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FORENSIC DNA PROFILING IN GHANA: CURRENT DEVELOPMENTS, CHALLENGES AND FUTURE DIRECTIONS

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Abstract

Ghana is one of nine African countries, the only one in West Africa that uses DNA profiling in criminal investigations. Forensic DNA analysis has proven effective in the identification of crime suspects while exonerating innocent suspects. It appears that DNA profiling has been effective in deterring offenders and reducing crime in Ghana. The Forensic DNA Laboratory (FDNAL) of the Ghana Police Service (GPS) is the only mandated DNA profiling institution that conducts crime-related DNA profiling in the country since its inception in 2011. However, development of this area of expertise has been stalled due to technical, financial and legal issues which include accreditation, the enactment of a DNA law and establishment of a DNA database. This paper seeks to depict the current status of forensic DNA technology in Ghana and provides suggestions towards making the FDNAL achieves the maximum best thereby fulfilling its mandate of serving the forensic DNA needs of the country specifically, and the sub-region as a whole.

Keywords: Ghana, criminal investigation, forensic DNA profiling.

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1. Introduction

We are in the era of genomics where information obtained from human genomes are used as markers for mapping of diseases, disease diagnosis and for human identification (Edwards, Civitello, Hammond, & Caskey, 1991; Butler, 2005; Altshuler, Daly, & Lander, 2008). Currently highly repetitive DNA units (2-6 base pairs) commonly referred to as short tandem repeats (STRs) are widely applied in human identification for the purposes of investigating criminal cases and paternity disputes (Jeffreys, Wilson, & Thein, 1985). The STRs are abundant and shorter than other variable number tandem repeats that were earlier used for DNA profiling and therefore have higher discriminative power and suitable to be analysed in degraded and admixed casework samples (Hill, Kline, Coble, & Butler, 2008; Godinho et al., 2008). The Forensic DNA Laboratory (FDNAL) of the Ghana Police Service (GPS) is the only mandated institution that conducts crime-related DNA profiling in Ghana since its inception in 2011. However, development of forensic DNA application in the country (i.e. conducted exclusively by FDNAL) has been stalled due to technical, financial and legal issues which include accreditation, the enactment of a DNA law and establishment of a DNA database.

2. Problem Statement

INTERPOL (2016) report have a total of 84 member countries which have adopted DNA techniques for criminal investigations, 69 of these countries have recognised national DNA database, and 73 and 31 member countries reported for Y-STR and mitochondrial DNA in their analyses respectively. Nine African countries including Algeria, Botswana, Egypt, Seychelles, South Africa, Sudan, Swaziland, Tunisia and Ghana use DNA profiling in police investigations. Ghana is the only West African nation using DNA profiling in police investigations via the FDNAL. However, the significant value of DNA profiling services provided by the FDNAL for criminal investigations and their current and future developments in relation to existing DNA guidelines (e.g. Scientific Working Group on DNA Analysis methods) and regulations (e.g. DNA law) have not been evaluated and discussed.

3. Research Questions

- Is FDNAL and DNA profiling relevant for solving crimes in Ghana?
- Does FDNAL follow the guidelines and regulations adopted by other DNA laboratories worldwide?
- Does Ghana require a DNA database as an intelligent crime solving tool?
- What are needed for a sustainable development of FDNAL, DNA profiling and data banking in Ghana?

4. Purpose of the Study

This study was conducted to critically appraise current developments at the FDNAL since its establishment in 2011 and to provide suggestions for future of DNA profiling in Ghana.

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5. Research Methods

Data were obtained from the FDNAL and the Statistics Unit in the Criminal Investigation Department (CID) of the Ghana Police Service (GPS) from 2011 to 2017. Routine DNA profiling procedures, instruments, kits and quality assurances procedures were collected from the FDNAL protocols. Information on DNA profiling guidelines, sample collection, DNA analysis and legislature were obtained from the Scientific Working Group DNA Methods reports (SWGDAM, 1995) and articles available in Web of Science, Scopus and PubMed.

