# ARE HUMAN IDENTIFICATION METHODS EFFECTIVELY UTILISED? A RETROSPECTIVE REVIEW OF UNIDENTIFIED REMAINS BETWEEN 2019-2020 AT SALT RIVER MORTUARY, CAPE TOWN, SOUTH AFRICA


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## PLAGIARISM DECLARATION

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# ABSTRACT

Unidentified human remains (UHRs) are a global issue, particularly in developing nations. Various identification methods exist ranging from visual recognition to DNA profiling. While DNA is utilised at Salt River Mortuary (SRM), there is slow turnaround and seldom feedback from the state laboratory. Thus in 2020, SRM began submitting samples for DNA profiling to a private laboratory (Unistel) as well. It is currently unknown whether this agreement has improved identification outcomes. To address this, post-mortem records from 7672 cases admitted to SRM in 2019 and 2020 were retrospectively reviewed. Of those, 1101 cases (14.4%) had unconfirmed identities seven days after admission. Subsequently, 84.7% (n=933/1101) were identified using visual recognition (86.3%; n=805/933) with requests in fingerprint analysis (74.3%; n=693/933) and success rate of DNA profiling slightly higher in 2020 (45 %; n=117/260) compared to 2019 (42 %; n=120/286); with 15.3% (n=168/1101) of decedents remaining unidentified (UHRs). Of the 168 UHRs, DNA profiling was requested in 69% (n=116/168) and notably, 19% (n=32/168) had no identification attempts with stillbirth and non-viable cases accounting for 68.8% (n=22/32) of these. On average, DNA profiling was requested within 27 days of post-mortem in 2020. Retrospective DNA profiling of 2019 UHR cases (29.9%) was requested following the Unistel agreement. Where UHR DNA profiling was requested from Unistel, reports were obtained in 37.9% (n=44/116). However, DNA profiles from Unistel were not uploaded onto the National Forensic DNA Database of South Africa, which limits the value of DNA as an identification tool in cases without an alleged family member available for comparison. The remainder of cases were sent to the state laboratory (n=72/116), but only 8.3% (n=6/72) of reports were received. These findings indicate that using a private laboratory improved the success rate of DNA for identification at

SRM, when kinship analysis was possible. Still, improved collaboration between private and state DNA laboratories is required to facilitate investigative leads using the DNA database.

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# Abbreviations

| Abbreviation | Meaning |
|---|---|
| ± | Approximately |
| = | Equals to |
| < | Less than |
| ≤ | Less than and equal to |
| α | Level of significance |
| % | Percentage |
| Bp | Base pairs |
| AFIS | Automated Fingerprint Identification System |
| CODIS | Combined DNA Index System |
| DMP | Data management plan |
| DNA | Deoxyribonucleic acid |
| e.g. | Example |
| et al. | And others |
| Etc | Etcetera |
| FACT | Forensic Anthropology Cape Town |
| FPS | Forensic Pathology Services |
| HREC | Human Research Ethics Committee |
| i.e | That is |
| IUPP | Initial unidentified persons population |
| N | Sample size |
| NFDD | National Forensic DNA Database |

| | |
|---|---|
| OAD | Office Autopsy Database |
| OFPI | Observatory Forensic Pathology Institute |
| PCR | Polymerase chain reaction |
| PM | Post-mortem |
| PMI | Post-mortem interval |
| Qpcr | Real time polymerase chain reaction |
| RSA | Republic of South Africa |
| SAPS | South African Police Service |
| SRM | Salt River Mortuary |
| STRs | Short tandem repeats |
| UHRs | Unidentified human remains |
| UK | United Kingdom |
| USA | United States of America |
| VIC | Victim Identification Centre |

# CHAPTER 1: INTRODUCTION

## 1.1 Background of identification and its importance

A medico-legal investigation is an inquiry into unnatural and sudden deaths utilising knowledge in law and medicine [1]. The main purpose of conducting medico-legal investigations is to establish the cause of death and circumstances surrounding death which in turn may assist in criminal court proceedings [1]. Additionally, the investigation seeks to determine the identity of the decedent and fulfil legal responsibility [1, 2].

Human identification refers to the confirmation of an individual's name and identity [3]. Identifying decedents acknowledges the fundamental rights of all individuals to have an identity before and after death [4-6]. Not only does identifying a decedent respect this right but it also assists in keeping a record of the individual's status should it come into question during legal and civil matters [7].

Identification is important for the performance of administrative proceedings such as release of insurance and inheritance monies, and completion of justice in criminal investigations [8-11]. Identifying the deceased carries humanitarian and social value hence provides some social justice to the next-of-kin as they may wish to carry out traditional burial practices and convey respect to the deceased [10]. Furthermore, determination of the decedent's identity can assist loved ones in their acceptance of the death and overcome ambiguous loss which is grief experienced due to physical or psychological loss of a loved one without closure [8;10;12;13].

### 1.1.1 Identification methods

There are various ways in which identification of a decedent may be conducted however each case provides a unique scenario of manner and cause of death, area of recovery as well as time of admission to forensic facility thus, the decision on which identification method employed is case-specific [3]. The selection and application of identification methods is made by forensic professionals and is dependent on the preservation condition of the decedents body (*e.g.* skeletonised, decomposed), availability of experienced personnel, and infrastructure in place [10;11;14;15]. Regardless of the type of case, identification methods have constantly been a topic of research and discussion [3]. These include primary methods, also known as scientific identification, comprising of fingerprint, deoxyribonucleic acid (DNA), and dental analyses. Comparatively, secondary methods, also known as presumptive, possible or putative identification, analysing external physical features may be undertaken which include visual recognition, anthropological analysis and analyses of tattoos, scars and personal effects [ 16-18].

Visual recognition is the most frequently used method of identification globally [3;9;19]. This method involves the viewing of the body by the next-of-kin as well as producing identification documents to support the relationship/confirm identity [20]. While time efficient and cost-effective, the reliability of this method of identification is questioned [21]. This is due to risk of confirmation bias whereby the identifier seeks evidence to prove the preconceived idea of the body being their loved one and may be attributed to emotional distress [22]. Furthermore, this method may not be possible due to poor preservation of the body [10;11].

In cases where visual recognition is not possible, methods using biological characteristics for identification may be undertaken. These methods include, but are

not limited to fingerprint analyses, anthropological estimation, or DNA analyses which are particularly valuable in cases where the deceased has suffered physical trauma and where next-of-kin is unknown [10;11;23;24].

Fingerprint analysis involves the examination of the basic patterns/ridges formed on the skin surface of the fingers [25]. Recovered or taken fingerprints can be manually compared to known ante-mortem records or searched through a fingerprint database in order to determine or verify an individual's identity [26] Other scientific means of identification such as radiology and odontology, require reference to ante-mortem medical records [14;27]. However, developing countries such as India and South Africa (RSA) have limited access to medical services and databases, and as a result will not have ante-mortem records available for comparison [28;29]. In instances where there are no physical characteristics other than skeletal remains, anthropological methods may be employed. Forensic anthropologists are called upon to examine the bones of the deceased and gather information which provide estimations of sex, age, stature, and ethnicity that is useful in successful identification [30]. While these methods are valuable in the identification process, they are not always appropriate or available hence, genetic means utilising biological DNA samples have received significant attention and proven to be beneficial [31-33].

### 1.1.2 Identification through DNA profiling

DNA is a macromolecule containing genetic material found in all living cells and can be extracted from biological samples [34]. The genetic information is stored within the cell nucleus and is inherited from both parents through the process of conception [35]. The chances of two random, unrelated people sharing the exact same DNA profile is

extremely low [36]. Each individual's genome holds a vast amount of DNA that is the target for DNA profiling [37].

DNA profiling is a technique used whereby repeat motifs about six nucleotides or less (≤ 6 bp) called short tandem repeats (STRs) found in DNA are compared to generate an individual's unique genetic profile [38;39]. The location of STRs (loci) on a chromosome are highly polymorphic and as a result varies significantly between individuals which in turn assists in the identification process [39]. This allows forensic DNA profiling to be used for several purposes, involving both living and deceased individuals, such as linking an individual to a crime, reuniting missing or deceased individuals with their loved ones as well as identifying unknown decedents [40]. The main objective of DNA profiling is to match two DNA profiles to one another, either via direct matching principles, kinship analysis or familial searching [41].

Missing persons and unidentified human remains (UHRs) can be identified through the performance of DNA profiling, whereby the identity of these individuals may be confirmed or excluded after analysing biological samples and generating DNA profiles [42]. Direct matching refers to the comparison between a DNA profile generated from a direct DNA sample from the missing person and a DNA profile from an unidentified body to determine if a match (*i.e.,* no observable difference between samples, the samples are concordant) can be made [40;43]. In the event that a direct sample from the missing person cannot be obtained, kinship analysis may be performed whereby samples are compared with a specific relationship question in mind.

Kinship analysis is utilised to determine possible genealogical relations between individuals whereby DNA from close family members (parents, children, siblings *etc.*) is analysed and that profile is compared to a DNA profile generated from a missing or

unidentified person's DNA [40]. A match can be established due to biological relatives sharing a percentage of DNA, depending on their relationship [44]. A match can be established due to biological relatives sharing a percentage of DNA, depending on their relationship. Although all humans share 99.9 % of DNA with each other, a portion of the variable 0.1 % of DNA will also be shared between biological relatives. Parent-child relationships share 50 % of this variable portion of DNA because the child inherits half of their genetic material from each biological parent. Similarly, full siblings share approximately 50 % of DNA however, due to random assortment of DNA from their parents, the specific segments that they share can vary. If siblings share only one biological parent, they are referred to as half-siblings and share approximately 25 % of their DNA. Other possible relations with 25 % shared DNA may be found in grandparent-grandchild or aunt/uncle and niece/nephew relationships [45].

Familial searching may also be conducted whereby the unknown individual's profile is intentionally searched through the DNA database to detect and rank a list of individuals who may potentially be close relatives to the unknown individual [46;47]. Despite DNA analyses being an effective and invaluable tool, there are ethical and judicial concerns regarding this technique such as protection of privacy, informed consent, information obtained, incidental findings and discrimination or bias due to unequal racial representation on databases [35;48].

To achieve a DNA profile, there are six main steps involved in forensic DNA profiling: (1) sample collection, (2) DNA extraction, (3) DNA quantification, (4) DNA

amplification, (5) capillary electrophoresis and lastly (6) analysis, comparison, and interpretation (Figure 1.1).

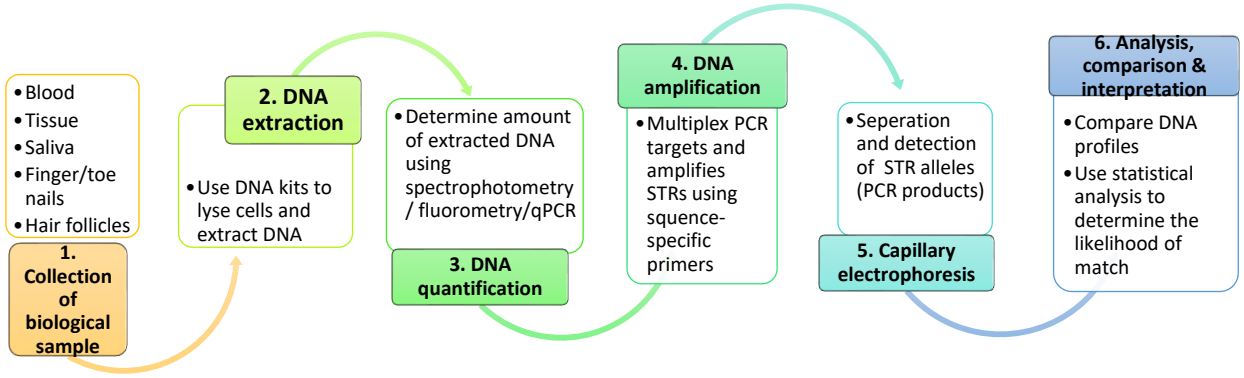


*Figure 1.1: Experimental workflow of DNA profiling adapted from [40].*

The process of identification utilises comparative analysis of the biological sample collected from the decedent after a post-mortem (PM) and from their personal belongings or obtained from close living relatives. DNA may be extracted from post-mortem biological materials such as blood, tissue, saliva, nails or hair follicles [35] (Figure 1.1). In terms of sample collection for the intention of assisting in identification, the type of sample obtained depends heavily on the condition of the body and what sample types are available for collection. External factors such as exposure to the environment, chemical contaminants and time taken to obtain sample may negatively impact the condition of DNA causing degradation [49-51]. Personal belongings such as toothbrushes and hairbrushes are rich sources of residual DNA and may also be used for comparison in direct matching [35;40]. When personal items are not available, samples from close living relatives of the deceased may be obtained such as less invasive, buccal swabs or blood for the performance of kinship analysis [49].

