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Citation: Amankwaa, Aaron and Addo, Judith Amankwa (2022) Forensic DNA analysis and database governance in Ghana. In: Law, Practice and Politics of Forensic DNA Profiling: Forensic Genetics and their Technolegal Worlds. Taylor & Francis, London, pp. 56-71. ISBN 9781032385280, 9780367338497, 9780429322358

Published by: Taylor & Francis

URL: <https://doi.org/10.4324/9780429322358-6>
<<https://doi.org/10.4324/9780429322358-6>>

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Abstract:

There is limited information about forensic DNA profiling and databasing in Africa. According to the INTERPOL global DNA profiling survey results (2019), 11 out of 53 African countries responded 'yes' to the question of whether they deployed DNA profiling (INTERPOL, 2019). Seven of these countries had also set up a DNA database, and two reported that such a database was planned. Twelve other countries responded to the survey but did not authorise the public release of the information provided. This chapter narrates developments in Ghana, one of the 11 African countries that have commenced using DNA profiling in their criminal justice system, but not without critical challenges.

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Forensic DNA analysis and database governance in Ghana

Aaron Opoku Amankwaa and Judith Amankwa Addo

Introduction

Case Study: The ‘Takoradi Missing Girls’

On different days in 2018, three young women and a girl set out in the morning for the day's activities. In the late hours of the day, their families became worried about their whereabouts and reported their disappearance to the Ghana Police Service. The families of the missing women later received calls from unknown individuals demanding ransom for their release, confirming that they had been kidnapped. The police traced the calls, leading to the arrest of Samuel Udoetuk-Wills, a Nigerian national, in December 2018. However, days after his arrest, he escaped from police custody. In the course of the investigation, in August 2019, the police discovered the personal belongings of one of the girls and some skeletal remains in Udoetuk-Wills's hideout. Based on a DNA test by the forensic unit of the Ghana Police Service, it was confirmed that the remains belonged to the four missing persons. The police arrested another suspect, John Oji, a Nigerian national, and both suspects were convicted of the murders of the four victims and sentenced to death by hanging (Aklorbortu and Dzodzegbe, 2021). Following the investigation and conviction of the two suspects, the families of the missing victims

requested copies of the DNA test results and demanded an independent DNA test (Agyei Annim, 2021).

There is limited information about forensic DNA profiling and databasing in Africa. According to the INTERPOL global DNA profiling survey results (2019), 11 out of 53 African countries responded 'yes' to the question of whether they deployed DNA profiling (INTERPOL, 2019). Seven of these countries had also set up a DNA database, and two reported that such a database was planned. Twelve other countries responded to the survey but did not authorise the public release of the information provided. This chapter narrates developments in Ghana, one of the 11 African countries that have commenced using DNA profiling in the criminal justice system, but not without critical challenges such as illustrated in the case study referenced earlier.

Ghana began using forensic DNA analysis in 2011 when the Ghana Police Service Forensic Science Laboratory (FSL) was refurbished under the European Union-Ghana Police Project (Amankwaa et al., 2019). Through this project, about €3 million were invested in the development of the FSL. ¹ The FSL is made up of five main units, including a DNA department, and the Accra-based laboratory is the main provider of forensic services to all 17 police regions in Ghana. In addition to the services provided by the FSL, other state institutions/agencies and private organisations offer forensic services to the police. These include the Ghana Standards Authority, DNA Diagnostic Centre (DDC) Ghana and some government and private hospitals. The capacity of the FSL to support police investigations and prosecutions has been criticised by Amankwaa et al. (2019), highlighting the need for investment in the central laboratory and the establishment of regional forensic centres through public-private partnerships and collaboration with university and hospital laboratories to aid the police in crime investigation and prosecution.

The governance of the use of forensic DNA in Ghana can be described as an *unregulated technolegal world*. The current regime is characterised by the lack of a dedicated legislative framework, robust quality management systems and independent statutory bodies to oversee the collection, retention, use and destruction of DNA records for policing purposes. In this chapter, we review the governance of DNA analysis as an emerging forensic practice in Ghana and the