6. Findings

The core mandate of CID, GPS is to carry out criminal investigations towards conviction or exoneration of any individual in a criminal case or in some instances, to establish the relationship between disputed individuals (paternity determination) as well as identification of missing persons. This mandate is collaborated with scientific evidence provided by the Forensic Science Laboratory (FSL). The FSL is made up of five units namely Serology, Chemistry or Drug, Firearms or Ballistic, Questioned Documents and Photography Units. It is also the only forensic laboratory in the country and located in the national capital, Accra.

6.1. Establishment of FDNAL in Ghana

In 2011, Serology Unit of the FSL was upgraded to a Forensic DNA laboratory with funding from The European Union and Government of Ghana. The upgrade was in respect of refurbishment of building, purchase and installation of state of the art equipment, reagent purchasing and training of DNA analysts. Equipment's installed include 3500 AB genetic analyser, 7500 real-time PCR machine, 9700 AB conventional PCR machine and its related laboratory accessories from Applied Biosystems, USA.

6.1.1. DNA sampling

In many countries, suspects in criminal cases are required to submit their genetic sample for DNA testing. However, in England and Wales sample submission is required for any person (suspects) irrespective of being charged or reported (Wallace, Jackson, Gruber, & Thibedeau, 2014). Submission of DNA sample by arrestees in Ghana is voluntary. If a voluntary request from an investigation officer for a DNA sample is refused by a suspect, the officer proceeds to the court to obtain an order to compel the suspect to comply. Blood sample and buccal cell samples are the most frequent genetic materials used in DNA extraction and analysis (Brito et al., 2011). The standard genetic material used at the FDNAL for DNA extraction and analysis is the buccal cell. The FDNAL relies exclusively on buccal swabs to collect buccal cells samples from suspects, detainees, drugs dependents, volunteers, alleged parentage and the next-of-kin of missing persons referred to as reference samples. The reference samples are collected by officers of the FDNAL at the laboratory or at locations mostly suggested by the investigators to be convenient for both suspects and victims (mostly at the FDNAL). Casework samples or crime samples are mostly collected by investigators and brought personally to the laboratory. These include stains (blood and semen), bones from exhumations, nails, hairs and autopsy samples.

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A chain of custody form is completed prior to sample collection and duly documented in the laboratory repository on submission to the case officer at the FDNAL. Each sample collected is properly labelled and given a unique case number. Prior to DNA extraction, presumptive and confirmatory tests are performed for suspected blood using Siemens Hemastix and Hexagon OBTI test kits (Sirchie, USA) respectively. In contrast, acid phosphatase (AP) test strips and prostrate-specific antigens (PSA) test strips (both from Insite, USA) are also used for presumptive and the confirmatory tests for semen. DNA extraction is done using Invisorb Forensic Spin Kit (Invitek, Germany) and DNA quantified using Real-Time 7500 machine (Applied Biosystems, USA). All analytical works for preliminary and confirmatory tests, DNA extractions and quantifications are conducted according to manufacturers' protocols.

6.1.2. DNA profiling

The laboratory started DNA profiling using 11 loci SGM Plus kit (Applied Biosystems, USA) in 2011 and upgraded to 15 loci Identifiler Plus kit (Applied Biosystems, USA) in 2013. Since 2016, the 6-dye, GlobalFiler PCR Amplification Kit manufactured by Applied Biosystems, USA, has been adopted by the FDNAL. The currently used 24-locus STR consists of STR loci accepted by Combined DNA Index (CODIS) Core Loci working Group which include Amelogenin, D7S820, D3S1358, D10S1248, vWA, D16S539, CSF1PO, TPOX, D8S1179, D21S11, D18S51, TH01, FGA, D5S818, D13S317 and the European Standard Set of Loci, D1S1656, D22S1045, ,D2S441, D12S391, D2S1338, D19S433 and SE33 locus. The kit has been optimized for samples obtained from the crime scene and from suspects and can be used for the direct amplification of buccal swabs or quantified extracted DNA (Ludeman et al., 2018; Applied Biosystems, 2009). Target STR loci are amplified in a final reaction volume of 25 µl using 1 ng concentration of template DNA. Polymerase chain reaction is performed using GeneAmp® PCR System 9700 Thermocycler (Applied Biosystems, USA). Capillary electrophoresis is carried out using 3500 Genetic Analyzer (Applied Biosystems, USA). The GeneMapper™ ID-X ver. 3.2 (Applied Biosystems, USA) is used to assign fragment sizes to the generated data profiles using and an internal lane standard (Figures 01 and 02).