Once the biological sample is obtained, it then undergoes extraction whereby DNA kits may be utilised to lyse cells and isolate the DNA in solution [39]. Thereafter, the amount of DNA that is extracted from the biological sample is quantified using spectrophotometry, fluorometry or real-time polymerase chain reaction (qPCR). DNA quantification is performed to ensure that a known and precise amount of DNA is used during DNA amplification. This step involves STRs being targeted with sequence-specific primers and amplified utilising multiplex PCR [37]. Due to their allelic diversities, STRs are viewed as the most efficient genetic markers as they are target regions within the DNA sequence that are useful in distinguishing between or matching two individuals [52].

After amplification, the STR loci (PCR products) undergo separation and detection via capillary electrophoresis whereby the DNA fragments are filtered according to their size with the aid of a capillary gel matrix [37]. Whilst the fragments travel down the capillary, they are detected by a laser that excites the fluorescent tags integrated into the amplicons of the primers [37]. There are four different dye channels therefore, four different fluorescent dye colours are used to tag different sets of primers. Once the fluorescent tag is excited by light of the appropriate wavelength, signals are detected, and peaks correlating to the fluorescent dyes are generated by software to produce an electropherogram [40]. Smaller DNA fragments travel faster compared to larger ones hence they appear first on the electropherogram. The electropherogram depicts a series of numbers representing the lengths of specific STR regions known as alleles in the DNA profile that are used to differentiate between individuals [40].

In contemporary DNA profiling processes, advanced multiplex assays such as the GlobalFiler™ PCR Amplification Kit (Thermo Fisher Scientific, MA, USA) and 8-dye PowerPlex® STR multiplex kits (Promega Corp., WI, USA) can be used [53,54]. These

assays utilise multiple dye channels for simultaneous detection of DNA markers. This enables analysis of a broader range of genetic markers in a single reaction thereby increasing discriminatory power [55;56].

The two DNA profiles, either generated through direct matching or kinship analysis, are compared by analysts to determine a match or relationship respectively. After comparison, analysts use statistical analysis to assess and interpret the likelihood of a match within a given population [35]. The probability that a random individual in this given population has the same set of analysed STR markers is assessed to provide a measure of the strength of the match [36]. In some cases, the DNA profile of the missing or unidentified persons may be stored on a DNA database for future reference.

### 1.1.3 DNA databases

The power of identification from DNA profiling is highly desirable and assists in establishing DNA databases for the storage of DNA profiles that can be used by law enforcement to identify suspects, missing persons and UHRs [38]. The development of DNA databases allows profiles from new or unsolved cases to be compared with stored profiles or kept on the database for future reference in hopes of attaining useful links. Within these DNA databases, a missing persons index or repository is developed to assist with the identification of unknown bodies found [3;19].

Many countries have established a national DNA database, the first being developed in the United Kingdom (UK) which served as a catalyst for the development and expansion of databases in other countries [37]. According to the Interpol Global DNA Profiling Survey 2019, out of 194-member countries, DNA profiling is used in 89 and national DNA databases are utilised by 70 with only 31 countries having a specialized missing persons repository [57]. The DNA profiles added to the DNA database are

dependent on the country's law [58]. Several countries utilise the Combined DNA Index System (CODIS) software to manage DNA profiles collected at the national, state and local levels and organised into various indices [47]. Like the CODIS system, the RSA national DNA database includes index categories of DNA profiles from convicted criminals, suspected offenders, DNA obtained from crime scenes, law enforcement and laboratory staff profiles, missing persons and UHRs as well as reference DNA profiles belonging to relatives of missing persons [59]. According to RSA law known as the 'DNA Act', these indices must not contain any a) genetic disposition or other distinguishing feature, other than the sex of that person; b) medical information; c) historical information and d) behavioural information of that individual [60]. The retention period or the periods within which the DNA samples and profiles must be destroyed depends on the index category [60]. For the purpose of identification, missing individuals' and UHRs' DNA profiles are retained on the database until the case is solved [60].

If a match is found either through direct matching, kinship analysis or via the DNA database, the next-of-kin may claim the body from the forensic facility after visual confirmation and presentation of legal documents to support the relationship (Figure 1.2). However, should there be no leads within the legislative timeline after all possible methods of identification have been attempted, the municipality (local authority) arranges for a pauper burial (state-held burial) but, this might occur months or years later [20;21]. Unfortunately, while there are developments in identification methods, a portion of decedents do remain unidentified across the globe [10].

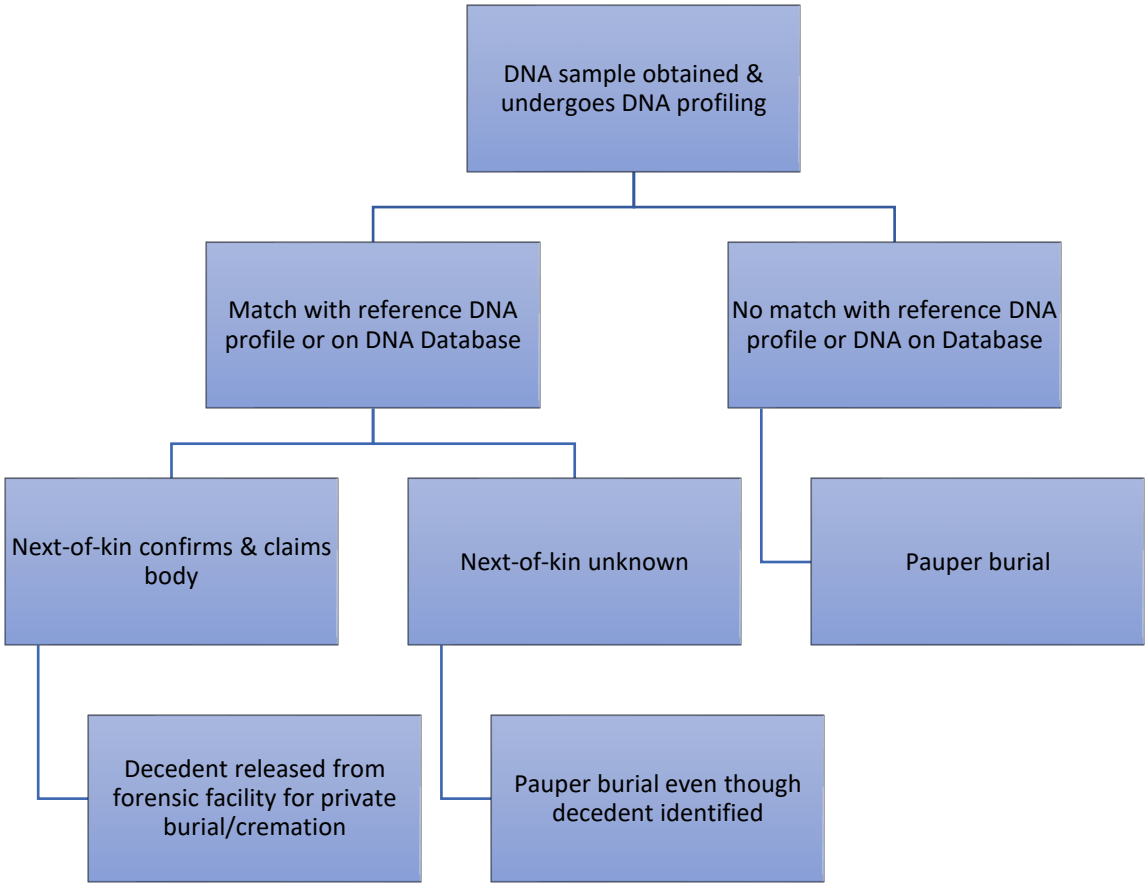


*Figure 1.2: Process of matching a DNA profile in South Africa*

### 1.1.4 Unidentified bodies

Across countries, there are various terminologies and intricacies regarding UHRs which may also be referred to as bodies that are 'unclaimed' or experience 'homelessness' but in essence, all terms refer to decedents with an unknown identity [14; 61-64]. While this is considered admissible in some countries, others have defined conditions under which these phrases are applied [10].

For instance, in India 'unclaimed' refers to a decedent who has not been collected from the forensic facility by the next-of-kin or personal friends within a prescribed period (72 hours) [14; 62-68]. Whereas, in RSA, 'unclaimed' decedents refer to those whose next-of-kin is known however, they are unable to collect and provide a burial or

cremation of the remains [20]. Furthermore, in RSA, ‘unidentified’ decedents refer to those who have no confirmed identity within 30 days of death despite all efforts of identification and consequently next-of-kin is unknown hence the bodies become the responsibility of the state [20]. However, in the United States of America (USA), the classification of unidentified bodies is made after 48 hours [19] and are referred to as John (male) or Jane (female) Doe [61].

For the purpose of this study, decedents without a confirmed identity within seven days of admission to the forensic facility after performing the post-mortem are referred to as the ‘initial unidentified population’ while those remaining unidentified after 30 days of the post-mortem investigation are termed as ‘UHRs’.

### 1.1.5 The burden of unidentified human remains internationally

The burden of unidentified decedents is experienced internationally and differs between developing countries (*e.g.* India and RSA) and developed countries (*e.g.* Italy and USA), with developed countries appearing to be less affected by this [8-11; 62-69]. The extent of UHRs being a burden and placing strain on forensic facilities differs between countries and is often associated with their socioeconomic standards [11;62;65]. The management of these large numbers of UHRs can place financial burdens on facilities to store the bodies over long periods of time and make arrangements for subsequent burials or cremations. Other factors that may play a role in the increase of UHRs may be attributed to diminished family ties in modern societies as well as legal and illegal immigration [9].

Mazzarelli *et al.* (2021) reviewed 25 years of UHRs in Milano, Italy, where 3.2 % (n = 726/22 434) of cases were unidentified at admission [8]. However, after the utilisation of various identification methods, 72.7 % (n = 528/726) were successfully identified

while 13.8 % of the decedents remained unidentified [8]. Similarly, in Garches, France, it was observed that 76.1 % (n = 134/176) of cases were identified after autopsy while 10.2 % (n = 18/176) of decedents remained unidentified after investigations [69]. In Georgia, USA, a study found that 4.4 % (n = 100/2 279) of cases were originally unidentified however, after the utilisation of scientific methods, 78 % were subsequently identified within two days [19].

Contrastingly, in a developing country such as India, UHRs accounted for 24.5 % (n = 614/2 515) of cases admitted to the Police Morgue facility in Calcutta, with only 17.8 % (n = 109/614) of these having been subsequently identified [62]. This data is also supported by studies conducted in other parts of India where figures of UHRs at admission to forensic facilities ranged from 4 % to 15.2 %, however attempts of identification are not discussed in these studies [14; 65; 68].

### 1.1.6 The burden of unidentified human remains in South Africa

In RSA, the number of unidentified remains is not dissimilar to other developing nations [10]. A study conducted at Pretoria medico-legal facility, Gauteng, indicated that 9 % (n = 848/9 417) of individuals undergoing forensic autopsy remained unidentified between January 2005 to December 2008 [11]. Similarly, the Johannesburg mortuary, Gauteng, found that 8.1 % (n =693/8 560) of cases remained unidentified between January 2018 and July 2020 [21]. This is also a common occurrence in the Western Cape province at Salt River Mortuary (SRM), Cape Town [23; 70]. Reid *et al.* (2020) revealed that 2 476 (9.2 % per annum) individuals remained unidentified between 2010 and 2017 despite various identification methods used [23].

### 1.1.7 Call for efficient utilisation of DNA profiling and DNA databases to assist with the burden of unidentified human remains

Although in some instances, UHRs cannot be avoided despite attempts of identification, researchers have found cases where methods are not used efficiently particularly DNA profiling. Ward (2018) found that Australia has experienced backlogs in identifying UHRs due to DNA samples not being routinely processed [71], similarly, this difficulty is shared across parts of India [14; 72]. Furthermore, many researchers have highlighted the value and need of retaining biological samples for DNA analyses which have been underutilised [10; 67; 69; 72; 73], as well as the development of national DNA databases for missing individuals and UHRs [67; 68; 70; 73; 74]. Reid *et al.* (2020) observed that biological samples were retained for DNA analysis at SRM, Cape Town, in only 23.6 % (n = 584/2 476) of unidentified cases [23]. This was more than that recorded by Kumar *et al.* (2014) (8 %; n = 10/123) but less than half recorded by Evert *et al.* (2011) (50 %; n = 420/848) [11;65]. These results indicate that DNA analysis has been underutilised hence, it was suggested that more collaborative approaches should be undertaken to assist in reducing the burden of UHRs [11; 14; 21; 23].

