adventitious matches, or false positives, which can correspond to a third of total 6 loci plus one mismatch (Van der Beek, 2011). Additionally, the scale of the exchanges foreseen to occur prompted a revision and expansion of the European Standard Set, whereby the DNA Working Group of the European Network of Forensic Science Institutes (ENFSI) and the European DNA Profiling group (EDNAP) defined five more DNA markers that became the European standard through Resolution 2009/C 296/01 (EU Council, 2009).

Therefore, given the risk of generating false positives, Decision 2008/616/JHA established a set of matching rules, which also determine what type of profiles can be sent for transnational comparison. Typically a DNA database can be divided into several "files" containing profiles according to the motive for inclusion: convicted offenders, crime scene stains, unidentified missing people, and reference profiles from relatives of missing people, crime scene and laboratory personnel for elimination purposes. A Member State can establish what type of profiles it wants to compare against other databases. For example, only new profiles of individuals may be sent for comparison. This is because the original national databases are not accessed, but a Prüm copy containing the relevant profiles is made for transnational comparison (Van der Beek, 2011). Some databases are allowed to include profiles of suspects and to retain them for a time period (e.g., Austria, Finland, Estonia, Latvia, etc.) and other only include the DNA profiles in the database after a penal conviction (e.g., Portugal, and Romania). Nevertheless, the rules are that a DNA profile eligible for comparison must abide to the following criteria: contain at least six fully designated loci; reference profiles (i.e., from identified people) must contain at least six of the seven ESS loci; mixed profiles cannot be included for comparison[3].

Since the comparison process in Step 1 is automated, there are matching rules that must be applied to the software matching tool. A match occurs when both alleles of six mutually available loci have the same value. This will indicate the existence of a hit to the operator. If two DNA profiles have equal allele values in all common compared loci it corresponds to a Quality 1 match. The matching rules also define "near matches". A near match occurs when all but one allele are equal in both DNA profiles. The matching system is designed to allow one mismatch or "wildcard", that is, a six loci match plus a mismatch. It is important to allow a mismatch since it can be caused by a typing error or an allele-calling error during the generation of the DNA profile. Sometimes, amplification artefacts can occur, like allele drop-in or drop-out, or null-alleles, whereby alleles are not amplified during PCR[4] (ENFSI, 2016). Matches that allow one mismatch are designated as Quality 2 matches. Quality 3 and Quality 4 matches allow a mismatch in one base pair, or more than one base pair, of an allele of a given locus, respectively (Van der Beek, 2011).

Full matches (Quality 1), near matches (Quality 2, 3 and 4), and "no hits" are to be reported to both NCPs involved in the exchange, in order to assess the need to provide, or ask, for follow-up procedures regarding further available personal data or information on the DNA profile. When a match is reported during the automated procedure of comparison, NCPs are

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[3] A DNA profile can be considered "mixed" if it cannot be attributed to a single contributor. If there is more than one contributor, the amplification of the biological material will not discriminate between individuals and the analysis will reveal an electropherogram or image showing more than two alleles at a given locus.

[4] PCR stands for *Polymerase Chain Reaction* which is a molecular biology technique that allows the amplification, or the making of multiple copies, of specifically targeted sequences of DNA (Jordan & Lynch, 1998).

responsible for their validation. This is performed by calculating the evidential value or likelihood ratio of the match. If necessary, NCPs can contact each other directly in order to request more information. When a match is validated, Step 2 procedures, involving mutual legal assistance, may be initiated.

Standardizing operational statistics

The scale in which the exchanges of DNA data take place warrant mechanisms for its oversight and accountability. In 2015, the national DNA databases of the operational Member States contained a total sum of 5.672.214 profiles of individuals[5], and reported 25.959 total matches[6]. In accordance with its tasks of supervising and supporting the implementation of the Prüm Decisions, DAPIX regularly convenes in order to assess and discuss the current state of affairs. Since 2010, DAPIX has issued documents accounting for the "state of play" of the implementation of the Prüm Decisions and, since 2011, started discussing proposals for the publication of common statistics on DNA data exchange. The presentation of statistics to the EU Council on the results of the transnational DNA data exchange are important in view of the system's transparency and accountability. Statistics can also provide insights into the local practices of DNA profiling and databasing (e.g., figures of database growth in terms of people and crime scene stains), and the transnational patterns of cross-border crime (Bernasco, Lammers, & Van der Beek, 2016; Santos & Machado, 2017). Moreover, statistical reports could help systematize information about criminal cases solved with the aid of Prüm, thus allowing an understanding of its effectiveness beyond anecdotal cases of success (Taverne & Broeders, 2015, 2016).