key issues associated with the current regime. There is presently no published review of the operation, growth, governance and performance of the DNA analysis unit of the FSL. The first part of the chapter provides a concise overview of the legal basis of the EU-Ghana Police project, setting the context of developments in Ghana, the key conditions of the EU aid and the implementation of the agreement. In the second part, we examine existing research on forensic DNA analysis and its application in Ghana since 2011. The third part discusses the trajectory of the development of a forensic DNA database and its associated issues. We then assess the impact of the use of forensic DNA analysis in criminal investigations, focusing on two publicly available case studies. Further, the representations of forensic DNA analysis and databases in the Ghanaian media is discussed, highlighting the key debates on the collection, retention, destruction and use of DNA for policing purposes. The final part of the chapter discusses the key principles governing the use of forensic DNA in criminal investigations and how these principles are being applied in Ghana. We demonstrate that the emerging *technolegal world* in Ghana lacks a robust governance framework to protect citizens and produce public trust in the police and forensic science. We end with a reflection on the status of DNA profiling and databases in Ghana, identifying gaps in the technology, research, policy and legislation, with recommendations to improve forensic genetics practice in Ghana.

The EU-Ghana Police project

The legal basis of the EU-Ghana Police project was the Cotonou Agreement, which was signed between the European Community and the African, Caribbean and Pacific (ACP) Group in June 2000 (**ACP and European Community, 2000**). The aim of the agreement, which ended in December 2020, was to promote reduction of poverty, sustainable development and economic integration among partner countries. The Cotonou Agreement enshrined four key principles that defined the partnership between ACP countries, the European Union and EU Member States. These principles included equality of all partners and ownership of development strategies,

independence of ACP countries to determine development policies, public-private cooperation in the implementation of development strategies and conditionality of development needs to be based on countries' level of development.

Out of many billions of euros in European aid to ACP countries, the EU budget support for Ghana was estimated at €224 million (DEUG, 2012). The Ghana Police Service FSL was funded by the Ninth European Development Fund (EDF), with a total of €3 million to support crime fighting and improve security in the country. The areas of support for the FSL included construction, the supply of equipment (EuropeAid/129238/D/SUP/EU), software and forensic resources, vehicles and training (MOFEP, 2010, 2009a, 2009b). Currently, the scope and extent of the utilisation of the FSL resources are opaque, with limited information about the performance and subsequent development of the laboratory in the public domain. These issues raise questions about the accountability and transparency of the operation of the FSL.

Research on forensic DNA analysis in Ghana

Developmental and validation studies of forensic methods and procedures are crucial to demonstrate their reliability and thus usefulness as evidence in legal practices. These studies are furthermore required by established international standards (ILAC, 2014). Research output on forensic DNA analysis in Ghana is low, a gap that reflects the inadequate investment and prioritisation of forensic science in the last decade (Amankwaa et al., 2019; Koomson et al., 2019). To inform this chapter, a search was conducted on three academic databases – PubMed, ScienceDirect and Web of Science – to identify research work related to forensic DNA analysis in Ghana since 2011. The academic database search was conducted in August 2020.² A further literature search was conducted on the Ghana Police Service website and the two main universities in Ghana that are currently offering degrees and professional training in forensic science: Kwame Nkrumah University of Science and Technology and University of Cape Coast (Amankwaa et al., 2019). Additionally, a research inquiry questionnaire was sent to the FSL to

obtain information about the operation and performance of the DNA laboratory. The literature search identified 99 hits from the three academic databases: 11 from PubMed, 4 from Web of Science and 84 from ScienceDirect. Overall, 12 relevant primary research publications were identified following the screening of the database hits, examining the references of included papers and searches on the police and the educational institution websites. No validation studies of DNA profiling methods and procedures employed by the FSL were identified, including the validation of specific multiplex systems in casework.

Multiplex systems in forensic casework

Modern DNA typing is mainly based on autosomal STR analysis, which is strongly supported by continuous research in genetics, technological advancement and the development of quality standards (Butler, 2012). In many jurisdictions across the world, there are set standards or common practices on the number and specific STR markers for forensic casework. This practice ensures consistency and cross-comparison of DNA profiling results across forensic laboratories in the same jurisdiction. For example, in England and Wales, DNA-17 profiling is the current multiplex system used by forensic science providers in casework (FIND Strategy Board, 2019). The DNA-17 system comprises all the 16 common European markers and 15 markers from the CODIS loci, allowing international comparisons.