## 1.2 Rationale

In South Africa (RSA), the Inquests Act (Act no. 58 of 1959), states that the circumstances leading to death are legally defined as any death due to unnatural or sudden causes which include those due to (1) the application of an external or chemical force; (2) sudden and unexpected, or unexplained deaths, (3) procedure-related deaths, and (4) death as a result of the act of commission or omission of care [75]. As such, it is legally mandated that the performance of post-mortem

investigations be conducted by forensic pathologists to determine the cause of death and assist in the identification process as stated by the National Health Act No 61 of 2003 [20]. Furthermore, the Forensic Pathology Services (FPS) follow regulations to render their services in all cases of unnatural death which includes the guidance of identification and the timeline pertaining to the process [76].

Despite legislations, regulations and advancements in scientific methods being implemented, there are still high numbers of UHRs experienced in RSA [11; 21; 23]. This places a financial strain on the state and forensic facilities through the provision needs of storage, burial or cremation [11; 21; 23]. Many forensic facilities across RSA do not have the time, infrastructure, and resources in place to support all identification methods required and as a result, are burdened by high caseloads of UHRs [21; 30; 65].

Research on this subject has called for more collaborative approaches to identification methods, specifically DNA analysis and use of DNA databases, that utilise the Forensic Pathology Service (FPS), South African Police Service (SAPS) and private sector service providers effectively [11; 14; 21; 23]. To help address this, the Criminal Law (Forensic Procedures) Amendment Act (Act no. 37 of 2013) [60] was enacted, commonly referred to as the DNA Act which was drafted carefully to maintain an appropriate balance between individuals' rights and respect for privacy. As such the Act ensures that DNA usage and the DNA database are to be used to its full potential in combating crime as well as assisting in identification, whilst still ensuring minimal impact on civil rights.

While Evert (2011), Keyes *et al.* (2022) and Reid *et al.* (2020) have all highlighted the underutilisation of identification methods particularly DNA analyses in RSA, it is

unknown if this is still an ongoing issue [11;21;23]. Additionally, it is unclear if these methods are used appropriately or timeously and if this is another contributing factor to the high caseloads of UHRs.

According to Reid *et al.* (2020), 23.6 % of biological samples were retained for DNA analysis at Salt River Mortuary, Cape Town, however, there was no information regarding the outcomes of these analyses [23]. This information is crucial to assessing the quality of DNA results as well as determining whether any individuals were identified through DNA profiling. As of January 2020, SRM engaged in a contract agreement with an external service provider (Unistel) to improve the turnaround time of processing DNA samples of UHRs. This outsourcing agreement between SRM and Unistel was made in hopes of achieving successful identification and reducing the burden of UHRs over time. Successful identification is a person positively identified regardless of the methods used (or not used).

In terms of DNA, successful DNA analysis refers to the obtainment of an informative DNA profile from a biological sample. In this study, the usefulness of DNA as an identification tool is assessed. Hence, obtaining a DNA profile is a positive outcome as it can be used in kinship analysis to confirm a biological relationship or kept for future use should another reference profile become available. This in turn, encourages the development and use of the National Forensic DNA Database (NFDD) and emphasises the value of DNA in UHR cases. It will also become apparent how beneficial outsourcing with a private laboratory is in processing UHR DNA samples to assist in improving the identification process at SRM.

## 1.3 Aim and objective

### 1.3.1 Aim

This study aimed to evaluate whether identification methods were effectively utilised at Salt River Mortuary.

### 1.3.2 Objectives

The aim of this research study was achieved through the following objectives:

- Describe the remaining unidentified persons population at Salt River Mortuary/Observatory Forensic Pathology Institute (SRM/OFPI)
- Assess differences in the success of identification through the various methods with particular focus on the utilisation of DNA analysis, before and after the implementation of the tender agreement with Unistel
- Report on the efficacy and appropriateness of samples collected for DNA profiling in UHRs cases.

In this study efficacy refers to how well the sample serves its purpose to provide necessary genetic information to generate reliable results for forensic DNA identification. Appropriateness refers to the type of biological sample collected by the pathologist based on the body's condition.

### 1.3.3 Ethics and approvals

Ethical approval to conduct this study and access the online database was obtained from the Human Research Ethics Committee (HREC), Faculty of Health Sciences, University of Cape Town (REF: 198/2023, Appendix A) as part of a larger ongoing research study (HREC REF: 132/2021). Additionally, an application to conduct research at SRM/OFPI was also approved by the University of Cape Town's clinical

department head and head of Western Cape Government Forensic Pathology Services.

# CHAPTER 2: METHODOLOGY

## 2.1 Study design

This study was a retrospective cross-sectional study of all medico-legal case files at SRM/OFPI between the period 1 January 2019 and 31 December 2020. The specific time periods prior to and post the contract with Unistel were between 1 January and 31 December 2019 and between 1 January and 31 December 2020, respectively. The biological samples were routinely sent to SAPS for forensic DNA analysis. However, decedents from 2019 that were still unidentified in 2020 may have had a second sample taken retrospectively and sent to Unistel for DNA analysis. While, after the contract, biologicals samples continued to be sent to SAPS but were prospectively sent to Unistel in addition.

## 2.2 Research procedure

A Data Management Plan (DMP) was prepared containing information on how data will be collected, organised, managed, stored and preserved (Appendix B). Due to the sensitive nature of the information contained within the medico-legal case files, data was captured in a secure room on the University of Cape Town medical campus with limited access to personnel. Precautionary measures to ensure that the information was protected were taken by limiting data accessibility and anonymising the case numbers and names of individuals. The anonymised data collected was accessed on a privately-owned laptop that was password-protected and stored on an external hard drive which was kept in a secure location within the Division of Forensic Medicine and Toxicology after use. The data was shared monthly with supervisors onto a password protected Google Drive account, thereafter, downloaded as a backup for safekeeping and removed from the Google Drive.

Preliminary data for cases between 2019 - 2020 was provided from the Office Autopsy database containing demographic information (estimated age by pathologist and biological sex) and case details (admission category, alleged manner of death and type of DNA sample obtained). The remaining variables (actual age if known, date of death declaration, date of admission, identity at admission, location of recovery, cause of death, preservation status, date of PM, date of removal notice and date of release) were collected from the medico-legal case files uploaded on the online database (Appendix C). Additionally, data pertaining to identification methods: visual recognition, secondary identifiers, radiology, fingerprint, DNA and anthropological analyses were recorded (Appendix C). These variables were obtained from various medico-legal documents: post-mortem report, FPS001 (log incident), FPS002 (scene script), copy of identification document (corpse and next-of-kin), FPS012 (notification to claim and remove body), FPS013 (acknowledgement of receipt of body) and identification analysis reports among others (Appendix D).

Where documents were not electronically available on the online database, hard copy case files were reviewed by the researcher and a Special Study Module (SSM) student under the supervision of two employees at the SRM/OFPI archives. During this process, data from documents found were cross-checked against already collected data to ensure accuracy.

The data for 2019 and 2020 cases were each collated into a password-protected Excel spreadsheet (Microsoft Corporation, NM, USA). Thereafter, data for each year of analysis was filtered according to those not identified at PM. These cases were further categorised into those with confirmed identity after PM within seven days of admission (added to those identified at PM) and those with unconfirmed identity after PM within seven days of admission hereafter, referred to as the initial unidentified persons

population (IUPP) (Figure 2.1). The filtration was achieved by determining how many days between the date of notice of removal and the date of admission of the decedent. In cases where the notice of removal was missing, the date of release from SRM was used with discretion to determine if the decedent had a confirmed or unconfirmed identity within seven days of admission. This was carried out to determine the number of cases not identified within legislative timelines. Thereafter, the IUPP were then separated into those that were identified (claimed and unclaimed) and those remaining unidentified (UHRs) (Figure 2.1).

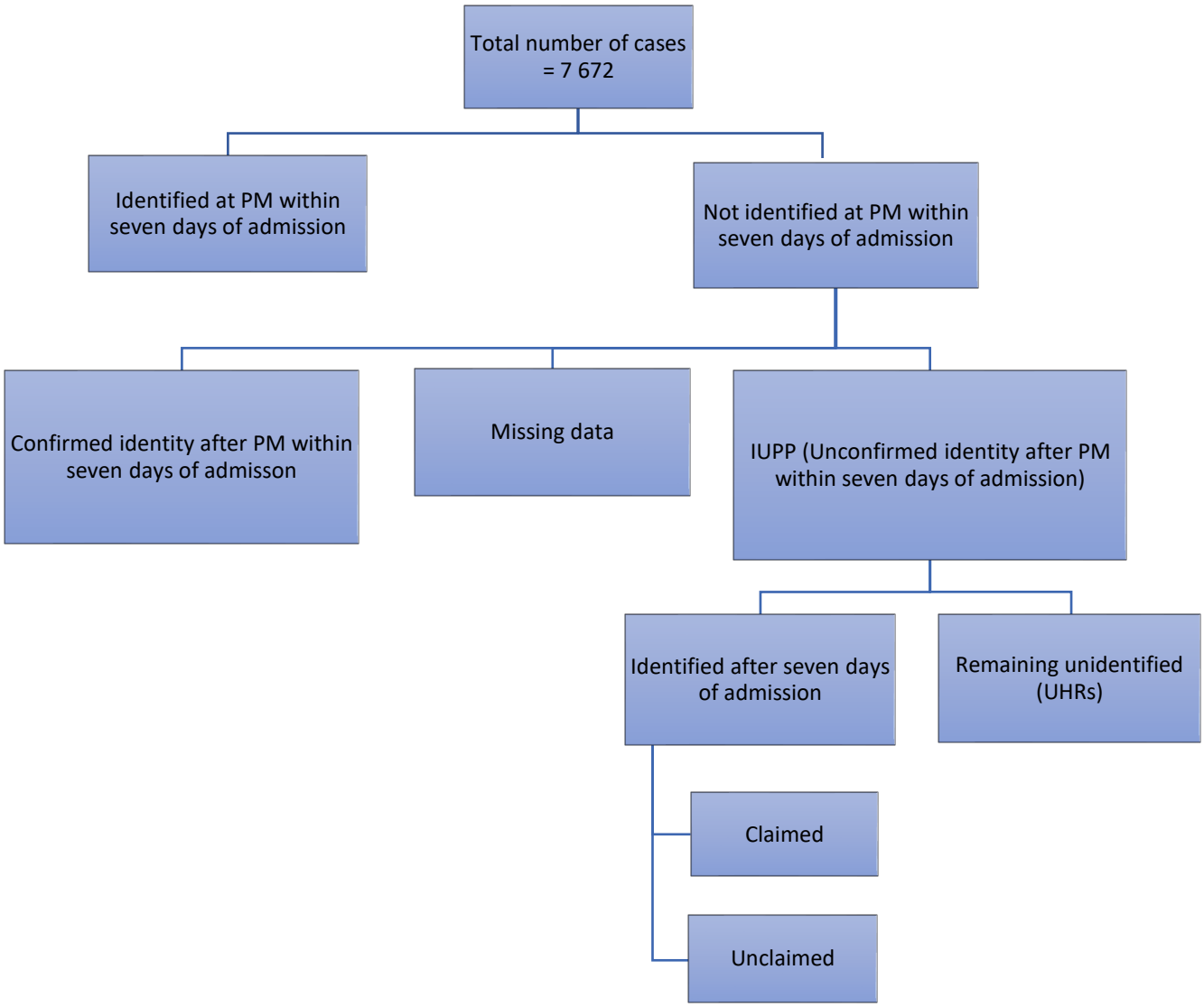


*Figure 2.1: Categorisation of the total caseload until desired study population(s)*

*PM: Post-mortem; IUPP: Initial unidentified persons population; Identified refers to decedents whose identity has been established and confirmed either through visual recognition or scientific means and body released from forensic facility; Claimed refers to decedents identified by next-of-kin and collected from forensic facility and Unclaimed refers to decedents identified either through scientific means or by next-of-kin unable to retrieve body from forensic facility.*

## 2.3 Data analysis

Once data was obtained and collated in Microsoft Excel 365, Version 2209 (Microsoft Corporation, NM, USA), descriptive statistical analysis was performed. This entailed determining the percentage of decedents belonging to the IUPP, those identified (claimed and unclaimed) and the UHRs. Other percentages regarding demographics (age and sex), identification methods utilised (visual, fingerprint, DNA, anthropological

analyses), DNA profiling requests and reports received, preservation conditions and sample type obtained were also calculated. The success rate of DNA profiling was determined for 2019 and 2020 (Equation 3.1). Thereafter, comparative statistical analysis using the two-sample z-test (level of significance, α = 0.05) was carried out between the proportion of cases identified through DNA profiling in 2019 and that of 2020 (Equation 3.2). The two-sample z-test was used to compare two independent samples to determine if the proportions were significantly different from each other. This test was chosen as the data were normally distributed and the sample sizes were greater than 10 which met the terms of the Z test as stated below.