However, to develop a common standard or model for the information among diverse local understandings, practices and technical architectures is not as expedite or feasible as one could expect. DAPIX document 12226/11[7] exposes the inherent challenges to this task. First, there is the issue of "meaningful" statistics. From the initial three options for accounting and reporting DNA exchange statistics, a model for reporting the number of investigations aided by Prüm DNA matches ("meaningful statistics) was disregarded because it was unfeasible. The reason for this is that it would require all MS to ensure that the investigative authorities provided feedback on the judicial outcome of cases. Currently, there are no formal Step 1 mechanisms to provide feedback to NCPs on how many matches led to investigative follow-up or to what extent the intelligence provided was useful in the investigation of a criminal case. Furthermore, even if there was such a system in place, in order to determine if a criminal investigation benefited from a Prüm DNA match, the information would not be provided in a useful time frame because of the length of the judicial proceedings. Nevertheless, the metric of "investigations aided" is currently employed by the FBI on its National DNA Index, which aggregates information on a state level[8].

The second proposed model would be to report the number of results that could have aided an investigation. That is, accounting for the matches that were considered relevant results by the public prosecution services or by the investigative authorities in Step 2, even without

[5] It should be noted that the French DNA database, with more than 3 million profiles, includes duplicate profiles.

[6] For reasons explained in these pages, the figure of total matches reported to DAPIX does not accurately portray the number of instances that led to criminal justice developments.

[7] Public documents are accessible at the register of the Council of the European Union: http://www.consilium.europa.eu/register/en/content/int/?lang=en&typ=ADV

[8] See, for example, the CODIS - NDIS Statistics: https://www.fbi.gov/services/laboratory/biometric-analysis/codis/ndis-statistics

waiting for the judicial outcome. However, this option would imply setting up a system to provide information back to Step 1 NCPs from the investigative authorities. This problem is that not all NCPs are able or even allowed to filter this type of information. The third option would be for NCPs to provide "filtered" statistics. This model would report all obtained results, accompanied by an explanation of their meaning.

The issues associated with the reporting of statistics are illustrative of the challenges involved in achieving a standard in a transnational context where there are different local technical solutions, available resources and institutional arrangements, competing to resolve tensions on a global scale (Timmermans & Berg, 1997). For example, although it would be more informative to provide explanations and a quantification of the types of matches (e.g., Quality of matches, validated matches, or matches obtained more than once), the ensuing debate about the statistical model to adopt revealed that not all Member States were in a position to deliver these "filtered" statistics (see Document 14103/1/11). Although it is stated that the Commission preferred option 2, a majority of Member States delegates (15) voted for option 3, that is, "unfiltered" statistics (Document 14103/11).

Therefore, the contents of "unfiltered" statistics laid out in the annex to Document 14103/1/11include the following information: All unique Quality 1 and 2 matches (sorted by country and match type); Match types are classified by stain-person, stain-stain, person-person and total matches; Quality 3 and Quality 4 matches are not to be included unless validated through a reanalysis with supplemental information. It was also decided to include only matches based on outgoing requests in order to prevent duplicate counting. The statistics also report on the total number of unique profiles sent and received in the respective year, as well as figures about the Member States national DNA databases like the total number of profiles (stains and persons) included at the start and at the end of the year.

This model of reporting statistics on DNA data exchange was decided to be implemented for 2011 and re-evaluated in the following year. With the first statistical report (Document 11367/12), the Austrian delegation suggested that the directionality of the matches could be included (i.e., between *own* and *external*). The statistical tables for 2011 were changed and started to discriminate matches accordingly (see Document 14383/2/12)[9]. Nevertheless, these reports include the disclaimer stating the limitations of the data. Namely, that total matches include all unique (not duplicate matches) Quality 1 and Quality 2 matches, and that there can be false positives among them.

The application of the "unfiltered" model of statistics presents a design incompatibility with the Prüm system, insofar as there is no retention of information about profiles received that do not result in matches. The process of decision for the model of statistics to be collected had to coordinate the different interests, activities and local contingencies of each Member State (Timmermans & Epstein, 2010). The final option for "unfiltered" statistics was a compromise that balanced flexibility and rigidity that enabled NCPs to comply with the need to provide match statistics. Jordan and Lynch (1998) argue that the embedding of a standard in other technologies contributes to the preserving of the standard. In the case in point, however, it is most likely that the use of different software solutions for DNA database management will raise the demand for a tailored solution to the issue of standardized statistics that fit the information needs of the participants (Star & Ruhleder, 1996).