6.1.3. Cases received for DNA profiling

Number of cases received by FDNAL from 2011 to 2017 is shown in Table 01. These cases have been successfully solved via DNA technology. The highest cases referred to the DNA laboratory for analysis (65 cases) was in 2017 and the lowest cases was recorded in 2011 (17 cases). However, in the years 2015 and 2016 cases submitted to the FDNAL was by far less than expected. Several reasons could be attributed to this reduction including the effectiveness of implemented crime prevention programs. Figure 03 shows number of cases received by FDNAL for murder, civil (paternity disputes), sexual assault and causing harm, and others (DNA related cases with no specific crime label). Of the 235 cases submitted at FDNAL, murder was the highest (103), followed by civil cases (42) and other DNA related crimes (41). We also observed that the recorded cased at the FDNAL was in no way close to the capacity of the laboratory. The laboratory is equipped with a high throughput analyser which can process two 96-well plates at a time (168 samples).

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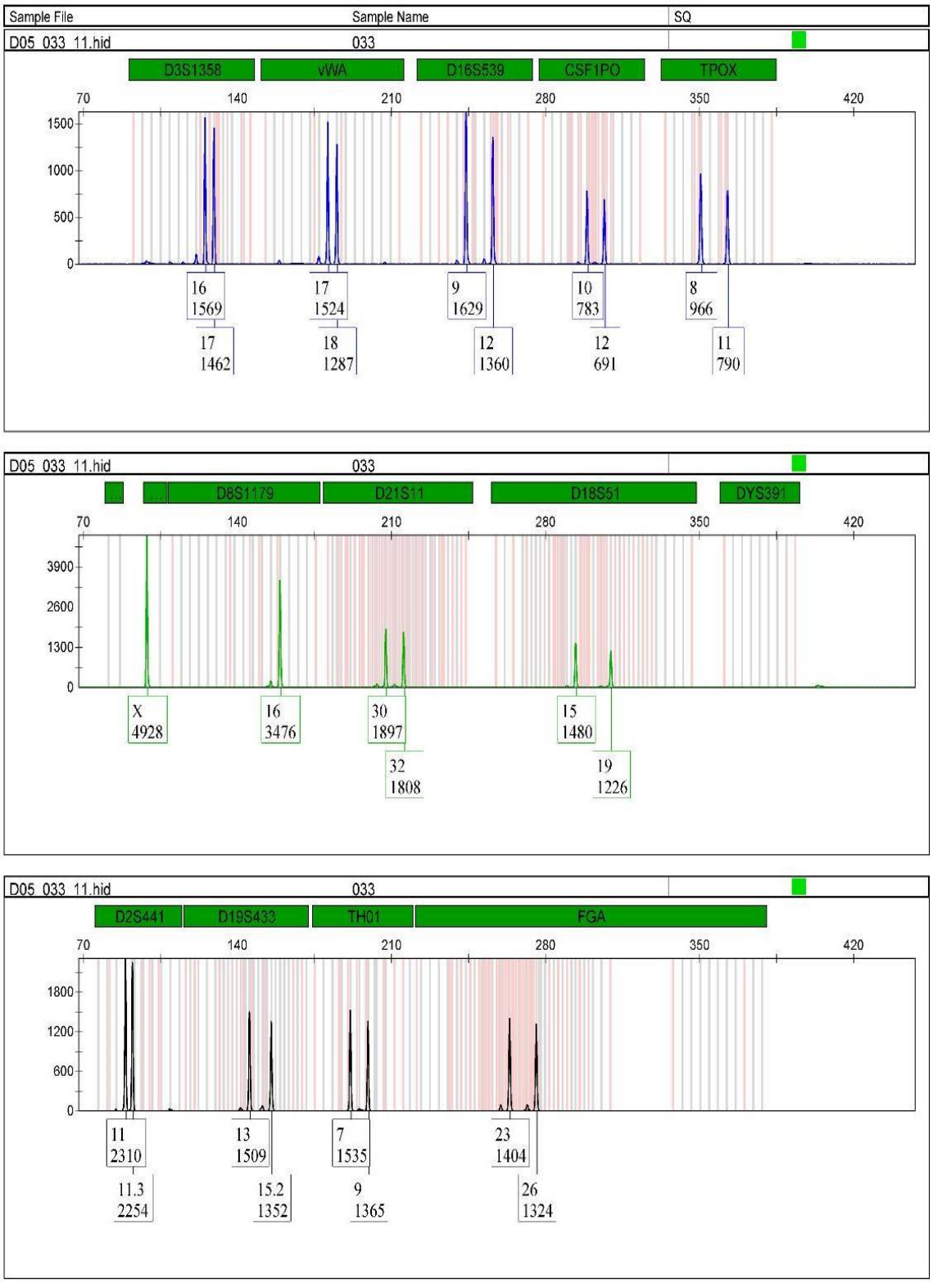