$$\frac{Successful\ identification\ from\ DNA\ profiling}{Number\ of\ DNA\ profiling\ requests} \text{ x } 100$$

*Equation 3.1: Success rate calculation for DNA profiling*

*Null hypothesis*: $H_0$: π1 = π2 (The proportion of sample group one is equal to the proportion of sample group two)

*Alternate hypothesis*: $H_A$: π1 ≠ π2 (The proportion of sample group one is not equal to the proportion of sample group two)

$$z = \frac{P_1 - P_2}{\sqrt{\hat{P}(1-\hat{P})(\frac{1}{n_1} + \frac{1}{n_2})}}$$

Where:

$P_1$ = Proportion identified through DNA Profiling in 2020

$P_2$ = Proportion identified through DNA Profiling in 2019

$n_1$ = Total number of cases that requested DNA profiling in 2020

$n_2$ = Total number of cases that requested DNA profiling in 2019

$\hat{P} = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}$

*Equation 3.2: Two sample z-test for proportions*

Terms for Two sample z-test for proportions:

- Samples are independent
- Samples are large
  - $n_1 p_1$ and $n_2 p_2$ ≥ 10
  - $n_1$ (1 – $p_1$) and $n_2$ (1 – $p_2$) ≥ 10

# CHAPTER 3: RESULTS

## 3.1 Overview of cases admitted to SRM

During the study period between 1 January 2019 and 31 December 2020, a total caseload of 7 672 decedents were admitted to SRM for medico-legal investigation. A total of 6 344 cases had a confirmed identity within seven days of admission, hence, did not meet the criteria of this study and were excluded. There were 227 cases for which identification documentation and release records (notice of removal and acknowledgement of receipt) were not obtainable at the time of research hence deduction was not possible, as a result, these cases were not included in further analyses. Upon collecting the data at the start of the study, it was found that Unistel was involved in analysis of 2019 and 2020 samples which was not anticipated.

At the time of autopsy within seven days of admission to SRM/OFPI, 47.7 % (n = 3 660/7 672) of decedents had an unconfirmed identity. However, after autopsy investigations, it was observed that 14.4 % (n= 1 101/7 672) remained with an unconfirmed identity and are hereafter considered the IUPP (Figure 3.1).

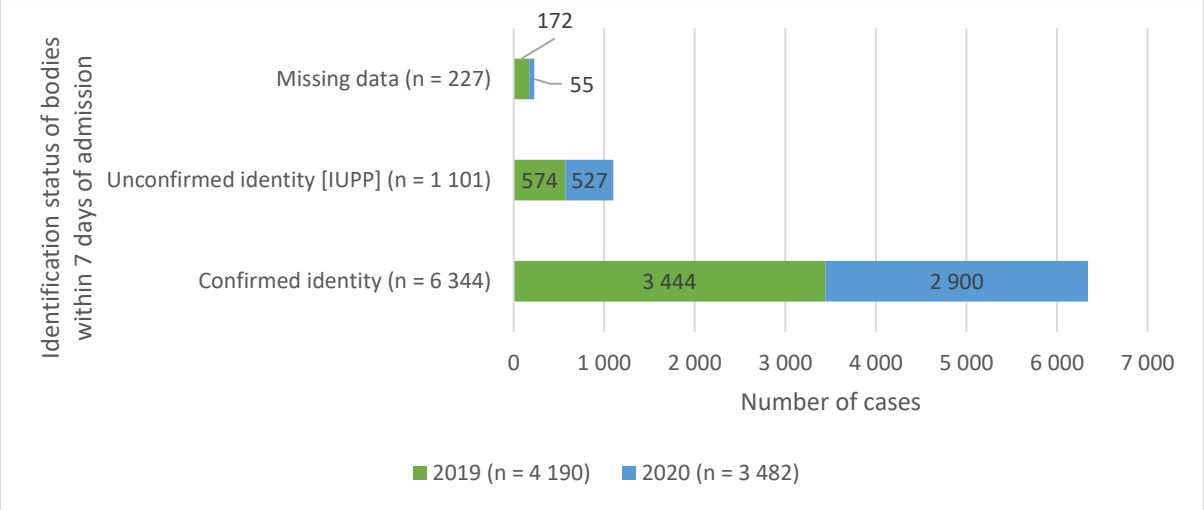


*Figure 3.1: Identification status of decedents within seven days of admission to Salt River Mortuary in 2019 and 2020.*

*Confirmed identity refers to those that were identified within seven days of admission (hereafter excluded); Unconfirmed identity [IUPP] refers to the Initial unidentified persons population without an identity within seven days of admission after post-mortem and missing data refers to those with missing documents surrounding identification and release records not found on the online database or hardcopy files (hereafter excluded).*

Subsequently, of the IUPP, 84.7 % (n = 933/1 101) were identified, with the majority of those being claimed (92.9 %; n = 867/1101) and the minority unclaimed (7.1 %; n = 66/1101) (Table 3.1).

*Table 3.1: Identification status of Initial unidentified persons population at Salt River Mortuary for 2019 and 2020.*

| **Final Identification status of IUPP** | **Year of analysis** | | **Total** | |
|---|---|---|---|---|
| | **2019** | **2020** | | |
| Identified (Claimed) | 461 | 406 | 867 | 933 |
| Identified (Unclaimed) | 17 | 49 | 66 | |
| Remained unidentified | 96 | 72 | 168 | |
| **Total** | **574** | **527** | **1 101** | |

Of the 84.7 % of decedents identified (n = 933/1 101), claimed and unclaimed, the majority had visual recognition conducted (86.3 %; n = 805/933) with requests in fingerprint analysis (74.3 %; n = 693/933), and DNA profiling (58.5 %; n = 546/933) (Figure 3.2). DNA profiling was requested slightly more in 2019 cases (59.8 %; n = 286/478) compared to 2020 cases (57.1 %; n = 260/455) whereas the opposite was true for fingerprint analysis (2019: 71.5 %; n = 342/478, 2020: 77.1 %; n = 351/455) (Figure 3.2). While the percentage of decedents identified through fingerprint analysis could not be determined due to a lack of fingerprint reports at the time of research, 43.4 % (n = 237/546) of cases where DNA profiling was requested were successfully identified. The success rate of identification through DNA profiling was found to be slightly higher in 2020 (45 %; n = 117/260) compared to 2019 (42 %; n = 120/286). After comparative statistical analysis using the z-test, there was no significant difference observed between the proportions of cases identified through DNA profiling in 2019 and that in 2020 at the α = 0.05 level (Appendix E).

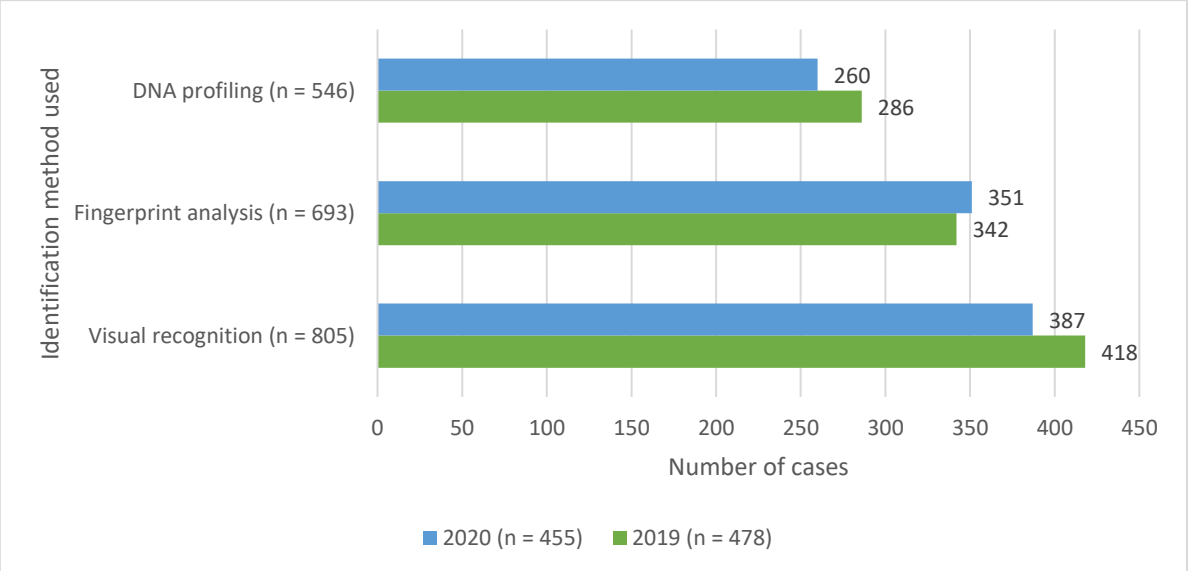


*Figure 3.2: Methods applied/requested on identified decedents from the initial unidentified population at Salt River Mortuary for 2019 and 2020.*

*Majority of identified decedents underwent visual recognition (86.3 %) with requests made for fingerprint analysis (74.3 %) and DNA profiling (58.5 %).*

## 3.2 Overview of decedents remaining unidentified (UHRs)

Of the IUPP, 15.3 % (n = 168/1 101) of decedents remained unidentified with a mean of 84 unidentified decedents each year (Table 3.1). Over this period, it was observed that 73.2 % (n = 123/168) of decedents remaining unidentified were biologically male while 5.4 % (n = 9/168) had an unknown sex due to poor preservation (66.7 %; n = 6/9) and non-viable foetuses (33.3 %; n = 3/9). The majority of UHRs fell within the 'non-viable & stillbirth' age category (25.6 %; n = 43/168) followed by the '30-39 year' age category (24.4 %; n = 41/168) (Figure 3.3). In Figure 3.3, neonates were defined as infants born alive but demised within 14 days of birth.

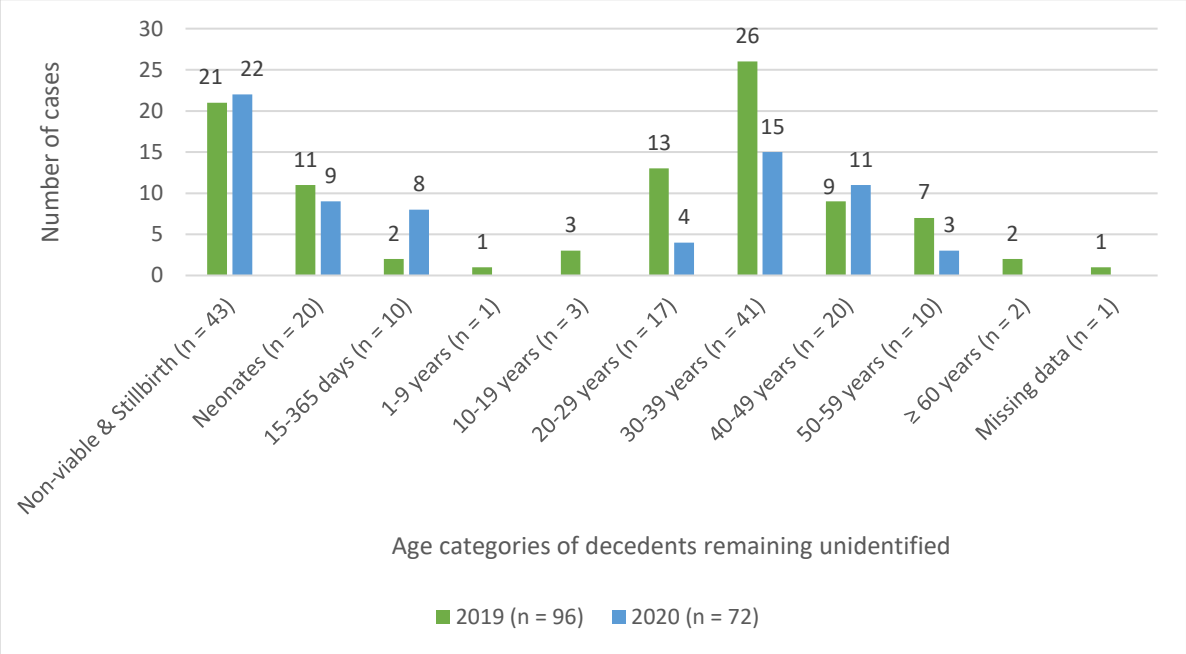


*Figure 3.3: Distribution of decedents remaining unidentified at Salt River Mortuary in 2019 and 2020 was according to the age category estimated by the pathologist.*

*A quarter (25.6 %) of those remaining unidentified fell within the 'non-viable &stillbirth' followed by the category of '30-39 years'.*

Of those remaining unidentified, DNA profiling was requested in 69 % (n = 116/168), fingerprint analysis in 39.3 % (n = 66/168) and anthropological analysis in one case (Figure 3.4). Similarly, to those identified, DNA profiling of UHRs was requested more in 2019 (69.8 %; n = 67/96) compared to 2020 (68.1 %; n = 49/72). It was observed

that 29.9 % (n = 20/67) of 2019 UHR cases were retrospectively sampled and sent for DNA profiling following the tender agreement. Notably, 19 % (n = 32/168) of decedents remaining unidentified had no identification attempts (Figure 3.4) with stillbirth and non-viable cases accounting for 68.8 % (n = 22/32) while the remainder of cases (31.2 %; n = 10/32) had a preservation condition of well-preserved however no DNA samples were collected as mentioned further on. Well-preserved refers to a body that did not sustain major alteration to the physical characteristics of the decedent unlike with putrefied, burnt, saponified and mummified decedents [9].