In Ghana, there is no ‘nationally approved’ multiplex system or standard set loci for forensic casework, which suggests that different laboratories may use multiple systems for forensic DNA investigations. A standardised set of loci (e.g., the European Standard Set [ESS] loci of twelve core markers) is required to ensure the harmonisation of databases and the exchange of forensic DNA data (Prainsack and Toom, 2013). The current ‘open status’ in Ghana, however, may lead to complications in the comparison of DNA results from crime scenes and individuals. For example, it may not be possible to detect full profile matches if different multiplex test kits with different sets of markers are used for the analysis of biological samples

from crime scenes and individuals. Further, the absence of a common set of loci may hinder the development of a common forensic DNA database to support police investigations ([ENFSI DNA Working Group, 2017](#)).

The evidence from the literature suggests that the GlobalFiler multiplex system ([Wang et al., 2015](#)) and other DNA-24 systems have been used in research and casework by scientists affiliated with the FSL ([Afrifah et al., 2020](#); [Badu-Boateng et al., 2018](#); [Kofi et al., 2020](#)). The DNA-24/GlobalFiler includes all the DNA-17 loci and the CODIS loci. The additional loci are the DYS391 and Y indel, which are specific to the Y chromosome. The DNA-24/GlobalFiler system was adopted by Scotland for casework in 2015 ([BBC News, 2015](#)). The DNA-24 profiling system is beneficial because it provides an opportunity to compare DNA results both nationally and internationally. The system is also superior to current existing multiplex systems because it offers high discriminatory power and sensitivity in DNA analysis. The advantages of the DNA-24 systems suggest a need for a comprehensive evaluation and validation of the multiplex system for application in forensic casework in Ghana. Following such evaluations, the system may be adopted as a common standard for forensic STR typing.

In addition to adopting a common multiplex system, there is a need to develop appropriate STR allele frequency databases to support the estimation of the significance of matching profiles in the population. This is important because DNA profiling technology only targets very few specific segments or markers of the entire genome of an individual. Hence, DNA profiles are not 'unique', making the interpretation of matching profiles a probabilistic evaluation exercise ([M'charek, 2000](#)). Population frequency databases provide information about the frequency of each possible STR allele or genotype in a specific population. This ethnic-specific data allows forensic scientists to estimate the random chance of occurrence of a profile in the relevant subpopulation. Ghana is a multi-ethnic society, with more than ten different ethnic groups. The major ethnicities include the Akans (48%), Mole-Dagbon (17%), Ewe (14%), Ga-Dangbe (7%) and others (14%) ([CIA, 2020](#)). To calculate a more accurate random match probability of profiles generated from crime scene traces and subject samples, forensic DNA

scientists must have access to a representative allele frequency database (M'charek, 2000). In our literature search, we found six publications related to the STR allele frequencies, SNP and mtDNA haplotype frequencies of ethnic groups from Ghana (Fendt et al., 2012; Kofi et al., 2020; Poetsch et al., 2011; Sanchez-Faddeev et al., 2013b, 2013a; Wepeba, Iyengar, and Goodwin, 2019). These studies provide information that can be used for calculations in forensic casework to determine the significance of DNA evidence.

There is currently an ongoing project at the University of Central Lancashire investigating the allele frequencies of the GlobalFiler STR loci among four major ethnic groups from Ghana: 282 Akans, 250 Ewes, 262 Ga-Dangbe and 253 Mole-Dagbon and Northern minority ethnic groups (Wepeba, Iyengar, and Goodwin, 2019). The results of this study will provide new STR population frequency data for the main ethnic groups. The availability and accessibility of this data will significantly enhance the quality of forensic DNA casework in Ghana as well as enhancing the transnational exchange of DNA data. It is not clear to what extent the FSL utilise the existing population frequency databases and how DNA match evidence is interpreted and reported to the court. This information is wanting in available court proceedings and police public reports/communications in cases involving DNA (*Asante v The Republic*, 2017; Mensah, 2019).

National forensic DNA database in Ghana

A national forensic DNA database is a national intelligence database containing DNA profiles from known individuals and profiles generated from crime scene traces. In stranger offences (i.e., where the perpetrator is unknown), crime scene profiles can be searched in the database to identify potential suspects or unknown individuals who may be linked to the investigation. Currently, Ghana has no national electronic database of forensic DNA data (INTERPOL, 2019). Although there is no dedicated legislation on the collection, retention and use of DNA for policing purposes, the Data Protection Act 2012 categorises DNA information as special

personal data that can be used in the administration of justice where necessary ([Parliament of the Republic of Ghana, 2012](#)). The existing regime implies that there is no possibility of forcing a suspect to provide a bodily sample for DNA analysis or storing forensic DNA data without a justification of its relevance in the case. However, an initial trajectory towards the creation of a database at the FSL has been established with limited statutory oversight, an approach described as ‘rogue’ databasing, in which DNA is collected legally, but there is no statutory basis for its retention ([Murphy, 2013](#)). The 2016 Interpol Survey on DNA profiling suggests that some DNA records from casework are being retained by authorities ([INTERPOL, 2016](#)). It is not clear whether profiles are held in an electronic format or hard copies or whether adequate measures are in place to assure the quality, security, legality and integrity of DNA samples and profiles.