[9] The table headers are thus formatted as Stain own-Person ex; Stain own -Stain ex; Person ex – Stain ex; Person own – Person ex, distinguishing between "own" and "external".

Given the constraints, most countries do not report the total number of DNA profiles received from other countries. The Netherlands invokes article 26(2)[10] of Decision 2008/615/JHA to justify the absence of data on the total number of unique DNA profiles received from other countries. Others, like Spain, explain the absence of this data with a design feature of the databasing software CODIS 7. Furthermore, there are instances when Member States did not report statistics, like France in 2012 or Latvia in 2013. In sum, achieving a standard for operational statistics is more of a political objective than an operational requirement for the Prüm system to function, and one that will require overcoming multiple sites of resistance (Bowker & Star, 1999).

Global standards and local practices

This section develops an empirical approach to some features of the implementation of the Prüm Decisions. It draws on extracts from 11 interviews performed with National Contact Points for Step 1 of Prüm DNA in a total of 11 EU countries. The interviews were conducted between December 2015 and December 2016. The interviews took place in locations chosen by the interviewees. The interviews were all recorded with the exception of one interviewee who did not authorize the recording. The resulting verbatim transcripts and interview notes were subsequently anonymized. The majority of the interviews (8) was conducted individually, and the other three involved other relevant participants, namely forensic experts sharing tasks with the NCPs. The majority of interviewees had a PhD or MsC in the field of Biology. The recruitment was made by sending an invitation by email, using the contacts indicated in the "Manual for Law Enforcement Information Exchange" (Document 6704/16) as well as information provided by privileged informants.

A semi-structured script was used, covering themes associated to the interviewees' perspectives and experiences about forensic DNA technologies, governing regulations and workflow with other institutions and agencies, the implementation of the Prüm system on a national and on the EU level, data protection and ethical issues, and perceptions of relations with the public. The resulting materials were subjected to a qualitative content analysis, which provided situated perspectives on the themes of data protection, harmonization, and how local actors perceive, implement, and cooperate in a system for the transnational exchange of data.

The implementation of transnational standards tends to generate frictions with stabilized practices and institutional features, not only at a national level, but also in the sphere of the EU (Hufnagel, 2012). From its inception, the Prüm Treaty has raised criticism regarding the way in which it was discussed and drafted between a small group of Member States without due participation by national parliaments (Kierkegaard, 2008; Topfer, 2008). Other authors have expressed concerns that the way in which Prüm restricts the "principle of availability" (EU Council, 2004), by preserving national autonomy and control over data, is a source of mistrust among Member States, leading to sub-optimal policies (Balzacq et al., 2006; Balzacq & Hadfield, 2012).

The focus on technical and scientific standards for the operationalization of Prüm's Step 1 tends to minimize interoperability issues that lie before and beyond the automated comparison of DNA profiles in Member States' databases, but are nonetheless a part of it. These include the social, cultural, legal and organizational contexts in which forensic DNA databases are

[10] This article states that the processing of data is only permitted to establish matches and to prepare police or judicial requests. It also states that the supplied data (e.g., DNA profile data) shall be deleted immediately after comparison. Therefore, according to this, it would not be "allowed" to record how many unique profiles were received.

designed and regulated (De Hert & Gutwirth, 2006). For example, considering the system for the transnational exchange of data through Prüm, McCartney and colleagues have considered the challenges of technical and scientific harmonization (viability); legal issues (legitimacy); and ethical and socioeconomic aspects (acceptability) (McCartney, Wilson, & Williams, 2011). These authors argue that the transition from the technological viability of the Prüm system to its operational reality was not particularly well managed. That is, even if the technical compatibility issues could be overcome, there may still be relevant problems of legitimacy and acceptability, not only because of the lack of democratic involvement of national parliaments, but also in view of the balancing of costs and promised benefits (McCartney et al., 2011), which may be unequally distributed (Wilson, 2016). For instance, it implied additional costs for countries that did not have a national DNA database, and this system will potentially carry more benefits to those countries that have better criminal investigation resources and benefit from the inclusion of known offenders in the databases of other countries (Santos & Machado, 2017). Nevertheless, Member States are still obliged to implement DNA profiling and databasing and to make data available for exchange, independently of their perspectives on the acceptability of this system (McCartney et al., 2011).