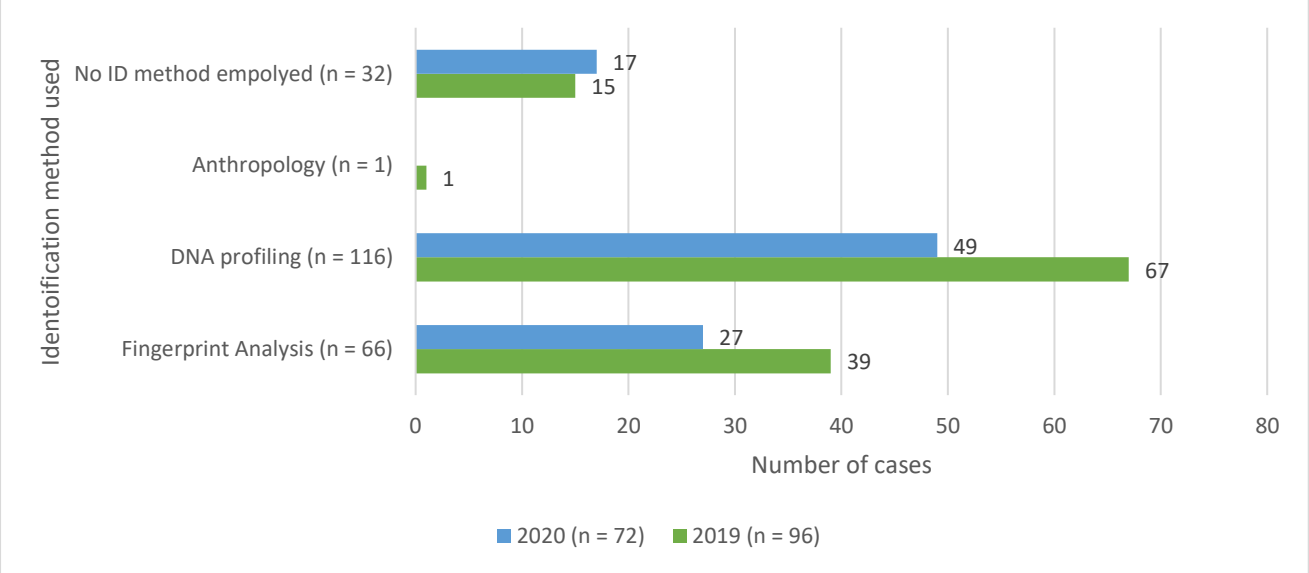


*Figure 3.4: Identification attempts made on decedents remaining unidentified at Salt River Mortuary for 2019 and 2020.*

*Requests were made for DNA profiling (69 %); Fingerprint analysis (39.3 %) and anthropology (0.6 %) however 19 % had no methods of identification attempted.*

## 3.3 DNA profiling requests in those remaining unidentified (UHRs)

It was noted that from those remaining unidentified, 69 % (n = 116/168) had DNA profiling requested, of which 37.9 % (n = 44/116) were sent to Unistel while the remainder (62.1 %; n =72/116) were sent to SAPS state laboratory for processing (Figure 3.5). While overall more cases were sent to SAPS, it was observed that there

was a decrease in the number of requests sent in 2020 (55.1 %; n = 27/49) compared to 2019 (67.2 %; n = 45/67) (Figure 3.5).

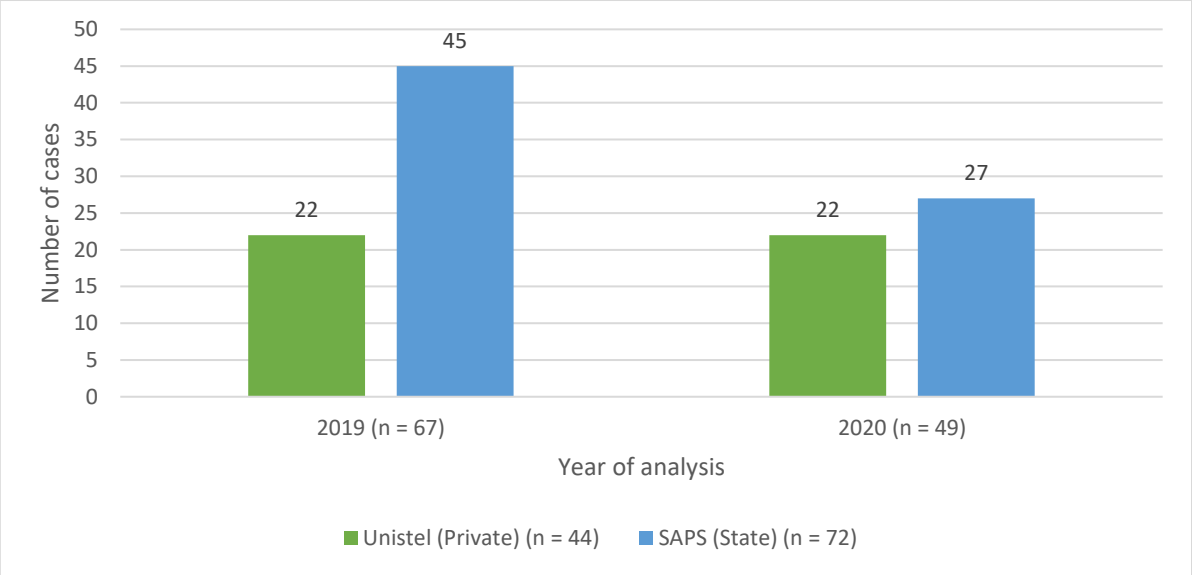


*Figure 3.5: Distribution of DNA profiling requests from those remaining unidentified to laboratories in 2019 and 2020.*

*DNA profiling requested in 2019 (57.8 %) and 2020 (42.2 %) was sent to Unistel (37.9 %) and SAPS laboratories (62.1 %) for processing.*

## 3.4 DNA profiling reports in those remaining unidentified (UHRs)

Although requests were made in 116 (69 %) UHR cases, DNA reports were not received in all. While 62.1 % were sent to the state laboratory, only 8.3 % (n = 6/72) of reports were received. Contrastingly, of the 44 (37.9 %) DNA profiling requests sent to Unistel, reports were obtained in all cases (Figure 3.6). The 50 reports received from either Unistel or SAPS laboratories did not lead to identification/match as there were no reference samples (either direct sample or next-of-kin sample) to compare these profiles to hence were kept for future reference. Furthermore, of the 50 UHR cases where reports were received from either Unistel or SAPS laboratories, 94 % (n = 47/50) showed that full DNA profiles were obtained, while 6 % (n = 3/50) from Unistel could not generate DNA profiles from the sample obtained. These three cases (2 % each) represented a nail sample, retrospectively sampled in 2020 from a well-

preserved body, and two bone samples from decomposed bodies: one from 2019 and one from 2020.

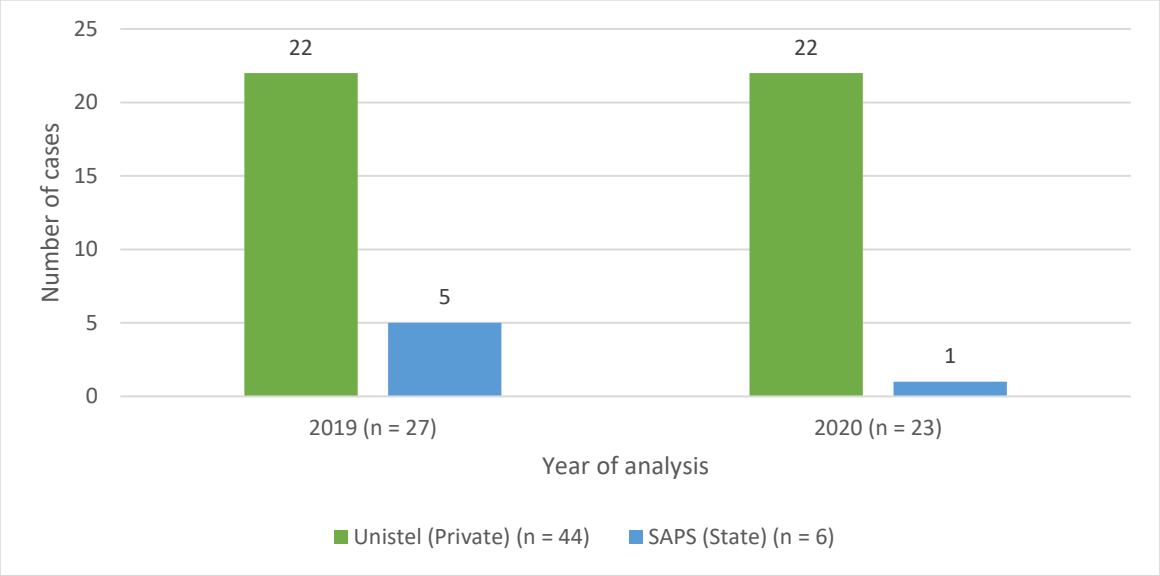


*Figure 3.6: Distribution of DNA profiling reports received from those remaining unidentified to laboratories in 2019 and 2020.*

*Of the cases where DNA profiling was requested, all reports were received from Unistel while only 8.3 % were received from SAPS laboratories.*

## 3.5 Timeline of DNA profiling in those remaining unidentified (UHRs)

For the two-year study period, post-mortem investigations were conducted on average within five days of the decedents' death declaration (Figure 3.7). DNA profiling was requested, on average, within 111 days of autopsy in 2019 whilst in 2020, requests were made within 27 days (Figure 3.7). Additionally, reports from Unistel were received from date of request on average within 152 days in 2020 as compared to average of 100 days in 2019. Furthermore, the average time taken to receive the Unistel report from the autopsy was 421 days in 2019 whilst in 2020 it was almost half that (mean = 211 days).

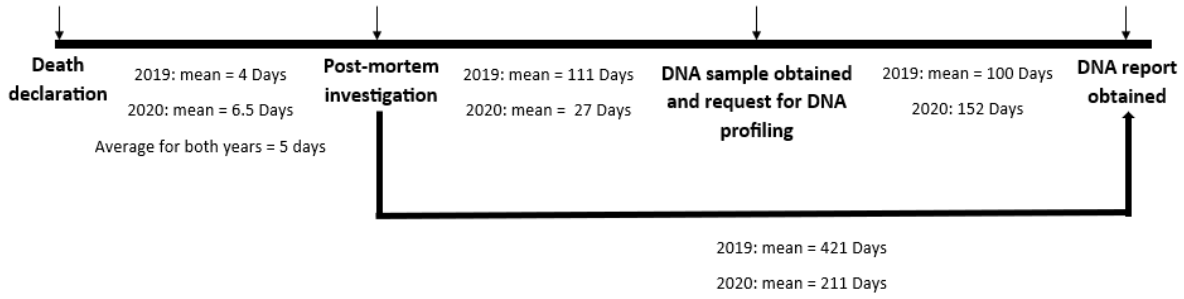


*Figure 3. 7: Line diagram indicating the various time intervals of importance from decedents' death declaration to receival of DNA reports for 2019 and 2020 at Salt River Mortuary.*

## 3.6 Sample type collected and preservation condition of those remaining unidentified (UHRs)

During this two-year review, 69 % (n = 116/168) of UHR cases had biological samples collected for DNA profiling. The most common sample type collected was blood (49.1 %; n = 57/116) followed by bloodspot (31.9 %; n = 37/116) across all preservation condition categories, except in skeletal cases where the most favoured sample type obtained was bone (n = 2) (Table 3.2). In 25 % (n = 42/168) of UHR cases, no sample was obtained.