Figure 01. A section of a full STR profile obtained using Globalfiler PCR amplification Kit

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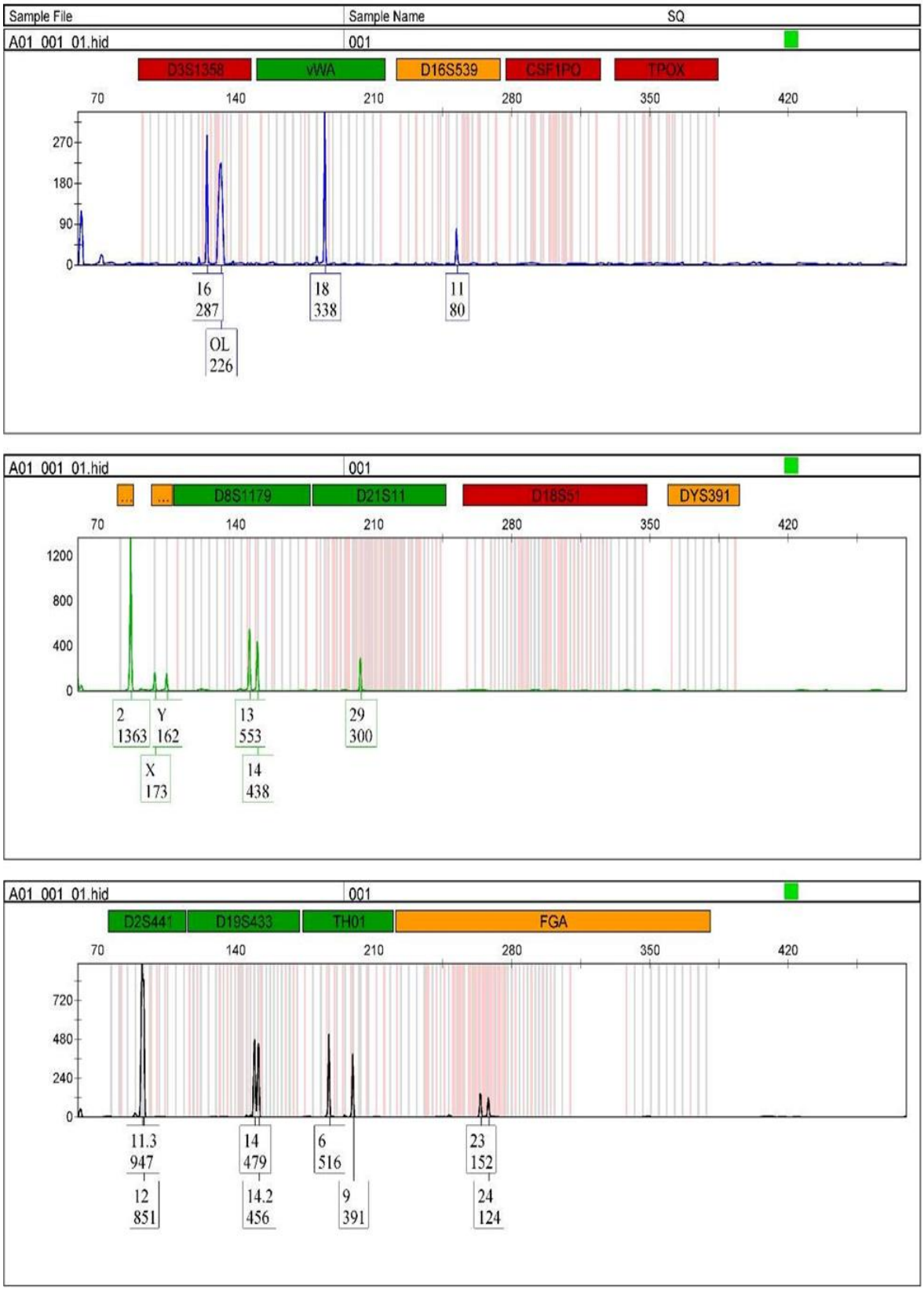