To date, there has been no adequate parliamentary or public debate or research into public views on the acceptability of forensic DNA and databases for policing purposes. This lacuna has been recognised by other authors and stakeholders and its mending as an essential requirement to ensure that sensitive policing technologies, such as DNA databases, are acceptable to citizens ([Science and Technology Committee, 2005](#); [Wallace, 2006](#)). The implications of the gaps outlined here include possible legal challenges on the privacy of individuals and the efficiency of the police in detecting or solving crime. [Table 4.1](#) provides a breakdown of the DNA profiles held in Ghana as of 2016 based on the available Interpol report. The report provides no clarification on the custodianship of the DNA profiles or where the profiles are held in Ghana ([INTERPOL, 2019](#)). Information about match rates and the contribution or value of the held profiles is unknown. These accountability issues are partly due to the absence of oversight bodies for the use of forensic DNA in Ghana.

Profile category	Number
Reference	202

Crime scene	338
Missing person	3
Relatives of missing person	1
Unidentified human remains	1
Others	648
Total	1,193
<i>Source:</i> INTERPOL, 2016	

Impact of DNA analysis in Ghana

The use of DNA evidence has been tested in Ghana's courts of law. Transcripts of some of those cases are available, and they provide an insight into forensic DNA typing in Ghana. We discuss these cases in this section as well as the portrayal of forensic DNA evidence in the media.

On 23 April 2002, the police received reports of an armed robbery at Lashibi, a suburb of Accra. The case involved the robbery of a vehicle and some electronic gadgets. Subsequent investigations by the police led to the arrest of four men, who were later convicted at the High Court, Fast Track Division, Accra. The evidence relied upon in the case included the recovery of the missing items from the homes of the alleged suspects and confession evidence. One of the convicted suspects, Mr Frimpong, appealed their conviction on the grounds of inappropriate evaluation of the circumstantial evidence by the court. Although this case did not feature DNA evidence, the Supreme Court, whilst commenting on the use of circumstantial evidence, classified DNA as acceptable evidence by the law courts (*Frimpong v The Republic, 2012*).

In *Asante v The Republic, 2017*, DNA evidence (paternity testing) was used to support the exoneration of an individual who was previously convicted by the High Court, Tamale, for an alleged defilement (i.e., sexual intercourse with a minor) in 2003. The initial conviction in 2005 was based on the account of the complainant (then a juvenile) and a positive pregnancy

test. At the time of the trial, no DNA or scientific tests were carried out to determine the paternity of the child. A subsequent appeal of the conviction was dismissed in 2006 by the Court of Appeal, and in 2012, the Supreme Court granted leave for a second appeal. Following court approval in 2014, the FSL carried out a DNA test of the appellant and the child from the disputed pregnancy in 2015, which excluded the appellant as the father. Commenting on the use of DNA evidence in criminal investigations, the Supreme Court noted its high accuracy and reliability, as well as the potential to help resolve sexual offences (*Asante v The Republic*, 2017). This is largely consistent with comments made by the courts in other jurisdictions (National Research Council [US] Committee on DNA Forensic Science, 1996; *R v Bates*, 2006; *R v Doherty*, 1996). An issue that emerged from the media reports of the case was the delay in DNA testing and the lack of transparency in the test procedure. For example, Graphic Online reported that the prosecution team was not aware of the DNA tests (*Bokpe and Akese*, 2016).

