CHAPTER 10

Sample Tracking and Management

The laboratory must be prepared for an influx of samples following a mass fatality event. The physical location of each sample—and all other data associated with it—must be tracked through the DNA analysis processes. This chapter discusses important considerations in sample accessioning, naming and numbering schemes, handling the possibility that remains may be commingled, and work lists that can be generated by the LIMS to facilitate DNA identifications.

The size and quality of the DNA from victims' remains greatly affects the ability to obtain DNA profiles for identification purposes. Similarly, the availability of reference samples from close biological relatives or from personal effects can impact the ability to identify victim remains. In addition, the often chaotic environment at a mass disaster site can lead to sample mixups. Even when the sample collections are conducted by another agency, the laboratory manager should be directly involved in establishing guidelines for collection, handling, and preservation of all samples to ensure quality and accuracy throughout the process.

Chain of custody and the origin ("provenance") of collected remains are important aspects of the identification management process. They are also critical to the collection of reference samples for comparison with victim remains. Chain-of-custody practices are necessary for reference-sample attribution, even when there is no criminal investigation component to the identification effort (e.g. in a natural disaster), since death certificates based on DNA identification will always include forensic elements.

Establishing the source of personal effects that are used as reference samples—for example, toothbrushes, razors, medical biopsy samples, clothing—can be problematic. The Kinship and Data Analysis Panel (KADAP) developed an informational brochure to help victims' families understand what types of samples are helpful in making an identification based on DNA analysis (see appendix G).

It is important to keep in mind that other sample issues can complicate the identification process. These include inconsistencies that may arise from data in the Victim Identification Program (VIP) forms. For example, there may be inadvertent reference-sample switching by bereft loved ones. Or, there may be name misspellings or unlinked nicknames (for example, Bobby vs. Bobbi vs. Bob vs. Rob vs. Robert) associated with the same last name. Inconsistent case numbering during field collections can also occur. These issues can reduce the efficiency and accuracy of the identification process.

Family members may state with certainty that their missing relative was the only one to have contact with a personal effect that is brought in for DNA testing. However, mixed DNA profiles from toothbrushes or other personal effects may eliminate that reference sample as a single-source reference. If one of the profiles on a personal effect can be attributed to another family member, the remaining profile may be inferred as the victim's, but this situation adds uncertainty concerning source and missed or shared alleles and makes for a more complex analysis.

Other complications—including assumed, but incorrect, parentage—may come to light after DNA testing. In some mass fatalities, such as a tidal wave, personal effects belonging to victims can be lost or contaminated at the site itself. Managing sample collection and tracking in a controlled, documented fashion is essential to the DNA identification process.

One of the most important decisions that a laboratory responding to a mass fatality event will have to make is whether to treat the incident as a humanitarian effort, civil incident, or criminal matter. This decision will drive chain-of-custody requirements. Exhibit 19 describes some of these issues.

Most public forensic laboratories have a chain-of-custody system in place, and generally it makes sense to use the existing system as a foundation in a mass fatality incident response, modifying the processes as necessary (particularly if the movement of samples must be tracked to and from multiple laboratories). It is also important to keep in mind when establishing documentation processes for tracking the provenance of samples that personal effects provided as reference samples can be incorrectly characterized by loved ones as having been used solely by the victim. It is not unusual for mixed DNA profiles to be found on shared intimate items, such as toothbrushes. As previously mentioned, these types of mixed profiles can also reveal that family members may have had incorrect assumptions about biological relationships, so it is helpful to have a policy in place to deal with such discoveries.

In a transportation mass fatality event, for example, collecting samples can be complicated because people who are traveling usually have their personal effects with them, and these can be lost or contaminated at the scene. In this case, additional DNA testing, such as mitochondrial DNA (mtDNA), may help to resolve identifications by grouping maternally linked victims.

In planning for a mass fatality incident response, it is important to consider how samples will be accessioned into the laboratory. Laboratories are likely to maintain higher efficiency if their existing Laboratory Information Management System (LIMS) can be used for handling mass disaster samples. (See chapter 9 of this report for a discussion of LIMS systems.) When evaluating whether a forensic LIMS can be adapted to a mass fatality incident, the laboratory director should consider whether:

- The mass fatality samples can be segregated from regular casework samples. (The laboratory likely will want to track casework and mass fatality samples and metrics separately.)
- Numbering should begin with "1" or a different numbering sequence should be established to designate mass fatality incident samples as separate from casework samples. (It is helpful for mass fatality incident samples to be numbered sequentially, not mixed with routine casework numbers.)
- The LIMS can support a single sample being given more than one sample number and can support cross-referencing multiple sample