It was observed that physical inhibitors of visual recognition were present in 37.5 % ( n = 63) of UHR cases consisting of burns (13.7 %; n = 23/168), decomposition on land (13.7 %; n = 23/168), trauma (4.2 %; n = 7/168), skeletonisation (3.6 %; n = 6/168), decomposition in water (1.2 %; n = 2/168) and scavenging (1.2 %; n = 2/168) while 62.5 % (n = 105/168) of UHR fell within the 'well-preserved' category; however, 36.2 % (n = 38/105) of these decedents had no samples obtained for DNA profiling (Table 3.2).

*Table 3.2: Biological samples collected in various preservation conditions of those remaining unidentified at Salt River Mortuary in 2019 and 2020.*

| | **Biological sample type collected** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Preservation Condition of body** | Blood (n = 57) | Blood Spot (n = 37) | Nail (n = 15) | Bone (n = 14) | Hair (n = 4) | Tissue (n = 2) | Teeth (n = 1) | No sample obtained (n = 42) |
| Well-preserved (n = 105) | 37 | 20 | 8 | - | 3 | 1 | - | 38 |
| Burns (n = 23) | 11 | 7 | 2 | 4 | - | - | - | - |
| Decomposition (Land) (n = 23) | 4 | 6 | 3 | 8 | 1 | - | - | 1 |
| Trauma (n = 7) | 3 | 3 | 1 | - | - | - | - | - |
| Skeletonised (n = 6) | - | - | 1 | 2 | - | 1 | 1 | 2 |
| Decomposition (Water) (n = 2) | 1 | 1 | - | - | - | - | - | - |
| Scavenged (n = 2) | 1 | - | - | - | - | - | - | 1 |

Trauma refers to any severe physical change of the decedent's body appearance due to injury or impact. Scavenged refers to the condition of the decedent's body after it has been fed on by animals.

# CHAPTER 4: DISCUSSION

Forensic human identification plays a vital role in medico-legal investigations which in turn assists in the course of justice in legal and social matters [1;77]. The burden of UHRs persists as an international issue, including at SRM/OFPI. There are many financial implications borne by the City of Cape Town and state services (FPS) in storing and arranging burials or cremations of unidentified bodies [76]. There is also the financial aspect regarding the funding of resources particularly with private service providers to improve processing of unidentified decedents such as the tender agreement with Unistel in order to reduce the number of UHR. Thus, it is imperative that standardised procedures in identifying unknown decedents are reviewed and updated to account for advancements in legislation, professional practice, and efficient accessibility of resources.

## 4.1 Unidentified population

Across the two-year review period, it was observed that at the time of autopsy, 47.7 % (n = 3 660/ 7 672) of decedents had an unconfirmed identity. However, after autopsy investigations, it was observed that 14.4 % (n = 1 101/7 672) remained with an unconfirmed identity, and after utilisation of various identification methods, 2.2 % (n = 168/7 672) of cases remained unidentified.

These results differed significantly from international literature such as that observed at the Institute of Legal Medicine (Milano, Italy) where the percentage of unconfirmed identities accounted to 3.2 % (n = 726/22 434) while 0.45 % (n = 100/22 434) remained unidentified and 0.44 % (n = 98/22 434) remained with suspected yet unconfirmed identities over the 25-year period [8]. Similarly, the results of this current study were higher when compared to that reported by the University Hospital (Garches, France)

where 9.1 % (n = 217/2 384) of decedents had a dubious identity at the time of autopsy, with a final 0.8 % remaining unidentified (n = 18/2 384) [69]. In comparison to another developing country such as India, the results of this study also differed from those observed at Calcutta Mortuary, where 24.5 % (n = 614/2 515) of cases were unidentified at PM, with 20.1 % (n = 505/2 515) remaining unidentified thereafter [62]. When compared to RSA literature, the results of this study were dissimilar from that reported at the Pretoria Medico-Legal Laboratory, where an average of 9 % UHRs per annum (range 7 – 10 %; n = 2 253 – 2 461) was observed [11]. More importantly, when compared to prior years (2010 - 2017), the percentage of UHRs at SRM/OFPI, was found to be 9.2 % per annum (range 7.7 - 11.9 %; n = 2 904 – 3 886) [23].

The higher number of UHRs in RSA compared to that experienced by developed countries may be due to the low socio-economic standards. Some factors contributing could be due to homelessness, lack of funds restricting transportation to forensic facilities for the identification process, lack of original identity documentation especially with regards to illegal immigrants and lack of reference data for comparison (*e.g.* ante-mortem dental and medical records, DNA profiles and fingerprints on national database) [10;11;21;23]. The difference in the percentage of UHRs at SRM/OFPI over the years may be attributed to the subjective recording of data as the past study only reviewed the Office Autopsy Database (OAD) containing summary information of all cases filled by FPS staff whereas this study reviewed the actual case files. Nonetheless, the significant decrease in UHRs over time, shows increased effort in identifying decedents and improvement of identification methods, particularly focusing on DNA profiling. This may be accredited to legislative changes (passing of the DNA Act) [60] in RSA encouraging and supporting DNA usage as well as media coverage promoting the benefits of DNA utilisation in the identification process. Importantly, the

lower caseload in 2020 due to Covid-19 allowed more time to be dedicated to efforts of identification through retrospective sampling of 2019 cases. Another factor to consider why the decrease in UHRs at SRM/OFPI occurred may be attributed to the collaborative agreements made with external service providers, such as that with Unistel for timely processing of DNA, and families not having to pay for these services themselves.

Of those remaining unidentified, male decedents accounted for 73.2 % (n = 123/168) with majority of decedents falling within the 'non-viable & stillbirth' age category (25.6 %; n = 43/168) followed by the '30-39 year' age category (24.4 %; n = 41/168) (Figure 3.3). The latter was similarly reported by Reid *et al.* (2020) where the most common age category observed was between 20 - 39 years [23]. This was also in accordance with other studies across the globe by Evert *et al.* (2011) in RSA, Paulozzi *et al.* (2008) in the USA and Kumar *et al.* (2015) in India, where 75 %, 46.6 % and 39.8 % of decedents fell within the 20 – 40 years age category respectively [11;14;61]. RSA is home to many migrants and refugees seeking better education, employment and/or political, social or religious freedom [15;78-80]. These individuals are more likely to be male and often leave their families behind to establish themselves, thus it is possible that these individuals contribute to the UHR population due to a lack of identification documentation and family ties to assist in identification [65;81]. This could account for the underrepresentation of females in the UHR population.

## 4.2 DNA utilisation for identification purposes

Several researchers have called for the efficient utilisation of DNA profiling and databases to assist with reducing the burden of UHRs [14; 71; 72]. As a result, the

tender agreement with Unistel to conduct DNA profiling was evaluated in this study to determine if DNA was used efficiently for identification purposes at SRM/OFPI.

It was observed that 84.7 % (n = 933/1 101) of the IUPP were identified with the most utilised method being visual recognition (86.3 %; n = 805/933) as it is often carried out even after scientific means (Figure 3.2). Of the IUPP, 43.4 % (n = 237/546) of cases where DNA profiling was requested were successfully identified. Although there was no significant difference found, the success rate was slightly higher in 2020 (45 %; n = 117/260) compared to 2019 (42 %; n = 120/286) even though the requests were more in 2019 cases (Figure 3.2). The 3 % increase in 2020 indicates that outsourcing with Unistel was beneficial in increasing the chances of identification.

Similarly, to identified cases, DNA profiling of UHR cases was requested more in 2019 (57.8 %; n = 67/116) compared to 2020 (42.2 %; n = 49/116) (Figure 3.4). The higher percentage of requests in 2019 UHR cases was due to 29.9 % (n = 20/67) being retrospectively sampled during the COVID-19 lockdown, with submission to Unistel for DNA profiling after the tender agreement was made in 2020. Furthermore, of those in which requests were made (69 %), 62.1 % were sent to the SAPS laboratory for processing however, a decrease in the number of requests to SAPS was noted in 2020 (55.1 %; n = 27/49) when compared to 2019 (67.2 %; n = 45/67) (Figure 3.5). This indicated that Unistel was favoured for processing DNA samples once the tender agreement was established in 2020 due to retrospective sampling of 2019 cases. This was further supported by the longer timeframe observed where the average time taken to receive the Unistel report from date of PM was 421 days in 2019 whilst in 2020 it was almost half that (211 days) (Figure 3.7). Additionally, the increase in the average time taken to receive the reports from Unistel after the date of request from 2019 cases (100 days) to 2020 cases (152 days) may be attributed to limited staff working in the

laboratory during COVID-19 lockdown hence the longer turnaround time of DNA reports.

As noted, biological samples were retained for DNA profiling in 69 % of UHR cases which was observed to be more than that recorded by Evert *et al.* (2011) (50%) and Kumar *et al.* (2015) (8 %) [11;14]. More importantly, it was almost three times more than that observed by Reid *et al.* (2020) (23.6 %) [23]. This shows improvement in identification attempts at SRM/OFPI over the years, possibly attributed to the tender agreement in place with Unistel as well as considering the different review periods and legislative changes since.

While it is promising that biological samples were retained for DNA profiling, only 8.3 % (n = 6/72) of reports were received from the state laboratory (Figure 3.5). This is due to state laboratories not issuing reports in failed and no-match outcomes, however, due to the lack of reports, it is uncertain if failure to process the DNA samples occurred or if there is a delay in processing. Additionally, despite all reports received from Unistel, these DNA profiles are not uploaded onto the NFDD of South Africa, which limits the value of DNA as an identification tool in cases without an alleged family member available. Consequently, the impact of this results in these decedents remaining unidentified while their DNA profiles/reports are kept on file at the mortuary instead of being further investigated and used effectively to assist in identification. This highlights the under-utilisation of DNA databases which not only act as an important tool for identifying criminals but also in efforts to improve identification rates via the missing persons and UHRs index [60]. If carried out, it would allow the uploaded UHR DNA profiles to be cross-checked against other indices, utilising direct-matching and familial matching principles. Interpol created I-Familia, a global database, utilised for identifying missing persons based on international DNA kinship matching. This

database is beneficial in identification of missing persons and UHRs when direct comparison is not possible, by using DNA samples from close relatives instead, held separately from any criminal data. Utilisation of I-Familia or similar databases can enhance opportunities to identify unknown decedents and provide answers to families [82].

Although an increase in sample retainment of UHRs was noted at SRM/OFPI over the years, 25 % (n = 42/168) of cases had no sample collected for DNA profiling even though 90.5 % (n = 38/42) of these had a preservation condition of well-preserved (Table 3.2). These results indicate that DNA is not being used to its full potential and samples should be retained even if analysis occurs later however, no retainment of samples is possibly due to cases pertaining to stillbirths and non-viable foetuses which was also the age category where majority of UHR cases fell (25.6 %; n = 43/168). This was two times more than that reported by Reid *et al.* (2020) (10.7 %) but similar to that reported by Evert *et al*. (2011) (20 %) [11;23]. It is also noted that stillbirths and non-viable cases are not usually reported on due to the manner in which they are 'disposed' of [83]. Identification in these cases is extremely challenging due to the decedent's young age whereby there are no records of reference DNA profiles and stored fingerprints on databases. While retaining samples for identification in these cases is beneficial, disposal of or attempts to hide neonates is considered illegal resulting in a concealment of birth charge [84]. Consequently, it is unlikely that the next-of-kin will come forward as it is suspected that these decedents are intentionally abandoned. As a result, these cases are usually not investigated further due to the lack of evidence surrounding the identity of the neonate and consequently to whom the charge should be laid against. This explains why stillbirth and non-viable cases accounted for 68.8 % (n = 22/32) of cases with no identification attempts (19 %, n = 32/168).

## 4.3 Efficacy and appropriateness of UHRs samples collected for DNA profiling

It was observed that physical inhibitors of visual recognition were present in 37.5 % (n = 63) of UHR cases consisting of burns (13.7 %; n = 23/168), decomposition on land (13.7 %; n = 23/168), trauma (4.2 %; n = 7/168), skeletonisation (3.6 %; n = 6/168), decomposition in water (1.2 %; n = 2/168) and scavenging (1.2 %; n = 2/168) (Table 3.2). In these cases, scientific means of identification such as DNA and anthropological analysis were particularly valuable as visual recognition and fingerprint analysis was not possible. The time taken between date of death declaration and date of post-mortem investigation (mean = 5 days) indicates that samples collected would not be subject to DNA degradation and therefore would not be an issue for DNA profiling [61]. This means that the DNA samples obtained were likely fit for analysis to generate full DNA profiles which in turn can be utilised in identification.