Since the establishment of the FSL and the first uses of DNA evidence in court, the Ghanaian media has promoted the value of forensic science and reported real-life information about the use of forensics by the police (*Akese*, 2015; *Daily Guide*, 2011). Generally, the portrayal of the science of forensic DNA analysis in the Ghanaian media is positive, with several news reports highlighting its accuracy and objectivity and its use in other jurisdictions (*GhanaWeb*, 2019; *Mensah*, 2019; *Savage*, 2019). However, reports of police investigation issues and trends in criminal activities have resulted in calls by stakeholders for the effective utilisation and regulation of forensic services, including the adoption of an independent structure for the FSL to improve public confidence in the criminal justice system (*Baneseh*, 2018; *Bokpe and Akese*, 2016; *Effah*, 2019; *Gadugah*, 2015; *Ghana News Agency*, 2013; *Mensah*, 2016). These discussions have mainly occurred in the media due to the absence of an authoritative body or professional society on forensic science.

The Takoradi missing girls case illustrates some of the critical issues associated with forensic DNA practice in Ghana. The four young women disappeared in 2018 in the Western Region of Ghana, and it soon turned out that they were kidnapped. The unknown perpetrators

demanded ransom for their release (Myjoyonline, 2019). Following a protracted investigation and intelligence challenges, the police discovered unidentified human remains at the residence of a key suspect in the case. In September 2019, based on DNA analyses, the police confirmed that the human remains belonged to the missing girls. The investigation received intense media and public attention, with demands for accountability and transparency from politicians and the families of the victims (Modern Ghana, 2019). Although the DNA evidence provided some form of closure in the case, there were controversies about the management of the investigation, the lack of details about the DNA analysis conducted by the FSL and the interpretation of the results (Ghana News Agency, 2019). For example, the police initially reported that they had found the whereabouts of the missing persons, which was later revealed to be false, with the families accusing the police of deceit (Myjoyonline, 2019). The conflicting reports from the police subsequently damaged public trust in the integrity of the investigation. These issues highlight, among other things, the relevance of the principles of accountability and transparency in the governance of forensic science and DNA analysis in Ghana. In 2021, the two key suspects in the investigation were sentenced to death at the Sekondi High Court based on DNA and other circumstantial evidence (Aklorbortu and Dzodzegbe, 2021).

These case studies demonstrate how the absence of robust quality management systems and governance structure can lead to mistrust in police investigations and the criminal justice system. The available published evidence on the impact of forensic DNA analysis shows limited use of the technology to support the identification of suspects and conviction or exoneration of individuals. Whilst the evidence suggests the potential of DNA analysis in assisting the police to solve crime and missing person cases, as well as correcting miscarriages of justice, several legal, regulatory and quality issues need to be addressed. To fully understand the value and impact of the use of forensic DNA evidence in Ghana, there is a need for authorities to collect data on the number of cases involving DNA evidence and its impact on case outcomes and make this information available in the public domain. Currently, no such data is provided, and requests for information from authorities have been a challenge with several bureaucratic hurdles. The lack of

data on the impact and effectiveness of forensic science, including the use of DNA evidence, is a contemporary issue that has also been raised in Europe and other jurisdictions (Amankwaa and McCartney, 2019; Toom, 2014; Toom, Granja, and Ludwig, 2019; Wiles, 2020).

Governance principles for the use of forensic DNA

In this last part, we discuss the key governance principles proposed in literature to govern the technolegal world of forensic DNA analysis and databases. The collection, retention and use of DNA for policing purposes is a widely debated topic in the socio-legal scholarship on forensic genetics (e.g., Machado and Silva, 2019; M'charek, 2008; Skinner and Wienroth, 2019; Toom, Granja, and Ludwig, 2019). This is mainly because DNA holds sensitive information about our health, predisposition to diseases, biological relationships and ancestry. For these reasons, countries that use DNA in criminal investigations adhere to various standards ensuring ethical and proportionate use by authorities (M'charek, 2008). These principles include viability, legitimacy and acceptability (McCartney, 2014; McCartney, Wilson, and Williams, 2011), as well as effectiveness, transparency and accountability (Toom, Granja, and Ludwig, 2019). We consider these principles in the context of DNA profiling and databasing in Ghana.