Figure 02. A section of a partial STR profile obtained using Globalfiler PCR amplification kit

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6.2. Challenges and future directions of forensic DNA profiling in Ghana

DNA profiling has revolutionized the science of crime detection and several developments have been seen for the last two decades (Gill, Jeffreys, & Werrett, 1985; Romeika & Yan, 2013). The following sub-sections discuss several challenges and future directions of DNA profiling in Ghana.

Table 01. Number of cases submitted to FDNAL in 2011 to 2017

Type of Cases/Year	2011	2012	2013	2014	2015	2016	2017
Murder	11	19	15	19	7	13	19
Sexual assault	3	5	2	4	2	2	4
Causing harm	1	2	3	5	2	2	5
Civil	1	1	4	9	4	4	19
Stealing	-	-	-	-	-	-	2
Others	1	3	13	6	4	6	8
Robbery	-	2	-	1	-	-	6
Human trafficking	-	1	-	-	-	-	1
Possession of human parts	-	-	1	-	-	-	-
Unlawful entry	-	-	2	-	-	1	-
Missing persons	-	-	3	1	-	-	1
Kidnapping	-	-	1	-	-	-	-
Use of offensive weapon	-	-	-	1	-	-	-
Unnatural death	-	-	1	-	-	-	-
Total	17	33	45	46	19	28	65

6.2.1. Enactment of DNA law and the establishment of DNA database for Ghana

Many countries worldwide have developed well recognised Forensic DNA databases including United Kingdom, New Zealand, France and USA (Sachil, Anoop, Pratibha, & Raghvendra, 2016). The growing public acceptance of DNA databases has contributed to the establishment of new databases including that of Malaysia (Mohd et al., 2019). The usefulness of DNA databases in providing another layer of evidence in crimes where no suspect is found is phenomenal. Offenders' profiles stored in DNA database help the police to quickly arrest repeated offenders and this has become a deterrent factor to potential criminals. Recent changes to the requirements and use of these databases include the inclusion of profiles from arrested persons or suspects who are yet to be proven guilty and the extended search for profiles of similar or close matches known as familial searching. Based on the level of similarity between the profiles in the database, familial searching can infer relatedness between a suspected sample and a data based person who could be the true perpetrator (Maguire, McCallum, Storey, & Whitaker, 2014). This advancement in the use of the DNA databases is been adopted in many countries including Canada, where 21 states have laws that mandates law enforcement officers to collect DNA samples from yet to be proven guilty arrestees or suspects to be included in the States CODIS DNA database with the intended aim of verifying the persons criminal record or linkage to some cold cases (Henning, 2009). Thus, each country is required to have its own DNA law that clearly specifies sample collection procedures, how long profiles are to be kept on the database, who manages the DNA database, when a particular profile can be included in the database, extent of usage etc. Specific types of DNA databases can be established based on the forensic marker (STR) of choice. For example DNA databases exist for STR markers in autosomal, Y chromosome, X chromosome STR and mitochondria sequences, etc (Butler, 2005, Toni & Michael, 2015; Prieto et al., 2011; de Saint

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Pierre et al., 2012). Currently Y chromosome STR population data exists for the Ghanaian population (Kofi et al., 2019). However without legislature, this data cannot be used for criminal identification purposes. DNA database has so far not being developed in Ghana. Enactment of laws related to DNA identification and regulation would lead to the establishment of DNA database for the country.