The most common sample type collected was blood (49.1 %; n = 57/116) followed by bloodspot (31.9 %; n = 37/116) across all preservation condition categories, except in skeletal cases where the most favoured sample type obtained was bone (n = 2) (Table 3.2). The collection of blood and bloodspots, with advantages and disadvantages for each, depends on the case and specific analysis to be conducted. Blood retained provides a larger sample volume, usually to conduct multiple tests or repeated analysis including toxicology and DNA profiling. It is collected in tubes with anticoagulants that allow for better preservation of DNA compared to bloodspots and has specific storage conditions [85]. Whereas dried bloodspots are less invasive and more stable at room temperature, making storage and transportation simpler compared to liquid blood samples [85,86]. Bloodspots are more economical especially if retained for

identification purposes where small amounts of DNA are utilised and are recommended in resource-poor settings [85].

These results show the appropriateness biological samples collected based on the preservation condition of UHRs and are further supported by the 94 % (n = 47/50) of UHRs cases where full DNA profiles were generated and received however, the remaining 6 % from Unistel did not generate DNA profiles from the sample obtained. It was found that 4 % (n = 2/50) of these were 2019 cases retrospectively sampled a year later hence, the DNA samples were likely highly degraded at the time of collection or were possibly degraded further during storage and/or transportation to laboratory for processing [37]. Additionally, the average timeframe in which DNA samples were collected and sent for profiling after PM in 2019 (111 days) compared to 2020 (27 days) indicated that the collection and request process occurred more swiftly in 2020 and is better aligned with legislative timelines compared to 2019 results (Figure 3.7).

On the other hand, the remaining 2 % with no DNA profile generated was attributed to the advanced decomposed state of the decedent in which bone was obtained for analysis. The retainment of bone is plausible, particularly in cases where the body has suffered exposure to the environment, as research shows that high quality and quantity of DNA is preserved within and is effective for DNA testing [87]. However, extraction of DNA from hard tissues like bone is more challenging than that from other tissues additionally, intrinsic factors like bone type and density can contribute to DNA preservation [87-89]. Usually long bones (*e.g.,* femur and tibia) are retained for DNA analysis as in this case, however of recent, studies have shown that small cancellous bones of hands and feet have proven to be useful in identification for relatively long post-mortem intervals (PMI) [87;90;91]. As a result, the type of bone collected may

have been attributed to the quality of DNA used for testing leading to no profile being generated.

Notably, 19 % of decedents remaining unidentified (n = 32/168) had no identification attempts for this two-year period, meaning no use of resources and efforts of identification methods despite having access. Of the 19 %, stillbirth and non-viable cases accounted for 68.8 % (n = 22/32) as mentioned above while the remainder of cases (31.2 %; n = 10/32) had a preservation condition of well-preserved however no DNA samples were collected. Although samples should have been retained in the well-preserved cases for future reference, fingerprint analysis should have been conducted however, it may not guarantee identification. Firstly, if the decedent is under the age of sixteen hence will not have a fingerprint on the system at the South African Department of Home Affairs and secondly, if the decedent is not a South African citizen hence fingerprints will not be uploaded onto the Automated Fingerprint Identification System (AFIS) for comparison [21;60].

## 4.4 Limitations, recommendations, and future studies

The major limitation of this study, as with other retrospective studies was the lack of documents present at the time of research. The missing data pertained to identification documentation and release records (notice of removal and acknowledgement of receipt) hence deduction was not possible, as a result, these cases were not included in further analyses. The ages of the decedents who remained unidentified was estimated by the pathologist and put in the autopsy reports. Due to these challenges, this study may not accurately represent the unidentified population at SRM/OFPI. Furthermore, fingerprint analysis reports were not obtainable for all cases hence the success rate of identification through fingerprints could not be determined.

While identification methods were used or requested in majority of UHR cases (81 %; n = 136/168), these results highlight the need for an improved standardised procedure of identification. Although retainment of samples for DNA profiling has improved over the years, it is still not being done routinely in a portion of unidentified cases (19 %) revealing ineffective use of DNA. In cases of retainment, biological samples should be obtained as soon as possible and not retrospectively sampled. Similar to DNA, anthropological and odontological analyses are under-utilised in UHR cases, suggesting that these methods are undervalued or there are barriers/challenges to utilising them routinely. The use of anthropological and odontological should be considered in extreme cases of decomposition where DNA profiling and fingerprint analysis are not possible for identification.

To improve the effective use of resources, it is recommended that Standard Operating Procedures (SOPs) be revised to ensure forensic personnel (FPS and SAPS) are aware of their responsibilities. This includes retaining samples timeously and requesting appropriate analyses for identification purposes depending on the condition of the body. Furthermore, it would be beneficial for forensic professionals to be more informed or mindful of the type of sample retained as it is important for the successful generation of DNA profiles, this relates back to research showing that bloodspots are more economical than blood for identification purposes and cancellous bones are more useful in relatively long PMI cases compared to long bones.

Routine communication between stakeholders is required in order to reduce the burden of unidentified decedents. Efforts of other collaborators such as the Victim Identification Centre (VIC) and Forensic Anthropology Cape Town (FACT) should be utilised to improve chances of identification. The findings of this study indicate that using Unistel improved the success rate of identification through DNA usage at

SRM/OFPI, when an alleged family member was available for kinship analysis. However, this tender agreement does not contribute to the NFDD and thus limits the investigative value of cases in the future, particularly in cases where reference samples are not available for comparison.

Therefore, it is recommended that collaboration/communication between private and state facilities are improved to facilitate investigative leads using a DNA database or repository as it is underutilised. This supports research conducted by Cattaneo *et al.* (2010), Evert et *al*. (2011) and Reid *et al.* (2020) for the development of efficient use of DNA databases [9;11;23] as well as other international literature [67; 68; 71; 73]. It is recommended that DNA profiles generated by private laboratories be uploaded on the NFDD to effectively be utilised and investigated. Alternatively, a UHR repository may be developed for local mortuaries in which SAPS can access all efforts made towards identification (e.g. DNA and fingerprint results, presence of secondary identifiers: tattoos, clothes), to pursue investigative leads of identity. It is also recommended that SAPS provide feedback/reports on DNA processed, especially in cases where there are failed outcomes, or no match occurs. This ensures communication between SAPS and FPS and provides clarity on why no reports were received rather than assuming it was due to failed outcomes or delays in processing.

Furthermore, this study highlights the need for improved resource expenditure into and collaboration between the state laboratories and local mortuaries for DNA profiling as outsourcing to a private laboratory is expensive and not a long-term solution. While DNA usage has been encouraged publicly of recent in RSA, improved effort of all stakeholders should be made to educate the public on how to report a missing person as well as the importance of kinship analysis in identification, should the body be discovered.

It is recommended that future studies continue to investigate the utilisation of DNA profiling at SRM/OPFI for later years to account for any differences observed in these two years as a result of the COVID-19 pandemic. It would also be beneficial to investigate the use of other collaboration agreements made with SRM/OFPI such as that with FACT. Research investigating the success rate of DNA profiles generated by SAPS laboratories for identification purposes should also be conducted to determine if DNA databases are an effective tool in identification.

## 4.5 Conclusion

DNA profiling is an invaluable tool used in criminal and forensic investigations. The number of cases requesting DNA profiling and those receiving reports did improve substantially from 2019 to 2020. This is due to various factors implemented such as legislative changes, research, media coverage and tender agreements encouraging and supporting DNA utilisation as well as possibly fewer UHRs cases in 2020 due to the Covid-19 pandemic.

Of particular interest, the tender agreement made with Unistel was found to be beneficial in processing DNA samples to assist in improving the identification process at SRM/OFPI. This was supported by the retrospective sampling of the 2019 UHR cases observed after the establishment of the agreement. However, DNA profiles generated by Unistel do not contribute to the national database, so while helping to generate profiles on a local basis, it does not address the national or global issue of UHRs. Additionally, collaboration with private external service providers is not feasible in the long run hence state facilities require resource expenditure and an improved standardised procedure in processing DNA. The majority of UHRs had DNA profiles generated (94 %) indicating the appropriateness of biological samples collected

however in 4 %, no profiles were generated due to retrospective sampling highlighting that samples should be obtained more timeously.

As such, an improved standardised procedure for a faster sampling and request process that is less expensive should be implemented. To achieve this, samples should be obtained and sent for analysis within 3 days of admission. Bloodspot samples should be retained over whole blood samples as it is more suitable for identification purposes and cost-effective. Communication between FPS, SAPS and other collaborators needs to be improved by adding DNA profiles to NFDD and issuing reports for all analyses even if failed outcomes occur. Through a collaborative effort, it is hoped that efficient usage of resources can lead to successful identification and further reduction in UHRs cases.

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# Appendix A

Ethics approval letter (HREC ref 198/2023)

**UNIVERSITY OF CAPE TOWN**
**Faculty of Health Sciences**
**Human Research Ethics Committee**

**Room 45 E-52-E-Floor- Old Main Building**
**Groote Schuur Hospital**
**Observatory 7925**
**Telephone** [021] 406 6492
**Email:** hrec-submissions@uct.ac.za
**Website**: https://health.uct.ac.za/home/human-research-ethics

14 April 2023

**HREC REF: 198/2023**

**A/Prof L Royle**
Department of Pathology
Division of Forensic Medicine & Toxicology
Email: Laura.royle@uct.ac.za
Student: dhrkis001@myuct.ac.za

Dear A/Prof Royle

**PROJECT TITLE: ARE HUMAN IDENTIFICATION METHODS EFFECTIVELY UTILISED? A RETROSPECTIVE REVIEW OF UNIDENTIFIED REMAINS BETWEEN 2019-2020 AT SALT RIVER MORTUARY, CAPE TOWN, SOUTH AFRICA**
**(MPHIL CANDIDATE- MS KISHARIA DHARAMDEV)**

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee (HREC) for review.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

**Approval is granted for one year until the 30 April 2024.**

Please submit a progress form, using the standardised Annual Report Form (FHS016) if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

***The HREC acknowledge that the student: Ms Kisharia Dharamdev will also be involved in this study.***

**Please quote the HREC REF 198/2023 in all your correspondence.**

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

Yours sincerely

**PROFESSOR M BLOCKMAN**
**CHAIRPERSON, FACULTY OF HEALTH SCIENCES HUMAN RESEARCH ETHICS COMMITTEE**

HREC/ref 198.2023

# Appendix B

Data Management Plan (DMP)

## ARE HUMAN IDENTIFICATION METHODS EFFECTIVELY UTILISED? : A RETROSPECTIVE REVIEW OF UNIDENTIFIED REMAINS BETWEEN 2019-2020 AT SALT RIVER MORTUARY, CAPE TOWN, SOUTH AFRICA - Student Full DMP

### 1. Project Details

**PROJECT NAME - Replicate the title of your project, dissertation or thesis exactly as it appears in your proposal document.**

ARE HUMAN IDENTIFICATION METHODS EFFECTIVELY UTILISED? A RETROSPECTIVE REVIEW OF UNIDENTIFIED HUMAN REMAINS AT SALT RIVER MORTUARY, CAPE TOWN, SOUTH AFRICA FOR 2019 - 2020

**PERSONAL DETAILS - Indicate the name(s) and student number(s) of the student(s) who will be involved in this project, dissertation or thesis.**

MPhil Biomedical Forensic Science Student: Kisharia Dharamdev

**SUPERVISOR(S) DETAILS - Indicate who will supervise this project, dissertation or thesis. If you do not yet have a supervisor, leave this section blank.**

Supervisor: Mrs Kate Megan Reid (rdxkat001@myuct.ac.za) Principle investigator/Co-supervisor: Dr Laura Heathfield (laura.royle@uct.ac.za)

### 2. Project Summary

**RESEARCH SUMMARY - Briefly summarise your study. Include the study's objectives, design, and methods.**

Human identification plays a vital role in death investigations and assists with, civil, criminal, and administrative matters following death. The identification process involves the utilisation of the decedents' physical and/or biological characteristics to positively confirm their identity. Primarily, identification of the deceased is confirmed by the next-of-kin or a legal guardian through visual recognition. However, when visual identification is not possible, scientific means of identification may be utilised such as DNA, fingerprint, anthropometric and odontology analyses. These methods when physical identification is not possible due to advanced decomposition and/or skeletonization or when next-of-kin are unknown and reference databases are to be compared against. Unfortunately, many individuals remain unidentified despite the implementation of various identification methods during post-mortem investigations. Due to high number of Unidentified Human Remains (UHRs) experienced in South Africa, a call has been made for a more collaborative approach in the utilisation of external resources to assist in successful identification. Following the passing of the Criminal Law (Forensic Procedures) Amendment Act (Act no 37 of 2013), commonly referred to as the DNA Act, Salt River Mortuary sought out collaborative agreements to improve the processing of DNA samples of unidentified human remains as of January 2020. The expected outcome of this study is to see an improved effort in successful identification after collaborative agreements to generate DNA profiles of the unidentified bodies so they can be added onto the DNA database and be potentially matched should reference DNA become available. This study will aim to evaluate how the identification of unidentified remains has changed following the implementation of collaborative agreements between Salt River Mortuary and external service providers. This will be achieved by: • Describing the unidentified persons population at Salt River Mortuary • Reporting on the efficacy and appropriateness of identification methods used in these cases • Assessing differences in the success of identification before 2019 and after 2020 the implementation of the framework changes with an external service provider • Proposing recommendations for a standardized procedure for the identification of unknown decedents Methods: This study will be a retrospective cross-sectional study of all medico-legal case files at Salt River Mortuary pertaining to unidentified human remains between the period 1 January 2019 and 31 December 2020. Cases where the identification of an individual is known before autopsy will be excluded. All relevant data from autopsy records etc via LiveLink database will be analysed such as the demographic information and case details which provides context on the suitability of the method/s of identification chosen. The data-capturing process will take place in a secure room on the University of Cape Town medical campus with restricted access to personnel. The anonymised data collected will be stored on a privately owned laptop that is password protected and will be backed up on an external hard drive. The information obtained will then be collated in Microsoft Excel 365, Version 2209 (Microsoft, USA) to carry out descriptive statistical analysis as well as GraphPad prism, Version 9.5.0 (730).