Viability is concerned with the quality, reliability and transparency of forensic information, such as matching DNA profiles, and the processes used to produce that information (McCartney, 2014; Wienroth, 2020). It is an important principle on which other concepts, such as acceptability and effectiveness, are established. The concept of viability involves using appropriate and proportionate procedures and meeting prescribed standards, which ensure the production of quality outcomes. Assessing viability in Ghana's case, it is important to evaluate whether forensic laboratories are meeting the required international standards and using the right protocols and procedures to prevent errors from being made to help ensure the credibility and reliability of results. Although the police FSL and other laboratories in the country provide DNA testing services for criminal and/or civil cases, these laboratories have not adopted international

accreditation standards, such as ISO 17025 and ISO 17020 (Amankwaa et al., 2019). In addition, there are, as far as we know, no internationally accepted quality management systems ensuring that forensic labs are employing best practices and validated methods in crime scene investigations, laboratory analysis and the interpretation, evaluation and presentation of forensic evidence. The absence of robust technical guidance and standards to regulate the activities of the FSL and other forensic providers suggests that the reliability and the admissibility of forensic evidence may be questionable (i.e., subject to potential challenges in court). The operation of the FSL and forensic providers remains arcane, with limited published data on the validation of methods and procedures, competency requirements of personnel, record-keeping and disclosure requirements, environmental conditions and management of potential errors and contamination. The status of forensic science provision in Ghana means that miscarriages of justice involving problematic forensic evidence may be difficult to detect. The lack of operational transparency has raised concerns about trust in the police and the competence of the FSL to carry out DNA analysis (Agyei Annim, 2021). In this respect, the current status of forensic DNA typing in Ghana demonstrates some similarities to the introduction of this technology in the US in the late 1980s and early 1990s (Lander, 1989; Lynch et al., 2008; M'charek, 2000).

Legitimacy is another key principle that encompasses the justifications for and the establishment of appropriate legal boundaries on the creation, retention, use and destruction of forensic DNA information/material (McCartney, 2014; Wienroth, 2020). It is based on the concepts of justification, lawfulness, the ethical and proportionate application of any interference with rights and 'doing the right thing'. In this context, where human subjects are involved, legitimacy spells out laws that ensure the right treatment is meted out to individuals, and their rights are protected in every interaction. As the FSL and other forensic providers gather, retain, utilise and share forensic data/material, it is crucial to assess the legitimacy of their activities under existing law and within the wider societal context. In Ghana, specific laws that regulate forensic activities are currently not in existence, although there are some general regulations, including the Data Protection Act 2012, which classifies DNA as special personal data. A major

legal gap is the absence of a clear statutory basis for the acquisition, inclusion, use, retention and destruction of forensic DNA samples and profiles (Amankwaa et al., 2019). Further research investigation is required to determine the extent of the impact of this gap on the criminal investigation process and challenges to the admissibility of DNA evidence. In many jurisdictions, the introduction and further development of forensic DNA practices have followed a common trajectory (Williams and Johnson, 2008), in which DNA typing is first used on a case-by-case basis in violent crimes and is later routinely deployed in other cases, like volume crimes. Cases in which the Ghana police have successfully used DNA evidence demonstrate that Ghana's forensic DNA practices are still in the early phase of such common trajectory (Aklorbortu and Dzodzegbe, 2021; *Asante v The Republic*, 2017).

A third principle, **acceptability**, is based on considerations of democratic concepts that require the input of citizens in establishing the laws of the country (McCartney, 2014; McCartney, Wilson, and Williams, 2011). Acceptability is also based on trust in a state and its institutions and trust in technology. As mentioned earlier, acceptability builds on viability. Individuals tend to trust and believe in a system that can evidence itself to be credible, reliable and efficient. In Ghana, for instance, the proliferation of video surveillance over the years has been massive. It is common to come across surveillance cameras installed in various business facilities and some homes, even when the services of security personnel are employed. This is mainly because people trust in the power of technology to help prevent and combat crime by assisting the police in apprehending perpetrators. In 2019, the Ghana Police Service started the installation of about 1,000 surveillance cameras across the country, which many citizens allegedly consider as a positive step towards curbing crime (Salia, 2019). Just as with video surveillance, there appears to be public trust in the potential of forensic DNA to help solve crimes, although there are concerns about the quality assurance processes of the FSL (Agvei Annim, 2021; Savage, 2019). While the use of forensic DNA has been in the national news regarding its value in specific cases, there has been little or no public debate on the establishment of an appropriate legal framework.