The differentiated contexts of implementation was taken into account as far as to balance the need for minimal common operating and regulatory standards with the local trajectories and contingencies. As previously stated, the Prüm Decisions promote a flexible and autonomous regulation in most aspects. The level of data protection in Prüm is bound to conform to minimal standards that are not specific to the technologies involved (O'Neill, 2010). Although there is a potential benefit of Prüm in the sense that it reduces the amount of circulating personal data (Prainsack & Toom, 2010), one of the interviewees expressed concern about the how the application of a minimal standard of data protection allows differentiations that may imply the suppression of individual rights following a DNA match:

> *It is of course a question of how easily countries give up those persons by giving up their information. If the country does not protect their people it is definitely a problem. (…) Once they get these matches they are given up, and they are basically by themselves. I think it might not be only our country's problem. B01*

The type of personal information that is given to a requesting country is not regulated, providing NCPs with a degree of discretion conditioned by the information that is available, and the time it takes to gather it. It can vary according to the Member State requesting the information and be limited to basic information like name, gender, date of birth and available criminal records, or it can be extended to mobilize human resources and secondary types of information. As explained by one of the interviewees, this can be a quite thorough process:

> *So, when we receive this unique reference number (…) we retrieve personal data, then we make checks in our Ministry of Interior's database for relatives or for border-crossing or for criminal and judicial records; all collected information is sent back to requesting countries; and additionally we send a request to the competent authorities, depending on the crime and… the place where the person is registered for living, to collect intelligence… about… to ask police officers on field 'Do you know this person? Who are his or her accomplices?' and of course, when we receive this information we send it back to the requesting country. This is the process. K01*

The workflow description provided in the extract above goes to the extent of having local police inquire into acquaintances of the suspected person. This is in contrast with practices in other countries where the type of custody and oversight of the DNA database does not allow personal data to be gathered and sent without a formal request to a judiciary authority.

If it's a person, they will only give the name, the birth date and the place of birth, and nothing else. And then, if the country needs more information, they have to send again a new rogatory commission. I01

Perspectives on local implementation appear to be differentiated according to particular historical, social, cultural and geopolitical trajectories. For example, although there is a perceived common goal and purpose to the Prüm system (i.e., to allow faster communication to fight cross-border crime), the priorities of interconnection between countries do not abide by any scheduled program. Rather, how and when to establish a connection remains a flexible consideration to the actors involved. The factors that may influence the decision to connect two countries can be associated to the perceived relevance in terms of cross-border crime, but also to simple matters of convenience, interpersonal relations between NCPs and political decisions. Therefore, neighboring countries are usually the first to establish interconnections after becoming operational, especially if there is a history of past cooperation.

We have a close cooperation with the Slovaks and the Czechs (…) So we we're meeting very often before and we decided that we would establish Prüm exchange with the Slovak colleagues. G05

The importance of sharing borders and beneficial cooperation experiences is emphasized by contrast when NCPs attempt to establish interconnections beyond the conventional priorities. The extract below is an example of how local constraints can hamper interconnections. In this case, the NCP expresses a will to establish a new connection that remains unanswered by their counterpart:

And we have asked others to start, too, but from all of them we don't have a satisfying answer to why they can't. But some countries, for example Slovenia, has not even answered to our letters, and we've sent several of them, and we don't know what is their status. B01

This is illustrative of the differentiated levels of implementation and the impact of local asymmetries and practices for a harmonized and fully functioning system for the exchange of information.

In spite of the standardized definition of the types of hits/matches that can occur and that should be reported, the operational context and local practices in each country tend to adapt these standards to their own circumstances and informational needs (Star & Griesemer, 1989). On the one hand, there is the uncertainty of relevance criteria of the hits in the Prüm DNA exchange in terms of their follow-up. For example, the NCP of one country stated that the investigative authorities were not interested in person-to-person matches and, therefore, only stain-to-person or stain-to-stain hits were validated and reported. In another country, it was described how some reported hits lead nowhere because the cases are already "too old", meaning that the time period for judicial action was prescribed. On the other hand, there are different ways of dealing with the quality of the hits. A hit with mismatches can be reported and pursued for validation. However, these can also be de-prioritized according to the workload and available personnel. One of the interviewees was working in a laboratory where there were less than 10 people who were responsible for the national DNA database, casework laboratory, and transnational cooperation. The lack of staff and the high volume of non-confirmed 6 and 7 loci matches – since they would have to be confirmed – may have contributed to the decision to report only 8 loci matches:

We are validating this information very strictly, and we are informing our police officers only about good hits – we decided about this: only hits which have at least 8 common markers. We, of course, do some kind of statistical calculations… But we had doubts at *the beginning, because we had a lot of matches of only 6 or 7 markers matching with Germany, and this information went to the police officers, and finally it was not [a] match, so we decided that it is better to inform only about good hits. G05*

The confirmation of near matches is relevant insofar as it can make a difference between identifying a person and providing a clue that can help to solve a case, or represent a lost opportunity. The confirmation can be performed by requesting more information to the other country. This can involve a reanalysis of the biological sample with another STR kit with different markers, or a look at the original electropherogram to see if there was any mistake. One interviewee explained that there are informal understandings about how to proceed. This is a practical way of ensuring a distribution of workload and potential benefits:

In Prüm, we observe that it's an unwritten rule that who owns the case, who will be the person, the beneficiary, who will have benefits after solving that case will do all the steps for obtaining other type of data. So, if we have a crime scene that we have a near match with our sample, we try to do other investigative steps, like using another kit, re-amplifying the samples and so on. J01

Other empirical examples would supplement an overall impression of the coexistence of stable and harmonized standards of operation with moments of ambiguity whereby the involved actors engage in more or less *ad hoc* solutions to operational issues arising from the awareness of the differentiated nodes of the Prüm network.

Conclusion

This paper has provided an overview of the standards and protocols that were designed or implemented in order to guarantee the stability of the Prüm system, as well as the reliability of the exchanges of DNA information. Processes of standardization allow the creation of uniformities across time and space. A successful standard can be extend to heterogeneous communities of practice and be used in different activities and locations (Bowker & Star, 1999; Timmermans & Epstein, 2010). For instance, the European Standard Set of DNA loci was projected to define a type of metric that allows a minimum common denominator to different DNA database architectures that were set up along distinct periods and using a multiplicity of different loci.

The Prüm system configures a decentralized network where DNA data can be exchanged and compared among forensic DNA databases in the EU. It is an infrastructural solution that relies on a decentralized virtual network to make the gathering of criminal intelligence possible, thus curtailing the political, legal and jurisdictional issues that could be associated with a centralized database. The decentralized model of cooperation enables a wide degree of national and institutional autonomy in the governance of forensic DNA databases, while generating and enforcing the dissemination and harmonization of standards necessary for the operation of the system.

Historically, the expansion of the uses and applications of DNA profiling, as well as the more recent transnational agreements for the circulation of this type of information, have been accompanied by progressive steps on the level of scientific and technical harmonization. However, matters of social, legal, political and cultural convergence are more difficult to harmonize in a context that balances local needs and resources with global interests and collective definitions of the problems like cross-border crime and potential terrorist attacks (Timmermans & Berg, 1997; Timmermans & Epstein, 2010). This tension is illustrated, for example, by the fact that the proposed deadline for the operational status of DNA exchange was not met by a majority of Member States. Moreover, the diversity of legal regulations and rules of custody and access to forensic DNA databases tend to generate frictions when it comes to the exchange of personal data associated with DNA profiles.

In summary, the establishment of minimal and/or flexible standards (e.g., guidelines on data protection, communication and encryption protocols, standardization of DNA markers and rules for DNA comparison and matching), have allowed most Member States to achieve implementation and interconnections with other countries. The success of the operation of Prüm has been translated as DNA matches that provide relevant information the investigative authorities, allowing criminal cases to be solved (Taverne & Broeders, 2015). The transnational scientific and technical cooperation promoted by the Prüm system can also benefit the convergence of laboratory standards and practices, thereby contributing towards the upgrade and harmonization of forensic genetics. Nevertheless, the softer or more flexible aspects of the regulation of the transnational exchange of data may raise concerns regarding the standards of data protection and individual privacy. Namely, because the legislative criteria that dictate the inclusion and removal of a person's profile in a forensic DNA database are differentiated among EU Member States, but also because of the local police and judiciary practices and resources. Still, the Prüm system is not yet fully operational and it will be important to observe the future developments and how standards evolve.

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