Exhibit 19: How the Event Is Treated

Treat Incident As	Implication
Humanitarian effort	Although it is important to correctly identify a sample, strict chain-of-custody procedures and documentation may not be required. This can simplify and streamline processes—particularly among multiple laboratories—but this scenario may require new sample tracking processes.
Civil matter	Most mass fatality incidents have a civil component—i.e., the need to issue death certificates. Chain-of-custody procedures and documentation are required, but they are less stringent than for incidents considered as criminal matters. This scenario may allow simplification/streamlining of the sample handling processes and may (or may not) require new processes.
Criminal matter	Some mass fatality incidents (e.g., acts of terrorism) are criminal matters, and therefore, they require rigorous chain-of-custody procedures and documentation. Public forensic DNA laboratories currently have established chain-of-custody systems that can be used.

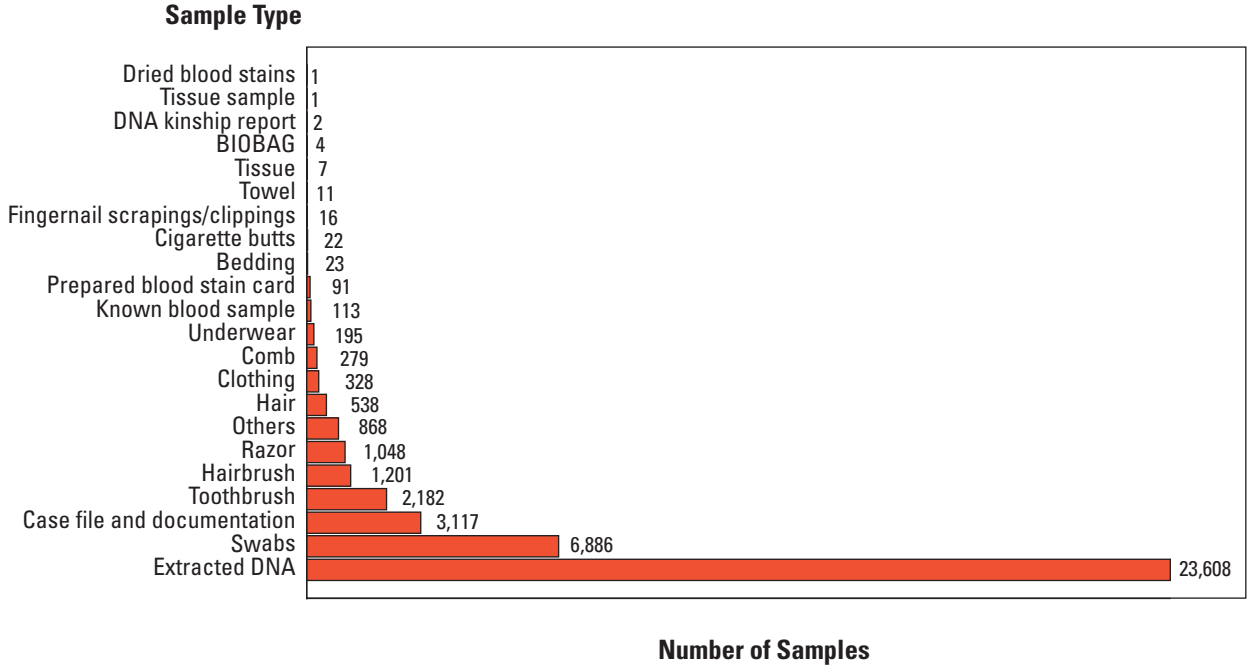
numbers. (Mass fatality incident samples often have several identifying numbers, analogous to case numbers assigned to an agency's casework samples. In addition, when multiple laboratories assist with analysis or interpretation, samples likely will receive multiple identifying numbers, one for each laboratory. The LIMS should be able to accept additional sample numbers and cross-reference them so the sample can be easily queried.)

Because of the large number of samples that may be accessioned in a mass fatality response, the laboratory may need teams of people entering data and checking each other's work if the samples are not barcoded.

The laboratory also should plan on receiving many different types of samples, and, therefore, must be capable of extracting DNA from numerous substrates and analyzing samples with varying quantities of DNA. Exhibit 20, provided by the New York City Office of the Chief Medical Examiner (OCME), shows the number of samples, by sample type, received during the World Trade Center (WTC) DNA identification effort.