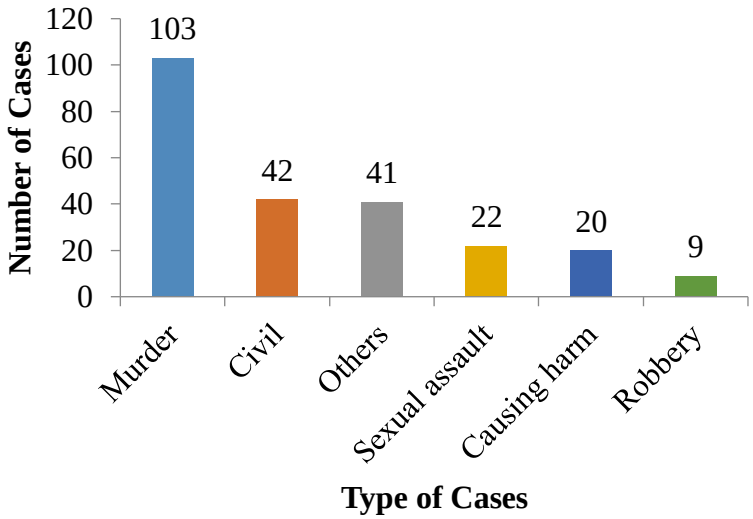

Figure 03. Total number of murder, civil, others, sexual assault, causing harm and robbery cases (2011 to 2017) submitted to FDNAL. Source: Data were obtained from FDNAL and Statistics Unit, CID, GPS

6.2.2. Training of investigators and analysts, and provision of collection centers

The major challenges for forensic DNA profiling in Ghana are mainly due to human factors which are involved at every stage of crime scene investigation. Thus, police officers especially those from crime scene units should receive proper training on biological sample collection and preservation. This is not the case of Ghana where very small number of officers have received training on crime scene and sample handlings even with the recent inclusion of crime scene training at the Detective Training School (CID, GPS). In this context, FDNAL encourages investigators to call for advice which include sample collection, packaging and transportation of samples to the laboratory. The provision of sample collection centers equipped with the necessary collection kits, storage cabinets and CCTV camera at various police stations will also encourage investigators to readily collect reference samples from suspects who mostly cannot be traced again on their first release after preliminary interrogation. Currently, FDNAL is involved in the collection of reference samples and our already limited staffs have to travel across the police district for sampling. Therefore, highly trained personnel at various sample collection centers are needed to remedy this critical issue. More interest in collecting biological evidences during crime scenes will go a long way to boast the number of cases submitted for analysis and also the efficient usage of equipment before periodic servicing dates.

The accuracy and validity of forensic DNA profiling also depend on the exercise of care at all stages of analysis in the laboratory. The analytical work should not only follow the relevant standard operating procedures, but must also be performed by highly trained and qualified analysts. The same goes for interpretation of analytical results, which in many cases rely on professional judgment and expertise.

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Currently, FDNAL has sufficient number of very competent analysts. It is important that sufficient amount of budget be allocated for their regular proficiency and competency tests via validation exercises and in-service professional training (Board, 2000; SWGDAM 2010).

7. Conclusion

The application of forensic DNA profiling has been established and has significant contribution in the criminal justice system in Ghana. Several main challenges and recommendations highlighted here such as accreditation, funding, DNA Law enactment and the establishment of a DNA database should be carefully considered by law enforcement agencies and the Government of Ghana for a sustainable development and realization of the advantages of DNA profiling in the country.

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