### 3. Description of the Data

**DATA REUSE DESCRIPTION - If you re-used data from third-party sources in your study, record pertinent details here such as**

**the source of the data, the extent of the data, usage rights or restrictions pertaining to the data, and how it was incorporated into your study.**

- I have used existing data in my study.

Data will be obtained from existing medico-legal autopsy reports. The data is stored in a secured excel based database or on a secure online database. Access will be applied for and obtained through secure credentials. Where needed, hard copy medico-legal documents stored at the repository at UCT will be reviewed in accordance with divisional protocols. All case reports will be kept in a secure locked office and signed out by the division secretary when needed. These credentials will not be distributed to other users, unless listed on the research project. Data will be obtained from the online database through collection of raw data, and no copies of original material will be made. All data will be backed up regularly onto a password secured USB device.

**DATA DESCRIPTION - Describe the data you have gathered for your study. Briefly describe the nature, scope and scale of the data you have produced.**

This study will be a retrospective cross-sectional study therefore data will be collected from existing medico-legal autopsy reports but will constitute original data as well as the analyses of data from Excel. While there will be a total of ~6000 cases spanning the two years of review, it is expected that only 10% of these will be reviewed in depth as part of the inclusion criteria (unidentified or unclaimed remains) set out for this study. This data will be collated into Microsoft Excel and will most likely be <800mb in size

## 4. Formats and Quality Control

**QUALITY CONTROL - Describe what measures you took to ensure the data you collected were of high-quality.**

All data will be collated into a data validated excel sheet which will prevent entry of typos or erroneous dates. Data will be scrubbed and cleaned following completion to fill in any dates and to double check variables. Another researcher on the study will recollect a subset of cases to ensure that no discrepancies have been completed.

**FILE FORMATS - Indicate the formats in which your data will be collected and processed. Clarify whether these formats require specialised proprietary software to access or if they will be produced in or converted to more open, accessible formats for long-term accessibility and preservation. In the case of physical data objects (such as artworks or models) indicate whether these will be digitised or otherwise preserved for accessibility.**

Statistics will be in .XLSX (Excel) or CSV Documents will be in PDF, .DOCX (Word)

## 5. Data Management, Documentation and Curation

**CURATION (MANAGING AND STORING) DATA - Describe how you organise and manage your data. Specify any file-naming conventions or community data standards you have adopted.**

Data will be managed and organised on Microsoft Excel. Files will be named YYYY/MM/DD_short description and version no_initial of student. SUpervisor will add details at the end of the each reviewed document.

**BACKUP AND STORAGE - Describe how your data is being stored and backed-up. If you are using a data service provider, provide details on for how long they will retain the data.**

Data will be collected and stored on the students OneDrive account which is password protected. Data shared with the supervisors and/or collaborators will be through OneDrive or Google Drive. This will ensure that the data files are accessible and secure should the electronic device be damaged or compromised. External hard back ups will occur monthly onto a separate password protected USB device that the student holds in a secure location at the Division of Forensic Medicine and Toxicology, UCT. Passwords will be regularly updated to reduce risk of compromised security. Regular back-up and sharing of the data will be according to the divisional SOP for data sharing, and will be only temporarily stored on the UCT Google Drive.

**METADATA STANDARDS AND DATA DOCUMENTATION - Articulate what metadata and documentation you have produced about the data you have generated, collected or re-used.**

Descriptive statistics will be performed for variables consisting of Demographic information (Biological sex, age) and case details (cause of death, manner of death, identification methods used, sample type obtained,Impact of environmental conditions on the remains etc) Microsoft Excel 365, Version 2209 and GraphPad prism, Version 9.5.0 (730). The completed mini dissertation will include a methods chapter explaining in detail how the data was collected and how the data was analysed.

## 6. Data Security and Confidentiality of Potentially Disclosive Information

**SECURITY - Indicate to what extent your data can be considered sensitive or at-risk. Describe how you will control access to your data. Indicate whether you anticipate a need for encryption or password-controlled access, and if so, how you will enforce that access.**

This data does contain sensitive information hence privacy and confidentiality will be maintained by ensuring that the data is anonymized and accessible to authorized personnel only. Data will be stored on a privately owned laptop which is password-secured.

**ETHICS AND PRIVACY - Describe, as per your Ethics Clearance form or other similar documentation, any ethical or privacy issues that your data are subject to (if any). Summarise the main risks to the confidentiality and security of information related to human participants, the level of risk, and how this risk will be managed. If your project did not require ethical clearance, you may ignore this section.**

There are no physical risks involved in this study due to its retrospective nature however, the data collected will be anonymised to insure privacy and confidentiality. Identifying information such as: names of deceased or next-of-kin; addresses and identity numbers will not be recorded. Thus, the risk and vulnerability is considered to be low.

## 7. Data Sharing and Open Access

**DATA OWNERSHIP - If you have used existing datasets, note down any restrictions the data providers have indicated regarding data sharing. Otherwise, leave blank.**

- I have used existing data in my study and I have noted down the relevant restrictions as pertains to data sharing(details below).

Data is being collated from existing medico-legal case files. There is no restriction on using this data, provided that is securely and confidentially handled. Raw data sets cannot be published or shared without appropriate agreements in place.

**DATA LICENCE - Indicate under which licence you intend to share your research data. If you are not sharing your data, provide the appropriate justification as per the UCT Research Data Management guidelines.**

- CC BY

At the conclusion of my study, I will publish my data under a CC BY licence on ZivaHub.

**DATA PUBLICATION - Indicate where you intend to publish your research data at the end of your project.**

Final dissertation, including anonymised data will be published on the UCT online library. All data files (raw data, analyses etc) will be returned to the principal investigator at the end of my study.

## 8. Relevant Institutional or Study Policies

**Indicate the relevant departmental, unit, or institutional policies that influence your data management activities.**

UCT Intellectual Property Policy and NRF Open Access Statement

# Appendix C

Variable classification for data collection

| Variable | Classification |
|---|---|
| Age | • Estimated/reported age at time of post-mortem<br>• Age as per birth certificate/ID/passport/drivers license |
| Biological sex | • Male<br>• Female<br>• Unknown |
| Identity at admission | • Suspected<br>• Unknown |
| Declaration of death | Specify as recorded |
| Date of Recovery (admission) | Specify as recorded |
| Location of recovery | • Housing<br>• Road<br>• Hospital<br>• Waters<br>• Open land<br>• Railway<br>• Other |
| Admission category of death | • Sudden and unexpected<br>• Procedure related<br>• Road traffic accident<br>• External trauma<br>• Other |
| Alleged manner of death | • Homicide<br>• Suicide<br>• Accidental<br>• Undetermined/under investigation<br>• Natural |
| Cause of death | Specify as recorded (Natural/Unnatural/Under investigation) |
| Date of post-mortem examination | Specify as recorded |
| Date of removal notice | Specify as recorded |
| Date of release | Specify as recorded |
| Physical condition of body | • Relatively normal<br>• Decomposed (land)<br>• Decomposed (waters)<br>• Burnt<br>• Skeletonised<br>• Scavenged<br>• Trauma |
| | • Visual identification<br>• Fingerprint analysis |

| | |
|---|---|
| Human identification methods used | • DNA analysis<br>• Anthropology<br>• Odontology<br>• Entomology<br>• Secondary identifiers (Clothing/scars/tattoos)<br>• Photographs / facial reconstruction<br>• Radiology<br>• Other (specify) |
| Whether DNA sample was retained for DNA analysis | • Yes<br>• No |
| Sample type obtained | Depending on identification methods used:<br>• Blood<br>• Buccal<br>• Bone<br>• Nail<br>• Other (specify) |
| Facility performing DNA analysis | • State laboratory<br>• Private laboratory |
| Whether results were received from DNA analysis | • Yes<br>• No<br>• Unknown |
| Identification status after identification methods employed | • Identified<br>• Unidentified<br>• Unclaimed |
| Body release | • Private<br>• Pauper burial/State-held<br>• Unknown |

## Appendix D

Variables collected from various medico-legal documents.

| **Variable** | **Medico-legal documents** |
|---|---|
| Age | Copy of ID (Corpse and next-of-kin) or BI 1663 document |
| Biological sex | FPS002 – Scene script |
| Identity at admission | FPS002- Scene script |
| Declaration of death | FPS002 – Scene script |
| Date of Recovery (admission) | FPS002 – Scene script |
| Location of recovery | FPS001 – Log Incident / FPS002 – Scene script |
| Admission category of death | FPS002 – Scene script |
| Alleged manner of death | FPS002 – Scene script |
| Cause of death | Post-mortem report or BI 1663 document |
| Date of post-mortem examination | Post-mortem report or BI 1663 document |
| Date of removal notice | FPS012 – Notification to claim & remove body |
| Date of release | FPS013 – Acknowledgement of receipt of body |
| Physical condition of body | Post-mortem report |
| Human identification methods used | Post-mortem report/analyses reports |
| Sample type obtained for DNA analysis | Post-mortem report |

| | |
|---|---|
| Facility performing DNA analysis | DNA analysis report/results |
| Results received from DNA analysis | DNA report/results |

## Appendix E

Two sample z-test for proportions of cases identified through DNA profiling in 2019 and that in 2020.

Proportion identified through DNA Profiling in 2020: $P_1$ = 117/260

Proportion identified through DNA Profiling in 2019: $P_2$ = 120/286

Total number of cases that requested DNA profiling in 2020: $n_1$ = 260

Total number of cases that requested DNA profiling in 2019: $n_2$ = 286

$H_0$: π1 = π2

$H_A$: π1 ≠ π2

$\hat{P} = \frac{n_1 P_1 + n_2 P_2}{n_1 + n_2}$ = 0.6744505495

$z = \frac{P_1 - P_2}{\sqrt{\hat{P}(1-\hat{P})(\frac{1}{n_1}+\frac{1}{n_2})}}$

$= \frac{0.03041958042}{\sqrt{0.2195299478\ (7.342657343\ x10^{-3})}}$

= 0.76

0.76 < Z-crit

Therefore, we can accept the null hypothesis. There is no significant difference between the proportions of cases identified through DNA profiling in 2019 and that in 2020 at the $\alpha = 0.05$ level.

## Appendix F

Additional summarised data regarding important time intervals from decedents' death declaration till DNA reports received for 2019 and 2020 at Salt River Mortuary.

| Time interval | 2019 cases | | 2020 cases | |
|---|---|---|---|---|
| | Standard deviation (Days) | Range (Days) | Standard deviation (Days) | Range (Days) |
| Death declaration to post-mortem investigation | 3 | 0-23 | 6 | 1-29 |
| Post-mortem investigation to DNA sample obtained and request for DNA profiling | 202 | 0-756 | 84 | 0-412 |
| DNA sample obtained and request for DNA profiling to DNA report received | 202 | 4-694 | 144 | 13-479 |
| Post-mortem investigation to DNA report received | 199 | 176-789 | 160 | 16-575 |

*Range refers to the variation between the minimum and maximum number of days each time interval occurred.*