A laboratory responding to a mass fatality event must establish a sample-naming scheme that distinguishes personal items, kinship samples, and disaster samples. To limit potential sample mix-ups and ensure that different DNA technologies produce compatible results, the laboratory also

Exhibit 20: Types of Samples From the World Trade Center Response



Source: Information provided by the New York City Office of the Chief Medical Examiner.

In a mass disaster event like the terrorist attacks on the World Trade Center, the commingling of remains is a real possibility. Tissue samples often yielded multiple profiles—seemingly conflicting results—and we soon learned that the most reliable results came from the analysis of bone.

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will need to track the number and type of analysis performed on each sample.

Typically, DNA laboratories encode information in the sample name or identification number. Although this is not optimal from an information technology (IT) perspective, it is a common practice in forensic DNA analyses, because it allows analysts to track analysis-related information along with the sample name. For victim samples, data encoded in the sample identification number may include:

- Identity of the laboratory (in a multilab response) that performed the extraction.
- Identity of the laboratory (in a multilab response) that performed the analysis.
- Extraction attempt number.
- Type of DNA analysis performed (e.g., short tandem repeat (STR), single nucleotide polymorphism (SNP), mtDNA).
- Plate number, tube number, well number, etc.

For personal effect samples, data encoded in the sample name may include:

- Victim identification number.
- Identity of the laboratory (in a multilab response) that performed the extraction.
- Identity of the laboratory (in a multilab response) that performed the analysis.
- Extraction attempt number.
- Type of DNA analysis performed (e.g., STR, SNP, mtDNA).
- Plate number, tube number, well number, etc.

For kinship samples, data encoded in the sample name may include:

- Victim identification number.
- Relationship to victim (e.g., biological mother, father).

In the WTC identification effort, forensic anthropologists triaged disaster samples and decided which ones would undergo DNA analysis. The anthropologists usually were able to separate human from non-human remains. They attempted to identify commingled remains, a seemingly single tissue that yields multiple profiles. These presented some of the greatest challenges in managing the DNA effort. Any laboratory responding to a mass fatality event must identify the extent of commingling (i.e., determine how many individuals are represented in the sample), and then create, administratively, a subsample for each.

DNA personnel should work closely with the anthropologists—or other professionals who are designated to perform the triage—to develop a decision tree for collecting DNA samples from the disaster site. Such a decision tree should consider these issues:

- Commingling of remains—although it requires a different way of thinking, in many types of mass fatality responses, it will simplify the laboratory's work to assume that remains may be commingled.
- Whenever possible, bone or deep tissue should be sampled; bones are much less likely to yield multiple profiles than tissue.
- Unless the tissue is covered by intact skin, do not assume that a tissue sample belongs to one individual. Remains that are not directly linked by tissue should be treated as belonging to separate individuals. Even when the sample is covered with skin, multiple DNA profiles can occur if the victims were in contact with each other.
- When bone is surrounded by tissue, treat the tissue and bone as separate samples, and assign them separate sample numbers.