In addition to viability, legitimacy and acceptability, effectiveness and accountability are critical to the implementation of forensic DNA (Amankwaa, 2019; Amankwaa and McCartney, 2019; IAG, 2018; Toom, Granja, and Ludwig, 2019). **Effectiveness** involves the evaluation of the actual outcomes of a system in terms of whether it meets certain pre-defined expectations (Amankwaa and McCartney, 2019). In measuring the effectiveness of forensic DNA and databases, Amankwaa and McCartney (2019) have identified seven indicators: ‘crime-solving capacity, incapacitation effect, deterrence effect, privacy protection, legitimacy, implementation efficiency and implementation cost’. There is presently no available data to systematically assess the effectiveness of the use of forensic DNA in Ghana using these parameters. Nevertheless, there are a few criminal cases in which DNA evidence played a critical role in apprehending offenders or exonerating an individual who had been wrongfully convicted (Aklorbortu and Dzodzegbe, 2021; *Asante v The Republic*, 2017). As a result, there are some indicators of the potential crime-solving capacity and incapacitation effects of the use of forensic DNA.

Lastly, **accountability** is essential to ensure that the use of forensic DNA is compatible with the law and compliant with established standards. This principle is mainly applied through the establishment of independent governance or regulatory bodies, which serve as checks and balances vis-à-vis forensic activities by service providers and the police (Amankwaa, 2019; FIND Strategy Board, 2020; IAG, 2018; Tully, 2021). Yet, no independent forensic science regulator or national DNA database strategy board, which provides codes of practice and conduct or to which forensic science providers are accountable, such as are in place in England and Wales, have been established in Ghana (FIND Strategy Board, 2020). This conundrum, therefore, explains the ongoing public mistrust of the work of the police FSL (Agyei Annim, 2021; Amankwaa et al., 2019).

In summary, although the FSL has commenced the collection, retention and use of DNA records, the application of the five key principles outlined here is inadequate in the regulation of DNA profiling and databasing. Our analysis demonstrates that the emerging technolegal world in Ghana is unregulated and tenuous. As stated earlier, there has been no public discourse or

initiative to establish a legal and operational framework for forensic DNA profiling and databasing. The laboratories of the FSL are yet to be accredited against international standards, such as ISO 17025 (ISO, 2017), to assure the quality of DNA practices (ENFSI DNA Working Group, 2017). Further, there is presently no specific statutory basis for DNA profiling and databasing for policing purposes, and research on the impact and effectiveness of forensic science is lacking. To improve the status of DNA profiling and databasing in Ghana, the FSL and other forensic providers should adopt the specific recommendations of international agencies, such as the ENFSI DNA Working Group, which align with the five key principles for the governance of forensic DNA information.

Conclusion

There is a growing acceptance of forensic DNA analysis and databasing in the justice system of Ghana since the EU-Ghana Police Project in 2011. This investigative tool has contributed to a few criminal investigations and assisted in correcting miscarriages of justice. Available reviews on forensic science in Ghana suggest a wide scope and potential for the application of DNA profiling and databasing. However, there are critical gaps in the governance of this technolegal world, including issues concerning the accreditation of the FSL, validation of DNA analysis processes and retention of DNA data, establishment of a core standard set STR loci and an allele frequency database and the absence of a dedicated legislative framework and independent regulatory bodies.

To develop forensic DNA practice in Ghana, a national policy strategy should be established by relevant stakeholders to improve the infrastructure for DNA profiling and databasing. This should include accreditation of DNA laboratories and research into the allele and haplotype frequencies for the different DNA polymorphisms for the major ethnic groups in Ghana. The availability of these population frequency databases will ensure the robust and transparent interpretation and evaluation of forensic DNA evidence. Further, there should be a

national agreement on the core loci for forensic casework to ensure consistency in practice and support for the establishment of a national forensic DNA database and the transnational exchange of DNA information.

Another critical area for improvement is the incorporation of the five governance principles of DNA profiling and databasing in specific legislation. The adoption of a specific legal/governance framework from the onset of DNA profiling and databasing is highly recommended in the literature (M'charek, Hagendijk, and de Vries, 2013; National Research Council [US] Committee on DNA Technology in Forensic Science, 1992; Toom, 2012). This approach is considered effective in ensuring that the ethical costs of the use of forensic DNA and databases, such as interference with privacy rights, are carefully weighed and protected by authorities. Further, this model is thought to be more efficient and cost effective in assisting law enforcement authorities in achieving the public security objectives of the criminal justice system.

Notes

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1 See Ghana Police. (n.d.). Forensic Science Laboratory. Retrieved 14 August 2020, from <https://police.gov.gh/en/index.php/forensic-science-laboratory-fsl/>.

2 The following keywords and string search were used for the literature search: (“forensic DNA analysis” OR “STR typing” OR “DNA fingerprinting” OR “DNA profile” OR “DNA profiling” OR “DNA database”) AND Ghana.