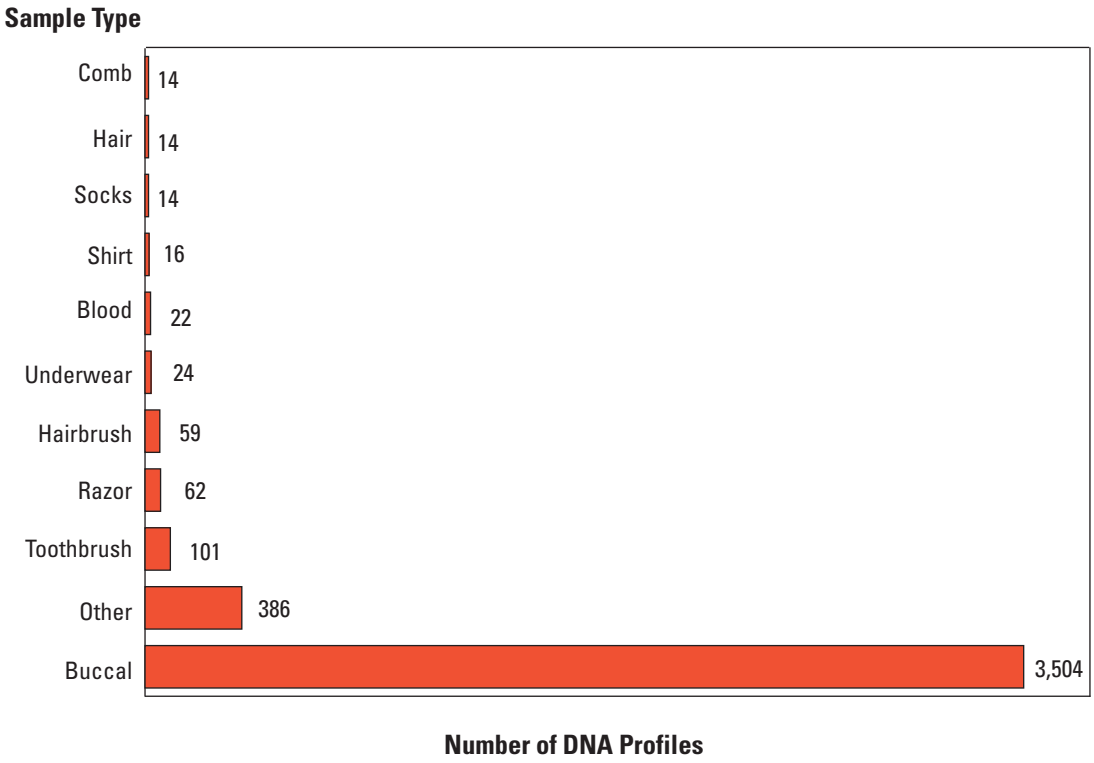
The laboratory is likely to receive and analyze disaster samples before personal effect items or kinship samples. Depending on the duration of the recovery effort, the laboratory may not be able to examine all of the remains and choose only the samples most likely to yield DNA profiles. In an extended recovery effort, the laboratory will have to work samples as they arrive and not assume that "better" or "larger" samples will be available in the future.

Personal items and kinship samples can be collected over a long period of time. Of the three types of samples (disaster, personal effect item, and kinship), personal effect items usually are the most precious because the DNA they yield is likely to be a small quantity. The best personal items from a DNA perspective are toothbrushes, razors, and hairbrushes. Saved letters, with their original licked stamps and envelopes may also provide sufficient quantities of usable DNA for references, but those who provide such letters should be made aware that the testing process will alter the appearance of the envelope. Exhibit 21, provided by the OCME, depicts DNA profiles, by sample type, from the WTC response.

Initially, the laboratory may choose to analyze the most promising personal effect items, analyzing other items only if necessary. Kinship samples can be considered less precious, because they usually have abundant DNA and, hopefully, additional samples can be collected from victims' relatives, if necessary.

In a mass fatality incident response, the laboratory will need a strategy for managing its work. Although work lists may be unnecessary in a small laboratory for routine limited-volume testing, in a mass fatality incident, testing and verification is much more complex, requiring work lists to provide structure, accountability, and traceability in managing the data.

Exhibit 21: DNA Profiles by Sample Type From the World Trade Center Response



Source: Information provided by the New York City Office of the Chief Medical Examiner.

Work lists that are automatically generated by the LIMS greatly facilitate fast and accurate DNA identifications. Since the identification process may change in response to additional testing needs, the LIMS must be flexible. It also must support a "comments" field, where sample and match-specific information can be stored, easily identified, and viewed by laboratory personnel.

Without work lists, our efforts in the World Trade Center identification effort were redundant. Work lists helped to keep the nonintentional redundancy to a minimum.

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Work lists—which should contain sample numbers, dates of previous procedures, and comments—also can be used to:

(1) Notify laboratory personnel of the matching, identification, and reporting tasks that need to be performed.

(2) Minimize duplication of effort by documenting completed work.

(3) Avoid inefficient data processing that can occur when analysts must:

- Search more than one database for a potential match.
- Compare potential matches to identifications that have been established and should have been documented in the LIMS.
- Spend time deducing what new potential matches need to be processed whenever a new match is attempted.

(4) Identify work volumes, allowing the laboratory director to assess the progress of work and target bottlenecks with resources.

(5) Serve as a repository for sample information. By maintaining documentation of the case analyses, the analyst is able to identify processing history, and, by documenting each stage of matching, identification, and reporting with date and user information (in a stage field), the analyst can determine:

- The stage of each potential match/identification.
- How long a potential match/identification has been in each stage.
- The last person responsible for creating information on the potential match/identification.

Other work lists that may be important in a mass fatality identification effort include:

- New match between a previously untested remains fragment and an already tested remains fragment.
- New potential match made with a single personal effect and available kin.
- New potential match made with a single personal effect (no kin).
- New potential match made with kin only.
- Administrative review.
- Reference rerun.
- Administrative resolution.